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FINAL ENVIRONMENTAL STATEMENT

related to the

Rocky Mountain Energy Company's

BEAR CREEK PROJECT

(CONVERSE COUNTY, WYOMING)

prepared jointly by the

U. S. NUCLEAR REGULATORY COMMISSION
(coordinating agency)

the

U. S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

and the

U. S. DEPARTMENT OF AGRICULTURE
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A Final Environmental Statement for the Rocky Mountain Energy Company for the operation of the Bear Creek Uranium Mining and Milling Project in north-central Converse County, Wyoming, has been prepared by the staffs of the U.S. Forest Service, the U.S. Geological Survey, and the U.S. Nuclear Regulatory Commission and was issued by the Office of Nuclear Material Safety and Safeguards of the Nuclear Regulatory Commission. This statement provides (1) an evaluation of environmental impact and adverse effects of the proposed mill, and (2) a consideration of the principal alternatives. Also included are comments of governmental agencies and other organizations on the Draft Environmental Statement for this project, and staff responses to these comments. The Nuclear Regulatory Commission has concluded that, after weighing the environmental, economic, technical, and other benefits of the Bear Creek Project against environmental and other costs and considering available alternatives, the action called for is issuance of a source material license to the applicant, subject to conditions stipulated in the source material license.

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SUMMARY AND CONCLUSIONS

This final environmental impact statement was prepared by the staffs of the U. S. Forest Service, the U. S. Geological Survey, and the U. S. Nuclear Regulatory Commission and was issued by the U. S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards.

1. This action is administrative.

2. The proposed action is the issuance of approvals, permits and licenses to the Rocky Mountain Energy Company for the implementation of the Bear Creek Project, Docket No. 40-8452.

   The Bear Creek Project consists of certain mining and milling operations involving uranium ore deposits located in Converse County, Wyoming. Mining of uranium from nine known ore bodies will take place over a period of ten years (estimated); a mill with a nominal capacity of 1000 tons per day of ore will be constructed and operated as long as ore is available. The waste material (tailings) from the mill, also produced at a rate of about 1000 tons per day, will be stored onsite in an impoundment.

3. Summary of environmental impacts and adverse effects:

   a. The site is predominantly ranchland with both cattle and sheep being grazed. Pronghorn antelope, which graze primarily on forbs and sagebrush, are common in the area. Establishment of the Bear Creek Project would convert about 3000 acres from grazing use to mining and milling activities for a period of about ten years. Mining activities would disturb (and remove vegetation from) a total of about 1800 acres but, because of ongoing reclamation efforts, the maximum acreage disturbed at any one time would be about 1400 acres, and the average about 805 acres. An estimated 165 acres of highwalls and water remaining after reclamation would be lost to agricultural production. The milling activities would disturb about 250 acres; 150 of these would be reclaimed after operations cease, but the 100-acre tailings area, under present plans, must be considered unavailable for further productive use.

   b. Water will be removed from aquifers at an estimated rate of about 1000 gpm (range 600 to 2000 gpm) by mine dewatering. Some of this water will be used to control dust during mining and milling operations. The rest will be stored onsite and occasionally released to existing stream channels. The quality of the discharged water will be closely monitored and will meet the requirement of the NPDES permit (see Appendix L) issued for the project. Mill process water will be obtained from a separate well drilled for this purpose; usage is expected to be less than 300 gpm. The long-term effects on the groundwater are expected to be minor. Surface water will not be affected by normal operations; the mining plan anticipates the establishment of 75-150 acres of water impoundments at the termination of operations.

   c. There will be no discharge of liquid or solid effluents from the facility. The discharge of pollutants to the air will be small and the effects negligible. The concentrations of, and lung-dose-rates from, radionuclides in the air at the nearest ranch (the Manning Ranch) and the nearest ranch in the prevailing wind direction (the Carson Ranch) are:

Nuclide	U-238	U-234	Th-230	Ra-226	Pb-210	Rn-222
Conc. in air (pCi/m^3):						
Manning Ranch	5×10^{-5}	5×10^{-5}	2.8×10^{-5}	2.7×10^{-5}	2.7×10^{-5}	11
Carson Ranch	6.5×10^{-5}	6.5×10^{-5}	3.5×10^{-5}	3.3×10^{-5}	3.3×10^{-5}	14
Dose rate to lungs from inhalation (mrem/yr):						
Manning Ranch	2.0×10^{-2}	2.5×10^{-2}	1.8×10^{-1}		6.4×10^{-2}	44
Carson Ranch	2.0×10^{-2}	2.4×10^{-2}	1.7×10^{-1}		6.2×10^{-3}	56

The dose rates from radon have been computed for individuals in well-ventilated rooms within the Carson and Manning ranchhouses. The dose to the lungs of an individual from the radon-222 in the open air in the vicinity of the ranches is 0.7 mrem/yr. Combining all inhalation pathways results in a lung-dose-rate commitment of 46 mrem/yr at the Manning Ranch and 58 mrem/yr at the Carson Ranch. The corresponding total dose rate to the bone is 1.1 mrem/yr and the whole-body-dose rate is computed to be 0.04 mrem/yr.

d. The Bear Creek Project requires the commitment of about 4500 tons of the country's uranium mineral resource, and relatively small commitments of common building materials, equipment, and fuels.

e. The mining operations will result in overburden dumps and pits. The overburden remaining after operations cease will comprise about 22 million tons and will occupy about 900 acres. Most of the pits will be filled with overburden but about 185 acres of pits (filled to some extent with water) will remain. The milling operations will result in a tailings impoundment of about 150 acres; when operations are terminated, it is anticipated that the extent of the tailings pile can be reduced to about 100 acres by movement of the dried tailings into the center of the impoundment. About three million tons of tailings will be produced over the lifetime of the project. The overburden and tailings piles remaining after operations cease will change the existing topography, and hence the esthetic appreciation of some onlookers.

f. The Bear Creek Project will provide employment and induced economic benefits to the region, but will also result in socioeconomic stress. The stress will exist mainly in the communities of Douglas and Glenrock and in Converse County School Districts No. 1 and 2. The demand for housing may be difficult to satisfy. There will be some disruption of traffic patterns in the region of the project and some loss of hunting opportunity, but these effects should be minor.

4. Principal alternatives considered:

   a. Alternative mining methods
   b. Alternative reclamation procedures
   c. Alternative sites of the mill
   d. Alternative mill processes
   e. Alternative tailings management
   f. Alternative fuels
   g. Alternative of no action.

5. The following Federal, state, and local agencies were asked to comment on this environmental statement:

   Council on Environmental Quality
   Department of Commerce
   Department of the Interior
   Department of Health, Education and Welfare
   Federal Power Commission Federal Energy Administration
   Department of Transportation
   Environmental Protection Agency
   Department of Agriculture
   Advisory Council on Historic Preservation
   Department of Housing and Urban Development
   Energy Research and Development Administration
   Office of the Governor, State of Wyoming
   State Planning Coordinator, State of Wyoming
   Department of Agriculture, State of Wyoming
   Department of Environmental Quality, State of Wyoming
   Department of Game and Fish, State of Wyoming
   Board of Commissioners, Converse County, Wyoming
   Upper Cheyenne River Soil and Water Conservation District #38, Douglas, Wyoming
   Thunder Basin Grazing Association, Douglas, Wyoming

6. This final environmental impact statement will be made available to the public, to the Council on Environmental Quality, and to other specified agencies in June 1977.

7. On the basis of the analysis and evaluation set forth in this statement, it is proposed that any approval, permit, or license issued for the Bear Creek Project should be subject to the following conditions for the protection of the environment:

   a. The applicant shall construct the tailings impoundment to incorporate the features discussed under Alternative III of Section 10.4. The dam shall be constructed to satisfy the safety criteria of the NRC.

   b. The applicant shall implement the environmental monitoring programs and shall take the necessary mitigating actions, as summarized in Section 6 (Table 6.4) of this document.

   c. The applicant shall establish a control program which shall include written procedures and instructions to control all activities as prescribed herein and shall provide for periodic management audits to determine the adequacy of implementation of environmental conditions. The applicant shall maintain sufficient records to furnish evidence of compliance with all the environmental conditions herein.

   d. Before engaging in any activity not evaluated by the agencies, the applicant will prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not evaluated, or that is significantly greater than that evaluated in this environmental statement, the applicant shall provide a written evaluation of such activities and obtain prior approval of the appropriate agency for the activities.

   e. If unexpected harmful effects or evidence of irreversible damage not otherwise identified in this statement are detected during construction or operations, the applicant shall provide to the agencies an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage.

8. Position of the Agencies:

   The proposed position of the Nuclear Regulatory Commission is that, after weighing the environmental, economic, technical, and other benefits of the Bear Creek Project against environmental and other costs and considering available alternatives, the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR 51 is the issuance of a source material license to the applicant, subject to conditions 7.a-e above.

   As announced in a Federal Register Notice dated June 3, 1976 (41 FR 22430), the NRC is preparing a generic environmental statement on uranium milling. Although it is the NRC's position that the tailings impoundment method, discussed in 7.a above, represents the most environmentally sound and reasonable alternative now available, any NRC licensing action will be subject to express conditions that approved waste generating processes and mill tailings management practices may be subject to revision in accordance with the conclusions of the final generic environmental impact statement and any related rule making.

   Subject to opportunities that future information and events may disclose, the current position of the Forest Service is to approve (per 36 CFR) the Mining and Reclamation Plan with modifications (related to soil restoration and revegetation) regarding mining areas II and III (mining claims). The Forest Service concurs* with the Mining and Reclamation Plan, with modifications (related to soil restoration, revegetation and highwall reduction) relative to mining area I (lease area). This position is essentially one of acceptance of the company's proposal with respect to mining areas I, II and III provided that the highwalls on National Grassland surface of the B-1 pit is reduced to 3:1 slopes. Additionally, soil and vegetation data acquired by the company after July 7, 1976, should be used to supplement the existing plan as to reclamation. The rationale and analysis of alternatives leading to this position is presented in Appendix I.

   The Department of the Interior will render its decision on the mining and reclamation plan of the mineral lease after the NEPA process is completed. This will be based on the FES, the comments received, and other data as appropriate.

   After issuance of the DES in January 1977, the applicant submitted to the USGS an amendment to the mining plan, see Section 3.1. This amendment was reviewed and evaluated by the appropriate agencies. Changes resulting from this amended mining plan have been incorporated in this final environmental statement.

*President's Reorganization Plan No. 3 of 1946, subject to the provisions contained in 43 CFR 32112.

CONTENTS

	Page
SUMMARY AND CONCLUSIONS	i
CONTENTS	iv
FIGURES	ix
TABLES	x
FOREWORD	xiii
1. INTRODUCTION	
1.1 The Applicant's Proposal	1-1
1.2 Federal and State Authorities and Responsibilities	1-1
1.3 Background Information	1-4
1.4 Status of Reviews and Actions by Federal Agencies	1-5
1.5 Status of Reviews and Actions by State Agencies	1-5
1.6 The Five Criteria to be Addressed in Mill Licensing Actions	1-5
2. THE EXISTING ENVIRONMENT	
2.1 Climate	2-1
2.1.1 General Influences	2-1
2.1.2 Winds	2-1
2.1.3 Precipitation	2-1
2.1.4 Storms	2-1
2.2 Air Quality	2-1
2.3 Land Use	2-4
2.3.1 Topography	2-4
2.3.2 Land Ownership	2-4
2.3.3 Agriculture	2-5
2.3.4 Commercial and Industrial	2-5
2.3.5 Transportation	2-11
2.4 Water Resources	2-11
2.4.1 Groundwater	2-11
2.4.2 Surface Water	2-15
2.5 Geology, Mineral Resources and Seismicity	2-16
2.5.1 General Geology	2-16
2.5.2 Mineral Deposits	2-16
2.5.3 Seismicity	2-19
2.6 Soils	2-19
2.6.1 Physical Characteristics of Onsite Soils	2-32
2.6.2 General Chemical Properties of Onsite Soils	2-32
2.7 Vegetation	2-32
2.7.1 Grassland	2-32
2.7.2 Meadow	2-32
2.7.3 Sagebrush	2-32
2.8 Wildlife and Fish	2-34
2.8.1 Terrestrial Vertebrates	2-35
2.8.2 Aquatic Vertebrates	2-36
2.8.3 Terrestrial Invertebrates	2-36
2.8.4 Threatened and Endangered Species	2-36
2.9 Preoperational Radiation Environment	2-36
2.10 Social Profile	2-37
2.10.1 Regional Demography	2-37
2.10.2 Community Characteristics	2-37
2.10.3 Social and Cultural Characteristics	2-43
2.10.4 Housing	2-45
2.10.5 Government, Public Services, and Public Finance	2-47
2.11 Recreational Activities	2-55
2.12 Esthetic Considerations	2-55
2.13 Archeological and Historical Values	2-55
References for Section 2	2-57

Page

3. APPLICANT'S PROPOSED MINING AND MILLING OPERATIONS
3.1 Mine . . . 3-1
3.1.1 The Proposed Action . . . 3-1
3.1.2 Mining Procedures . . . 3-1
3.1.3 Reclamation Procedures . . . 3-17
3.1.4 Deleterious Strata and Control Measures . . . 3-20
3.1.5 Surface Water Drainage Control . . . 3-20
3.1.6 Roads . . . 3-21
3.1.7 Personnel . . . 3-21
3.1.8 Support Facilities . . . 3-22
3.1.9 Proposed Mining Equipment . . . 3-24
3.1.10 Protective Measures and Fencing . . . 3-24
3.2 The Mill . . . 3-24
3.2.1 External Appearance of the Mill . . . 3-26
3.2.2 The Mill Circuit . . . 3-26
3.2.3 Non-radioactive Mill Wastes and Effluents . . . 3-29
3.2.4 Control of Mill Waste and Effluents . . . 3-29
3.2.5 Sanitary and Other Mill Waste Systems . . . 3-30
3.3 Radioactive Effluents . . . 3-30
3.3.1 Radioactive Liquid Wastes . . . 3-30
3.3.2 Radioactive Release from the Mining Operation . . . 3-33
3.3.3 Transportation of Ore to Mill . . . 3-33
3.3.4 Ore Pad, Feed to Mill, and Ore Grinding . . . 3-33
3.3.5 Leaching Operation . . . 3-35
3.3.6 Uranium Concentrate Drying and Packaging . . . 3-35
3.3.7 Tailings . . . 3-35
3.3.8 Uranium Concentrate Transportation . . . 3-37
3.3.9 Source Terms . . . 3-37
3.4 Stabilization and Decommissioning . . . 3-37
References for Section 3 . . . 3-40

4. ENVIRONMENTAL IMPACTS
4.1 Air Quality . . . 4-1
4.1.1 Mine . . . 4-1
4.1.2 Mill . . . 4-1
4.2 Land Use . . . 4-2
4.2.1 Topography . . . 4-2
4.2.2 Mine . . . 4-2
4.2.3 Mill . . . 4-2
4.2.4 General . . . 4-2
4.3 Water Resources . . . 4-5
4.3.1 Mine . . . 4-5
4.3.2 Mill . . . 4-6
4.4 Mineral Resources . . . 4-6
4.5 Soils . . . 4-7
4.5.1 Mine . . . 4-7
4.5.2 Mill . . . 4-7
4.6 Environmental Impacts on Vegetation . . . 4-8
4.6.1 Mine . . . 4-8
4.6.2 Mill . . . 4-8
4.7 Environmental Impacts on Wildlife . . . 4-8
4.7.1 Mine . . . 4-10
4.7.2 Mill . . . 4-10
4.8 Radiological . . . 4-10
4.8.1 Air Exposure Pathways . . . 4-13
4.8.2 External Exposure . . . 4-13
4.8.3 Radioactive Food Pathway . . . 4-23
4.8.4 Radioactive Water Pathway . . . 4-23
4.8.5 Radiological Impact on Biota other than Man . . . 4-27
4.9 Impacts on the Community . . . 4-28
4.9.1 Physical Impacts . . . 4-28
4.9.2 Employment, Population, and Income . . . 4-28
4.9.3 Social and Cultural Characteristics . . . 4-31
4.9.4 Housing . . . 4-31
4.9.5 Government, Public Services, and Public Finance . . . 4-31
4.9.6 Availability of Other Goods and Services . . . 4-38
4.9.7 Summary . . . 4-38
References for Section 4 . . . 4-41

Page

5. ENVIRONMENTAL EFFECTS OF ACCIDENTS
5.1 Accidents Involving Radioactivity . . . 5-1
5.1.1 Mine Accidents . . . 5-1
5.1.2 Mill Accidents . . . 5-1
5.2 Accidents Not Involving Radioactivity . . . 5-7
5.2.1 Mine Accidents . . . 5-7
5.2.2 Mill Accidents . . . 5-8
5.3 Transportation Accidents . . . 5-8
5.3.1 Shipments of Yellowcake . . . 5-8
5.3.2 Shipments of Ore to the Mill . . . 5-10
5.3.3 Shipments of Chemicals to the Mill . . . 5-10
References for Section 5 . . . 5-10

6. MONITORING PROGRAMS AND OTHER MITIGATING MEASURES
6.1 Air Quality . . . 6-1
6.2 Land Use and Topography . . . 6-1
6.2.1 Mine . . . 6-1
6.2.2 Mill . . . 6-2
6.2.3 Environmental Monitoring Program . . . 6-2
6.2.4 Federal Environmental Approvals and Permits . . . 6-2
6.2.5 State Environmental Approvals and Permits . . . 6-2
6.3 Water Resources . . . 6-2
6.3.1 Mine . . . 6-2
6.3.2 Mill . . . 6-4
6.3.3 Environmental Monitoring Program . . . 6-4
6.3.4 Federal Environmental Approvals and Permits . . . 6-5
6.3.5 State Environmental Approvals and Permits . . . 6-5
6.4 Mineral Resources . . . 6-5
6.5 Soils . . . 6-6
6.5.1 Mine . . . 6-6
6.5.2 Mill . . . 6-6
6.6 Vegetation . . . 6-6
6.6.1 Mine . . . 6-6
6.6.2 Mill . . . 6-7
6.7 Wildlife . . . 6-7
6.7.1 Environmental Monitoring . . . 6-7
6.8 Radiological . . . 6-7
6.8.1 Preoperational Programs . . . 6-7
6.8.2 Operational Effluent Monitoring Program . . . 6-7
6.8.3 Measurement and Monitoring Programs . . . 6-8
6.9 Community . . . 6-8
6.9.1 Monitoring and Coordination . . . 6-8
6.9.2 Public Finance . . . 6-8
6.9.3 Other Goods and Services . . . 6-12
6.9.4 Housing . . . 6-12
6.9.5 Cultural Impacts . . . 6-12
6.10 Changes in the Monitoring Programs and Mitigative Measures . . . 6-12
References for Section 6 . . . 6-12

7. UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS
7.1 Air Quality . . . 7-1
7.2 Land Use and Topography . . . 7-1
7.2.1 Topography . . . 7-1
7.2.2 Land Use . . . 7-1
7.3 Water Resources . . . 7-1
7.4 Mineral Resources . . . 7-2
7.5 Soils . . . 7-2
7.5.1 Mine . . . 7-2
7.5.2 Mill . . . 7-2
7.6 Vegetation . . . 7-2
7.6.1 Mine . . . 7-2
7.6.2 Mill . . . 7-2
7.7 Wildlife . . . 7-3
7.7.1 Mine . . . 7-3
7.7.2 Mill . . . 7-3
7.8 Radiological . . . 7-3
7.9 Community . . . 7-3
7.9.1 Public Finance . . . 7-3
7.9.2 Abandonment . . . 7-3
7.9.3 Social Impacts . . . 7-3

Page

7.9.4 Cultural Impacts 7-4
References for Section 7 7-4

8. RELATIONSHIP BETWEEN SHORT-TERM USAGE AND LONG-TERM PRODUCTIVITY
8.1 Air Quality 8-1
8.2 Land Use and Topography 8-1
8.3 Water Resources 8-1
8.4 Mineral Resources 8-1
8.5 Soils 8-1
8.5.1 Mine 8-1
8.5.2 Mill 8-2
8.6 Vegetation 8-2
8.6.1 Mine 8-2
8.6.2 Mill 8-2
8.7 Wildlife 8-2
8.7.1 Mine 8-2
8.7.2 Mill 8-2
8.8 Radiological 8-2
8.9 Community 8-2

9. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES
9.1 Air Quality 9-1
9.2 Land Use and Topography 9-1
9.3 Water Resources 9-1
9.4 Mineral Resources 9-1
9.5 Soils 9-1
9.5.1 Mine 9-1
9.5.2 Mill 9-1
9.6 Vegetation 9-1
9.7 Wildlife 9-2
9.8 Radiological 9-2
9.9 Community 9-2

10. ALTERNATIVES
10.1 Alternatives to the Proposed Mining and Reclamation Plan 10-1
10.1.1 Alternatives on the Federal Lease Area 10-1
10.1.2 Mining Alternatives 10-3
10.1.3 Surface Reclamation Alternatives 10-4
10.1.4 Impacts and Effects of the Five Alternatives 10-7
10.1.5 Summary 10-7
10.2 Alternative Sites for the Mill and Mill Tailings Disposal Facilities 10-11
10.3 Alternative Mill Processes 10-12
10.4 Alternative Methods for Tailings Management 10-13
10.4.1 Introduction 10-13
10.4.2 Viable Alternatives 10-13
10.4.3 Evaluation of Alternatives I through VIII 10-18
10.4.4 Other Alternative 10-19
10.5 Alternative of Using an Existing Mill 10-19
10.6 Alternative Energy Sources 10-20
10.6.1 Fossil and Nuclear Fuels 10-20
10.6.2 Solar, Geothermal, Synthetic Fuels 10-22
10.6.3 Byproduct Uranium 10-22
10.6.4 Conservation of Energy 10-23
10.7 Alternative of No Licensing Action on Mill 10-23
References for Section 10 10-24

11. NRC BENEFIT-COST SUMMARY FOR THE BEAR CREEK MILL
11.1 General 11-1
11.2 Quantifiable Economic Impacts 11-1
11.3 The Benefit-Cost Summary 11-1
11.4 Staff Assessment 11-1

12. DISCUSSION OF COMMENTS 12-1

APPENDIX A. COMMENTS A-1

APPENDIX B. STATEMENT OF UNDERSTANDING BETWEEN THE NUCLEAR REGULATORY COMMISSION, UNITED STATES GEOLOGICAL SURVEY OF THE DEPARTMENT OF THE INTERIOR, AND THE UNITED STATES FOREST SERVICE OF THE DEPARTMENT OF AGRICULTURE B-1

		Page
APPENDIX C.	ACQUIRED LANDS MINERAL LEASE W-4416	C-1
APPENDIX D.	SOILS DATA	D-1
D-1.	Estimated Potential Yields	D-2
D-2.	Soils Maps of Mining Areas	D-4
D-3.	General Descriptions of Soils Mapping Units of the Bear Creek Project Area	D-7
D-4.	Estimated Yields and Range Site Identifications	D-13
D-5.	Irrigation Feasibility Study	D-25
APPENDIX E.	ANIMAL SPECIES REPRESENTATIVE OF THE STUDY AREA	E-1
APPENDIX F.	METHODOLOGY AND ASSUMPTIONS FOR FORECASTING PUBLIC NEEDS AND PUBLIC FINANCE	F-1
APPENDIX G.	LETTER CONCERNING ARCHEOLOGY AND PRESERVATION	G-1
APPENDIX H.	BASIS FOR NRC EVALUATION OF THE BEAR CREEK MILL PROPOSAL	H-1
APPENDIX I.	FOREST SERVICE POSITION REGARDING APPROVALS AND PERMITS	I-1
APPENDIX J.	LETTER CONCERNING BONDING INTENTION	J-1
APPENDIX K.	DETAILED RADIOLOGICAL ASSESSMENT	K-1
K-1.	Water Balance for the Bear Creek Project	K-5
K-2.	Radioactive Release from the Mining Operation	K-7
K-3.	Argonne Steady-State Uranium Dispersion and Dosimetry Code (UDAD)	K-8
K-4.	Dose Rate as a Function of Direction and Distance to 80 Km	K-16
K-5.	Time-Integrated Dose from Inhalation of Airborne Particulates and Radon in the Vicinity of Bear Creek to 80 Km	K-30
K-6.	Dose Rate from Airborne and Ground-Deposited Radionuclides	K-49
K-7.	Time-Integrated Dose from External Exposure to Airborne Radionuclides	K-53
K-8.	Time-Integrated Dose from External Exposure to Surface Activity during the Period of Bear Creek Uranium Milling Operation	K-77
K-9.	Food Pathway--Fish	K-101
APPENDIX L.	NPDES PERMIT FOR THE BEAR CREEK URANIUM PROJECT	L-1

FIGURES

Figure		Page
1.1	Map of the Vicinity of the Bear Creek Project	1-2
1.2	Topographical Map of the Bear Creek Project Area	1-3
2.1	Aerial View of the Bear Creek Site, Showing Exploratory Activities	2-4
2.2	Surface Ownership Map	2-7
2.3	Mineral Rights Ownership Map with RMEC Mining Claims Superimposed	2-9
2.4	Local Watersheds of the Bear Creek Project Area	2-15
2.5	Regional Tectonic Map	2-18
2.6	Regional Earthquake Epicenter Map	2-21
2.7	The Quality Rating and Distribution of Soil Units in Mining Area I	2-23
2.8	The Quality Rating and Distribution of Soil Units in Mining Area II	2-25
2.9	The Quality Rating and Distribution of Soil Units in Mining Area III	2-27
3.1	A Typical Open-Pit Uranium Mine in Wyoming	3-2
3.2	The B-4 Pit and Overburden Dump Areas	3-5
3.3	Dilts East and B-4 Pit and Dumps before Reclamation	3-6
3.4	The B-3 Site	3-7
3.5	Mill Site, Tailings Pond, B-1 Orebody, and Dump Areas before Reclamation	3-8
3.6	Dilts West Pit and Overburden Dump Area	3-9
3.7	B-13 East Pit and Overburden Site	3-11
3.8	Reclaimed Areas with Lakes	3-12
3.9	Northern Area of the Project	3-15
3.10	Original Contour of the B-13 Area	3-16
3.11	Final Contour of the B-1 Pit	3-18
3.12	Mine Shops Area, Yard Utilities Plan	3-23
3.13	Artist's Rendition of the Bear Creek Uranium Mill	3-27
3.14	Generalized Flowsheet for the Milling Process	3-28
3.15	Decay Scheme for Uranium-238	3-31
3.16	Radionuclide Dispersions via Pathways Relevant to Bear Creek Project Activities	3-32
3.17	Bear Creek Project Water Balance	3-34
3.18	Profile through the Tailings Pond	3-36
4.1	Major Radiation Exposure Pathways	4-11
4.2	Pathways for Internal Exposure Used for Estimating Annual Dose Rates to Tissues at Risk	4-12
4.3	Concentration of U-238 in Air Estimated from UDAD Code	4-14
4.4	Concentration of Th-230 in Air Estimated from UDAD Code	4-14
4.5	Concentration of Ra-226 in Air Estimated from UDAD Code	4-15
4.6	Concentration of Pb-210 in Air Estimated from UDAD Code	4-15
4.7	Concentration of Ra-222 in Air Estimated from UDAD Code	4-16
4.8	Distance of Nearby Ranches from the Site	4-17
4.9	Concentration of U-238 on the Ground Estimated from UDAD Code	4-24
4.10	Concentration of Th-230 on the Ground Estimated from UDAD Code	4-24
4.11	Concentration of Ra-226 on the Ground Estimated from UDAD Code	4-25
4.12	Concentration of Pb-210 on the Ground Estimated from UDAD Code	4-25
6.1	Environmental Monitoring Stations	6-11
D-2.1	Soils Map of Mine Area I	D-4
D-2.2	Soils Map of Mine Area II	D-5
D-2.3	Soils Map of Mine Area III	D-6
F.1	Methodology for Financial Projections	F-2
H.1	The LWR Fuel Cycle	H-2
H.2	Minimum Annual U_3O_8 Requirements	H-4
H.3	Maximum Annual U_3O_8 Requirements	H-4
K-3.7.1	Safety Factor for U-238 for Bone	K-14
K-3.7.2	Safety Factor for Rn-222 for Lungs	K-15

TABLES

Table		Page
1.1	Status of Regulatory Approvals and Permits Required Prior to Initiation of Project	1-6
2.1	Joint Frequency of Annual Average Wind Speed and Direction for Casper, Wyoming	2-2
2.2	Mean Precipitation for Bill, Wyoming	2-2
2.3	Mean Total Airborne Particulates at the Bear Creek Site	2-3
2.4	Surface Land Ownership	2-5
2.5	Acres and Animal Unit Months of Grazing Unavailable per Year	2-11
2.6	Geologic Formations at the Bear Creek Site	2-12
2.7	Summary of Groundwater Analyses, Bear Creek Project Area	2-13
2.8	Summary of Surface Water Characteristics, Bear Creek Wyoming	2-17
2.9	Earthquakes Less than 150 Miles from the Bear Creek Project Site	2-20
2.10	Soil Mapping Units Rated as Sources of Topsoil Material	2-29
2.11	Estimated Acre-Feet of Soil Available for Reclamation by Quality Class and Disturbed Areas	2-31
2.12	Land Capability and Range Classification for Soil Mapping Units, Bear Creek Project Area	2-33
2.13	Vegetative Species Composition at the Bear Creek Site	2-34
2.14	Radiological Monitoring Stations within 200 Miles of the Plant	2-38
2.15	Population Data for Selected Political Entities in the Project Site Region	2-38
2.16	Distribution of the 1970 Population within 50 Miles of the Bear Creek Mill	2-39
2.17	Distribution of Projected 1996 Population within 50 Miles of the Bear Creek Mill	2-39
2.18	Agricultural Data Summary for Wyoming and Converse County	2-40
2.19	Estimates of Employees Living in Converse County--1975	2-40
2.20	Projected Employment for New Energy-Related Developments in Converse County	2-41
2.21	Converse County Employment Estimates through 1985	2-42
2.22	Projected Demographic Changes in Converse County	2-44
2.23	Indicators of Societal Change in Converse County	2-46
2.24	Projections of Needed Revenues and Expenditures, Town of Douglas	2-51
2.25	Projections of Needed Revenues and Expenditures, Town of Glenrock	2-52
2.26	Projections of Needed Revenues and Expenditures, Converse County	2-53
2.27	Projections of Needed Revenues and Expenditures, Converse County School District #1	2-54
2.28	Projections of Needed Revenues and Expenditures, Converse County School District #2	2-56
3.1	Tentative Schedule for Surface Mining Operations	3-4
3.2	Estimate of Surface Acreage to be Disturbed and Reclaimed During Operation	3-20
3.3	Bear Creek Mine Project Personnel	3-21
3.4	Equipment Proposed for the Bear Creek Surface Mining Project	3-25
3.5	Principal Parameters and Conditions Used in Radiological Assessment of the Bear Creek Milling Operation	3-38
3.6	Average Annual Emissions Resulting from the Bear Creek Project	3-38
4.1	Potential Change in Soil Capability and Range Sites for all Mine Areas Excluding Roads, Powerlines, etc.	4-3
4.2	Potential Yield Summary, Bear Creek Project Site	4-4
4.3	Total Concentration of Radionuclides in Air	4-18
4.4	Dose Rate to Whole Body from Inhalation of Particulates in Air	4-18
4.5	Dose Rate to Bone	4-19
4.6	Dose Rate to Lung	4-19
4.7	Dose Rate (Insoluble) to Gastrointestinal System	4-20
4.8	Dose Rate (Soluble) to Gastrointestinal System	4-20
4.9	Dose Rate to Liver	4-21
4.10	Dose Rate to Kidney	4-21
4.11	Projected 1977 Population Density within an 80-km Radius of the Site	4-22
4.12	Total External Dose Rate	4-25

Table		Page
4.13	Dietary Component of the Radioactivities Released into the Environment at Bear Creek Mine and Mill	4-26
4.14	Estimates of Converse County Employment through 1985	4-29
4.15	Projected Demographic Data for Selected Political Entities	4-30
4.16	Projected Financial Status of Selected Political Entities	4-32
4.17	Projected Financial Status of Selected Political Entities with and without Coal Gasification Development	4-34
4.18	Projections of Needed Revenues and Expenditures, Town of Douglas	4-35
4.19	Projections of Needed Revenues and Expenditures, Town of Glenrock	4-36
4.20	Projections of Needed Revenues and Expenditures, Converse County	4-37
4.21	Projections of Needed Revenues and Expenditures, Converse County School District #1	4-39
4.22	Projections of Needed Revenues and Expenditures, Converse County School District #2	4-40
5.1	Summary of Accidental Tailings Slurry Releases	5-5
5.2	Concentrations of Radionuclides and Chemicals in Tailings Solutions	5-6
5.3	Conditional Probabilities of Occurrence and Corresponding Release Fractions for Type A Containers Involved in Truck Accidents	5-9
6.1	Well Sites in an Ongoing Sampling Program, Bear Creek Project Area	6-3
6.2	Surface Water Sampling Stations in the Bear Creek Project	6-3
6.3	Representative Surface Water Data for Radiological Monitoring Stations in the Bear Creek Region	6-7
6.4	Radiological Monitoring Program, Bear Creek Project	6-9
10.1	Land-Use Goals	10-4
10.2	Relative Costs of Mining and Reclamation Alternatives	10-7
10.3	Summary of Existing and Predicted Soil Capability and Range Site Classes for All Disturbed Areas	10-8
10.4a	Potential Yield Summary for Areas to be Disturbed--Non-irrigated Potentials	10-9
10.4b	Potential Yield Summary for Areas to be Disturbed--Irrigation Potentials	10-10
10.5	Acreage Available for Potential Use According to Reclamation Alternatives Considered	10-11
10.6	Tailings Management Alternatives Rejected	10-19
10.7	Reserves and Current Consumption of Energy Sources	10-20
10.8	Estimated Relative Changes in Resources to be Used for Generation of Projected Energy Requirements	10-21
10.9	Uranium Requirements	10-22
10.10	U. S. Uranium Resources	10-22
D-1.1	Estimated Potential Yield--Crops	D-2
D-1.2	Estimated Potential Forage Yields--Native Range	D-3
D-4.1(a)	Estimated Optimum Yields of Nonirrigated Crops--Area 58	D-13
D-4.1(b)	Estimated Optimum Yield of Irrigated Crops--Area 58	D-14
D.4.2	USDA-Soil Conservation Service Descriptions of Range Sites Identified within the Project Area	D-15
D-5.1	Estimated Consumptive Water Use of Crops	D-25
D-5.2	Water Quantities	D-26
D-5.3	Actual Irrigable Land	D-26
F-1	Assumptions Used in Estimating Public Operating Expenditure Needs	F-3
F-2	Thresholds and Outlay Requirements for Capital Facilities	F-5
H-1	"National Energy Outlook" Forecast of Nuclear Capacity	H-3
J-1	Cost Estimate for Reclamation Program	J-3
K-3.1	Meteorological Input Data	K-9
K-3.2	Source Characteristics in Air	K-9
K-3.3	Effective Dispersion Factor for the Dryer	K-10
K-3.4	Effective Dispersion Factor for the Mine	K-11
K-3.5	Concentrations of Radionuclides in Air	K-11
K-3.6	Concentrations, Ratios, and Work Levels of Radon Daughters at Various Distances from the Site	K-12
K-4	Dose Rate as a Function of Direction and Distance to 80 Km	K-16
K-4.1--K-4.5	Dose Rate to Whole Body	K-17
K-4.6--K-4.10	Dose Rate to Bone	K-19
K-4.11--K.4.16	Dose Rate to Lung	K-22

Table		Page
K-4.17--K-4.21	Dose Rate to GI (sol)	K-25
K-4.22--K.4.26	Dose Rate to GI (insol)	K-27
K-5	Time Integrated Dose from Inhalation of Airborne Particulates and Radon in the Vicinity of Bear Creek to 80 Km	K-30
K-5.1--K.5.5	Dose to Whole Body	K-31
K-5.6--K.5.10	Dose to Bone	K-33
K-5.11--K.5.15	Dose to Lung	K-36
K-5.16--K.5.20	Dose to Kidney	K-38
K-5.21--K.5.25	Dose to GI System (soluble radionuclides)	K-41
K-5.26--K.5.30	Dose to GI System (insoluble radionuclides)	K-43
K-5.31--K.5.35	Dose to Liver	K-46
K-6	Dose Rate from Airborne and Ground-Deposited Radionuclides	K-49
K-6.1	Maximum Total Dose Rate from Ground and Cloud--Angle 45°	K-50
K-6.2	Total Dose Rate from Ground and Cloud--Angle 0°	K-50
K-6.3	Total Dose Rate from Ground and Cloud--Angle 90°	K-51
K-6.4	Total Dose Rate from Ground and Cloud--Angle 180°	K-51
K-6.5	Total Dose Rate from Ground and Cloud--Angle 270°	K-52
K-7	Time-Integrated Dose from External Exposure to Airborne Radionuclides	K-53
K-7.1--K.7.5	Dose to Whole Body	K-54
K-7.6--K-7.10	Dose to Skin	K-56
K-7.11--K.7.15	Dose to Ovaries	K-59
K-7.16--K-7.20	Dose to Testes	K-61
K-7.21--K-7.25	Dose to Small Intestine	K-64
K-7.26--K-7.30	Dose to Lung	K-66
K-7.31--K.7.35	Dose to Red Marrow	K-69
K-7.36--K-7.40	Dose to Skeleton	K-71
K-7.41--K-7.45	Dose to Spleen	K-74
K-8	Time-Integrated Dose from External Exposure to Surface Activity during the Period of Bear Creek Uranium Milling Operation	K-77
K-8.1--K-8.5	Dose to Whole Body	K-78
K-8.6--K-8.10	Dose to Skin	K-80
K-8.11--K-8.15	Dose to Ovaries	K-83
K-8.16--K-8.20	Dose to Testes	K-85
K-8.21--K-8.25	Dose to Small Intestine	K-88
K-8.26--K-8.30	Dose to Lung	K-90
K-8.31--K-8.35	Dose to Red Marrow	K-93
K-8.36--K-8.40	Dose to Skeleton	K-95
K-8.41--K-8.45	Dose to Spleen	K-98

FOREWORD

This environmental impact statement is issued by the U. S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards, in accordance with the Commission's regulation, 10 CFR Part 51, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

In keeping with the standing Federal policy of interagency cooperation, an agreement was made among representatives of the NRC, the United States Forest Service (FS), and the United States Geological Survey (USGS) that the NRC would act as the coordinating agency in the joint conductance of the environmental review required by NEPA relative to the proposed Federal actions described in this document. It was further agreed that the cooperating agencies would supply input to the environmental impact statement, with regard to matters in which these agencies would have a jurisdictional interest or responsibility. Accordingly, this environmental statement is intended to meet the requirements of NEPA both with respect to the issuance of permits for operations described herein, and with respect also to the jurisdictional responsibilities of the cooperating Federal agencies.

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of the NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Pursuant to 10 CFR 51, the NRC Division of Fuel Cycle and Material Safety prepares a detailed statement on the foregoing considerations with respect to each application for a source material license for a uranium mill.

When application was made for a license and other related Federal actions, the applicant submitted an environmental report to the three agencies. In conducting the required NEPA review, the agencies' representatives (staff) met with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the agencies have a thorough understanding of the proposed project. In addition, the staff sought information from other sources to assist in the evaluation, and to conduct field inspections of the project site and surrounding area. Members of the staff also met with State and local officials who are charged with protecting State and local interests. On the basis of all the foregoing, and other such activities or inquiries as were deemed useful and appropriate, the staff made an independent assessment of the considerations specified in Section 102(2)(C) of the NEPA.

This evaluation led to the issuance of a draft environmental statement by the Office of Nuclear Material Safety and Safeguards. The draft statement was distributed to Federal, State and local governmental agencies, and other interested parties for comment. A summary notice was published in the Federal Register, announcing the availability of the applicant's environmental report and the draft environmental statement.

After comments on the draft statement were received and considered, the staff prepared this final environmental statement that includes discussion of questions and comments submitted by reviewing agencies or individuals. Further environmental considerations were made on the basis of these comments and combined with the previous evaluation; the total environmental costs were then evaluated and weighed against the environmental, economic, technical and other benefits to be derived from the proposed project. This final environmental statement is being made available to the Council on Environmental Quality, to those agencies and individuals commenting on the draft environmental statement, and to the public in June 1977.

1. INTRODUCTION

1.1 THE APPLICANT'S PROPOSAL

Pursuant to the appropriate regulations, an application was filed by Rocky Mountain Energy Company (hereinafter referred to as the applicant or RMEC) to conduct certain mining and milling operations involving uranium ore deposits located in Converse County, Wyoming; these proposed operations are collectively referred to as the Bear Creek Project. The project consists of mining uranium from six known ore bodies over a period of 10 years (estimated) and construction and operation of a mill with a nominal capacity of 1000 tons/day. The waste material (tailings) from the mill, also produced at a rate of about 1000 tons/day, will be stored onsite in an impoundment.

The proposed Bear Creek Project is located in rural Converse County about 45 miles northeast of Casper and about 37 miles north-northwest of Douglas (Fig. 1.1). The nearest sizable settlement is Glenrock, about 29 miles south-southwest of the site. The largest ore body, in Sections 10 and 15 of T.38N, R.73W, lies beneath land largely owned by the Federal Government. The mill and the tailings pond will be located on mill site claims which may be patented and on land owned by the State of Wyoming. RMEC has mineral claims and leases for all of the uranium ore deposits that the company plans to mine. The proposed layout of the project, including the three mining areas, is shown in Figure 1.2.

1.2 FEDERAL AND STATE AUTHORITIES AND RESPONSIBILITIES

In the initial discussions of the proposed Bear Creek Project, it was recognized that activities would be conducted over which three Federal agencies have approving, permitting, or licensing authority. These agencies are: the U. S. Forest Service (FS); the U. S. Geological Survey (USGS); and the U. S. Nuclear Regulatory Commission (NRC). Consequently, in keeping with standing Federal policy of interagency cooperation, and in compliance with the Code of Federal Regulations, Title 40, Chapter V, Part 1500.7(b), it was resolved that the preparation of an environmental impact statement would be a joint effort between the FS, the USGS, and the NRC, with the NRC acting as the coordinating agency, and that the statement would contain an environmental assessment of the full range of Federal actions involved. Therefore, a Statement of Understanding between the FS, the USGS, and the NRC was prepared to establish the basis for the preparation of the joint environmental impact statement prescribed by the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190, 42 USC 4321, et seq.) and Executive Order No. 11514 (35FR4247).

The Statement of Understanding recognizes that the Regional Forester of the Rocky Mountain Region is vested with authority to administer the surface resources of National Forest System lands. The provisions of the Bankhead-Jones Farm Tenant Act of 1937, and the Multiple Use-Sustained Yield Act of 1960, apply to the mining and milling proposal and will be implemented through 43 CFR 3501.2-5(d), 36 CFR 251 and 252, and 30 CFR 231.10.

The Bureau of Land Management, which has authority to administer the Federal mineral estate, is not a partner in the preparation of this statement because it has no approval actions pending. The lease of concern here (W-4416) was granted in 1970, and operations under valid mining and millsite claims are nondiscretionary with the agency.

Forest Service mining regulations (36 CFR 252) apply to the surface of unpatented mining and millsite claims. Within 30 days of receipt of the proposed plan of operations, the authorized officer will:

a. Notify the operator that he has approved the plan of operations; or

b. Notify the operator that the proposed operations are such as not to require an operating plan; or

c. Notify the operator of any changes in, or additions to, the plan of operations deemed necessary to meet the purpose of the regulations in this part; or

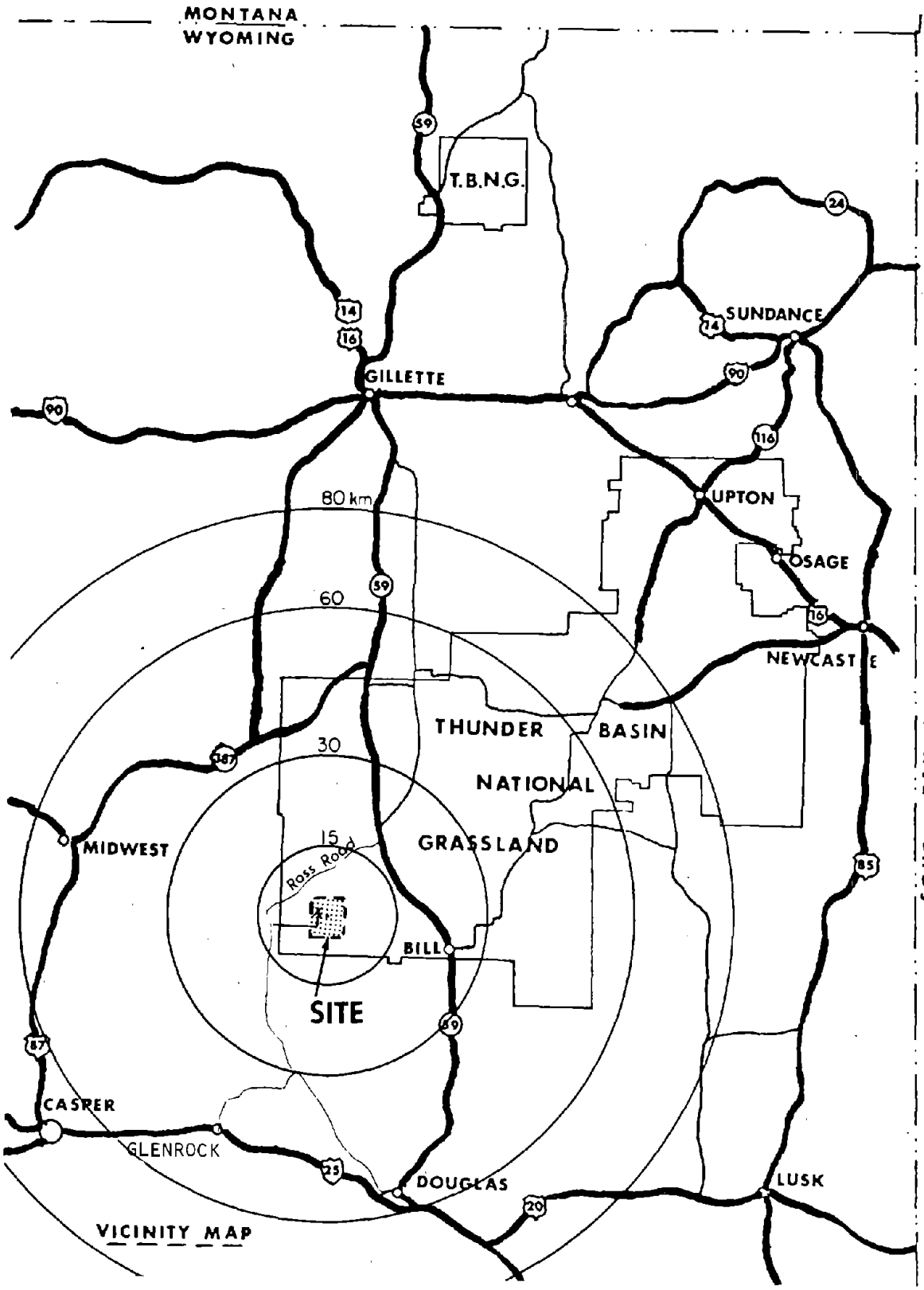


Fig. 1.1. Map of the Vicinity of the Bear Creek Project.

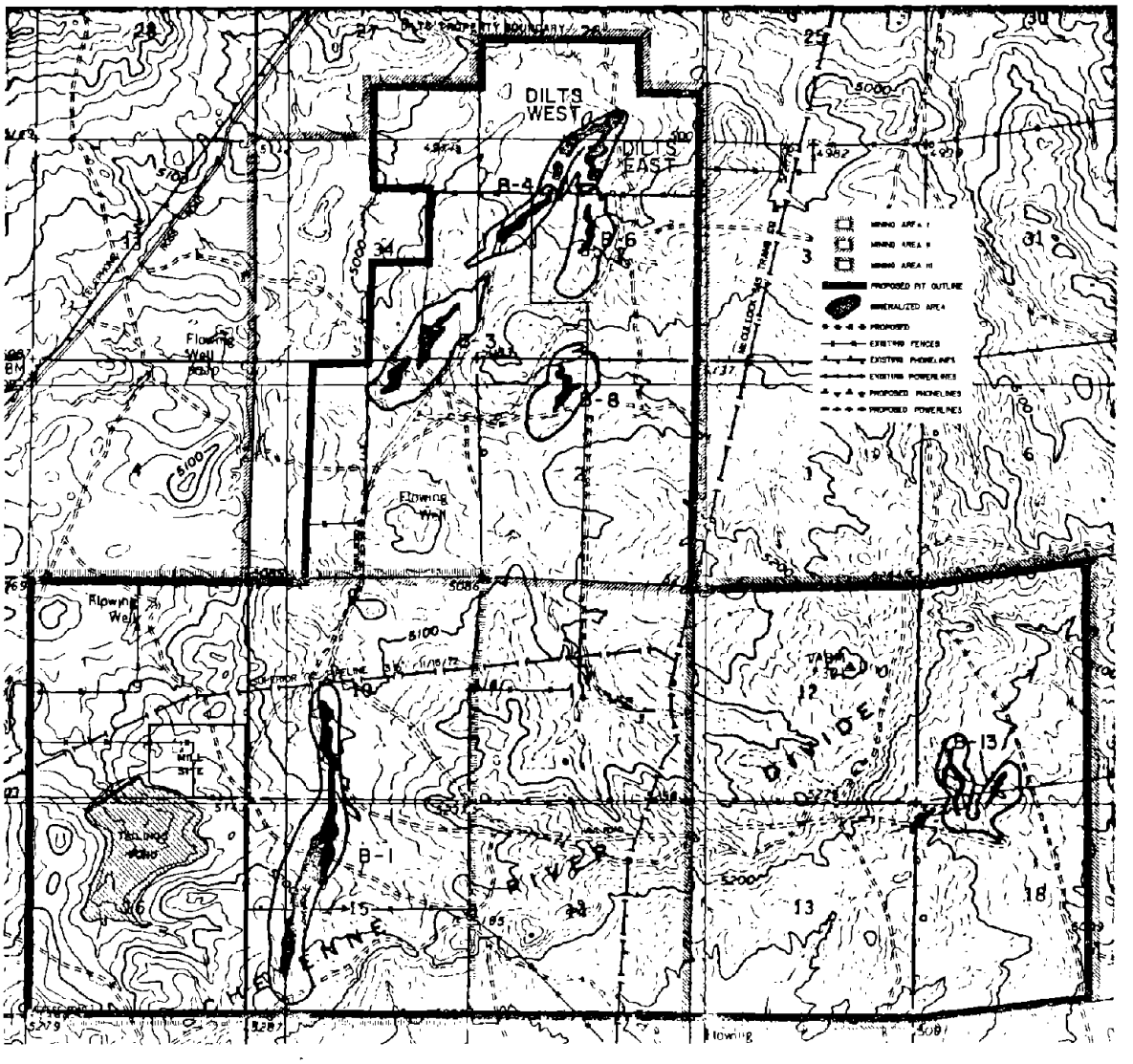


Fig. 1.2. Topographical Map of the Bear Creek Project Area. Provided by the Applicant.

d. Notify the operator that the plan is being reviewed but that more time, not to exceed an additional sixty (60) days, is necessary to complete such review, setting forth the reasons why additional time is needed: Provided, however, that days during which the area of operations is inaccessible for inspection shall not be included when computing the sixty (60) day period; or

e. Notify the operator that the plan cannot be approved until a final environmental statement has been prepared and filed with the Council on Environmental Quality. (This was the action taken.)

The Director for the USGS has the authority to administer mining operations on Federal mineral leases under the Mineral Leasing Acts and under the regulations set forth in 30 CFR 231. The options available to the Secretary of the Interior are discussed in Section 10.1.1.

The NRC has authority to issue or deny the source material license necessary to operate the uranium mill.

Within this framework, each agency was responsible for data collection and analysis and for the preparation of text treating their respective areas of responsibility: that is, the FS treated surface physical and biological resources; the USGS, mining and sub-surface resources; and the NRC, radiological health and safety, and milling operations. The complete text of this Statement of Understanding is provided in Appendix B. The objective of this agreement was the production of an environmental statement intended to meet the requirements of NEPA both with respect to the issuance of the various permits described herein, and with respect also to the jurisdictional responsibilities of the Federal agencies involved.

The State of Wyoming Department of Environmental Quality administers the state's Environmental Quality Act of 1973, and implementing rules and regulations. Article 4 of the Act established a permit and licensing scheme which is designed to insure adequate reclamation of mined lands. The licensing procedure is based on the operator's submission of a detailed reclamation plan to the state. A performance bond is required. According to the Land Quality Rules and Regulations (1975), reclamation shall restore the land to a condition equal to or greater than the "highest previous use" and are required to restore wildlife habitat. The Federal agencies will cooperate with the Department, and other state agencies, in approval actions where both Federal and state levels of government have an interest.

1.3 BACKGROUND INFORMATION

The region in which the proposed project is located is used primarily for livestock grazing, wildlife habitat, and mineral exploration. The state and Federal lands of the project site are under use arrangements with local ranchers and are utilized for grazing by cattle and sheep. Many unimproved roads and trails traverse the project area, providing access for ranching and mineral exploration activities. Several water wells occur in the area; some flow naturally and some are pumped. Several small impoundments for storing surface runoff have been built in the channels of intermittent streams.

The area in the vicinity of the project site is almost completely covered by mineral claims and leases. A series of inactive open-pit mines and spoil dumps from past uranium mining operations exists south of the site. A few oil wells are located to the east of the site and a natural gas pipeline crosses the project site.

The mining and reclamation activities of the Bear Creek Project are proposed on an acquired-land preference right lease (No. W-4416 reproduced as Appendix C), mining claims and mill site claims.

The preference right lease was awarded to the Union Pacific Railroad Company on April 1, 1970. In March 1974 the lease was assigned to the Union Pacific Mining Corporation, which merged into the Rocky Mountain Energy Company in April 1974.

The mining claims, except the Rey claims located over a portion of the B-13 ore body, were staked in 1967 by the Union Pacific Railroad Company and later transferred to RMEC. The Rey claims were staked in 1968 by the Homestake Mining Company and acquired in 1972 by RMEC.

The mill-site claims were staked by RMEC in 1974.

The terms of the preference right lease and Mining Claim Regulations (36 CFR 252) require RMEC to submit a mining and reclamation plan. An initial plan was submitted in July 1975 and supplemental plans have since been filed.

Prior to the issuance of a source material license to operate a uranium mill, the applicant is required to submit a license application prepared in accordance with NRC Regulatory Guide 3.5

and an environmental report* prepared in accordance with NRC Regulatory Guide 3.8. A discussion of the milling operation is presented in Section 3.2.

Pursuant to the provisions of paragraph 40.14(b) of 10 CFR 40, the applicant by letter dated January 20, 1976, requested an exemption from the provisions of paragraphs 40.31(f) and 40.32(e) to allow certain site preparation and construction activities before the issuance of a final environmental impact statement.

This exemption was granted by the NRC on April 1, 1976, after consideration of specific environmental factors, and was concurred in by the FS by letter to the applicant dated April 14, 1976. These activities, which began in the summer of 1976, were undertaken at the financial risk of the applicant.

1.4 STATUS OF REVIEWS AND ACTIONS BY FEDERAL AGENCIES

The following Federal regulatory approvals and permits are required before realization of the Bear Creek Project:

1. Approval of a mining and reclamation plan by the USGS (with FS concurrence) on the acquired-land mineral lease,

2. Approval of an operating plan by the FS, in connection with mining and mill site claims,

3. Issuance of a source material license by the NRC,

4. Issuance of special use permits for National Grassland surface by the FS for any needed ancillary facilities.

The current status (October 1976) of the regulatory approvals and permits issued by Federal agencies is given in Table 1.1.

1.5 STATUS OF REVIEWS AND ACTIONS BY STATE AGENCIES

The State of Wyoming requires that various permits or licenses be obtained prior to the initiation of various stages of mining and milling operations. The current status of the regulatory approvals and permits required prior to initiation of the Bear Creek Project is given in Table 1.1.

1.6 THE FIVE CRITERIA TO BE ADDRESSED IN MILL LICENSING ACTIONS

In order that uranium mills may be granted a source material license prior to the publication of the generic statement on uranium milling operation, the NRC [Fed. Reg. 41, 22430 (June 3, 1976)] requires address of the "five criteria" considered below.

1. It is likely that each individual licensing action of this type would have a utility that is independent of the utility of other licensing actions of this type;

   This statement is manifestly true for uranium mills in general and for Bear Creek in particular. The Bear Creek mill is located near the source of the ore, immediately adjacent to the largest ore body because of the high cost of hauling the ore, which typically contains less than five pounds of uranium per ton. The Rocky Mountain milling operation, therefore, is virtually independent of other milling operations; it is customary to erect a mill to process a given ore body and to disassemble the equipment when the uranium resource is depleted. In the case of Bear Creek, an alternative strategy utilizing an existing mill some 35 miles away was considered and rejected because of an economic penalty of about $2.50 per pound of concentrate resulting from added transportation costs and a mill-use fee. Clearly, each milling project is to be considered on its own merits; licensing actions with respect to one mill are independent of those applied to other mills, and a cost-benefit analysis can be performed for each licensing action of this type.

2. It is not likely that the taking of any particular licensing action of this type during the time frame under consideration would constitute a commitment of resources

*Rocky Mountain Energy Company, "Bear Creek Project Environmental Report" (prepared by Dames & Moore) with supplements, Docket No. 40-8452, July 1975. [Hereinafter this will be cited as the ER, with specific section number, page number, etc.]

Table 1.1. Status of Regulatory Approvals and Permits Required Prior to Initiation of Project

Permit or License	Granting Authority	Date of Application	Date Granted
Mining	DEQ[a]	July 1975 Rev. June 1976	November 1975 Pending
Air (to construct)	DEQ	January 1976	March 1976 Amended Jan. 10, 1977
Solid (construction) Waste Disposal	DEQ	May 1976	September 1976
Sanitary (mill office)	DEQ	May 1976 Rev. June 1976	July 1976
Mine Shop Waste Water	DEQ	June 1976	July 1976
NPDES[b]	DEQ	July 1976	September 1976
Mining (gravel and sand pit)	DEQ	December 1975 Rev. June 1976	February 1976 Pending
Mine Waste Water	DEQ	August 1976	September 30, 1976
Mill Waste Water	DEQ	To be submitted	
Water Wells (6)	SE[c]	July 1975 - August 1976	July 1975 - August 1976
Tailings Dam and Seepage Control Reservoir	SE	September 1975	February 1976 (?)
Mine Waste Water Settling	SE	August 1975	September 1976
Land Lease (tailings pond)	State of Wyoming	-	May 1975 (executed)
Right-of-way (access)	USFS[d]	January 1976 (?) Resubmitted April 1976	April 1976 (denied) May 1976 (conditional)
Mill construction	USFS	March 1976	April 1976 (conditional)[e]
Fence construction	USFS	April 1976	May 1976
Mining/Reclamation	USGS[f]	June 1975 Rev. March 1976	Pending
Exemption [10 CFR 40.32(e) and 10 CFR 40.14]	USNRC[g]	January 1976 (Clarification of exemption - August 1976)	April 1976

[a]Wyoming Department of Environmental Quality.

[b]National Pollutant Discharge Elimination System.

[c]Wyoming State Engineer.

[d]U. S. Forest Service.

[e]Conditions satisfied April 22, 1976 (pending completion of EIS).

[f]U. S. Geological Survey.

[g]U. S. Nuclear Regulatory Commission.

that would tend to significantly foreclose the alternatives available with respect to any other individual licensing action of this type;

The proposed Bear Creek action involves the construction and operation of a mill to produce "yellowcake" from local uranium ore bodies. As pointed out in the response to the first criterion, uranium mills are normally located close to an economically exploitable ore body. The ore body would not likely be exploited to provide feed for a more distant mill. As to the commitment of resources, none of the materials involved in the construction and operation of the mill is unique, or in short supply; hence, licensing this mill would not affect any licensing action with respect to other mills. Air, land, and water resources would be used locally, but not to an extent which would preclude the erection and operation of another mill nearby.

3. It is likely that any environmental impacts associated with any individual licensing action of this type would be such that they could adequately be addressed within the context of the individual license application without overlooking any cumulative environmental impact;

The Bear Creek EIS has considered the environmental impacts associated with the proposed licensing action, assessed their severity, and proposed monitoring programs and other actions to mitigate the impacts. Cumulative impacts have been addressed within the context of the individual license. The relative isolation of the proposed site virtually ensures that all appropriate environmental impacts can be adequately addressed in a site-specific EIS, with the possible exception of long-term effects from the tailings impoundment; these effects will be evaluated in a forthcoming generic environmental statement. The major objective of the generic statement is the generation of proposals to mitigate such impacts.

4. It is likely that any technical issues that may arise in the course of a review of an individual license application can be resolved within that context;

The applicant has considered alternative mill processes and other technical issues in its license application and environmental report. The staff has reviewed the applicant's evaluations and, in addition, has evaluated other technical issues. All of these evaluations and, presumably, any further technical issues which may arise during review are resolvable within the context of the individual licensing action, inasmuch as this mill is independent of other mills. In addition, the license will be conditioned as required by the FR notice of June 3, 1976 (41 FR 22431) to permit revision of waste generation and management practices, etc.

5. A deferral on licensing actions of this type would result in substantial harm to the public interest as indicated above because of uranium fuel requirements of operating reactors and reactors now under construction.

Some of the pertinent information from the statement is abstracted below:

> U.S. uranium mills produced 11,600 tons of yellowcake in 1975, using 70% of stated capacity. The stated capacity, 16,570 standard tons, would be exceeded in 1981, if currently operating and scheduled reactors operated at an 80% plant factor, and in 1983, with a 60% plant factor. It is quite likely that new mills will be needed prior to these dates because most of the current mills have been operating for more than ten years and are facing obsolescence; furthermore, even in a new mill, continuous operation at full capacity is rarely achieved. The entire output is used to fuel nuclear reactors to produce electricity for utility customers.

There is a need for new mill capacity prior to 1981 (probably as early as 1979). The customary interval from the issuance of a source material license for a new mill to the loading of reactor fuel is five years. Bear Creek is one of a small number of new mills that have been proposed in the last several years; a deferral of its operation could extend the time required for the delivery of needed fuel, and could adversely affect the ability of reactors now operating or under construction to deliver needed electrical power. Such a shortfall of electrical energy is generally construed to be harmful to the public interest.

2. THE EXISTING ENVIRONMENT

2.1 CLIMATE

2.1.1 General Influences

The weather and climate of central Wyoming is dominated by low- and high-pressure centers, with attendant frontal systems, that migrate through the area throughout the year. The climate is semiarid, with a mean annual precipitation of 12.0 inches. More than 50 percent of the annual precipitation is received during the months of May, June, and July, in the form of wet snow and rain. Temperatures vary from summer highs near 100°F (38°C) to winter lows near -40°F (-40°C). The seasons are distinct, with mild summers and harsh winters. Spring and fall are transition seasons, with warm days and cold nights. Heavy snowfalls can be expected during both these seasons.[1]

2.1.2 Winds

The prevailing wind direction is westerly to southwesterly, and the speeds are quite high. Characteristics of wind speed and direction, abstracted from meteorological records for Casper, Wyoming, are presented in Table 2.1. Based on evaluation of local meteorological patterns, the staff concluded that the Casper data are representative of the site. Strong winds are fairly frequent; the strongest recorded wind speed was 81 mph from the southwest and occurred in March 1956.[2]

The local topography strongly influences micrometeorological conditions at the site. The dilution of airborne contaminants resulting from normal operating releases will be determined largely by small-scale turbulence in the local area, combined with the prevailing wind, and with the mode of release (ground-level or elevated). Onsite collection of meteorological data was initiated recently, and two year's data will have been collected before the plant begins operation.

2.1.3 Precipitation

The average annual precipitation at Bill, Wyoming, located approximately 15 miles east of the site, is 12.0 inches, but relatively large variations occur in the monthly and seasonal totals. Late spring and summer precipitation is normally derived from scattered thunderstorms; the land area affected and amounts of rain falling during such storms is extremely variable. The mean monthly total precipitation and snowfall for Bill, averaged over the 13 years ending in 1960, are listed in Table 2.2. The maximum annual precipitation recorded at Casper during the last 35 years was 16.24 inches, occurring in 1941.

2.1.4 Storms

Winter storms, with attendant snowfall, low temperatures, and high winds are common. Summer thunderstorms, occasionally spawning tornadoes, are frequent in spring and summer. These tornadoes tend to be notably less destructive than those occurring farther east. Five tornadoes have been reported within 50 miles of the site since 1950.[3]

2.2 AIR QUALITY

The Bear Creek site is included in the Casper Intrastate Air Quality Control Region. Present air quality in the area is considered to be good. The current mean suspended particulate content is an estimated 13 to 21 micrograms per cubic meter;[4] whereas, the national primary standard is 75 and the proposed Wyoming State Standard is 60 micrograms per cubic meter.[5] Data on background levels of sulfur dioxide, hydrocarbons, and oxides of nitrogen are lacking. The Environmental Protection Agency (EPA) has proposed that the Powder River Basin be classified as an "air quality maintenance area", meaning that this region is viewed by the EPA as having the potential for significant decline in ambient air quality due to the projected increases in mining and industrial activity.

Table 2.1. Joint Frequency of Annual Average Wind Speed and Direction for Casper, Wyoming, 1966-1975, with 2.2% Calm Distributed in the Table

Direction	Speed, mph						
	0-3	4-6	7-10	11-16	17-21	>21	Total
N	0.4%	1.5%	1.4%	0.8%	0.3%	0.1%	4.5%
NNE	0.4	1.9	2.2	2.1	0.6	0.1	7.3
NE	0.2	1.0	1.4	1.0	0.2	0.1	3.9
ENE	0.2	0.9	1.1	0.6	0.1	0.0	2.9
E	0.4	1.3	1.7	1.2	0.2	0.1	4.9
ESE	0.2	0.7	0.7	0.4	0.1	0.0	2.1
SE	0.2	0.6	0.5	0.2	0.0	0.0	1.5
SSE	0.2	0.7	0.4	0.1	0.0	0.0	1.4
S	0.2	0.7	0.4	0.3	0.1	0.0	1.7
SSW	0.2	0.9	1.8	4.5	4.3	2.4	14.1
SW	0.2	0.9	2.8	6.3	4.5	2.1	16.8
WSW	0.4	1.7	5.2	4.8	2.0	0.9	15.0
W	0.8	2.9	4.5	2.8	1.0	0.6	12.6
WNW	0.3	1.3	1.0	0.9	0.3	0.1	3.9
NW	0.2	1.1	1.0	0.5	0.2	0.0	3.0
NNW	0.4	1.8	1.3	0.6	0.2	0.1	4.5
	4.9%	19.9%	27.4%	27.1%	14.1%	6.6%	

Table 2.2. Mean Precipitation for Bill, Wyoming

Month	Mean Total Precipitation, inches	Mean Snowfall, inches
January	0.50	9.7
February	0.40	14.2
March	0.85	13.7
April	1.20	1.7
May	2.30	0.3
June	1.70	0.0
July	1.45	Trace
August	0.95	0.90
September	0.85	4.7
October	0.60	9.2
November	0.50	8.8
December	0.70	9.0
Annual	12.00	72.2

Currently, the fossil-fueled electric power plant located near Glenrock is considered to be the significant emission source in the air quality control region.[6] The Highlands Uranium Operation, located approximately 13 miles south of the project site, is not considered a significant emission source; however, the emissions and local air quality at the site are monitored.

Baseline monitoring of air quality has begun at the Bear Creek site. The data for total suspended particulates at the site are shown in Table 2.3. The data correspond with the general means for the area, and reflect the good air quality of the region.

Table 2.3. Mean Total Airborne Particulates at the Bear Creek Site[a]

Date	Total Suspended Particulates, micrograms per cubic meter
November 1974	9
December	9
January 1975	16
February	8
March	11
April	10
May	13
June	16
July	25
August	23
September	23
October	12
November	12
December	6
January 1, 1976	6
January 7	No data
January 13	26
January 19	5
January 25	14
January 31	6
February 6	Invalid
February 12	12
February 18	Invalid
February 24	11
March 1	12
March 7	14
March 13	12
March 19	Invalid
March 25	7
March 31	9

[a]From Meteorology and Air Quality Monitoring Program Reports, Rocky Mountain Energy Co., Bear Creek Project, Converse County, Wyoming, October 1974 to Date.

2.3 LAND USE

2.3.1 Topography

The RMEC's proposed Bear Creek project site is located in the southern portion of the Eastern Powder River Basin, which is a structural and topographic depression between the Bighorn Mountains and the Black Hills. The present topography is a result of erosion that has cut into the sedimentary rock outcrops that occur in the area. The basin is a plateau of low relief characterized by low rolling hills capped by sandstone and clinker deposits, and dissected by steep-sided gulleys, washes and broad alluviated valleys. The general topographical character of the site is shown in Figure 1.2 and an aerial view is presented in Figure 2.1.

The mill site and most mining units are located in the Bear Creek watershed that drains northeastward into Sand Creek, Antelope Creek, and then into the Cheyenne River; the B-13 mining unit is located in the Dry Fork Cheyenne River drainage. Elevations range from 4980 feet to 5290 feet above sea level. The Bear Creek drainage is mostly flat with some rolling hills and ridges consisting of outcropping sandstone rocks. The elevations of the Cheyenne River divide drop off steeply to the south at the southern portion of the B-1 mining unit.



Fig. 2.1. Aerial View of the Bear Creek Site, Showing Exploratory Activities.

2.3.2 Land Ownership

The site is located within the Thunder Basin National Grassland, consisting of intermingled land-ownerships which are administered by the Forest Service, State of Wyoming, and private owners. Table 2.4 shows the existing surface ownership for the four townships of the project and surrounding areas, within the National Grassland boundary.

Table 2.4. Surface Land Ownership
(T39N, R73W/ T39N R72W/ T38N R73W/ T38N R72W)

Ownership	Acres
U. S. Government	21,167
State of Wyoming	5,720
Private ownership	65,723
Total in four townships	92,610

The following list identifies the ranch headquarters located within a nine-mile radius of the proposed mill site:

Patterson Ranch	8 miles west
*Manning Ranch	4 miles west
*Hardy Ranch	4 miles northwest
Spracklen Ranch	8 miles north
*Carson Ranch	5.5 miles northeast
Dilts Ranch	9 miles northeast
Tillard Ranch	7 miles southeast
Baker Ranch	5.5 miles south
*Reynolds Ranch	7 miles south
Hornbuckle Ranch	4 miles south

All of the above listed operations designated by an asterisk will be directly affected by the RMEC project, one way or another. Specific locations of ranching operations and some details of surface ownership in the immediate vicinity of the site are shown in Figure 2.2. The holders of mineral rights, with the RMEC claims superimposed, are shown in Figure 2.3.

2.3.3 Agriculture

Ranching is the major land use in the Bear Creek area, involving both cattle and sheep production. A portion of four ranch operations will be directly affected by mining and milling operations. Cropland use in the vicinity is limited to some flood-irrigated hayland located two miles west-northwest and a sprinkler-irrigation system is operational approximately 12 miles to the northeast of the project area. Both irrigation systems depend on surface runoff from the Bear Creek drainage; however, there are no irrigation systems within the project area.

All pastures are fenced, and water for livestock is supplied by flowing wells, windmills, and/or small reservoirs. The present grazing capacity on and near the site is approximately four acres per Animal Unit Month (4 acres are required to sustain 1000 lb of live weight--a cow and calf--for one month) (see Table 2.5).

Estimates of the potential grain and forage crop production on lands within the proposed project area are shown in Tables D-1.1 and D-1.2 in Appendix D-1. Potential yields from irrigated lands were not considered due to lack of data. The estimated yields shown in the tables are based on information presented in Section 2.7.

2.3.4 Commercial and Industrial

Pacific Power and Light maintains two electric distribution lines, a 20-kV power line approximately four miles north and a 34.5-kV approximately two miles south of the mill site; the latter will furnish power to the mill site.

Mountain States Telephone maintains an aerial line located approximately one mile northwest of the mill site to service the ranchers in the area. The company has applied for a permit for a buried phone line that traverses the southern boundary of the Grasslands; this line will be extended north to the mill site in T38N, R73W.

There are two producing oil wells within the proximity of the project area, one in Section 11, SWNE and one in Section 2, SESE T38N, R73W. Several dry holes also have been drilled in the area.

Exxon and Kerr-McGee Companies are presently mining uranium approximately ten miles south of the Grassland boundary.

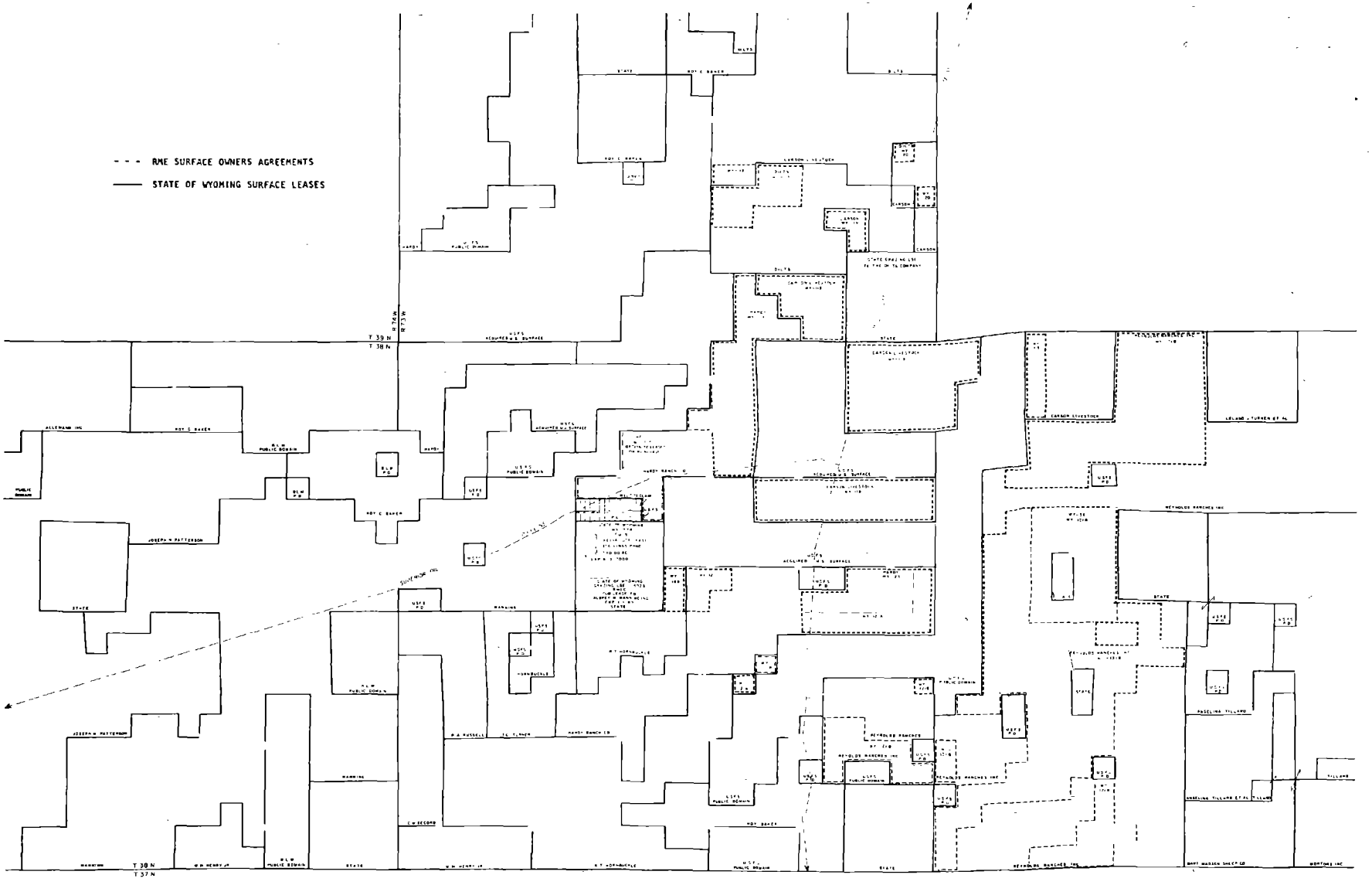


Fig. 2.2. Surface Ownership Map. Provided by the applicant.

A

B

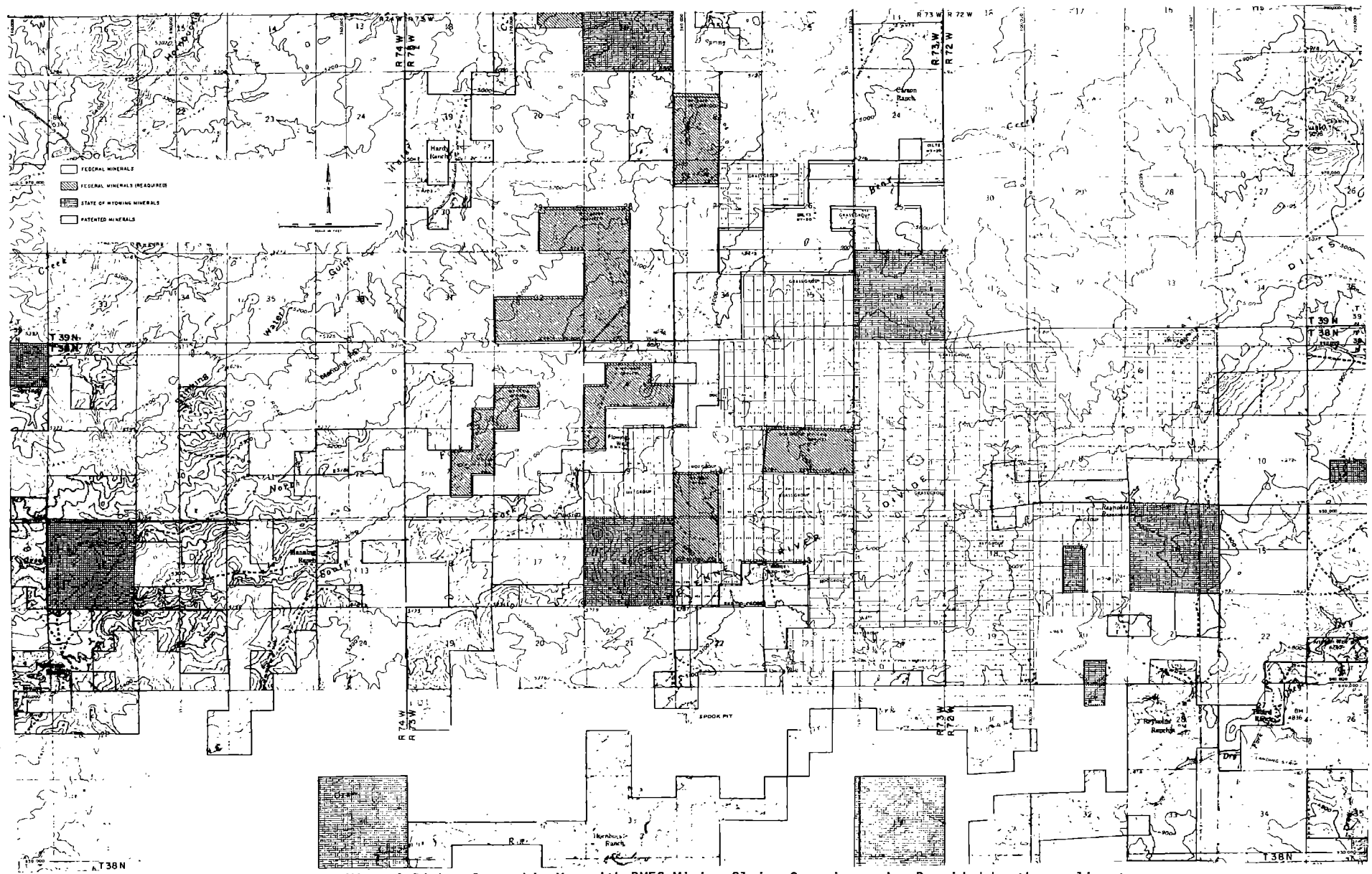


Fig. 2.3. Mineral Rights Ownership Map with RMEC Mining Claims Superimposed. Provided by the applicant.

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Table 2.5. Acres and Animal Unit Months of Grazing that Would Be Unavailable per Year on Specific Sites during the Period of the Proposed Project

Unit	Permittee	National Grassland		Private and State	
		Acres	AUMs	Acres	AUMs
B-1 & mill	Hardy #3	640	177	100	27
B-1 & mill	Hardy #1	0	0	240	66
B-1 & mill	Manning	80	22	640	177
B-3-4	Hardy #3	0	0	360	100
B-6-4	Carson	0	0	160	44
Dilts	Dilts	0	0	160	44
B-8	Hardy #3	80	22	0	0
B-13	Reynolds	200	55	0	0
B-13	Hardy #2	40	11	0	0
Haul roads	Hardy #2	320	88	0	0
	Hardy #3	80	22	180	50
Access road	Manning	5	1	44	12
		1445	398	1884	520

A sixteen-inch gas pipeline owned by McCulloch Gas Transmission Co. crosses the project area from north to south between the B-1 and B-13 pits. Superior Oil Company owns a 3 1/2-inch pipeline that connects with the McCulloch pipeline and extends westerly through Sections 8, 9, 10, and 11, T37N, R73W (see Fig. 1.2).

2.3.5 Transportation

Access to the area from the south is by Interstate 25, State Highway 93, and Ross County Road #31 (recently reconstructed by RMEC); and access from the east is by Highway 59, via Jenny Trail and County Road #34. There are numerous other dirt roads in the project area which were developed for ranching and mining activities. The Burlington Northern and Chicago & Northwestern Railroads operate an east-west line approximately 32 miles south of the project.

2.4 WATER RESOURCES

2.4.1 Groundwater

Geologic formations occurring at the surface and in the subsurface include in descending order (and increasing age) below land surface: (1) Alluvium, (2) Wasatch Formation, (3) Fort Union Formation, and (4) older rocks that are too deep to be affected by the proposed uranium mining. Table 2.6 shows the geologic formations, thicknesses, physical characteristics, and depth below land surface at the Bear Creek site. A summary of groundwater quality is presented in Table 2.7.

2.4.1.1 Alluvium

The alluvium consists of narrow deposits of sand, silt, and clay deposited along the principal stream valleys such as Bear Creek, South Fork Bear Creek, and Dry Fork Cheyenne River. No data are available on thickness of the alluvium, but it probably ranges from less than a foot along the valley edges to an estimated 30 feet in the deepest part of the valley fill. Water level in the alluvium is considered concordant with water in the stream channel during low-flow conditions.

No known water wells are used to withdraw water from the alluvium in the vicinity of the Bear Creek property, but such wells would yield a few gallons per minute, adequate for stock water purposes. The concentration of dissolved solids, often used as an indicator of water quality, is estimated to be 1000 to 1500 milligrams per liter, based on water quality data for alluvium water in other parts of the Powder River Basin.

Alluvium immediate to the smaller tributary drainages can be expected to be unsaturated, but saturation and infiltration of water to recharge underlying aquifers is possible during periods of runoff.

Table 2.6. Geologic Formations at the Bear Creek Site

ERA	System	Series	Formation	Thickness (ft)	Depth to top of formation (ft)	General physical character
CENOZOIC	Quaternary	Pleistocene and Holocene	Alluvium	0-30(?)	crops out	Sand, silt, and clay. Contains some indigenous pebbles, generally in lower part.
	Tertiary	Eocene	Wasatch Formation	100-400	crops out	Coarse- to fine-grained sandstone interbedded with siltstone, carbonaceous shale, and coal beds.
		Paleocene	Fort Union Formation	2,800	400	Fine-grained to conglomeratic sandstone interbedded with siltstone, carbonaceous shale, and coal beds.
MESOZOIC	Cretaceous	Upper	Lance Formation	3,000	3,200	Fine- to medium-grained sandstone and interbedded shale and claystone.
			Fox Hills Sandstone	700	6,200	Fine- to medium-grained sandstone and interbedded thin beds of sandy shale.
			Lewis Shale	600	6,900	Shale and interbedded thin beds of fine-grained sandstone.
			Mesaverde Formation	900	7,500	Thin-bedded to massive sandstone and interbedded shale.
			Cody Shale	4,000	8,400	Shale and fine-grained sandstone beds.
			Frontier Formation	900	12,400	Sandstone and interbedded shale.
		Lower	Mowry Shale	200	13,300	Siliceous shale.
			Thermopolis Shale	200	13,500	Soft black shale; contains thin beds of sandstone and bentonite.
			Cloverly Formation	150	13,700	Medium- to coarse-grained sandstone and interbedded siltstone.
	Jurassic		Morrison Formation	150	13,850	Varicolored claystone and interbedded fine-grained sandstone.
			Sundance Formation	400	14,000	Greenish gray shale and interbedded gray fine-grained sandstone.
	Triassic		Chugwater Formation	700	14,400	Dark red siltstone, sandstone, and shale.
PALEOZOIC	Permian		Goose Egg Formation	350	15,100	Red shale, gypsum, and thin-bedded limestone.
	Pennsylvanian		Tensleep Sandstone	500	15,450	Fine- to medium-grained sandstone.
			Amsden Formation	50(?)	15,950	Sandstone, shale and thin-bedded limestone and dolomite. *May be absent at the Bear Creek site.*
	Mississippian		Madison Formation	300	16,000	Massive to thin-bedded limestone and domomite.
	Cambrian		Flathead Sandstone	100	16,300	Fine- to coarse-grained quartzitic sandstone.
PRECAMBRIAN				---	16,400	Igneous and metamorphic rocks.

Table 2.7. Summary of Groundwater Analyses, Bear Creek Project Area[a]

Parameter	Well Site Number										
	1	2	3	4	5	6	7	8	9	10	15
Temperature, °C	12	12	12	12	10	12	11	12	13	12	10
Dissolved oxygen, mg/l	4	2	3	7	3	3	4	3	3	4	1
pH	7.4	7.3	7.2	7.4	7.3	6.9	7.0	8.1	7.6	8.2	7.0
Chemical oxygen demand, mg/l	46	4	9	45	1	1	1	1	1	1	69
Hardness as $CaCO_3$, mg/l	590	495	318	320	1140	360	660	50	120	5	2284
Alkalinity as $CaCO_3$, mg/l	155	212	128	154	268	206	161	178	161	128	304
Conductance, mmhos/cm	1.1	0.9	0.6	0.6	2.1	0.4	1.4	0.1	0.2	0.1	4.4
Total dissolved solids, mg/l	995	740	490	510	1680	450	1210	250	330	280	4349
Total suspended solids, mg/l	175	270	1090	73	10	20	10	20	10	10	32
Bicarbonate, mg/l	190	259	156	190	327	251	196	217	196	156	371
Carbonate, mg/l	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloride, mg/l	7.5	8.3	6.6	9.6	11.5	6.3	5.3	2.9	3.6	34.0	29.1
Cyanide, mg/l	0.03	-	-	0.03	0.05	0.05	0.05	0.05	0.05	0.05	-
Fluoride, mg/l	1.4	0.3	0.4	0.9	0.1	0.3	0.1	0.2	0.2	0.3	0.1
Nitrate, mg/l	0.5	0.1	1.2	0.7	1.2	1.8	0.2	0.1	0.1	0.1	1.2
Silica, mg/l	9	9	6	8	17	11	12	11	15	10	9
Sulfate, mg/l	345	110	100	160	360	40	194	11	24	20	800
Ammonia, mg/l	0.3	0.1	0.2	0.3	0.1	0.1	0.1	0.2	0.2	0.2	0.1
Aluminum, mg/l	1.7	3.3	11.3	5.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Arsenic, mg/l	0.01	0.01	0.01	0.03	0.05	0.01	0.01	0.01	0.07	0.01	0.01
Boron, mg/l	0.5	0.2	1.4	0.5	0.1	0.1	0.1	0.1	0.1	0.1	2.0
Cadmium, mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Calcium, mg/l	194	160	132	94	329	96	193	14	43	14	680
Chromium, mg/l	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Copper, mg/l	0.04	0.04	0.10	0.04	0.03	0.04	0.02	0.05	0.00	0.00	0.03
Iron, mg/l	1.2	1.6	5.3	3.5	2.2	6.6	0.5	1.5	0.8	0.1	10.6
Lead, mg/l	0.09	0.06	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.10
Magnesium, mg/l	27.7	26.0	18.2	23.8	58.0	32.7	34.0	2.7	9.0	2.2	184.0
Manganese, mg/l	0.06	0.36	0.25	0.14	0.09	0.08	0.16	0.02	0.02	0.01	0.12
Mercury, mg/l	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molybdenum, mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nickel, mg/l	0.01	0.02	0.03	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.03
Phosphorus, mg/l	0.02	0.02	0.01	0.05	0.08	0.01	0.04	0.01	0.01	0.01	0.01
Potassium, mg/l	91	12	10	36	17	4	14	4	6	3	11
Selenium, mg/l	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Silver, mg/l	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Sodium, mg/l	42	64	45	27	57	10	100	86	67	89	137
Uranium, mg/l	0.002	0.007	0.007	0.0015	0.001	0.007	0.018	0.001	0.001	0.001	0.003
Vanadium, mg/l	0.004	0.003	0.012	0.110	0.001	0.004	0.001	0.001	0.001	0.001	0.002
Zinc, mg/l	0.08	0.12	0.180	0.190	0.084	0.520	3.600	2.460	0.053	0.069	0.110
Fecal coliform/100 ml	6	40	1.7	2	15	61	-	46	125	11	-
Radium, pCi/l	0.7	2.2	2.3	0.6	1.1	1.1	-	-	0.4	-	-
Gross α, pCi/l	6.2	30.0	7.0	4.6	8.6	6.1	-	4.0	7.9	2.9	-
Gross β, pCi/l	14	7	5	0	1	0	-	1	0	0	-

[a]"Preliminary Ground Water Hydrological Report Bear Creek Project - Bear Creek, Wyoming, for Rocky Mountain Energy Co.," Wright Water Engineers, Inc., Denver, Colorado, March 1975.

2.4.1.2 Wasatch Formation

The general landscape of the proposed RMEC project site is developed from the Wasatch Formation except where the latter is overlain by alluvium along stream valleys. The Wasatch is as much as 400 feet thick at the site.

Sand is the principal constituent of the Wasatch Formation especially in the southern part of the Powder River Basin. Thick lenses of coarse- to fine-grained arkosic sandstone are commonly interbedded with siltstone, carbonaceous shale, and coal. Thin beds of conglomerate occur locally. The siltstone and shale are only semiconsolidated; the sandstone beds are generally friable.

Groundwater occurs in the Wasatch under both unconfined and confined conditions. In general, potentiometric heads (water pressures) increase with increasing depth below land surface.

The waters of the Wasatch Formation are variable in quality, but most could be classified as calcium sulfate waters. Dissolved solids in the water range from less than 500 milligrams per liter to more than 2000 milligrams per liter. In the general area of the RMEC project, groundwater from the Wasatch is used for livestock watering and, to a lesser extent, for domestic purposes.

Wells of the project area, developed to withdraw water from the Wasatch Formation, range in depth from about 100 feet to about 400 feet. Water levels can be expected to rise above the level at which water was encountered during drilling, but most wells are not free-flowing. However, some of the deeper Wasatch wells which are located at lower topographic positions, such as along stream drainages, are free-flowing at land surface.

2.4.1.3 Fort Union Formation

The Fort Union Formation underlying the southern part of the Powder River Basin is about 2800 feet thick and consists of poorly to semiconsolidated, fine-grained to conglomeratic sandstone interbedded with siltstone, claystone, carbonaceous shale and coal. The upper part of the formation is predominantly siltsone; ironstone lentils and coal beds are common and sandstone occurs as a minor constituent. Sandstone, mostly fine grained, is the predominant rock in the lower part of the formation, with thin-bedded claystone and siltstone occurring as minor constituents.

Water in the Fort Union Formation is confined (artesian) and some wells flow at land surface. This water is used for livestock watering and, to a lesser extent, for domestic purposes. The water is generally a relatively soft sodium bicarbonate water containing less than 1000 milligrams of dissolved solids per liter.

Drilled wells located in the proposed RMEC project area, and which extend into the Fort Union Formation, range in depth from about 500 feet to as much as 1000 feet. The water levels in these wells rise above the level at which water was encountered in drilling and many of the wells flow at land surface.

2.4.1.4 Recharge and Movement of Water

Sand, silt, clay, and shale are the principal rock types underlying the Bear Creek property that will be affected by the proposed uranium mining. Interstices within some of these rock types are periodically depleted of, and recharged with water. Recharge occurs as rainfall and snow melt infiltrate the soil surface and the amount of water percolating downward exceeds the soil moisture retention limits and plant requirements. At depths where rock strata are water saturated, large volumes of water may be in storage. In instances where rock grains are of uniform size and well rounded, groundwater may comprise as much as 30% of the total volume of the rock. The amount of water in storage, however, is not an indication of water yield from wells, because the amount and rate of water yield depends on the permeability of the waterbearing rock. In general, coarse-grained rocks yield water more readily than fine-grained rocks unless the permeability of the rock has been increased by such actions as fracturing and dissolution, actions not common in the vicinity of the Bear Creek property.

The rate of movement of groundwater is a function of permeability and the water moves in response to the potentiometric gradient. Movement of groundwater in the Bear Creek area is very slow, probably only a few feet per year.

Very limited hydrologic data for the general area of the Bear Creek site indicate a north-trending potentiometric gradient; thus, the regional trend of water movement is probably northward. The movement of water is controlled locally, however, by discharges along drainages via

seeps and springs and by evapotranspiration losses along drainageways. Consequently, local movement of water will be toward these discharge points.

2.4.2 Surface Water

Most of the Bear Creek Project site is drained by tributaries of South Fork Bear Creek. The extreme northern part of the site drains to Bear Creek, and the southeastern part to Dry Fork Cheyenne River. Principal streams and their tributaries in the vicinity of the mine property are shown in Figure 2.4. Bear Creek and Dry Fork Cheyenne River flow northeasterly into Antelope Creek and thence easterly into the Cheyenne River.

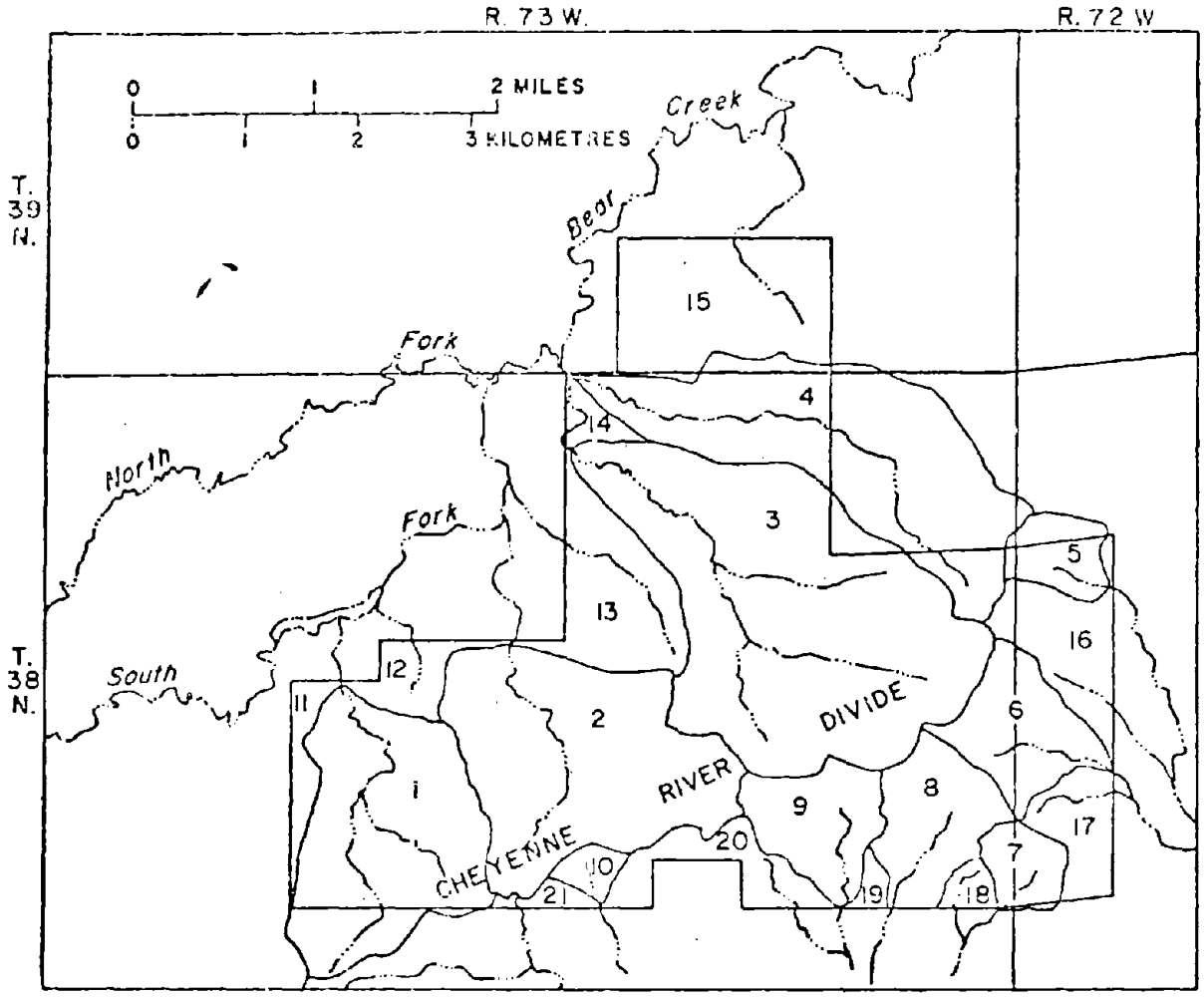


Fig. 2.4. Local Watersheds of the Bear Creek Project Area.

Number	Area, mi^2	Number	Area, mi^2	Number	Area, mi^2
1	1.26	8	0.45	15	0.88
2	1.52	9	0.41	16	0.35
3	2.57	10	0.08	17	0.29
4	1.56	11	0.11	18	0.12
5	0.22	12	0.19	19	0.05
6	0.46	13	0.56	20	0.44
7	0.18	14	0.09	21	0.05

Bear Creek drains to Betty Reservoir in a drainage about 24 miles long and 3 to 5 miles wide. About 97 square miles are drained by Bear Creek upstream from Betty Reservoir. Lonetree Creek also flows into Betty Reservoir from a drainage area of about 12.5 square miles. Betty Reservoir is about 14 miles northeast of the Bear Creek site.

The surface area of Betty Reservoir is about 250 acres and the capacity of the reservoir is about 2000 acre-feet. The reservoir is privately owned and was built for recreation, irrigation, and livestock needs. Water is pumped from the reservoir and distributed by ditches to irrigated areas and to livestock watering locations. Other small reservoirs and ponds have been constructed upstream from Betty Reservoir along Bear Creek and along Dry Fork Cheyenne River, mostly for livestock watering.

Bear Creek and Dry Fork are interrupted streams--streams that include short perennial reaches and intervening intermittent reaches. Potholes and small springs typify perennial reaches, the intermittent reaches are dry except for periods when rainfall or snowmelt runoff occurs.

Average annual runoff is estimated to be from 0.3 to 0.5 inches. Some runoff results from snowmelt, but peak flows result from convective-type storms during late spring and summer months. Local flooding of washes can result from intense localized thunderstorms. However, stream beds of these washes are dry for extended periods of time.

The quality of surface water is indicated by analyses of water from sampling stations in the area; the quality parameters and values are shown in Table 2.8. In general, surface waters, in the project area, appear to be of good quality and adequate for livestock use (ER, Sec. 2.6.2.7).

2.5 GEOLOGY, MINERAL RESOURCES AND SEISMICITY

2.5.1 General Geology

The Bear Creek uranium deposits are located in the Powder River Basin, a large structural and physiographic basin in northeastern Wyoming. Except on the north, the basin is completely surrounded by structural highlands. The Black Hills uplift is to the east, the Hartville uplift and Laramie Mountains to the south and southwest, and the Bighorn Mountains uplift to the west. Structurally, the basin is a north-northwesterly trending asymmetrical syncline; the west flank is steeper than the east flank (Fig. 2.5).

In the deepest part of the basin, about 18,000 feet (5500 m) of sedimentary rocks, ranging from Cambrian to Oligocene in age, overlie the crystalline basement rock. Table 2.6 is a generalized stratigraphic section from the southern part of the basin.

The project area is located about nine miles (14 km) east of the basement axis of the basin in an area where virtually flat-lying strata of the lower part of the Wasatch Formation of Eocene age is the bedrock. Here the Wasatch Formation consists of alternating claystone, siltstone, and sandstone of fluvial origin.

The base of the lowermost sandstone containing ore is about 200 to 300 feet (60 to 90 m) above the base of the Wasatch Formation.

The lithology of the rocks above the uranium-ore-bearing unit varies considerably throughout the project area because of extensive interfingering of claystone, siltstone, and sandstone; so no typical sequence of lithic types and thicknesses are uniformly characteristic of the overburden overlying the ore deposits. The overburden ranges from 100 feet (30 m) to 270 feet (80 m) in thickness, due to an increase in elevation of the surface from north to south over the deposits. The overburden is mostly claystone with several discontinuous lenses of sandstone up to 20 feet (6 m) thick. Throughout most of the area, claystone ranges from 60 to 90 percent of the total overburden and sandstone, from 10 to 40 percent.

2.5.2 Mineral Deposits

2.5.2.1 Uranium

Uranium has been produced in the area since the 1950s, initially from small shallow deposits in the Wasatch Formation. Since the mid 1960s when ore was discovered at depth, exploration by drilling, which continues to the present, has proved the existence of many large uranium deposits in the southern part of the basin. No precise data are available concerning the total tonnage discovered to date. There are at least ten deposits that contain more than one million tons of ore and probably as many as one hundred containing from a few tons to one million tons. Continuing exploration will probably reveal the presence of additional deposits. More than 90 percent of the known ore reserves occur in the Fort Union and Wasatch Formations; a few deposits occur in the Lance and Fox Hills Formations of Cretaceous age.

Table 2.8. Summary of Surface Water Characteristics, Bear Creek, Wyoming

Parameter	High	Low	Average	Median	Standard Deviation
Temperature, °C	19.40	1.00	5.90 (15)[b]	3.00	5.57
Dissolved oxygen, mg/l	12.00	4.90	8.70 (14)	9.00	2.68
Acidity, pH	8.80	7.40	8.00 (15)	8.00	0.57
Chemical oxygen demand, mg/l	245.00	10.00	51.00 (15)	37.00	58.47
Hardness as $CaCO_3$, mg/l	740.00[a]	52.00	249.00 (15)	172.00	192.00
Alkalinity as $CaCO_3$, mg/l	240.00	40.00	123.00 (15)	110.00	65.97
Conductance, mmhos/cm	1.26	<0.10	0.67 (14)	0.75	0.39
Total dissolved solids, mg/l	865.00	39.00	455.00 (15)	410.00	275.75
Total suspended solids, mg/l	388.00	<10.00	86.00 (13)	44.00	116.51
Bicarbonate, mg/l	283.00	43.00	145.00 (15)	140.00	81.41
Carbonate, mg/l	30.00[a]	<0.10	4.24 (15)	0.00	8.50
Chloride, mg/l	15.00	2.70	7.70 (15)	6.30	4.35
Cyanide, mg/l	0.02[a]	<0.01	0.02 (9)	0.01	0.02
Fluoride, mg/l	1.40	<0.10	0.39 (13)	0.24	0.34
Nitrate, mg/l	3.30	<0.10	0.82 (15)	0.40	0.95
Silica, mg/l	20.00	1.00	5.40 (15)	4.30	5.13
Sulfate, mg/l	390.00	7.20	136.00 (15)	100.00	139.51
Ammonia, mg/l	0.82	<0.10	0.37 (14)	0.28	0.28
Aluminum, mg/l	9.40	<1.00	3.01 (15)	1.00	3.12
Arsenic, mg/l	3.40	<0.01	0.36 (15)	0.01	0.92
Boron, mg/l	9.20[a]	<1.00	1.10 (15)	1.00	2.22
Cadmium, mg/l	<0.01	<0.01	-	-	-
Calcium, mg/l	120.00	15.00	48.00 (15)	44.00	25.80
Chromium, mg/l	0.01	<0.01	0.008 (15)	0.01	3.72
Copper, mg/l	0.04	0.02	0.02 (11)	0.02	0.01
Iron, mg/l	2.00	0.10	0.81 (15)	0.45	0.70
Lead, mg/l	0.04	<0.005	0.03 (15)	0.05	0.02
Magnesium, mg/l	99.00	3.70	29.40 (15)	16.30	27.99
Manganese, mg/l	0.29	<0.05	0.08 (15)	0.06	0.07
Mercury, mg/l	<0.01	<0.01	-	-	-
Molybdenum, mg/l	0.011	<0.005	-	-	-
Nickel, mg/l	0.030	<0.01	0.007 (15)	0.01	0.01
Phosphorus, mg/l	0.80	<0.01	0.18 (15)	0.04	0.26
Potassium, mg/l	80.00	2.70	14.60 (15)	10.00	18.67
Selenium, mg/l	0.01	<0.01			
Silver, mg/l	0.03	<0.01			
Sodium, mg/l	150.00[a]	2.00	56.00 (15)	78.00	47.25
Uranium, mg/l		<0.001			
Vanadium, mg/l	0.014	<0.001	0.004 (15)	0.01	0.03
Zinc, mg/l	0.50	<0.01	0.06 (15)	0.02	0.12
Ra-226, pCi/l[c]	6.0	0.0	1.75 (59)	0.90	0.83
Th-230, pCi/l[c]	0.7	0.0	1.30 (32)	0.08	0.30
Fecal coliform, per 100 ml	640.00	2.00	113.00 (11)	15.00	190.50

[a] Isolated high value.

[b] ( ) Number of values used for averaging.

[c] Values from the applicant's preoperational monitoring program initiated in 1976.

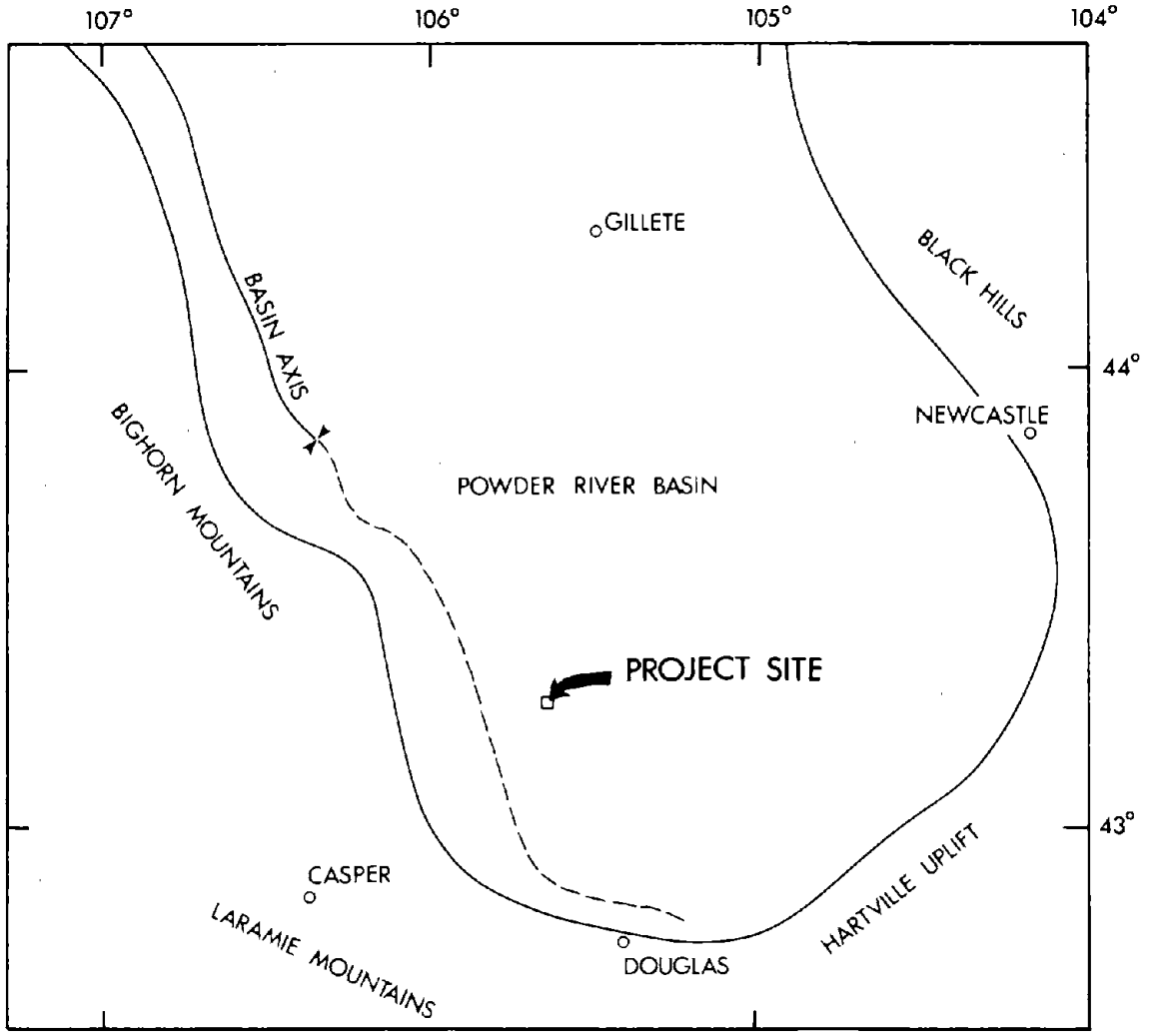


Fig. 2.5. Regional Tectonic Map.

Typically, the uranium deposits in the Fort Union and Wasatch Formations occur at a boundary between oxidized yellow and unoxidized gray sandstone and are known as roll front deposits. The boundaries, as viewed in plan, are generally very sinuous, occur at different stratigraphic horizons, and display no consistent trend. Ore grade is not continuous along the boundaries but occurs in local concentrations connected by thin low-grade mineralized sandstone.

Ore minerals are mainly uraninite (UO_2) and coffinite $[U(SiO_4)_{1-x}(OH)_{4x}]$, but small quantities of a variety of secondary uranium-vanadium complex minerals may be present. In and near the ore zone, vanadium, selenium, arsenic, and iron sulfides are also concentrated. The content in parts per million ranges from 10 to 100 for vanadium, 0.5 to 8 for selenium, and < 1 to 4 for arsenic in areas remote from ore. In and near ore the ranges are 50 to 2000 for vanadium, 10 to 270 for selenium, and 1 to 40 for arsenic. The weighted average values yield concentration factors of about 30, 260, and 40 for vanadium, selenium, and arsenic, respectively. Vanadium probably occurs mainly in the mineral montroseite [VO(OH)] or paramontroseite (V_2O_4). Selenium occurs as native selenium, ferroselite ($FeSe_2$) and, along with arsenic, as substitution for sulphur in the iron sulfide minerals pyrite and marcasite (FeS_2).

The ore-bearing unit ranges from 50 feet (15 m) to 100 feet (30 m) in thickness and consists of fine, medium, and coarse-grained sandstones that, for the most part, are poorly indurated. Some well-indurated, calcite-cemented sandstone may be found in and near the ore.

The nature of the Bear Creek uranium deposit is not directly observable at the surface but similarities to other deposits nearby are inferred from subsurface data. It is a roll front

deposit and, as such, is probably much like others in the Powder River Basin, the characteristics of which are known.

2.5.2.2 Oil and Gas

The Powder River Basin has been an important source of oil and gas since the early 1900s. Total production to date is approximately 1.3 billion barrels, and the ultimate yield of the more than one hundred active fields is estimated to exceed two billion barrels.[7] Production and estimated reserves of natural gas are also substantial. Oil and gas occur in 20 or more geologic formations (Table 2.6) under various conditions of entrapment and it is likely that large new discoveries will be made in the yet unexplored parts of the region.

The nearest oil producing area--the Dry Fork field--is about one mile east of the site. Production there is from Cretaceous formations several thousand feet below the Wasatch Formation. The proposed mine should have no effect on future exploration and oil and gas production.

2.5.2.3 Coal

Coal beds, principally in the lower part of the Wasatch and upper part of the underlying Fort Union Formations, are present throughout most of the Powder River Basin. Precise information concerning total quantities of coal is not available for the entire basin, but the presence of several hundred billion tons is a realistic estimate. Individual coal beds range in thickness from a few feet to more than 100 feet (30 m); many of the beds are 50 to 100 feet (15 to 30 m) thick. Deposits occur at the surface in many places, particularly near the basin margins, but are as deep as 6000 feet (1800 m) in the interior of the basin. Currently coal is being produced from nine open pit mines, one of which is 16 miles (26 km) northeast and another 24 miles (39 km) southeast of the site. Subsurface data indicate that thin, discontinuous coal beds of little economic value are present at the site.

Two Federal coal prospecting permits have been issued for areas in the immediate vicinity of the proposed uranium operation, i.e., within T. 38 N, R. 73 W; of these two, one permit involves land within Sections 10 and 15. The initial coal discovery was followed by application, about 1972, for a two-year extension of activity. However, the prospecting work that would normally have been done from 1972 to 1974 or 1975 was precluded by the Interior Department's coal leasing moratorium. The coal deposits discovered in Sections 10 and 15 range from 0.9 to 2.4 feet at depths of 53 to 293 feet. In Section 20, a maximum thickness of 3.9 feet of coal at a depth of 150 feet is indicated. The USGS may require certain stipulations related to conservation of the coal resource.

2.5.3 Seismicity

The project site is located in a minor risk zone that, except for a small part of eastern Nebraska and the Mississippi River Valley, extends over the entire Midwest. The nearest area of moderate-to-major risk is 250 miles (400 km) to the west along the Wyoming-Idaho border.

Thirty seismic events have been detected or reported within a 150-mile (240 km) radius of the site. Of these, only 12 are thought to be natural events related to faulting. The epicenter, near Casper, Wyoming, of the most intense event, estimated at VII on the Modified Mercalli Scale of Earthquake Intensities, is 48 miles (77 km) from the Bear Creek site. Of the other 11 events, two were of an intensity of VI; eight, an intensity of V; and one, an intensity of IV. Table 2.9 shows those fault-related events recorded within a 150-mile (240-km) radius of the site since 1850; Figure 2.6 is a map showing the location of the epicenters.

2.6 SOILS

The following soils information is derived from detailed reconnaissance soil surveys conducted on the project area in May 1975 by Dames & Moore and in May 1976 by the Soil Conservation Service. The surveys were conducted using the soil association concept of the National Cooperative Soil Surveys.[8] A soil association is a group of defined and named soil series occurring together in an individual and characteristic pattern over a geographic area. The soil series have been classified according to the criteria of the National Cooperative Soil Surveys.

Soil maps showing the distribution of soil units within the project area are presented as Figures 2.7, 2.8, and 2.9, representing Mining Areas I, II and III, respectively. Additionally, the relative suitability of the existing soils as media for plant growth is indicated and areas to be disturbed are superimposed on the soil distribution maps. The suitability ratings of soil mapping units, as sources of topsoil material, are summarized in Table 2.10; Table 2.11 indicates the estimated acre-feet (by quality class) of soil materials which are available for reclamation.

Table 2.9. Earthquakes Less than 150 Miles from the Bear Creek Project Site

Location	Intensity	Date	Distance from Project Site	
			Miles	km
Casper, Wyoming	VII	Nov 14, 1897	48	77
Chadron, Nebraska	VI	Jul 30, 1934	135	216
Black Hills, South Dakota	VI	Jun 26, 1966	135	216
Casper, Wyoming	V	Jun 25, 1894	48	77
Black Hills, South Dakota	V	Oct 11, 1895	123	197
Northern Wyoming	V	Nov 17, 1925	108	174
Central Wyoming	V	Feb 13, 1928	132	212
Black Hills, South Dakota	V	Nov 16, 1928	102	164
Southern Wyoming	V	Jan 20, 1954	126	202
Eastern Wyoming	V	Aug 21, 1964	51	84
Northern Wyoming	V	Sep 19, 1974	100	161
Western South Dakota	IV	Jun 26, 1966	105	169

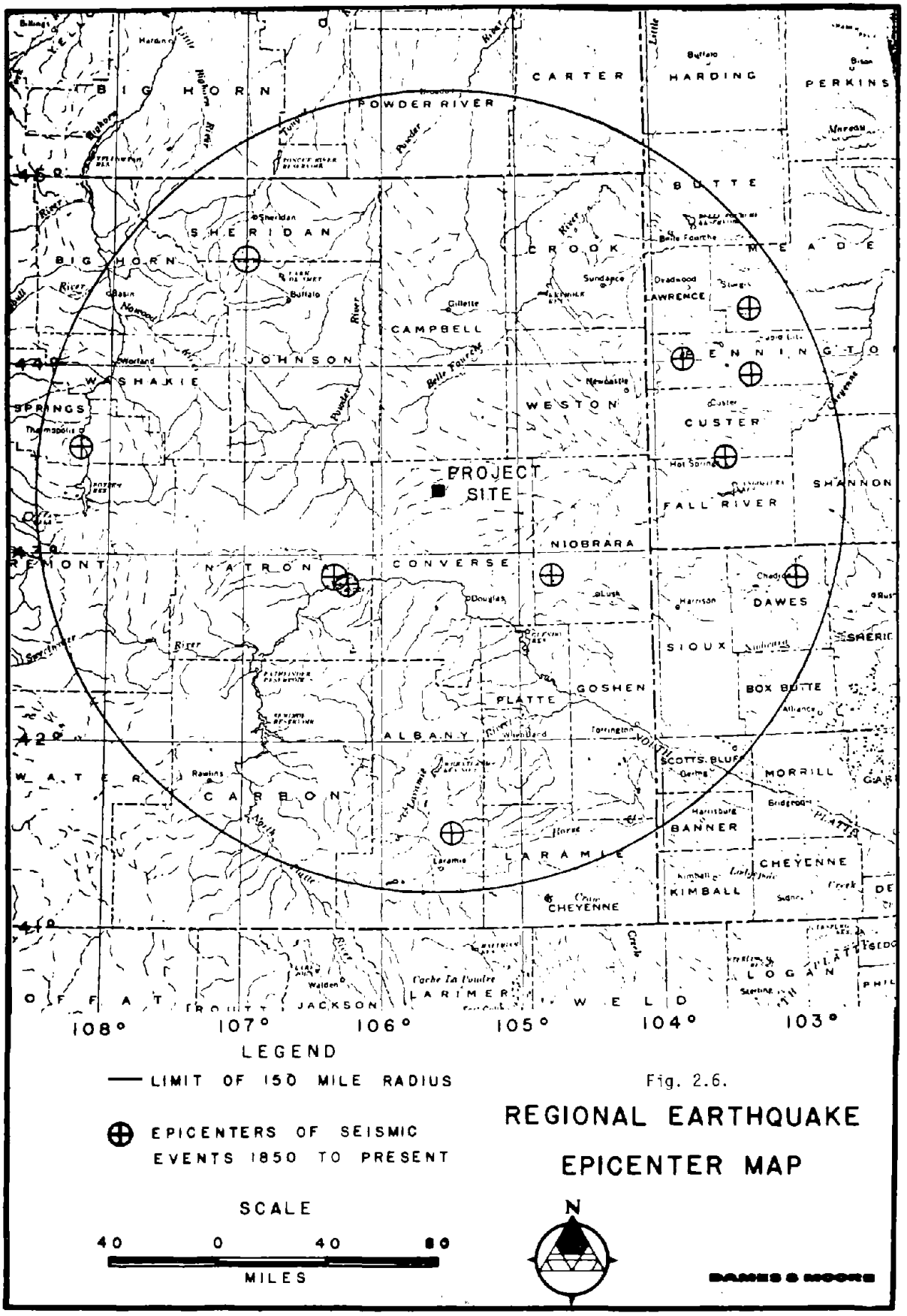
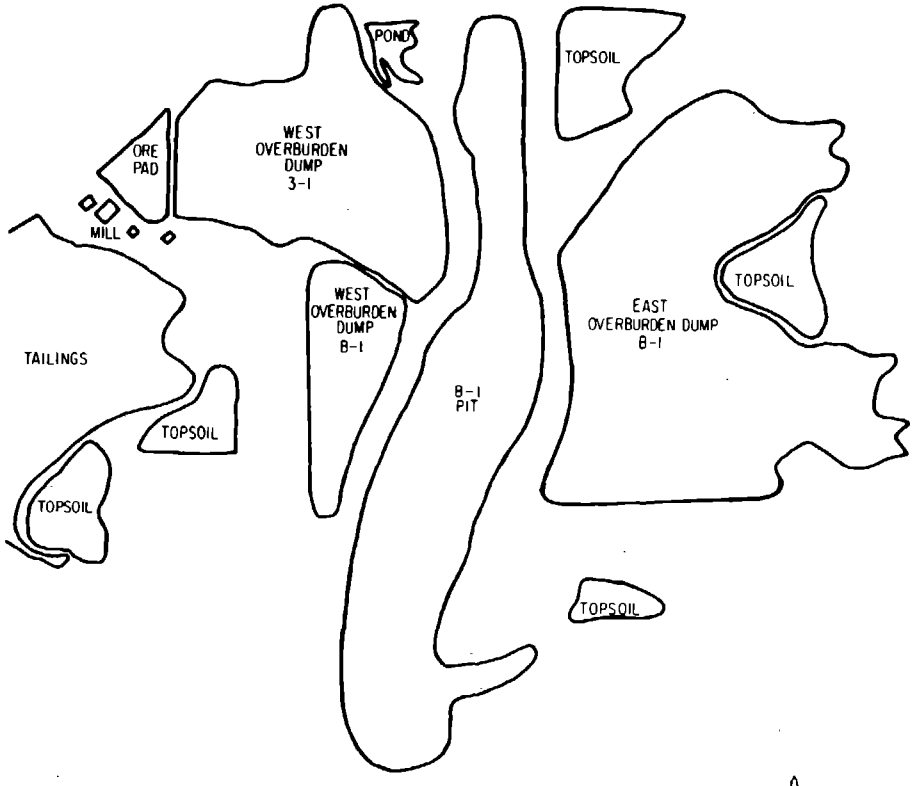


Fig. 2.6.

REGIONAL EARTHQUAKE EPICENTER MAP



A

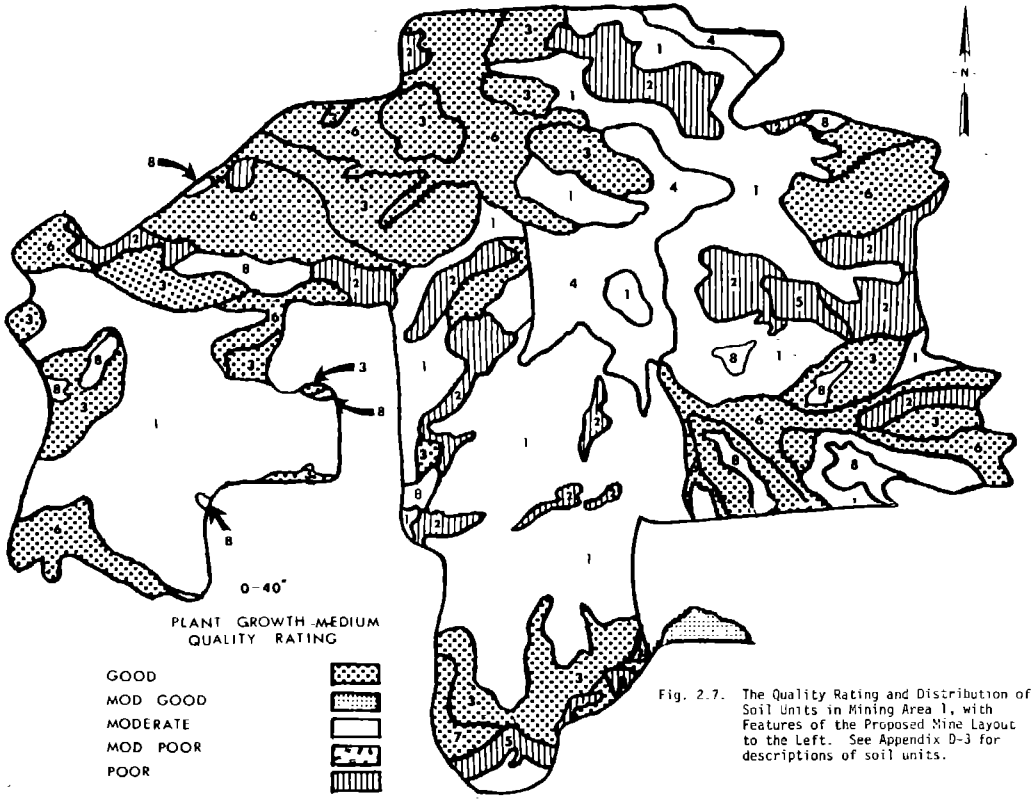
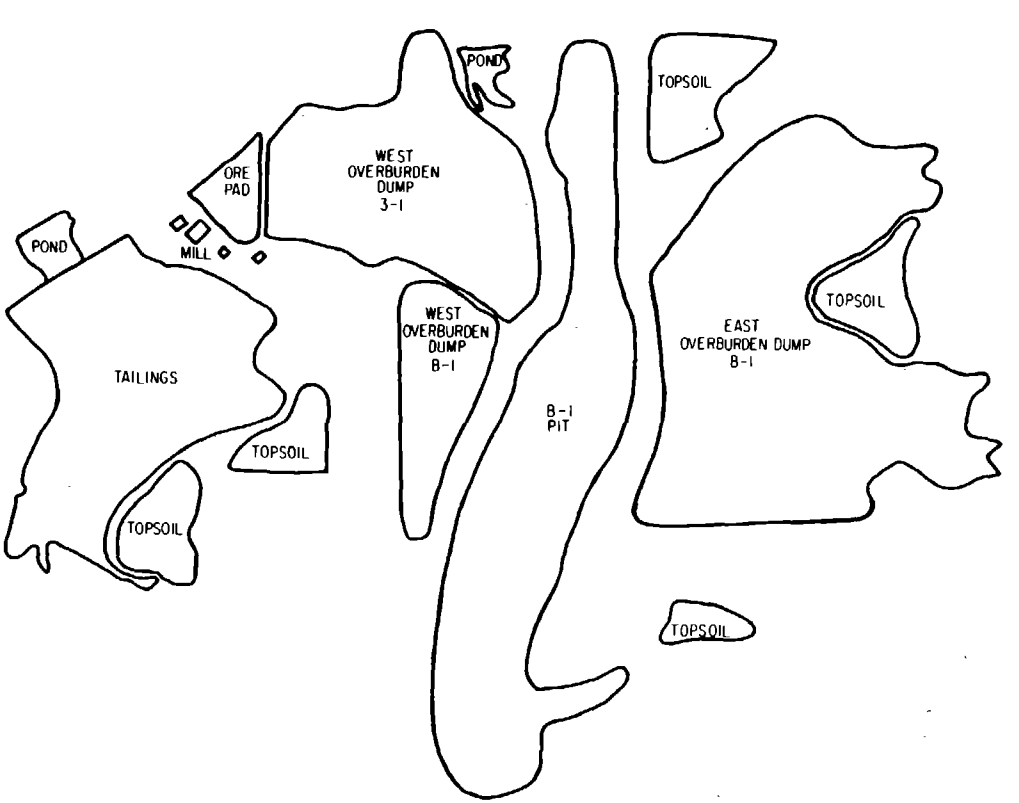


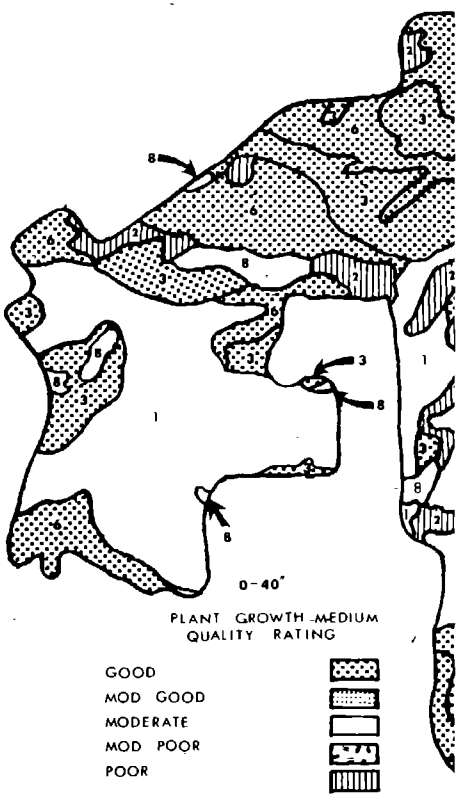
Fig. 2.7. The Quality Rating and Distribution of Soil Units in Mining Area 1, with Features of the Proposed Mine Layout to the Left. See Appendix D-3 for descriptions of soil units.

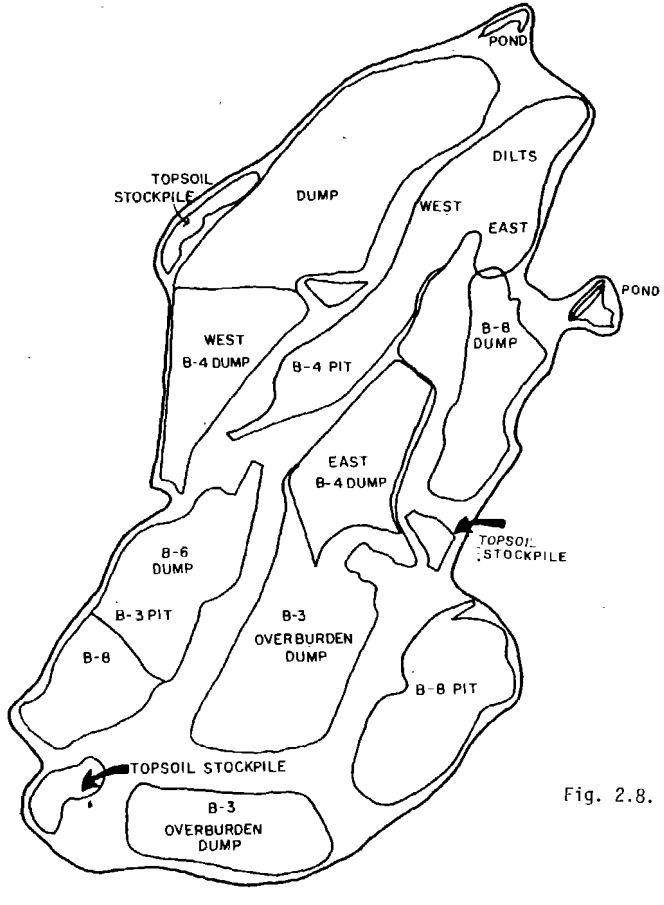
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B


POND
TOPSOIL
WEST
OVERBURDEN
DUMP
3-1
ORE
PAD
POND
MILL
WEST
OVERBURDEN
DUMP
B-1
EAST
OVERBURDEN DUMP
B-1
TOPSOIL
TAILINGS
B-1
PIT
TOPSOIL
TOPSOIL
TOPSOIL

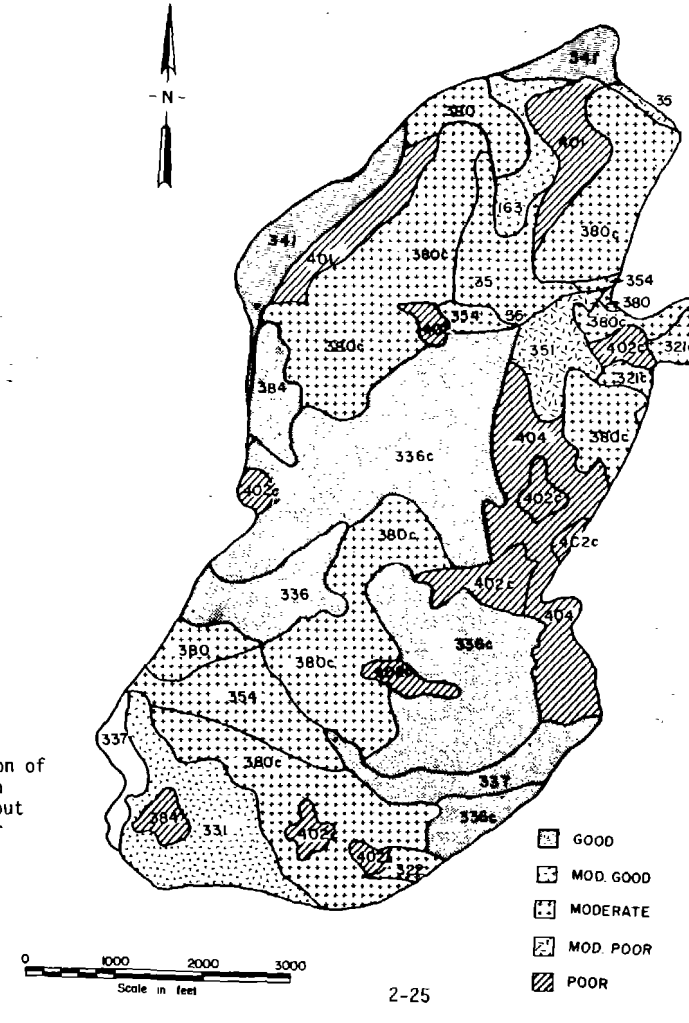
A


0-40'
PLANT GROWTH MEDIUM
QUALITY RATING
GOOD
MOD GOOD
MODERATE
MOD POOR
POOR

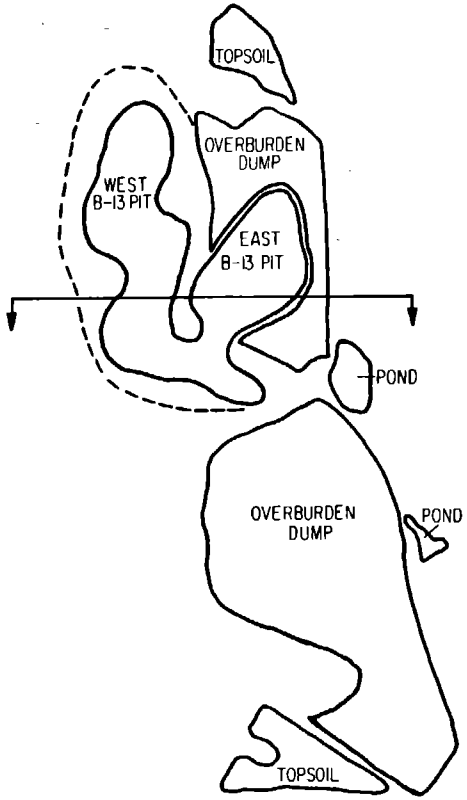


A

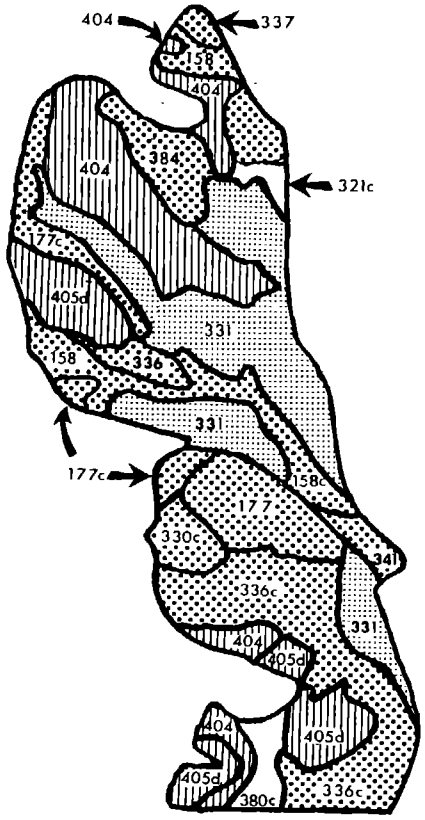
Fig. 2.8. *The Quality Rating and Distribution of Soil Units in Mining Area II, with Features of the Proposed Mine Layout to the Left. See Appendix D-3 for descriptions of soil units.*



B



A



0-40"

PLANT GROWTH MEDIUM QUALITY RATING

GOOD
MOD GOOD
MODERATE
MOD POOR
POOR

B

Fig. 2.9. The Quality Rating and Distribution of Soil Units in Mining Area III, with Features of the Proposed Mine Layout to the Left. See Appendix D-3 for descriptions of soil units.

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Table 2.10. Soil Mapping Units Rated for Suitability as Sources of Topsoil Material

Mapping Unit Number	Soil Series	Series Rating		Mapping Unit Ratings		
		0-12"	0-40"	0-12"	0-40"	Overall
1	Renohill Ulm Worfka	M. good M. good M. good	Mod. M. good --	M. good	Mod.	Mod.
2	Shingle Samsil Rock outcrops[a]	Poor Poor Not usable	-- -- --	Poor	--	Poor
3	Olney Pugsley Worfka	Good Good Good	Good Good --	Good	Good	Good
4	Bidman Briggsdale	Poor Poor	Poor Poor	Poor	Poor	Poor
5	Outcrops & other soils[a]	Poor	--	Poor	--	Poor
6	Fort Collins Cushman	Good Good	Good Good	Good	Good	Good
7	Terry Vona Otero Tassel	Good Good Good Poor	Good Good Good --	Good	Good	Good
8	Tassel Nelson Rock outcrops[a]	Poor Good Not usable	-- Good --	Poor	--	Poor
9	Kim Thedalund Limon Shingle	Good Good M. good Poor	Good Good Mod. --	Good	M. good	M. good
10	Haverson Kim Thedalund	Good Good Good	Good Good Good	Good	Good	Good
35	Limon	M. good	Mod.	M. good	Mod.	Mod.
56	Aeric Hapla-quents	M. poor	Poor	M. poor	Poor	Poor
80	Samsil	Poor	--	Poor	Poor	--
158 (158C)	Kim Stoneham	Good Good	Good Good	Good	Good	Good
163	Kim Limon	Good M. good	Good Mod.	Good	M. good	M. good
177 (177C)	Theduland Kim	Good Good	Good Good	Good	Good	Good
179	Ulm Renohill	M. good M. good	M. good Mod.	M. good	Mod.	Mod.
321C	Cushman Renohill	Good M. good	Good Mod.	M. good	Mod.	Mod.
322	Terry Tullock	Good Good	Good Mod.	Good	Mod.	Mod.
330C	Ft. Collins Theduland	Good Good	Good Good	Good	Good	Good
331	Ft. Collins Ulm	Good M. good	Good M. good	M. good	M. good	M. good
332C	Cushman Terry	Good Good	Good Good	Good	Good	Good
336 (336C)	Ft. Collins Cushman	Good Good	Good Good	Good	Good	Good
337	Ft. Collins Stoneham	Good Good	Good Good	Good	Good	Good

Table 2.10. Continued

Mapping Unit Number	Soil Series	Series Rating 0-12"	Series Rating 0-40"	Mapping Unit Ratings 0-12"	Mapping Unit Ratings 0-40"	Overall
341	Ustic Torri-fluvents	Good	Good	Good	Good	Good
351	Ustic Torri-fluvents Ustic Torri-psamments	M. poor	M. poor	M. poor	M. poor	M. poor
354	Ulm Bidman	M. good Mod.	M. good Mod.	Mod.	Mod.	Mod.
380 (380C)	Olney Bowbac	Good Good	Good Mod.	Good	Mod.	Mod.
384 (384C)	Olney Vona	Good Good	Good Good	Good	Good	Good
400	Shingle Samsil Gullied land[a]	Poor Poor --	-- -- --	Poor	--	Poor
401	Warf Shingle Tassel	Poor Poor Poor	-- -- --	Poor	--	Poor
402C	Shingle Lesset Tassel	Poor Poor Poor	-- -- --	Poor	--	Poor
404	Tassel Tullock Vona	Poor Good Good	-- Mod. Good	Poor	--	Poor
405	Tassel Terry Rockland[a]	Poor Good --	-- Good	Poor --	--	Poor
409	Samsil Shingle Warf	Poor Poor Poor	-- -- --	Poor	-- -- --	Poor

The suitability ratings for each soil association are given in the Environmental Report. In addition, supplementary information furnished by the applicant was used.

[a]Taxonomic groupings other than soil series.

Table 2.11. Estimated Acre-Feet of Soil Material Available for Reclamation by Quality Class and Disturbed Areas

The following is the estimated acre-feet of available soil material by quality class for each disturbed area.

Area I (B-1) - 775 acres disturbed (does not include 81 acres of topsoil piles)

	Available Acre-feet of Soil Material	
Quality Class	0-12" depth	0-40" depth
Good	205	680
Moderately good	227	261
Moderate	29	449
Poor	57	--

The total volume of good, moderately good and moderate material in the 0-40 inch depth is 1390 acre-feet. This could cover the entire disturbed area with about 21 inches of soil material.

Area II (B-3-4-6-8 and Dilts) 728 acres disturbed (does not include 20 acres of topsoil piles)

	Available Acre-feet of Soil Material	
Quality Class	0-12" depth	0-40" depth
Good	478	770
Moderately good	83	164
Moderate	31	1102
Moderately poor	15	51
Poor	102	340

The total volume of good, moderately good and moderate material in the 0-40 inch depth is 2036 acre-feet. This could cover the entire disturbed area with about 33 inches of soil material.

Area III (B-13) 283 acres disturbed (does not include 17 acres of topsoil piles)

	Available Acre-feet of Soil Material	
Quality Class	0-12" depth	0-40" depth
Good	144	456
Moderately good	71	217
Moderate	0	41
Moderately poor	0	0
Poor	68	227

The total volume of good, moderately good and moderate material in the 0-40 inch depth is 714 acre-feet. This could cover the entire disturbed area with about 30 inches of soil material.

Soil mapping units shown in Table 2.10 correlate with those shown in Figures D-2.1, D2.2, and D-2.3 of Appendix D-2. USDA-Soil Conservation Service land capability and range site classes for each mapping unit are listed in Table 2.12.

2.6.1 Physical Characteristics of Onsite Soils

Soil mapping unit descriptions indicating the general characteristics of soils in the project area are presented in Appendix D-3.

2.6.2 General Chemical Properties of Onsite Soils

The known chemical properties of the soils in the lease area indicate no concentrations of toxic materials.[9] There is a potential for toxic sodium concentrations in the lower portions of the Bidman and Briggsdale soils. These soils are of limited distribution, thus the potential for toxic conditions should be localized and may or may not occur in significant amounts. Chemical analysis of topsoil and overburden materials indicates that the occurrence of acid-forming, toxic materials is a minimal hazard as concerns the mining operation.

2.7 VEGETATION

Vegetative cover occurring on the project area is typical of the midgrass prairie and corresponds to the Shortgrass Grassland of the Standard Interagency Vegetation Types.[10] The present vegetative pattern and composition are the result of many factors; soil, slope, aspect, climate and grazing intensity are the predominant factors. There are no known threatened or endangered plant species within the area.

Three vegetative types occur on the project area as follows:

Type	Description	Acres	% of Total
1	Grassland	1343	36.5
2	Meadow	206	5.6
4	Sagebrush	2132	57.9
		3681	100

Specific range sites are correlated with soil types in Section 2.6 and characterized in Table D-4.2 of Appendix D.

2.7.1 Grassland

This vegetative community occupies 36.5% of the area and is dominated by grasses and grasslike plants with blue grama being the most abundant species. Range analysis indicates that vegetative density varies from 46-63%, litter from 20-30% and bare soil from 25-37%. Average species composition is shown in Table 2.13. Total vegetative production averaged 595 lb/acre in 1975 (ER, Supp. Sec. 2.2.2). Average vegetative production for this type varies from 500 to 1350 lb/acre within the project area depending upon range site and annual precipitation.

2.7.2 Meadow

The meadow community occurs in the bottoms of drainages where moisture accumulates in the soil; the type comprises 5.6% of the project area. Western wheatgrass and blue grama are codominant grass species with blue grama more prevalent in the drier portions. The presence of sagebrush is restricted due to the relatively greater soil moisture. Small pockets of riparian vegetation occur along the watercourse of Bear Creek, an intermittent stream. Vegetative cover averages 95%; litter, 5% and bare soil, 1%. Average composition of the type is shown in Table 2.13.

According to Dames & Moore (ER, Supp. Sec. 2.2.2), average production of vegetation of this type was 1129 lb/acre in 1975. Soil Conservation Service data indicates this vegetative type can be expected to produce 300 to 1500 lb/acre depending upon the range site and annual precipitation.

2.7.3 Sagebrush

The sagebrush community is the most prevalent vegetative type and occupies 57.9% of the area. Big sagebrush is the dominant shrub of the overstory; the understory is composed of grasses and forbs, with blue grama as the dominant species. This vegetative type is important as it produces

Table 2.12. Land Capability and Range Site Classifications for Soil Mapping Units of the Bear Creek Project Area[a]

Mapping Unit Number	Soil Association Name	Percent Slope	Land Capability Class Non-irrigated	Land Capability Class Irrigated	Range Site
1	Renohill-Ulm-Worfka	0-6 6-15 Outcrops	IVe VIe VIIIe	IVe -- --	Clayey
2	Shingle-Samsil-Outcrops		VIIe	--	Shallow loamy
3	Olney-Pugsley-Worfka	0-6 6-15	IVe VIe	IIIe IVe	Sandy Sandy
4	Bidman-Briggsdale	0-6 6-15	IVe VIe	IIIe IVe	Loamy Loamy
5	Rock outcrops, other soils		VIIIe	--	--
6	Fort Collins-Cushman	0-6 6-15	IVe VIe	IIIe IVe	Loamy Loamy
7	Terry-Vona-Olero		VIe	--	Sandy
8	Tassel-Nelson-Rock Outcrops		VIIe	--	Shallow sandy
9	Kim-Thedalund-Limon-Shingle	0-6 6-15	IVe VIe	IIIe	Loamy
10	Haverson-Kim-Thedalund	0-6	IVe	IIIe	Lowland
35	Limon clay loam	0-6	IVe	IIIe	Clayey
56	Acric Haplaquents		VIs	--	Saline subirrigated
80	Samsil clay	3-15	VIIe	--	Shallow clayey
158	Kim-Stoneham	0-6	IVe	IIIe	Loamy
158C	Kim-Stoneham	6-15	VIe	IVe	Loamy
163	Kim-Limon	0-6	IVe	IIIe	Loamy 70%-Clayey 30%
177	Thedalund-Kim	3-6	IVe	IVe	Loamy
177C	Thedalund-Kim	6-15	VIe	--	Loamy
179	Ulm-Renohill	0-6	IVe	IIIe	Loamy 50%-Clayey 50%
321C	Cushman-Renohill	6-15	VIe	--	Loamy 50%-Clayey 50%
322	Terry-Tullock	0-6	VIe	IVe	Sandy
330C	Fort Collins-Thedalund	6-15	VIe	IVe	Loamy
331	Fort Collins-Ulm	0-6	IVe	IIIe	Loamy
332C	Cushman-Terry	6-15	VIe	--	Sandy 40%-Loamy 60%
336	Fort Collins-Cushman	0-6	IVe	IIIe	Loamy
336C	Fort Collins-Cushman	6-15	VIe	IVe	Loamy
337	Fort Collins-Stoneham	0-6	IVe	IIIe	Loamy
341	Ustic Torrifluvents, fine loamy	0-6	IVe	IIIe	Lowland
351	Ustic Torrifluvents, Ustic Torripsamments	0-10	IVe VIe	 IIIe	Lowland 50% Sandy 50%
354	Ulm-Bidman	0-6	IVe	IIIe	Loamy
380	Olney-Bowbac	0-6	IVe	IIIe	Sandy
380C	Olney-Bowbac	6-15	VIe	IVe	Sandy
384	Olney-Vona	0-6	IVe	IIIe	Sandy
384C	Olney-Vona	6-15	VIe	IVe	Sandy
400	Shingle-Samsil-gullied land	3-15	VIIe	--	Shale 50% Shallow loamy 50%
401	Worf-Shingle-Tassel	3-30	VIIe	--	Shallow loamy
402C	Shingle-Lessat-Tassel	6-30	VIIe	--	Shallow sandy 60% Shallow loamy 40%
404	Tassel Tullock-Vona	6-30	VIIe VIe	--	Shallow sandy 50% Sandy 50%
405D	Tassel Terry Rockland	15-30	VIIe VIe VIIIe	--	Shallow sandy 50% Sandy 50% --
409	Samsil-Shingle-Worf	3-15	VIIe	--	Shallow loamy 50% Shallow clayey 50%

[a]Based on Soil Conservation Service Land Capability Classification and Range Sites for Converse County, Wyoming.

Table 2.13. Vegetative Species Composition of the Bear Creek Project Area

Species	% Composition (Mean)
Type 1 - Grassland	
Grass and Grasslike	
Blue grama (*Bouteloua gracilis*)	31
Western Wheatgrass (*Agropyron smithii*)	5
Sedge (*Carex filifolia*)	4
Junegrass (*Koeleria cristata*)	3
Others	3
Forbs	
Plantain (*Plantago purshii*)	3
Cactus (*Opuntia polycantha*)	1
Shrubs	
Big Sagebrush (*Artemisia tridentata*)	8
Silver Sagebrush (*Artemisia frigida*)	1
Type 2 - Meadow	
Grass and grasslike	
Blue grama (*Bouteloua gracilis*)	10
Six Week Fescue (*Festuca octoflora*)	5
Downy Brome (*Bromus tectorum*)	2
Western Wheatgrass (*Agropyron smithii*)	12
Sedge (*Carex filifolia*)	1
Forbs	
Various	1
Type 3 - Sagebrush	
Grass and Grasslike	
Blue grama (*Bouteloua gracilis*)	17
Sedge (*Carex filifolia*)	4
Junegrass (*Koeleria cristata*)	4
Six-week Fescue (*Festuca octaflora*)	3
Others	1
Forbs	
Cactus (*Opuntia polycantha*)	3
Plantain (*Plantago purshii*)	1
Shrubs	
Big sagebrush (*Artemisia tridentata*)	21

forage for range livestock, and food and cover for many species of wildlife. Range analysis indicates that vegetative cover varies from 41-50%; litter, 25-34% and bare soil, 19-29%. Species composition of the type is presented in Table 2.13. Average production in 1975 was 754 lb/acre. Productivity potential for this type will vary from 750-2100 lb/acre depending upon range site, annual precipitation and grazing intensity.

In addition to the three major vegetation types, a distinct vegetative community comprised of weedy species is present on the project area where the soil has been disturbed. Such sites as livestock watering areas, sheds, corrals and livestock trails are highly disturbed areas and support vegetation indicative of this. Species common to these areas include downy brome, Canadian thistle, annual sunflower, cocklebur and prostrate knotweed.

2.8 WILDLIFE AND FISH

The wild fauna of the Bear Creek Project area are a composite of native terrestrial, and to a lesser degree, aquatic animal communities representative of the three vegetative types identified in Section 2.7. Fauna representative of the project area are listed in Appendix E.

2.8.1 Terrestrial Vertebrates

Fifty-five terrestrial vertebrate species have been observed on or adjacent to the project area according to information provided by Dames & Moore (ER, Supp. Sec. 3.2.2). Birds were the most diverse (33 species), followed by mammals (12 species), and amphibians and reptiles (5 species). Twenty-five additional vertebrate species have been observed within three miles of the project area; most of these were sighted along the Cheyenne River and Bear Creek.

The area is yearlong habitat for pronghorn antelope, which subsist primarily on the sagebrush vegetative type. The major forage species utilized by antelope are sagebrush, rabbitbrush, and sagewort, which are important as winter browse. Use of forbs is high in the spring, declining in the fall and winter; grass use is minimal. Sagebrush stands are important as protective cover during winter storms and for concealment of newborn fawns. Data furnished by Dames & Moore (ER, Supp. Sec. 3.2.2) and observations of wildlife biologists confirm that the site lies within an antelope winter concentration area. Herds ranging from 60-100 animals have been observed in the area during the winter months (ER, Sec. 2.8.3.6), with lesser numbers observed during the summer. Department of Game and Fish estimates indicate an average of 5-6 antelope per square mile probably reside in the area on a yearlong basis. The decrease in summer populations is attributed to the lack of water. Antelope consume approximately 1.8 pounds of forage per day, or an average of 650 pounds per year.[11] Studies of competition between antelope and livestock (sheep) indicate a 3.2% overlap in use of preferred species.[11] Antelope move freely throughout the area although their movements are somewhat restricted by existing fences.

An estimated average of 24 muledeer were observed to inhabit the project area (ER, Sec. 2.8.3.6). A representative of the Wyoming Department of Game and Fish reported that an average of less than two deer per square mile reside in the area. Yearlong habitat is present in the south portion of the area and the immediate vicinity of the Cheyenne River. Big sagebrush is probably the most important winter browse species for the deer with other sagebrushes, rabbitbrush, rose, skunkbush, sumac, and serviceberry making up the balance of the diet. Deer, along with antelope, have been observed feeding on cultivated lands of the local ranches in the area, especially in the spring.

Rodents known to occur in the area include the 13-lined ground squirrel, deer mouse, prairie vole, desert cottontail, black- and white-tailed jackrabbits, and prairie dogs. All rodents are potential foods of larger predatory species such as carnivores and raptors. Desert cottontail densities vary from 41 to 254 per square mile and jackrabbit densities vary from 60 to 144 per square mile, as reported by Dames & Moore (ER, Sec. 2.8.3.6). Both species exhibit cyclic reproductive habits and populations vary widely from time to time. Rabbits compete with livestock and big game for available forage. The desert cottontail is considered a small game species and is hunted.

Predatory species occurring within the project area are the red fox, bobcat, badgers, striped skunks and coyotes. All are omnivorous and prey primarily on rodents. Coyotes, skunks, fox, and bobcats currently are important furbearers.

Various bird species utilize the project area for a seasonal or permanent residence, or as a resting place during migration. A list of bird species is presented in Appendix E.

Sage grouse and mourning dove are important upland game birds that occur in the project area, but not in significant numbers. Sage grouse density has been estimated by the Wyoming Game and Fish Department as less than two per square mile. Mourning doves are migratory and therefore populations vary with season of the year. Sage grouse rely greatly upon sagebrush for forage and cover. Small insects are an important food for young grouse in the spring.[12] The availability of water is generally a limiting factor as concerns young grouse survival, particularly during the summer months. Strutting grounds have not been observed within the project area but do occur nearby.

Stockwater ponds and small reservoirs in the area are used by waterfowl as resting places during migration, but the ponds lack sufficient aquatic and riparian vegetation to furnish waterfowl nesting habitat.

Common raptors indigenous to the area are listed in Appendix E. During winter, bald eagles have been observed along the Cheyenne River. No eagle nesting sites are known to occur within or adjacent to the project area.

Bats are active around creeks and ponds where they feed upon flying insects. The small-footed myotis has been observed in the project area (ER, App. D).

Amphibians are relatively uncommon on the project area because of the scarcity of aquatic habitat. Reptiles occurring on the site are primarily western rattlesnakes.

2.8.2 Aquatic Vertebrates

Reservoirs and stockwater ponds within the area provide a warm-water fish habitat. Unidentified (bullheads?) fish have been observed in a stockwater pond north of the proposed millsite. Fishery habitat is limited because the streams are intermittent.

2.8.3 Terrestrial Invertebrates

Arthropods are the most abundant animals in the Bear Creek area in terms of number of species and total numbers. Four classes of arthropods have been identified on the area: spiders and mites, centipedes, millipedes, and insects (ER, Sec. 3.8.3.2).

Arthropods function as herbivores, predators and scavengers within the ecosystem. Many arthropods are food sources for higher orders of animals. Arthropods may also compete with other animals by feeding upon sagebrush and grasses. They may reduce plant reproduction by consuming seeds and at the same time interact with the ecosystem as plant pollinators, disease vectors and decomposers.

2.8.4 Threatened and Endangered Species

No threatened or endangered species of wildlife have been identified within the project area or the immediate vicinity. However, the occurrence of black-footed ferrets in prairie dog towns is a possibility.

2.9 PREOPERATIONAL RADIATION ENVIRONMENT

The preoperational radiation environment at Bear Creek is a combination of the natural radiation environment and radiation resulting from industrial operations. The natural radiation environment is a result of cosmic radiation, primary, secondary and cosmogenic radioactivity, and terrestrial radioactivity. Industrially enhanced radiation results from natural uranium mining and milling (primarily at the Highland uranium operations about 25 km south) and the use of gas, coal, and construction materials by industries and homes.

The intensity of cosmic radiation is a function of altitude and at Bear Creek is about 50 mrem/year to the whole body.[13-18] External and internal exposure from cosmogenic radioactivity, essentially all from C-14, is about 1 mrem/year to the whole body.[19-21]

Terrestrial radiation is mainly from the primordial radionuclides K-40, Rb-87 and the series originating in U-238, U-235, and Th-232. The concentration of these radionuclides in the soil is dependent upon the epigenesis of the area.[22-23] Bear Creek is located over approximately 300 m of continental, marine and nonmarine deposits. The concentration of radioactivity in these deposits is about 1 pCi/g each for U-238, Th-232, Rb-87 and K-40. The resulting exposure rates at a height of 1 m are about 14 mR/year from U-238 plus all daughters, 22.1 mR/year from Th-232, 0.5 mR/year from Rb-87, and 0.14 mR/year from K-40.

Analysis of selected samples of surface soil indicated 10 mg/l of thorium (natural abundance 100% Th-232, 0.6 pCi/g of soil), and 5 mg/l of uranium (natural abundance 99.28% U-238, 0.92 pCi/g of soil) (ER, p. 2-211). The total exposure rate of Bear Creek from K-40, Rb-87, U-238 and Th-232 in the soil will thus be about 32 mR/year.

The concentration of Rn-222 in the soil is dependent upon the concentration of Ra-226 and the porosity, type and state of hydration of the soil. A soil with a density of 1.8 g/cm^3, porosity 0.6, emanating power 0.2, and containing 1 pCi Ra-226/g will have a concentration of about 0.6 pCi Rn-222/ml in the pore space of the soil.

The radon flux to the atmosphere from a dry, sandy soil containing 1 pCi Ra-226/g is estimated to be 1.6 pCi/m^2/sec.[24,25] The concentration of Ra-226 in sedimentary soil is about 0.5 pCi/g and the radon flux may be an order of magnitude less than that from a dry soil. Assuming secular equilibrium among the daughters of U-238 yields a flux of 0.9 to 1.5 pCi/m^2/sec. The annual quantity of radon released from the total area of the Bear Creek project (3×10^6 m^2) is estimated to be 75-150 Ci. The concentration of radon in air is a function of atmospheric conditions; the mean concentration is estimated to be in the range of 500-1000 pCi/m^3. With normal background conditions a continuous exposure would deliver a dose of about 2000 mrem/year to the lung.[26] With stagnant air or in closed spaces, the lung dose may be even larger (4000 mrem/year).

The annual average concentration (20 µg/m^3) of particulates in Wyoming air will contain 4×10^{-5} pCi/m^3 of Ra-226, 8×10^{-5} pCi/m^3 of Th-232, and 4×10^{-5} pCi/m^3 of Th-230. The dose from

these particulates to the lung, under normal conditions would be about 2 mrem/year, and the dose to the bone would be less than 1 mrem/year.

In Wyoming the whole body dose rate resulting from all domestic and industrial operations is estimated to be 25 mrem/ yr, as compared to the United States average of 30 mrem/yr. The medical whole body dose for Wyoming is estimated to be 75 mrem per year,[27,28] compared to an average of 150 mrem per year for the United States.[29]

Fifteen radiological monitoring stations have been active in the area for nearly two decades.[30] These stations are listed in Table 2.14. In addition, the table shows monitoring efforts conducted at nearby nuclear facilities. Preoperational data, at and near the site, have been made available by the applicant (ER, Sec. 6.1.5). Monitoring efforts include measurements of concentrations in the Cheyenne River, surface, ground, and tap water, milk, dietary components, and the atmosphere. A number of trophic and transfer chains in biota typical of the region have been sampled. Values obtained are discussed in detail in Section 6.8.

2.10 SOCIAL PROFILE

2.10.1 Regional Demography

The area surrounding the Bear Creek site is very sparsely populated. There are only four residences within a ten-mile radius of the mill, the nearest being the Hardy ranch, 3.9 miles to the northwest. The only nearby major population center (> 25,000) is Casper, 45 miles southwest. Population data for selected political entities are shown in Table 2.15. The average population density for Converse County is 1.4 persons per square mile. The 1970 distribution of population within 50 miles of the site is given in Table 2.16, and a population projection for 1996 is presented in Table 2.17.

2.10.2 Community Characteristics

Converse and Natrona Counties are sparsely populated and rural in character, except for Casper (pop. > 45,000)--the county seat of Natrona County. The primary socioeconomic impact of the Bear Creek Project will occur in Converse County, particularly Douglas and, to a less extent, Glenrock and the rural area between these towns and the project site. Because of comparatively short commuting times and available housing, the majority of the workers from the proposed development are expected to live in Douglas (37 miles SSE) and Glenrock (30 miles SSW) (see Fig. 1.1).

A secondary socioeconomic impact of the Bear Creek Project will occur in eastern Natrona County, particularly in Casper and its suburbs and on highways leading from Casper to Glenrock. The degree of socioeconomic impact on the secondary impact area is still somewhat uncertain. It will depend on the proportion of construction workers and operating employees who choose to live in the Casper area and commute to the plant, a distance greater than from Douglas or Glenrock. The intensity of the impact in the Casper area will be minimal because the relatively small number of employees moving into the city will be more easily absorbed within the larger population center. Energy resource development in Converse County has led to a shift from a heavily rural, agricultural (mainly ranching) economy to one in which economic prominence is shared by agriculture and by mining and construction interests.

Energy-related growth of population and employment has increased the importance of Douglas as the major population and trade center for the county. Indicative of this growth is the current construction boom in Douglas. To a lesser degree, increased development is also occurring in Glenrock, primarily in the housing sector. Casper, however, is likely to remain the primary health services and trade center for the region. It is within easy commuting distance on Interstate 25 from both Glenrock and Douglas, and offers a much greater selection of goods and services.

2.10.2.1 Employment

Traditionally, agriculture has been the principal source of employment in the county. For a detailed agricultural profile see Table 2.18. However, with energy development, employment associated with the mining, construction, transportation, communication and the utilities sectors has increased in importance, while that of agriculture has diminished. Table 2.19 shows 1975 estimates of employees residing in Converse County.

Projections of population and employment used in this section were made using present baseline conditions and expected new energy-related developments, excluding the proposed RMEC project, affecting conditions in Converse County. The new energy-related developments may include

Table 2.14. Radiological Monitoring Stations within 200 Miles of the Plant

Station	Distance from Plant, miles	Direction from Plant	Sampling Type[a]
Atlantic City, WY	116	WSW	ST
Bighorn, WY	119	NW	SA, TT
Cheyenne, WY	154	SSE	SA, ST
Edgemont, SD	90	E	SW, UM
Federal-American Partners, WY	107	W	UM
Hardin, MT	196	NW	SW, ST
Henry, NE	119	SE	SW
Highland, WY	13	SE	UM
Hot Springs, SD	108	E	ST, DA
Hulett, WY	110	NNE	ST
Laramie, WY	135	S	PM, ST, DA
Lucky Mc, WY	105	W	UM
Medicine Bow, WY	99	SSW	ST
Rapid City, SD	132	NE	PM, ST
Riverton, WY	140	W	ST
Scotts Bluff, NE	139	SE	TW
Shirley, WY	69	SSW	UM
Shoshoni, WY	125	W	ST
Torrington, WY	111	SE	ST
Union Carbide, WY	99	W	UM
Western Nuclear, WY	122	WSW	UM

[a]DA - diet analysis
LO - special milk station
NPS - nuclear power station
PM - pasturized and raw milk
PT - precipitation
SA - surface air
ST - surface water tritium
SW - surface water
TT - tap water tritium
TW - tap water
UM - uranium mill

Table 2.15. Population Data for Selected Political Entities of the Project Site Region[a]

Political Entity	Years		Percent Change
	1960	1970	
Wyoming	330,066	332,416	0.7
Converse County	6,366	5,938	-6.7
Douglas	2,822	2,677	-5.1
Glenrock	1,584	1,515	-4.4
Lost Springs	5	7	40.0
Natrona County	49,623	51,264	3.3
Casper	38,930	39,361	1.1
Edgerton	512	350	-31.6
Evansville	4,901	4,462	-9.0
Midwest	NA	825	--
Mills	1,477	1,724	16.7
Mountain View	1,721	1,641	-4.6
Paradise Valley	--	1,746	--

Source of table values: "Census of the Population," Bureau of the Census U. S. Dept. of Commerce.

[a]Estimated 1976 populations (see Sec. 2.10.2.2) are: Converse County, 8970; Douglas, 5300, and Glenrock, 2500.

Table 2.16. Distribution of the 1970 Population within 50 Miles of the Bear Creek Mill

Radial Sectors	Miles									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	0	0	0	0	0	0	43	137	192	246
NNE	0	0	0	0	0	28	41	133	183	232
NE	0	0	0	0	0	0	21	146	179	257
ENE	0	0	0	0	0	0	17	152	186	116
E	0	0	0	0	0	0	23	137	192	183
ESE	0	0	0	0	0	28	19	133	201	196
SE	0	0	0	0	0	0	20	157	251	117
SSE	0	0	0	0	0	0	86	216	2677	176
S	0	0	0	0	0	0	35	162	216	215
SSW	0	0	0	0	0	0	30	171	1515	263
SW	0	0	0	0	0	0	42	137	306	43,594
WSW	0	0	0	0	0	0	80	146	187	257
W	0	0	0	17	0	0	0	152	192	246
WNW	0	0	0	0	0	0	0	134	350	205
NW	0	0	0	3	0	0	45	137	116	98
NNW	0	0	0	0	0	0	85	115	187	198

Source: "Census of the Population," Bureau of the Census, U. S. Dept. of Commerce.

Table 2.17. Distribution of the Projected 1996 Population within 50 Miles of the Bear Creek Mill

Radial Sector	Miles									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	0	0	0	0	4	26	105	176	247	316
NNE	0	0	0	0	6	36	112	171	235	298
NE	0	0	0	0	4	26	112	187	229	329
ENE	0	0	0	0	9	27	105	195	239	149
E	0	0	0	0	6	24	107	176	247	235
ESE	0	0	0	0	4	36	105	171	258	251
SE	0	0	0	0	4	31	107	202	322	150
SSE	0	0	0	0	4	24	105	277	3437	225
S	0	0	0	0	6	22	105	208	277	276
SSW	0	0	0	0	4	18	111	219	1945	338
SW	0	0	0	0	4	33	109	176	393	55,974
WSW	0	0	0	0	6	24	100	187	240	329
W	0	0	0	17	9	22	102	195	246	316
WNW	0	0	0	0	6	27	105	172	449	263
NW	0	0	0	3	4	29	102	176	149	126
NNW	0	0	0	0	6	33	109	148	240	254

Table 2.18. Agricultural Data Summary for Wyoming and Converse County

	Wyoming	Converse County	County's Percentage of State Total
Number of farms	8,329	284	3.4
Total acreage	34,404,521	2,439,156	7.1
Average acreage/farm	4,131	8,589	
Market Value of All Agricultural Products Sold			
Total market value	$356,372,000	$10,190,000	2.9
Average per farm	$42,787	$35,879	
Crops Including Nursery Products and Hay			
Dollars	121,554,000	981,000	0.8
Livestock, Poultry and Their Products			
Dollars	234,724,000	9,209,000	3.9
Prevalent Livestock			
Number of cattle and calves	1,589,301	73,719	4.6
Number of sheep and lambs	1,388,393	115,739	8.3
Prevalent Crops (in bushels)			
Wheat (including winter wheat)	6,893,980	42,519	0.6
Barley (for grain)	5,713,738	74,000	1.3
Oats (for grain)	1,732,670	82,876	4.8

Source: U. S. Bureau of the Census, "Census of Agriculture, 1974; Preliminary Reports, Converse County, Wyoming."

Table 2.19. Estimates of Employees Living in Converse County-1975[a]

Agriculture	520
Mining	400
Construction	230
Manufacturing	60
Transportation, communications, and utilities	230
Trade	470
Finance, insurance, and real estate	100
Services	220
Government	420
Other	500
TOTAL	3150

[a]Estimates are based on data from Wyoming Employment Security Commission and the 1970 Census.

several uranium mines, several coal mines, and one coal gasification plant.* Because of the uncertainty associated with proposed Federal legislation relating to coal gasification commercialization and the developmental funding of such a technology, net financial impacts associated with the RMEC proposed project will be compared both with and without the development of the gasification plant.**

The estimated percentage of new workers for each development who will choose to live in the county is based on past trends, travel times, availability of housing and public services, and on the authors' synthesis of the judgments expressed by knowledgeable local observers. Table 2.20 shows the projected total energy-related employment (excluding RMEC) captured by Converse County.

Table 2.20. Projected Employment for New Energy-related Developments in Converse County (excluding Rocky Mountain Energy Company employment)

Years	Construction	Operating
1976	740	190
1977	1330	370
1978	1800	550
1979	1930	810
1980	1730	1020
1981	900	1380
1982	-	1380
1983	-	1380
1984	-	1380
1985	-	1380

Table 2.21 depicts county employment estimates (excluding RMEC data) through 1985 for both the basic and nonbasic sectors. Agricultural employment is expected to decline, while that of mining and processing will increase. The mining and processing work force should remain constant at approximately 1380 workers after 1981, unless further development and/or expansion takes place. Similarly, without further activity than that previously included in the baseline as new energy-related development, the basic construction work force is expected to leave the area in 1981, after peak employment of 1930 occurs in 1979. Nonbasic employment generated mainly by the development activities will generally increase over the time period, including 4520 employees in 1985.

2.10.2.2 Population

Converse County population in 1970 was 5938 and in 1976, an estimated 8970. In the past, the county census data has indicated a trend of decreasing numbers of people 21-64 years old. This represented a major out-migration of workers and young people; the 1960-1970 migration rate was a negative 13.8 percent. In contrast, the migration rate from 1970-1974 was a positive 18.4 percent. The recent gain can be attributed largely to the in-migration of new people into the areas because of the availability of high paying, energy-related job opportunities. Another

*Permits have been applied for and, as of July 1976, the listed developments appear likely to proceed.

**The decision to run the computer model without the gasification plant and the associated coal mine appears to be even more appropriate based on information in "Energy Research Digest," August 30, 1976. It is becoming less likely that a Federally backed synthetic fuels loan guarantee bill will be passed in the near future. If and when such legislation does go into effect, it may be that the loans will go to the plants utilizing cheaper processes than the single-feed Lurgi Process proposed for the Panhandle Eastern Project. However, the newer technologies are not yet demonstrated, and further delay in the Panhandle Eastern Project is at least a strong possibility.

Table 2.21. Converse County Employment Estimates through 1985[a] (excluding Rocky Mountain Energy Company employment)

Permanent Basic Employment	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Agriculture	440	440	430	430	420	420	410	410	410	400	400
Mining and processing	390	190	370	550	810	1020	1380	1380	1380	1380	1380
Other basic	260	260	270	270	280	280	290	290	290	300	300
TOTAL	1090	890	1070	1250	1510	1720	2080	2080	2080	2080	2080
Temporary (construction) basic employment	30	740	1330	1800	1930	1730	900	0	0	0	0
Basic/nonbasic multiplier[b]	1.8	1.2	1.0	.9	.9	1.0	1.2	1.5	1.5	1.6	1.6
Total nonbasic employment	2030	2780	3200	3550	3950	4160	4420	4110	4240	4380	4520
Total employment	3150	4410	5600	6600	7390	7610	7400	6190	6320	6460	6600

[a]Figures based on data from Wyoming Employment Security Commission for first two quarters of 1975 and Denver Research Institute estimates of employment.

[b]Basic/nonbasic employment multipliers are estimated separately for construction and permanent basic employees and are adjusted to take into consideration the overall rate of growth. During periods of rapid growth, the multipliers used are lower. Construction basic/nonbasic multipliers used range from 0.3 to 0.6, while permanent multipliers used range from 0.6 to 1.8. These multipliers are based on selective local interviews and on previous industry interviews.

factor may be the increasing number of indigenous young people who have chosen to stay in the county to obtain employment in the growing industrial sector.

Douglas is the social, political, population, and economic center of Converse County. The population of Douglas has doubled since 1970--from 2677 in 1970 to 5300 in 1976. As of 1970, approximately 45 percent of the county's population lived in Douglas.

The second largest community in Converse County is the town of Glenrock. Although much smaller in size than Douglas, its population has also increased rapidly. The population in 1970 was 1515 and in 1976 is estimated as 2500.

As the local population continues to increase, it is expected that Douglas, rather than Glenrock, will be most affected, since the former is closer to most proposed development sites and currently assures greater availability of goods and services. Growth will also result in increased school enrollments, particularly for Converse County School District #1 (Douglas).

Population forecasts are shown in Table 2.22 for Douglas, Glenrock and Converse County. School enrollment increases for District #1 and District #2 are also estimated. The forecasts are based on the following assumptions:

	Head of Household[a]	Living Alone	Non-Head of Household	Total
Basic Employees				
Energy-related Construction	0.60	0.40	--	1.00
All others	0.90	0.10	--	1.00
Nonbasic employees	0.60	0.10	0.30	1.00
Unemployeed	0.20	0.10	0.70	1.00

[a]Households are assumed to average 3.7 persons. Each family is assumed to include 1.2 school-age children.

Population capture rates for Douglas, Glenrock, Converse County, and Converse County School Districts #1 and #2 are based on past trends, travel times, availability of housing and public services, and on the authors' synthesis of sentiments expressed by knowledgeable local observers.

2.10.2.3 Income

Present wage rates for the county range from $280 per week[31] for miners to $75 per week[32] for those employed by the local government and forest/agricultural services.

The April 1975 "Survey of Current Business" gives the following per capita figures for personal income in the county.

	1969	1972	1973
National	$3,733	$4,549	$5,041
Converse County	$3,646	$4,763	$4,741

The average income of the projected population is expected to be greater than the income for the existing households. Average annual incomes for mining employees are already over $14,000[31] and over $19,000[33] for contract construction workers. These wages can be expected to increase as the demand for such services increases. The raising of mining and construction worker incomes is expected to exert an upward pressure on wages for other types of employment in the area, thus tending to raise incomes for old and new residents alike.

2.10.3 Social and Cultural Characteristics

As the Converse County economy has shifted from agricultural dominance towards parity between agricultural and energy-related resource extraction activities, parallel shifts have begun to occur in the social and cultural composition. In some ways, the county has been and still is relatively homogeneous. The population is predominantly white Protestant. In other ways, rapid changes are taking place. The occupational structure is shifting towards blue collar workers, and ranchers are facing a challenge to their traditional social and political leadership.

Table 2.22. Projected Demographic Changes in Converse County and Political Subunits Thereof (without the proposed Rocky Mountain Energy Company development)

Type of change	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Population										
Converse County	8,970	11,906	14,531	16,762	18,422	18,836	18,159	15,434	15,614	15,792
Douglas	5,300	8,089	10,416	12,390	13,996	14,377	13,570	10,665	10,814	10,962
Glenrock	2,500	2,646	2,889	3,123	3,161	3,190	3,327	3,405	3,430	3,455
School Enrollment										
Converse County School District #1	1,443	2,296	3,015	3,650	4,142	4,283	4,117	3,247	3,298	3,348
Converse County School District #2	768	812	904	960	1,002	1,015	1,032	1,086	1,095	1,104

The rapid growth which is anticipated in energy-related resource extraction will intensify the impact area's transition from a rural society to a more industrial one. These changes--organized in terms of social structure, polity, culture, and institutions--are summarized in Table 2.23.

2.10.4 Housing

Much of the existing housing in Converse County was erected several decades ago. Douglas has a mixture of large, "turn-of-the-century" homes, moderate-sized houses, and small frame bungalows. The older homes occur in the center of town while most new housing is in the eastern suburbs. There are also mobile home parks of varying age and size in the town. The housing situation in Glenrock is similar. There is the same type of mixture but proportionately more of the smaller units. Casper housing is a fairly representative mix, including large older homes and the more modern ranch and bi-level styles, with trailer courts on the fringe areas.

In the past several years, the housing construction industry in Converse County has picked up substantial momentum. Two large housing projects are planned, which would provide over 1000 new living units in Douglas. These will include single family homes, condominiums, and apartments. There is also an independent construction firm in Douglas that builds 15-20 homes a year on an individual basis. A new mobile home park being built in Douglas will provide space for 189 units on 32 acres.

There is a new housing development in Glenrock that will consist of approximately 50 units. The developers anticipate buying an additional 140 acres which will be used for more single family units, and possibly an industrial park. In addition, a proposed mobile home court, if built, will provide 100 new spaces.

Housing construction activity in Casper appears adequate only for the city's normal anticipated growth. Therefore, it would seem that Casper housing is not sufficient to serve as a "housing safety valve" for Converse County.

At present, there are no plans for new town developments in the region. None of the contacted industrial companies have announced plans for any housing developments, but RMEC is providing assistance to develop housing for its employees by guaranteeing the purchase of 50 single family units in two housing additions currently being developed in Douglas. The company has also been instrumental in initiating financing, through the Wyoming Community Development Authority and the Farm Loan Board, to develop water, sewer, and paving programs for Douglas and Glenrock.

In Douglas, homes range in price from $35,000 to $60,000. The cost of a lot is presently $8000, but is expected to increase to $9000 next year. This price includes development costs such as tap fees and street construction.

Oregon Trail Estates, in Glenrock, is being developed by Empire Inc. The homes range in price from $38,000 to $50,000. Lots in Glenrock usually cost from $7000 to $7500, including development costs.

Development and construction costs are also expensive in Casper, with most homes ranging from the low $40,000's to the upper $50,000's and lots varying from $7000 to $8000, including development costs.

Savings and loan institutions in both Douglas and Glenrock are capable of financing some home mortgages on fairly traditional terms; generally 30 year terms, with 9 to 9.5% interest and 10 to 20% down payments. Loan terms in Casper are quite similar, with very few VA or FHA loans granted because of the prevailing seller's market.

The limited housing availability in Converse and Natrona Counties will continue for at least a year or two, and perhaps for the next decade. There is substantial activity in new housing starts, but this is considered unlikely to alleviate the current housing shortage, much less keep up with new demands. In Casper, where the rental vacancy rate is less than one percent, housing availability has been marginal since 1960. Housing now under construction will help meet the demands of upper-income families but will do little to help lower-income groups. Another 800-1000 homes are needed immediately just to satisfy current demands.

While mobile home parks are an alternative to single family units, a 1973 attitudinal survey in Rock Springs - Green River, Wyoming, revealed that most of the permanent work force preferred owning single family homes.[34]

Based on the population projections shown in Table 2.22, and an average of 3.5 persons per dwelling unit, some 2200 additional new dwelling units will be needed by 1985, in addition to the 800-1000 units which are needed now. Unless present relationships between worker incomes, housing production costs, and mortgage terms are altered, the private housing production system will likely meet less than half of this demand. The Rocky Mountain Energy Company presently has plans to guarantee the purchase of 50 single family units in the Douglas area. The homes will be completed on a pre-arranged schedule, designed to coincide with RMEC's recruiting schedule. The price of the units will also be arranged so that they mesh with the company's salary and wage schedules.[35]

Table 2.23. Indicators of Societal Change--Converse County, Wyoming[a]

Indicators	Characteristics of Society--1976	Characteristics of Society--1985
Social Structure		
Economy	Total employment--3,150	Total employment--6,600
	Balanced economic base-- Agriculture is 39% of basic employment Mining and processing is 35% Retired individuals comprise 32.4% of population	Single industry economic base-- Agriculture is now 15% of basic employment Mining and processing is now 73%
	Expanding job opportunities within the county since 1970; gain of population since 1970 vs. a loss of population in the 1960's	Job opportunities will continue to draw new residents, they may also help stem out-migration of young people from the area
Technology	Agriculture technology fairly advanced; large power plant and several mines	Advanced mining and processing technology; more specialized; more diversified and sophisticated; improved technical, educational and professional services in the area
Occupational structure	Rancher & blue collar workers roughly equally significant	Blue collar dominated
Polity		
Regulates distribution of power	Rancher dominated counties (the 3 county commissioners are ranchers); county which has traditionally been antiplanning is now establishing and stressing more comprehensive planning mechanisms	Changes in occupational structure, technology, and economy all must be dealt with and will change constituencies; urban centers will be larger & more complex, will require more planning and administration
Adjudicates conflict and claims	Legislature is rural dominated; county government deals with few conflicts, largely between revenues (taxes) and expenditures (service requirements)	New conflicts: newcomer vs. old timer, more urban vs. rural strain; interindustry & environmental conflicts more common; more concern with & need for Federal intervention with more urbanization; unions probably more of issue & possibly a political force
Culture		
Expressive symbolism	Protestant Christian values--United Methodist, Baptist, Episcopal--37.5% of county population are church adherents (the national average is 50%)	?
	Emphasis on independence and self-reliance--80% of the farms (& ranches) are owner occupied (the national average is 62%); 20% of all the work force is self-employed (the national average is 11%)	More emphasis on political, social, and economic groups
Institutions		
Family	Attitude of permanence--attachment to the area is high; (76% of 1970 residents had lived in county for 5 years or more)	Presence of a large population who view themselves as temporary
	1972 divorce rate--4.26/1,000 population, an increase in the 1970 rate of 3.03/1,000	?
Education	Low dropout rate of 7.2% (the national average is 25%)	Dropout rate may come closer to the national average as the county becomes more industrial
Communities	Two very small service center towns; high proportion of permanent housing	Growth, more diversity in the two service centers, increase in the proportion of temporary housing; possible degradation of services and overcrowding to accompany rapid growth
SUMMARY	Traditionally an agrarian society, recent increase in the number of miners & construction workers; county now dominated by ranchers and employees of the energy industry; includes service and governmental components	More urban, complex society, including new extractive & processing components; county now dominated by the energy industry

[a]Among the sources used for this table and the ensuing discussion are: Daniel Bell, "The Coming of Post-Industrial Society," Basic Books, New York (1973); Bureau of the Census, 1970 Census of the Population, Characteristics of the Population of Wyoming, Washington, D. C., GPO, 1972; Bureau of the Census, 1970 Census of Housing, Detailed Characteristics of Wyoming, Washington, D. C., GPO, 1972; System for Social Research and Development, Wyoming Social Economic Data for 1972, Exchange Measure 1970-1972, University of Denver Research Institute 1974; Wyoming Dept. of Education; County Clerk of Converse County, Wyoming; Douglas W. Johnson, Paul R. Picard, and Bernard Quinn (eds.), "Churches and Church Membership in the U. S.," Lyndon Blendmary Research Center, Washington, D. C., 1974; Julie M. Uhlmann, Robert Kimble and David Throtmorton, "A Study of Two Wyoming Communities Undergoing the Initial Success of Energy Resource Development in Powder River Basin: Buffalo and Douglas, Wyoming - 1975," Laramie: U. of Wyoming, Dept. of Anthropology, 1976.

The price of housing in the region has risen rapidly over the past several years.[36] In view of the competitive demand for construction labor in the developing boom areas such as Casper, Douglas, and Glenrock, it appears that local housing costs have risen at an even faster rate, and will likely continue to do so.

2.10.5 Government, Public Services, and Public Finance

The primary impact area, Converse County, includes three incorporated towns (Douglas, Glenrock, and Lost Springs); two school districts (No. 1, based in Douglas, and No. 2 based in Glenrock); and two special districts (Rural Fire Protection, Hospital) involving portions but not all of the county.

Converse County is administered by three county commissioners and other specialized, elected county officials. Planning activities for the county are conducted by a Converse Area Planning Office, supported partly by the county and partly by the towns within the county. Pursuant to passage of the Wyoming Joint Powers Act (W.S. 9-18.7 et seq.), a Converse County Municipal and County Joint Powers Board was formed and held an organizational meeting on April 15, 1976.[37] The potential scope of authority delegated to Joint Powers Boards is broad and includes control of the following: water, sewerage, solid waste, recreation, police and fire protection, transportation systems, airports, public schools, community colleges, hospitals, courthouse and jails, public health facilities and municipal electrical systems. Thus far, the Converse Joint Powers Board has been functional in the areas of joint planning (see Sec. 2.10.5.1), solid waste disposal, public health, animal control, and fire protection.

The Town of Douglas is administered by a mayor, elected for a two-year term, and four councilpersons elected for staggered four-year terms. The town has appointed boards for planning and zoning and adjustment and shares in the support of the Converse Area Planning Office.

The Town of Glenrock also is administered by an elected mayor and four councilpersons, with an appointed advisory planning commission. The town similarly contributes to support of the Converse Area Planning Office.

The Town of Lost Springs, about 25 miles east of Douglas on U. S. Highway 18 and 20, has only seven residents. Because of its location, the town is unlikely to be impacted by the Bear Creek Project activities.

Converse County School District #1 is headquartered in Douglas and includes the eastern two-thirds of the county. The District operates a junior-senior high school, two elementary schools and eight rural schools with combined 1976 enrollments of 1443 students. A second high school and another elementary school are under construction.

Converse County School District #2 is headquartered in Glenrock and serves the western third of the county, west of a north-south line through the Dave Johnson Power Plant, east of Glenrock. The District operates a junior-senior high school, a grade school and three rural schools with combined 1976 enrollments of 768 students. The grade school has just been enlarged and another phase addition is planned for 1978.

2.10.5.1 Adequacy of Planning/Zoning

Attitudes of Converse County residents have changed in the last five years, from a predominantly negative attitude toward planning to a current state of awareness of the need for good planning. A Converse Area Planning Office, with two professional planners and support staff, is financially supported by the county, the towns of Douglas and Glenrock, and some Federal "701" funds. The Planning Office is currently being supervised by the Converse Joint Powers Board and is expected to evolve into the board's administrative office. Planning offices of Natrona County and Casper have also been integrated within the past 18 months. Both Converse and Natrona counties have adopted subdivision regulations.

The present Douglas zoning law, soon to be revised, specifies five zones and is unusually permissive:

Class A Residential:	Single family residences, duplexes
Class B Residential:	Class A uses, plus hotels, motels, gas stations
Class A Commercial:	All residential and commercial uses except for lumber and junk yards and mobile homes
Class B Commercial:	All uses except for mobile homes
Industrial:	No restrictions

Even so, mobile homes are permitted in any zone, by specific resolution of the town council.

The Converse Area Planning Office has just completed an interim concept plan for Douglas and adjacent area (in a three-mile radius); the plan was adopted in May 1976 and recently published. A similar plan for Glenrock, with a two-mile radial extension, is in preparation, with publication expected in early 1977. Thereafter, preparation of a Converse County master plan will begin. These will be the first master plans prepared for the three entities mentioned.

2.10.5.2 Public Facilities

Assessments of specific facilities and services are as follows:

Douglas

Administrative space is adequate to a population level of 7000 (present population of Douglas is about 5300).

Police and fire protection are adequate at the moment, given impending increases in personnel. Members of the fire department are volunteers.

Approximately 70 percent of the streets in Douglas are paved. As population and traffic congestion increase, the remaining 30 percent will have to be paved, and other system improvements will presumably have to be made.

Park, recreation and library facilities are quite good. Recreational facilities and programs are adequate for a much larger population, and there is a good county library. The population of Douglas has just reached a level at which a new neighborhood park is considered necessary.

Both water and sewer systems are presently used at near capacity. In April 1976, Douglas received a $1.855 million loan for utilities improvement from the Wyoming Community Development Authority.[38] Since Douglas would have considerable difficulty meeting that annual debt requirement, the town has also received a $1.79 million Coal Impact Tax grant payable in annual installments over the next 20 years. The combined grant-loan program will insure adequate utilities for a population level of about 11,000. The funds will pay for, among other things, additional water storage and filtration capacity and a new sewer system west of the North Platte River.

The 32-bed County hospital in Douglas is adequate to a population level of 13,000. A mental health clinic, established three years ago, is staffed by one psychologist and a receptionist. The psychologist divides his time between the school districts (two days weekly) and the clinic (three days weekly). The number of health care personnel is small for a town the size of Douglas; more doctors, dentists, and mental health specialists are needed. The problem is lessened somewhat by the relative nearness of and wide range of medical services available in Casper.

Converse County

There has been very preliminary discussion about an I-25, Highway 59 bypass.[39] There is considerable traffic on Highway 59 north of Douglas, and the road is considered hazardous. The intown intersection leading to Highway 59 is extremely congested. Given the number of people who drive east on I-25 from Casper and Glenrock to Douglas and then north, a bypass to Highway 59 would relieve much of the congestion.

Sufficient energy-related development will occur northwest of Douglas to make the condition of the Ross Road an important transport route. At present, it appears that the road will be paved but not otherwise improved; it will not be straightened, and curve radii will not be increased. Even if paved, the road will not meet State standards; therefore, the county will continue to be responsible for maintenance of the Ross Road. Plans are underway for improving the section of road from Glenrock to the southern end of the Ross Road. The project will begin in 1977 and will cost $1.2 million. The county will contribute approximately $215,000; State and Federal funds will make up the rest.

A new county courthouse is under construction. It should be completed sometime in early 1977 and will serve the community up to a population level of 14,000.

Facilities for the Sheriff's Department are presently adequate and new facilities are included in the courthouse which is being constructed.

Converse County School District #1

In December 1975, School District #1 passed a $7.58 million bond issue for construction of two new schools, one elementary and one high school. The district is now bonded to capacity. Target completion date for both schools is the fall of 1977. The district schools will then have a total enrollment capacity of 2600 students (present enrollment is 1443).

Glenrock

Administrative space is inadequate for the present population (approximately 2500).

Police and fire protection are presently adequate, although the town needs another police car. Members of the fire department are volunteers.

Streets are badly in need of repair and paving. Only about 10 percent of Glenrock's streets are presently paved, and the entire system is in extremely poor condition.

Park, recreation, and library facilities are adequate.

Both water and sewer systems are being operated at capacity limits. The sewage lagoons are full, and it is likely that the Glenrock system will soon fail to meet the State's effluent standards. The water system is not adequate to supply needs during certain seasonal periods. The town has received a grant for an engineering study for water and sewer planning.[40]

Converse County School District #2

The junior-senior high school of School District #2 is being operated at near capacity limits. A two-phase addition to the elementary school is under construction. Phase 1 will be completed by the fall of 1976 and will raise the capacity only to the 450-student level expected at that time. Phase 2 will be completed in the summer of 1978, and will raise the capacity to 600, though the district would prefer not to go over 500. Wyoming law limits school district indebtedness to 10 percent of assessed valuation. School District #2 has less than $1 million of its capacity left.

Casper and Natrona County

There are no particular current inadequacies in public facilities at Casper. Since Casper has been a relatively large city for a long time, there already exists a large base of services. This base will not be severely affected by the arrival of a given number of newcomers. There is one county-wide school district, and this permits the inclusion of all the county's taxable mineral resources in the district's assessed valuation base.

With two possible exceptions, the facilities available in Casper should readily accommodate population increases resulting from energy development in Converse County. First, housing is already a problem and will likely remain in short supply in the near future. The second difficulty is an erosion of Natrona County's assessed valuation base resulting from the declining productivity of the Salt Creek oilfield.

2.10.5.3 Local Tax Structure

Wyoming has no state income tax. The major revenue sources for the towns are intergovernment transfer from state-collected taxes and local property taxes. Wyoming imposes a three percent state sales tax. Of this, one-third (or 1%) is returned to the county of origin for distribution to the cities and the county on the basis of 1970 population figures.

Converse County also has a one percent sales tax, effective March 1, 1976. It is not a particularly stable source of revenue since the tax proposal must appear on the ballot every general election subsequent to its original enactment, and, if the proposal is ever defeated, there must be a two-year time lapse before it can appear again.

Assessed valuation in Converse County has increased rapidly in recent times; from about $84 million in 1974 to $128 million in 1975.[41] Of the $128 million, 45% is received from taxes on oil and gas developments in the county. This latest increase in assessed valuation provides Converse County with a relatively high valuation per capita--$14,463 based on a county population of 8,970 (state figure is $6656 based on a population estimate of 374,000). Most of the increase has been concentrated in the rural areas of School District #1. The assessed valuation per pupil figure is higher than the state average so the district receives no supplemental state school aid.

2.10.5.4 Adequacy of Future Governmental Services

The rapid rate of growth and social change which has been projected for the area can be expected to pose serious problems for local public officials. As indicated previously, the availability of public facilities and services in Glenrock, Douglas, and Converse County School District #2 is already strained by growth. Over the next five years, demands for new services and requirements for new public expenditures are likely to increase much faster than the local tax base for all political entities in the primary impact area.

The analyses which follow include detailed projections of expenditures necessary to maintain the existing level of public services and of the revenues available to meet those expenditures.* A description of the methodology and assumptions used in making the projections is provided in Appendix F. The projections are for the town of Douglas, the town of Glenrock, Converse County, and School Districts #1 and #2. The discussions do not include consideration of the Bear Creek project as proposed by RMEC.

Town of Douglas

Table 2.24 shows annual projections of needed expenditures and revenues for the town of Douglas. The town's present utilities expansion program (to accommodate 6000 new residents) will not be sufficient to provide services to all of the anticipated new residents. The investment of an estimated $5.3 million will be needed to expand utilities services. An additional investment of $0.9 million for other capital improvements and equipment--including administrative space, police and fire equipment, streets and recreation facilities--will be needed prior to 1982. Substantial increases will also be needed for operating expenditures. Town revenues from existing sources are likely to be more than $200,000 per year less than needed expenditures until the bonds for new capital facilities are paid off.

Town of Glenrock

Annual projections of expenditures and revenues for the town of Glenrock are shown in Table 2.25. The town's sewer and water system will require capital investment of approximately $1.1 million over the next three to four years to provide adequate services. The town will also need to spend an estimated $110,000 for other capital improvements--including administrative space, police and fire, and streets. Town revenues from available sources will likely be $50,000-$70,000 per year less than needed expenditures through 1985.

Converse County

Table 2.26 shows annual projections of expenditures and revenues for Converse County. Capital outlays will include $210,000 for improvements to the Glenrock-Ross Road in 1978 and $1.4 million for a hospital expansion once the county population exceeds 13,000.

County finance problems stem mostly from heavy reliance on property taxes as a source of operating revenues. Operating expenditures need to be increased concurrent with (or prior to) the arrival of the construction work forces for large development projects. Meanwhile--given the time necessary to build taxable improvements, assess them, bill the firms for taxes, and then receive the property tax payments--the increased property tax revenues associated with the new large-scale developments will lag more than two years behind the arrival of the work force. County revenues are likely to lag behind needed expenditures throughout the rapid growth period (1976 through 1980). By 1981, the growth rate will have leveled off and assessed valuation will have increased sufficiently to effect a reversal in the flow of county finances.

Converse County School District #1

As indicated in Table 2.27, the financial state of Converse School District #1 will likely be more seriously affected than that of Converse County. The district is presently planning to invest $7.6 million in renovating and constructing schools and classrooms. The new and expanded facilities will accommodate 2600 students (80 percent more than present enrollments). However, if growth occurs as anticipated, these expanded facilities will be overcrowded by 1978. The district would have to spend another $3.2 million over and above the presently planned expansion in order to accommodate future students in a currently acceptable manner.

As does the county, the school district relies heavily on property taxes as a source of operating revenues. Because of the manner in which property tax revenue receipts lag behind expenditure needs, operating costs will exceed revenues through 1981.

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*These projections are "order of magnitude" estimates, based on the announced intentions of large potential employers and on past local public budget decisions. They are deemed useful as indicators for this analysis; however the reader is cautioned against using them for other purposes at other times, without careful reevaluation.

Table 2.24. Projections of Needed Revenues and Expenditures, Town of Douglas
(without the proposed development)
(thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Town of Douglas										
Operating Revenues										
Ad valorem taxes	50	60	120	170	210	250	260	260	210	210
Sales, cig., gas tax	190	290	370	450	500	520	490	380	390	390
Highway tax alloc.	0	0	0	0	0	0	0	0	0	0
Fed. rev. sharing	30	40	50	60	70	70	70	50	50	50
Utility serv. chg.	240	370	480	570	640	660	620	490	500	500
Other user chg.	40	80	100	120	130	140	130	100	100	110
St., cnty, pvt con.	40	40	40	40	40	40	40	40	40	40
Miscellaneous	60	100	120	150	170	170	160	130	130	130
Total op. rev.	650	980	1280	1560	1760	1850	1770	1450	1420	1430
Operating Expenditures										
Gen'l admin.	120	180	230	280	310	320	300	240	240	240
Police & fire	180	270	350	440	500	510	480	360	360	370
Streets	50	80	110	140	150	160	150	110	120	120
Health, welfare, rec.	50	80	100	120	140	140	130	100	110	110
Utilities	290	350	600	640	770	780	760	600	610	610
Miscellaneous	30	40	60	70	70	80	70	60	60	60
Total op. exp.	720	1000	1450	1690	1940	1990	1890	1470	1500	1510
Surplus/deficit	-70	-20	-170	-130	-180	-140	-120	-20	-80	-80
Capital Revenues										
Ad valorem taxes	80	90	180	250	310	370	390	390	310	320
Utility tap fees	50	400	330	280	230	50	0	0	20	20
Other cap. rev.	140	10	20	20	20	70	80	80	80	80
Total cap. rev.	270	500	530	550	560	490	470	470	410	420
Capital Expenditures										
Admin.-capital	0	90	0	0	0	0	0	0	0	0
Police & fire	0	40	70	10	0	70	0	0	0	0
Streets	0	40	20	20	0	20	0	0	0	0
Parks, rec., libry	0	40	60	0	0	0	0	0	0	0
Utilities	1990	1300	0	2000	0	0	0	0	0	0
Miscellaneous	0	10	400	0	0	0	0	0	0	0
Total cap. exp.	1990	1520	550	2030	0	90	0	0	0	0
Cap. Debt Service	170	330	390	610	610	620	620	620	620	620
Surplus/deficit	-1720	170	140	-60	-50	-130	-150	-150	-210	-200
Total surplus deficit	-1790	150	-30	-190	-230	-270	-270	-170	-290	-280

Table 2.25. Projections of Needed Revenues and Expenditures, Town of Glenrock (without the proposed development) (thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Town of Glenrock										
Operating Revenues										
Ad valorem taxes	10	10	10	20	20	20	20	20	30	30
Sales, cig., gas taxes	100	110	120	130	140	140	140	150	150	150
Highway tax alloc.	0	0	0	0	0	0	0	0	0	0
Fed. rev. sharing	10	10	10	10	10	10	10	10	10	10
Utility serv. chg.	150	160	170	180	190	190	200	200	200	200
Other user chg.	0	0	0	0	0	0	0	0	0	0
St. cnty, pvt con.	20	20	20	20	20	20	20	20	20	20
Miscellaneous	40	50	50	60	60	60	60	60	60	60
Total op. rev.	330	360	380	420	440	440	450	460	470	470
Operating Expenditures										
Gen'l admin.	70	70	80	90	90	90	90	90	100	100
Police & fire	80	90	90	100	100	100	110	110	110	110
Streets	30	30	40	40	40	40	40	50	50	50
Health, welfare, rec.	10	10	10	10	10	10	10	10	10	10
Utilities	100	110	120	130	130	130	140	140	140	140
Miscellaneous	10	10	10	10	10	10	10	10	10	10
Total op. exp.	300	320	350	380	380	380	400	410	420	420
Surplus/deficit	30	40	30	40	60	60	50	50	50	50
Capital Revenues										
Ad valorem taxes	10	10	20	20	20	20	30	30	30	30
Utility tap fees	10	20	30	30	10	0	20	10	0	0
Other cap. rev.	0	0	0	0	0	0	0	0	0	0
Total cap. rev.	20	30	50	50	30	20	50	40	30	30
Capital Expenditures										
Admin.-capital	0	50	0	0	0	0	0	0	0	0
Police & fire	0	10	0	0	0	0	0	0	0	0
Streets	0	50	0	0	0	0	0	0	0	0
Parks, rec., libry	0	0	0	0	0	0	0	0	0	0
Utilities	30	50	1000	0	0	0	0	0	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0
Total cap. exp.	30	160	1000	0	0	0	0	0	0	0
Cap. Debt Service	30	50	150	150	150	150	150	150	150	150
Surplus/deficit	-10	-20	-100	-100	-120	-130	-100	-110	-120	-120
Total surplus/deficit	20	20	-70	-60	-60	-70	-50	-60	-70	-70

Table 2.26. Projections of Needed Revenues and Expenditures, Converse County
(without the proposed development)
(thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Converse County										
Operating Revenues										
Ad valorem taxes	1130	1150	1200	1400	1750	2190	2620	3000	3170	3170
Sales, cig., gas tax	100	140	170	190	210	210	210	180	180	180
Royalties	50	60	70	80	90	90	90	80	80	80
Health serv. fee	350	460	570	650	720	730	710	600	610	620
St. welfare fund	0	0	0	0	0	0	0	0	0	0
Grants	20	20	20	20	20	20	20	20	20	20
Fees & misc.	110	150	190	220	240	240	240	200	200	210
Total op. rev.	1760	1980	2220	2560	3030	3480	3890	4080	4260	4280
Operating Expenditures										
General admin.	530	650	740	820	880	890	870	770	780	790
Sheriff, rural fire	180	230	270	310	340	340	330	300	300	300
Library	100	130	160	190	200	210	200	170	170	180
Health & hospital	550	730	890	1030	1140	1160	1120	950	960	970
Roads & bridges	390	520	630	730	800	810	790	670	680	680
Welfare	120	160	190	220	240	250	240	200	210	210
Aid-schls/munic.	20	20	20	20	20	20	20	20	20	20
Misc.	70	90	110	130	150	150	140	120	120	120
Total op. exp.	1960	2530	3010	3450	3770	3830	3710	3200	3240	3270
Surplus/deficit	-200	-550	-790	-890	-740	-350	180	880	1020	1010
Capital Revenues										
Ad valorem taxes	280	280	290	340	430	540	640	740	780	780
Fed. rev. sharing	120	150	190	220	240	240	240	200	200	210
Total cap. rev.	400	430	480	560	670	780	880	940	980	990
Capital Expenditures										
Admin./judicial	570	0	0	0	0	0	0	0	0	0
Sheriff & fire	50	0	0	0	0	0	0	0	0	0
Hosp'ls & ment. hlth	80	0	1440	0	50	0	0	0	0	0
Roads & bridges	240	0	210	0	0	0	0	0	0	0
Other	90	0	230	0	130	0	0	0	0	0
Total cap. exp.	1030	0	1880	0	180	0	0	0	0	0
Cap. debt serv.	20	20	220	220	240	240	240	240	240	240
Surplus/deficit	-630	410	260	340	430	540	640	700	740	750
Total surplus/deficit	-830	-140	-530	-550	-310	190	820	1580	1760	1760

Table 2.27. Projections of Needed Revenues and Expenditures, Converse County School District #1 (without the proposed development) (thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Converse County School District #1										
Operating Revenues										
Ad valorem taxes	2880	3100	3320	4040	5250	6740	8180	9270	9800	9810
St. liqdn fund	0	0	0	0	0	0	0	0	0	0
St. trans. funds	0	0	0	0	0	0	0	0	0	0
Other st. funds	100	170	220	260	300	310	300	240	240	240
P.L. 81-874	0	0	0	0	0	0	0	0	0	0
Other Fed. funds	150	0	0	0	0	0	0	0	0	0
Miscellaneous	260	410	530	650	730	760	730	570	580	590
Total op. rev.	3400	3680	4070	4950	6280	7810	9210	10080	10620	10640
Operating Expenditures										
Instruction-op.	1860	2960	3890	4710	5350	5530	5310	4190	4260	4320
Transportation	120	190	250	300	340	350	340	270	270	280
Admr'n & misc.	1300	1640	1930	2180	2380	2440	2370	2020	2040	2060
Total op. exp.	3280	4790	6070	7190	8070	8320	8020	6480	6570	6660
Surplus/deficit	120	-1110	-2000	-2240	-1790	-510	1190	3600	4050	3980
Capital Revenues										
Ad valorem taxes	230	230	250	300	400	520	630	740	780	780
Other cap.	0	0	0	0	0	0	0	0	0	0
Total cap.	230	230	250	300	400	520	630	740	780	780
Capital Expenditures										
Capital (school)	470	7600	1600	1600	0	0	0	0	0	0
Capital (other)	210	30	30	30	0	0	0	0	0	0
Total cap. exp.	680	7630	1630	1630	0	0	0	0	0	0
Cap. debt serv.	270	1150	1330	1520	1520	1520	1520	1520	1520	1520
Surplus/deficit	-450	-920	-1080	-1220	-1120	-1000	-890	-780	-740	-740
Total surplus/deficit	-330	-2030	3080	3460	-2910	-1510	300	2820	3310	3240

Converse County School District #2

Table 2.28 depicts yearly revenues and expenditures for Converse County School District #2. District #2 finances will be more adversely affected than those of either Glenrock or Converse County, primarily because of heavy reliance on property taxes as a major revenue source.

The district is planning to invest $2.2 million for improvements and expansion of existing elementary facilities to accommodate approximately 600 students. As shown in Table 2.28, revenues from existing sources will continue to lag behind operating expenditure requirements for the entire period of analysis.

Summary and Implications

All five public entities, which have been analyzed in detail, are likely to be confronted with financial difficulties during the next five or more years as a consequence of rapid increases in the demand for public services. This is a baseline projection and therefore does not include considerations for the proposed RMEC development. In most cases the problems will be short-term; however, they will also be relatively severe. Local officials will be confronted with a dilemma. They will have to either sharply increase local tax rates, settle for a degraded level of local services, or find sources of external financial assistance. Casper, Natrona County, and the Natrona County School District are not expected to have significant public finance problems. Casper's tax base is currently sufficient to finance the level of growth which is anticipated. Also, most public facilities in Casper are adequate with some excess capacity available.

2.11 RECREATIONAL ACTIVITIES

Much of the Converse County recreational activity involves the outdoor sports of hunting, fishing, and snowmobiling. Neither Douglas nor Glenrock provides extensive recreational facilities.

Douglas maintains a golf course and several parks which provide some seasonal recreation. Cultural attractions in Douglas include the annual Wyoming State Fair, the Wyoming Pioneer Memorial Museum and the nearby Fort Fetterman Museum. Douglas has preliminary plans for developing a youth activities center, and a new park -- Bartling, in South Douglas; facilities will include tennis courts, two ball fields, and a picnic area.

Glenrock schools provide most of the recreational facilities (e.g., swimming) for the youth of Glenrock. The Baquero Rodeo and the Ayres Natural Bridge State Park near town are the two notable recreational features. Glenrock recently purchased an adjacent 80 acres of state land for the development of a golf course and perhaps later, a swimming pool and tennis courts.

The potential for intensive recreational use and development in the project area is low; no unique scenic or natural features are present, nor are there any existing recreational facilities. Although big game species (antelope and deer) occur in the area, hunting is limited because access across private lands is owner-controlled.

2.12 ESTHETIC CONSIDERATIONS

The landscape is characterized by gently rolling uplands, smooth texture and subdued colors of browns, grays and greens. Due to the short vegetation and low rolling land forms of the natural terrain, man-made facilities such as fences, utility lines, windmills, and oil wells are conspicuous in local landscapes. No sharp contrasts are apparent between the adjacent plant communities primarily dominated by shrub and/or grass species. Surface water bodies are virtually nonexistent in the area.

It is believed that the lack of variety in the landscape and the fact that relatively few viewers with intense concern for scenic quality will observe the area results in giving the project area a visual quality objective of "modification."[42] This designation implies that activities and intrusions can visually dominate the landscape, but such modification must be designed or located to best conform with the form, line, color, and texture of the onsite landscape and at a scale reasonably compatible with natural surroundings.

2.13 ARCHEOLOGICAL AND HISTORICAL VALUES

No known historical properties or values exist on the proposed project area.[43] An occasional flake (stone chip associated with primitive tool making) has been found in the area, thus indicating limited presence of man sometime in the prehistoric past. No archeological sites or

Table 2.28. Projections of Needed Revenues and Expenditures, Converse County School District #2 (without the proposed development) (thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Converse County School District #2										
Operating Revenues										
Ad valorem taxes	1160	1100	1070	1080	1110	1170	1240	1430	1450	1450
St. liqdn fund	0	0	0	0	0	0	0	0	0	0
St. trans. funds	0	0	0	0	0	0	0	0	0	0
Other st. funds	60	60	70	70	80	80	80	80	80	80
P.L. 81-874	0	0	0	0	0	0	0	0	0	0
Other Fed. funds	70	30	40	40	40	40	40	40	40	40
Miscellaneous	130	140	150	160	170	170	170	180	180	190
Total op. rev.	1420	1330	1330	1350	1400	1460	1530	1730	1750	1760
Operating Expenditures										
Instruction-op.	770	820	930	990	1040	1050	1070	1140	1150	1160
Transportation	50	50	60	60	70	70	70	70	70	70
Admr'n & misc.	460	480	510	540	550	560	570	590	590	590
Total op. exp.	1280	1350	1500	1590	1660	1680	1710	1800	1810	1820
Surplus/deficit	140	-20	-170	-240	-260	-220	-180	-70	-60	-60
Capital Revenues										
Ad valorem taxes	280	280	280	280	290	290	290	290	300	300
Other cap.	30	30	30	30	30	30	30	30	30	30
Total cap.	310	310	310	310	320	320	320	320	330	330
Capital Expenditures										
Capital (school)	680	1530	0	0	0	0	0	1600	0	0
Capital (other)	20	30	30	0	0	0	0	0	0	0
Total cap. exp.	700	1560	30	0	0	0	0	1600	0	0
Cap. debt serv.	280	450	450	450	450	450	450	620	620	620
Surplus/deficit	-390	-140	-140	-140	-140	-130	-130	-300	-290	-290
Total surplus/deficit	-250	-160	-310	-380	-390	-350	-310	-370	-350	-350

other significant cultural materials have been found.[44] Assurance of archeological clearance for the Bear Creek Project site is indicated in correspondence jointly authored by the Assistant State Archeologist and the State Historic Preservation Officer (see Appendix G).

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3. APPLICANT'S PROPOSED MINING AND MILLING OPERATIONS

3.1 MINE

3.1.1 The Proposed Action

During July 1975, the Rocky Mountain Energy Company (RMEC) filed a mining and reclamation plan for a uranium surface mining project, part of which would be on an acquired-lands mineral lease, W-4416 (Appendix C). The proposed mining and milling operations would be known as the Bear Creek Project. During January 1976 and January 1977, supplemental plans were filed which gives more detailed discussion of the deposit areas proposed for mining and includes the Dilts mining area. In February 1977 the applicant filed an additional plan revising the sequence for mining the various ore reserve areas. The operation, as addressed in the plans, concerns the mining of uranium from nine known ore reserve areas, identified as B-1, B-3, B-4, B-6, B-8, B-13W, B-13E, and Dilts-E and Dilts-W (Fig. 1.2). Of these nine areas, only the largest, B-1, would be mined under the applicant's Federal lease and Mine Operating Regulations 30 CFR 231. The others would be mined under terms of the United States mining laws and other mineral rights secured by RMEC from the owners of those mineral rights (see Fig. 2.3).

Within the boundaries of the site are public domain land, land acquired by the U. S. Government (administered by the U. S. Forest Service as part of the Thunder Basin National Grasslands), U. S. Geological Survey, State of Wyoming land, and private land. The surface ownership is shown in Figure 2.2. Thus the proposed project involves Federal, reacquired Federal, State of Wyoming, and private mineral rights and surface properties. The surface in the southern half of Section 10, and the northern half of Section 15 (B-1 area), is owned by the Federal Government. However, the surface of the southern portion of the proposed B-1 pit (Section 15) is privately owned and the company would compensate the owners for damage or disruption of surface use.

Total recoverable reserves in the nine ore bodies are estimated to be about 3.0 million tons--about 1.5 million tons in the large B-1 ore body, and an additional 1.5 million tons in the smaller areas.

Stripping of overburden began in September 1976, and mining is scheduled to begin sometime in mid-1977, with an initial production rate of about 900 tons of ore per day, or about 27,500 tons per month. It is planned to increase production to about 1400 tons of ore per day (330,000 tons per year) and to maintain that rate until about 1990, when currently delineated ore reserves would be depleted. Approximately 600,000 pounds of U_3O_8 would be produced annually. Construction of an access road to the site began in March 1976, with construction of mine electrical distribution system, mine shop, and changehouse proposed for May and June.

Exploration drilling would continue within the Bear Creek area, with final schedules contingent upon locating possible additions to known reserves.

The uranium content, except in rare, carefully picked samples, ranges from less than 0.1 to 1.0 percent; the highest grade material is located at the contact with oxidized sandstone. In unoxidized sandstone the grade diminishes gradually with distance from the oxidized edge of the ore zone. The width of the ore-grade material thus varies from place to place depending on how rapidly the grade diminishes with distance. Average uranium oxide content of the ore is less than three pounds per ton (< 0.15%).

3.1.2 Mining Procedures

Current information indicates that the only efficient and economical method of developing the erratically occurring zones of mineralization is the open-pit mining method. An aerial view of a typical open-pit mining operation is shown in Figure 3.1.

Mining by the open-pit method consists of topsoil and overburden removal followed by extraction of the uranium ore. Topsoil would be removed first and stored for future use in reclamation. The waste overburden, consisting primarily of unconsolidated sandstone and mudstone-claystone, would be broken and loosened with single-shank rippers mounted on crawler tractors. After the ore has been exposed, it would be removed with front-end loaders or crawler-mounted units, equipped with small buckets.

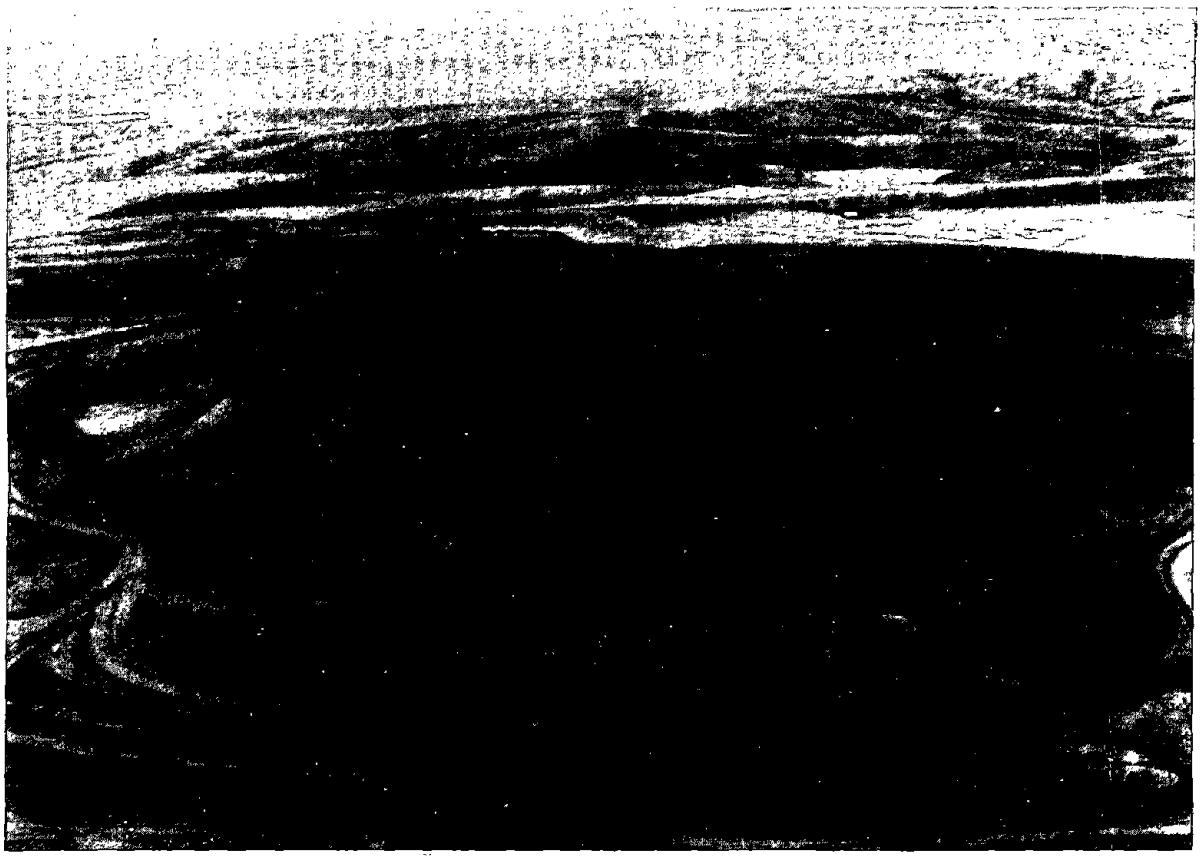


Fig. 3.1. A Typical Open-Pit Uranium Mine in Wyoming.

Overburden, removed at a rate of about 667,500 bank cubic yards per month, would be stored initially in waste dumps located away from drainages to minimize the effects of possible erosion. Also, such dumps would be located so as to extend ridgelines of hills in order to blend these structures with the topography; in addition, pit voids would be backfilled with overburden, where possible, and blended with existing natural contours. The completed dump would be covered with a layer of topsoil and seeded with native plants or suggested and recommended shrubs and grasses. Upon completion of mining activities, remaining overburden dumps would be graded, covered with topsoil, and revegetated, as described in Section 3.1.3.

Most of the ore is located beneath the local water table, so mine dewatering would be necessary and accomplished by the traditional method of allowing water to drain into a sump, from which it is pumped into settling ponds for clarification and necessary treatment. Small amounts of this water will be used for dust control and the remainder will be discharged into existing drainageways.

3.1.2.1 Sequence of Mining

The Bear Creek Mine will operate seven open pit mines plus two additional pits that will be developed on a recently acquired property, known as the Dilts.

Overburden removal rates will achieve a steady rate of approximately 677,500 bank cubic yards per month necessary to meet mill requirements of approximately 330,000 tons of ore per annum.

The proposed sequence of operations is as follows: B-4, B-3, Dilts-E, B-1, Dilts-W, B-6, B-13E, B-8, and B-13W (see Table 3.1).

Overburden removal operations will commence with the B-4 orebody. Overburden removal operations on the B-3 orebody will start approximately eight months after starting operations on the B-4 orebody. The B-4 operation was planned to reach ore at the expected startup time of the mill. Approximately nine months of overburden removal operations are required to reach the ore zones in B-4 (Fig. 3.2). The B-4 orebody will supply approximately seven months of mill feed ore. Because it takes approximately 16 months of overburden removal rates to reach ore in B-3, the Dilts-E pit will commence operations upon completion of mining in the B-4 pit.

Overburden from the B-4, Dilts-E and half of the material from the B-3 pit will be taken to surface overburden sites (Figs. 3.3 and 3.4). The final overburden sites will be shaped and contoured to blend in with the natural topography of the area. Topsoil and plant growth medium, which will have been previously removed from the disturbed areas, will be placed over the overburden sites and the area reclaimed.

When ore mining has been completed in the B-4 pit, the remaining overburden from the B-3 pit will be backfilled into the B-4 pit and between the two B-4 surface overburden sites. The final overburden site will be shaped to blend with the natural topography and then reclaimed.

The Dilts orebody will be mined in two sequences that will include an initial pit, Dilt-E, with a total volume of approximately 4.9 million cubic yards of overburden and 268,000 tons of ore. The Dilts-E pit will be stripped and mined in approximately one and one-half years. A period of approximately three years will elapse after mining has concluded on the Dilts-E pit before stripping will start on the Dilts-W pit. The overburden from the Dilts-E pit will go to a surface overburden pile that extends the west dump of B-4 and is graded to blend in with the natural topography (see Fig. 3.2).

After overburden removal for B-3 is completed, overburden removal will commence at B-1. All overburden for the first phase of the B-1 orebody will be taken to surface overburden sites (Fig. 3.5).

The initial stage of the B-1 operation will remove approximately 14.5 million bank yards to surface disposal sites on the east side of the orebody. Approximately 24 months are required to reach ore. During this period, ore will be supplied from the B-3 mine.

Upon completion of the initial B-1 stage, the Dilts-W pit will be stripped, with one million bank cubic yards used to partially backfill Dilts-E and the remaining four million yards to partially backfill the B-3 pit (Fig. 3.7).

After overburden removal operations are completed at Dilts-W, the stripping operations will move to the second phase of the B-1 pit.

The 9.5 months that it took to strip Dilts-W will have allowed the initial area of B-1 to be mined out. Approximately 6.5 million bank cubic yards will be contained in the second phase of the B-1 pit. Because of backslope requirements of the spoil material, all of the 6.5 million cubic yards of the second phase of B-1 will also be taken to surface overburden sites. As soon

Table 3.1. Tentative Schedule for Surface Mining Operations

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	*
Stripping	B-4	D-E B-3	B-3 B-1	B-1	D-W B-1	D-W B-1	B-1	B-1	B-1	B-6 B-1	B-6 B-13E	B-8 B-13E	B-8 B-13W	B-13W	B-13W	
Mining		B-4	D-E B-3	B-3 B-1	B-3 B-1	D-W B-1	D-W B-1	B-1	B-1	B-1	B-1 B-6	B-13E B-6	B-13E B-8	B-13W B-8	B-13W	
Reclamation			B-4 (partial)			D-E (partial)					B-4 (final) D-W	B-1 (final)	B-6	B-8	B-8 B-3	B-13

D = Dilts Pits
B = Bear Creek
* = After 1990

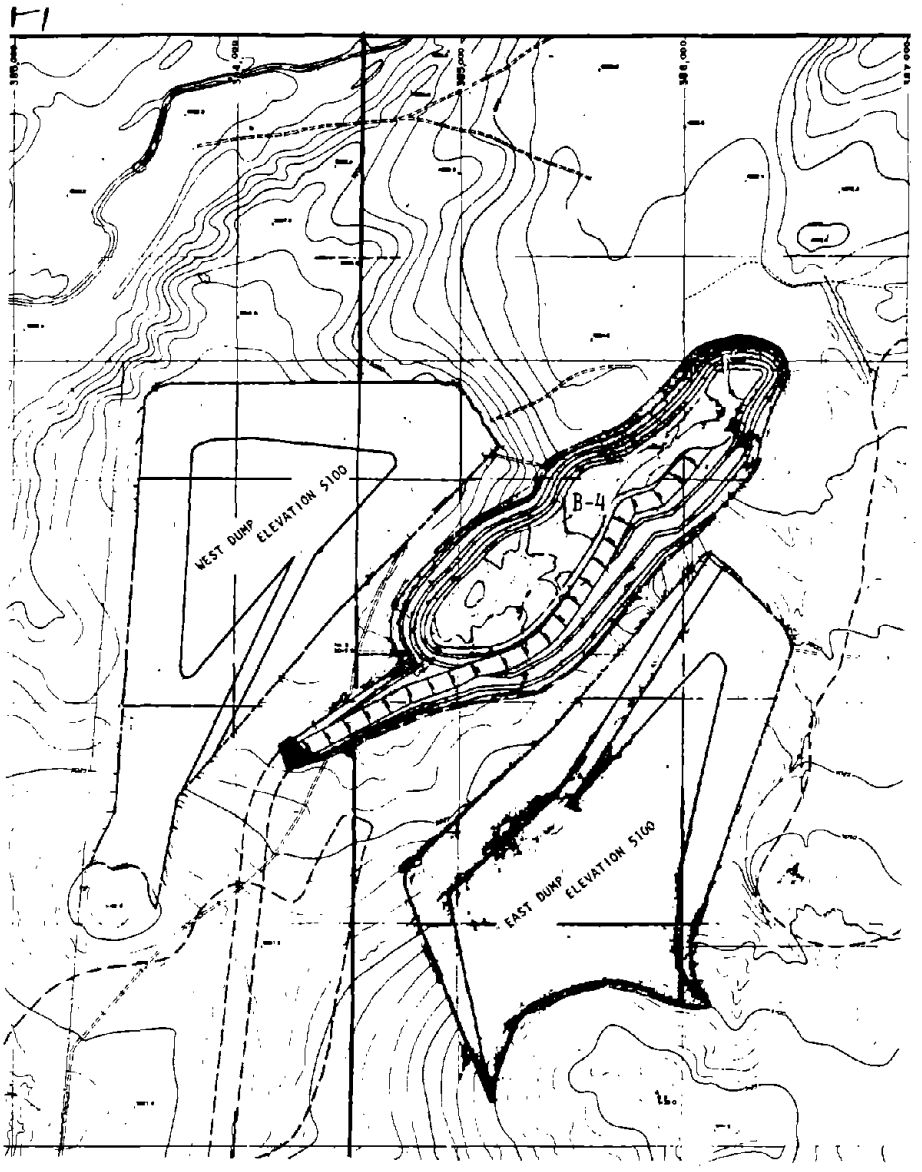


Fig. 3.2. The B-4 Pit and Overburden Dump Areas.

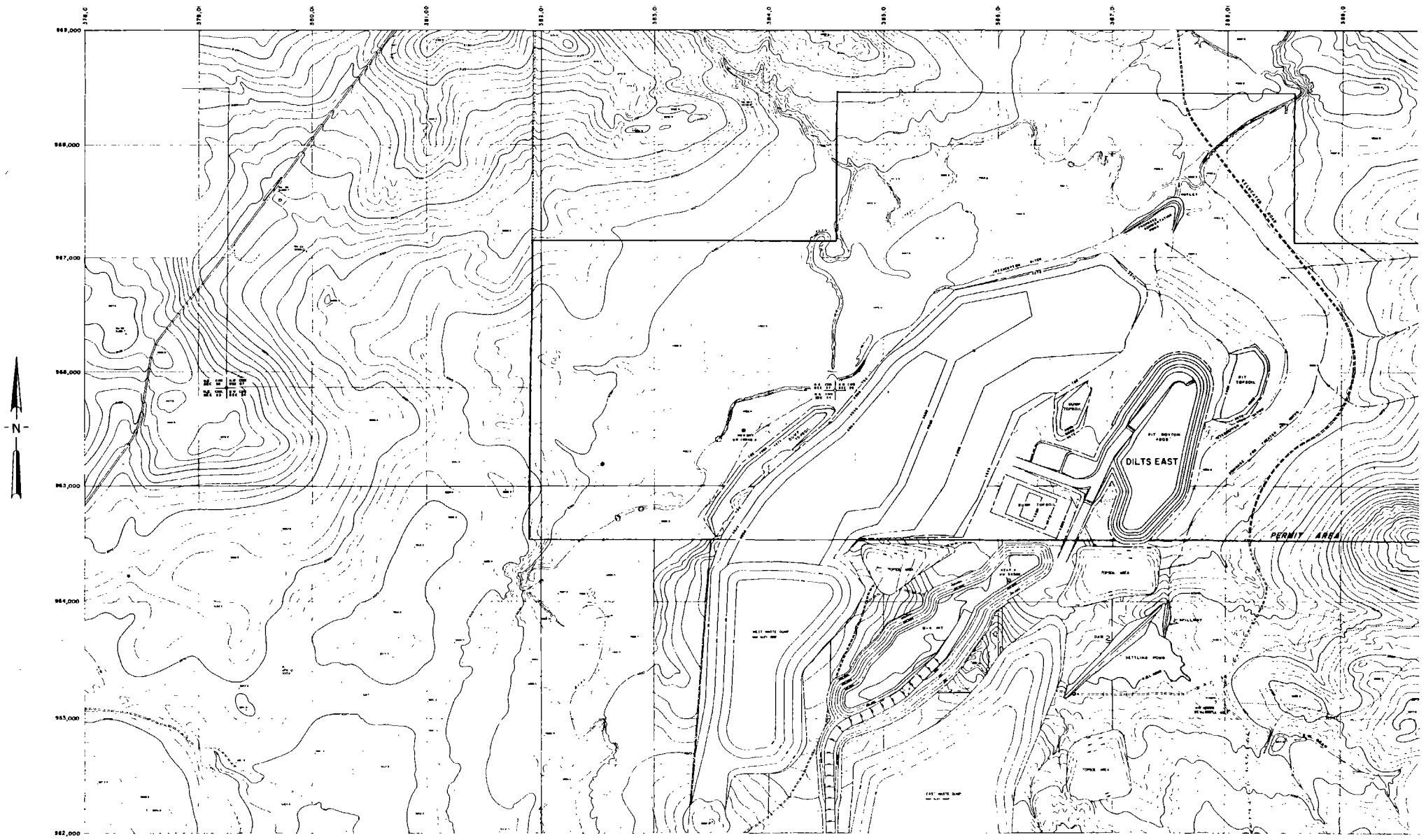


Fig. 3.3 Dilts East and B-4 Pit and Dumps before Reclamation.

3-6 A

R 73 W.

3-6 B

3-6 C

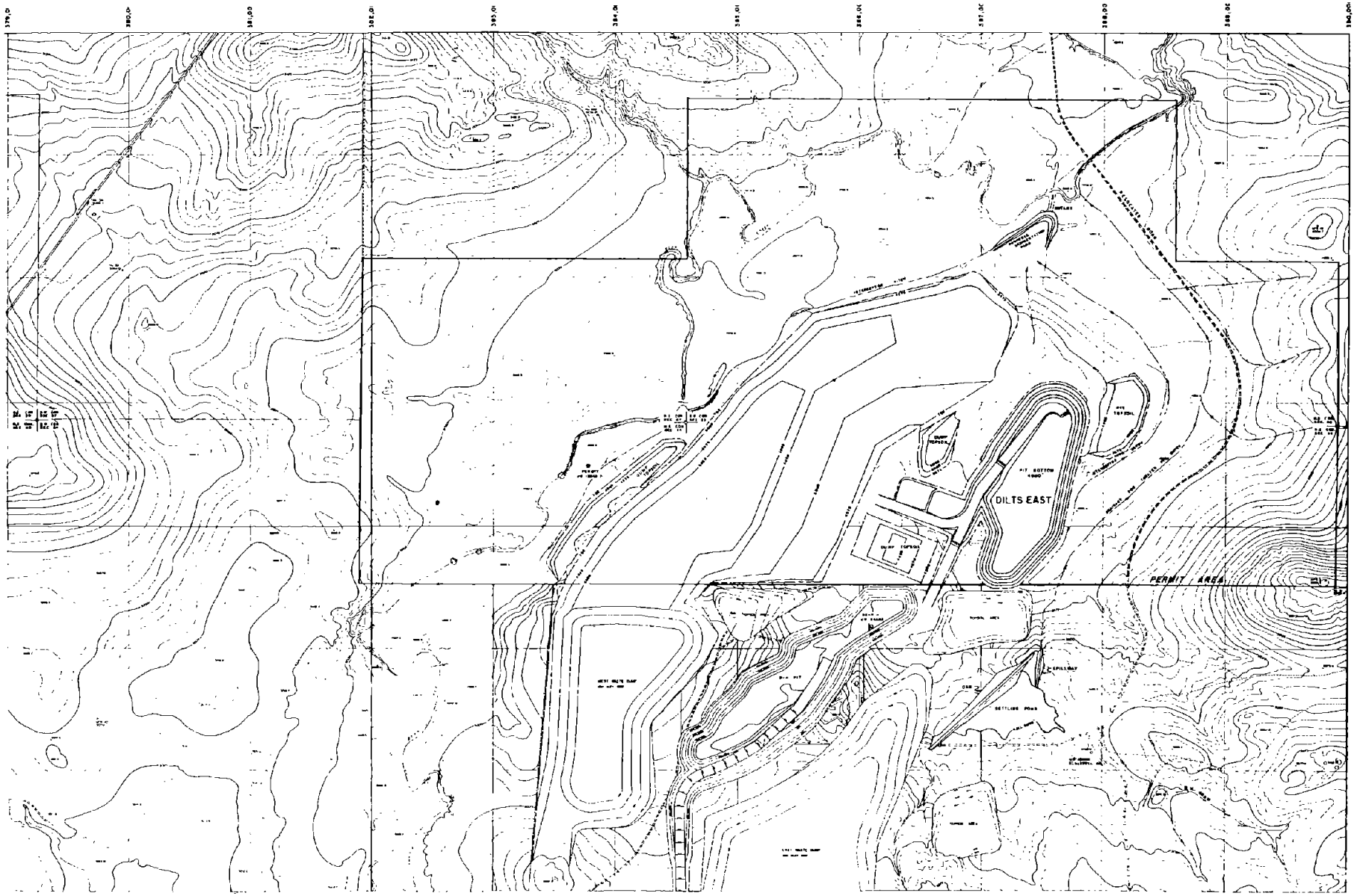


Fig. 3.3 Dilts East and B-4 Pit and Dumps before Reclamation.

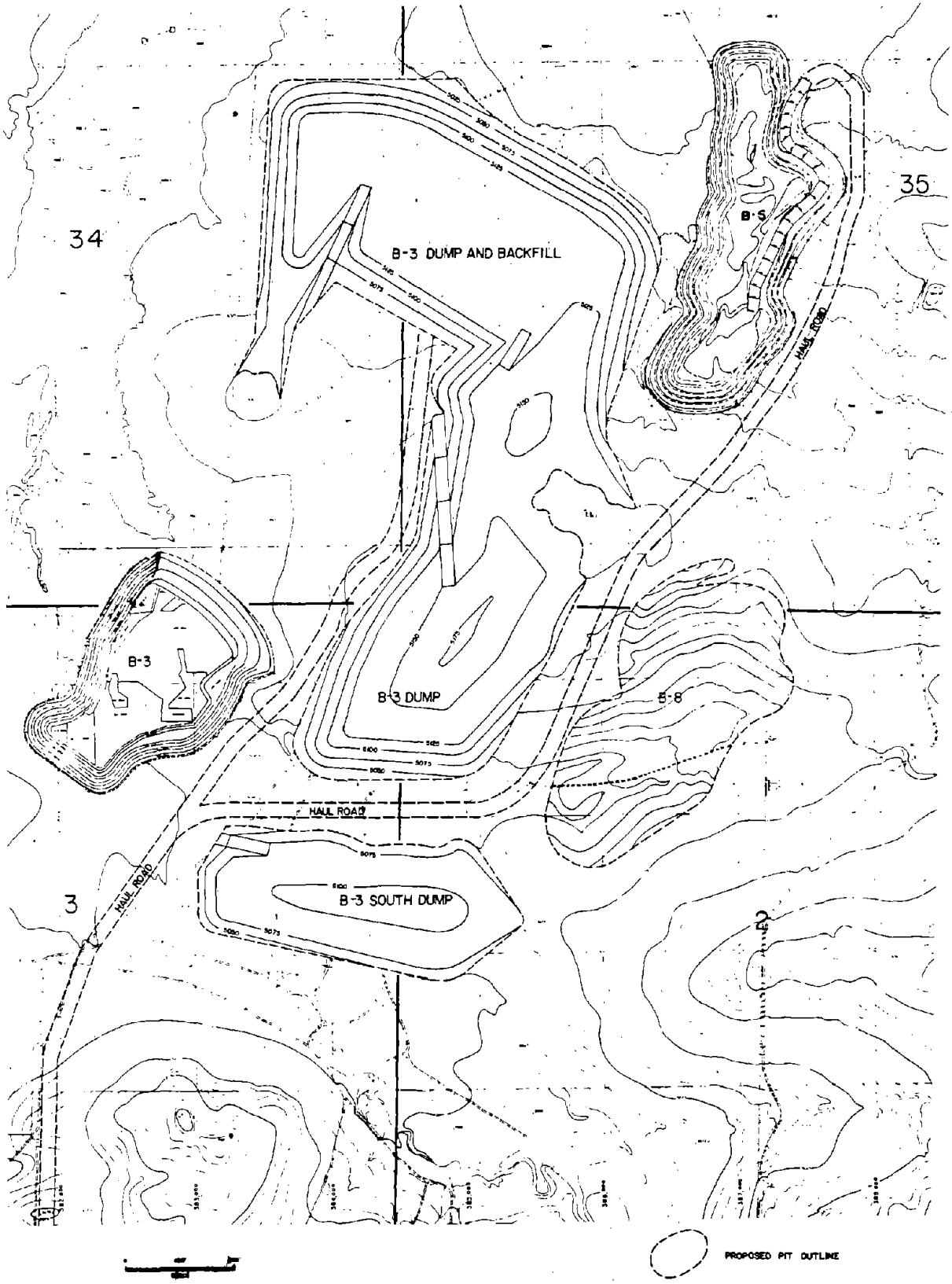
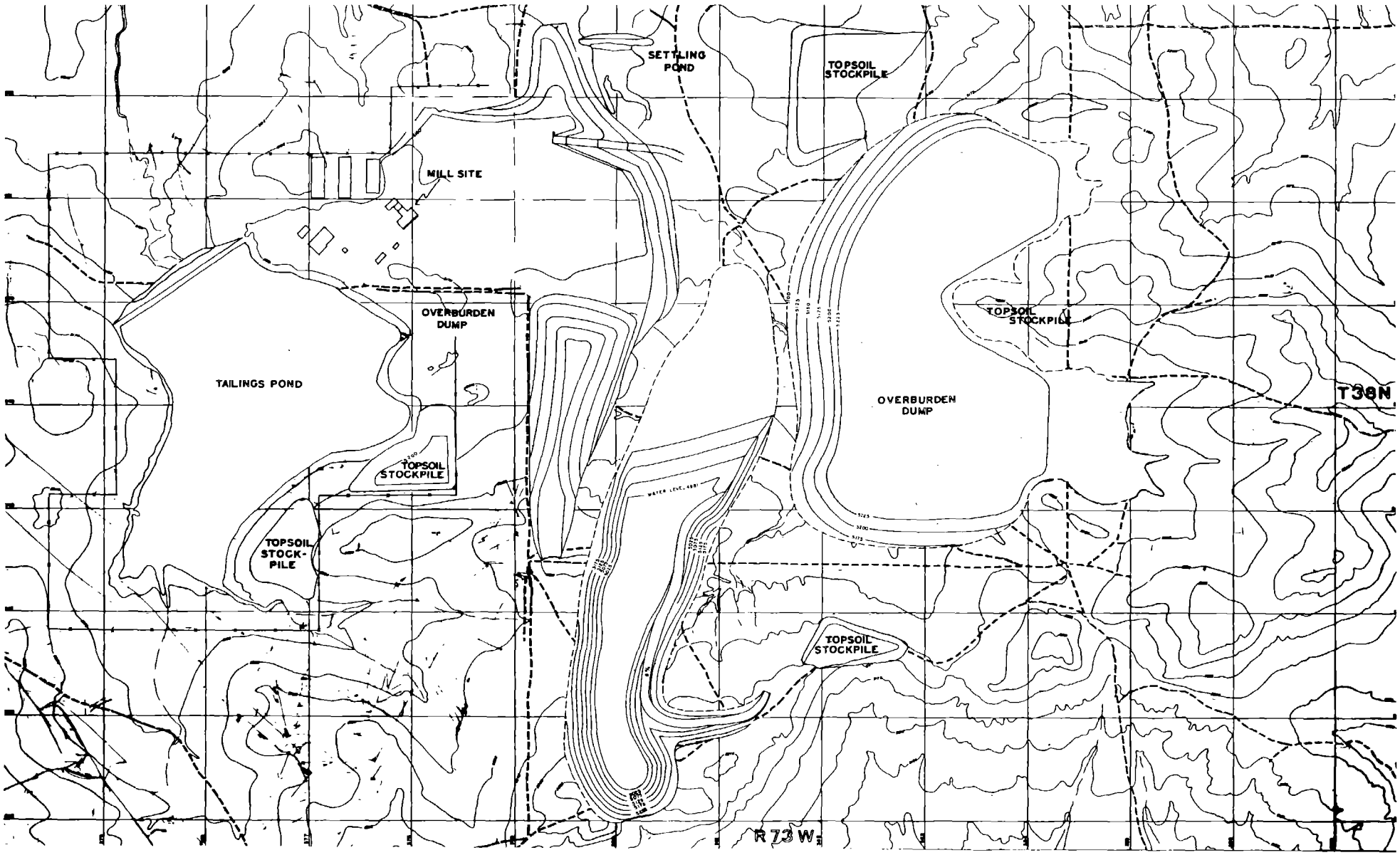
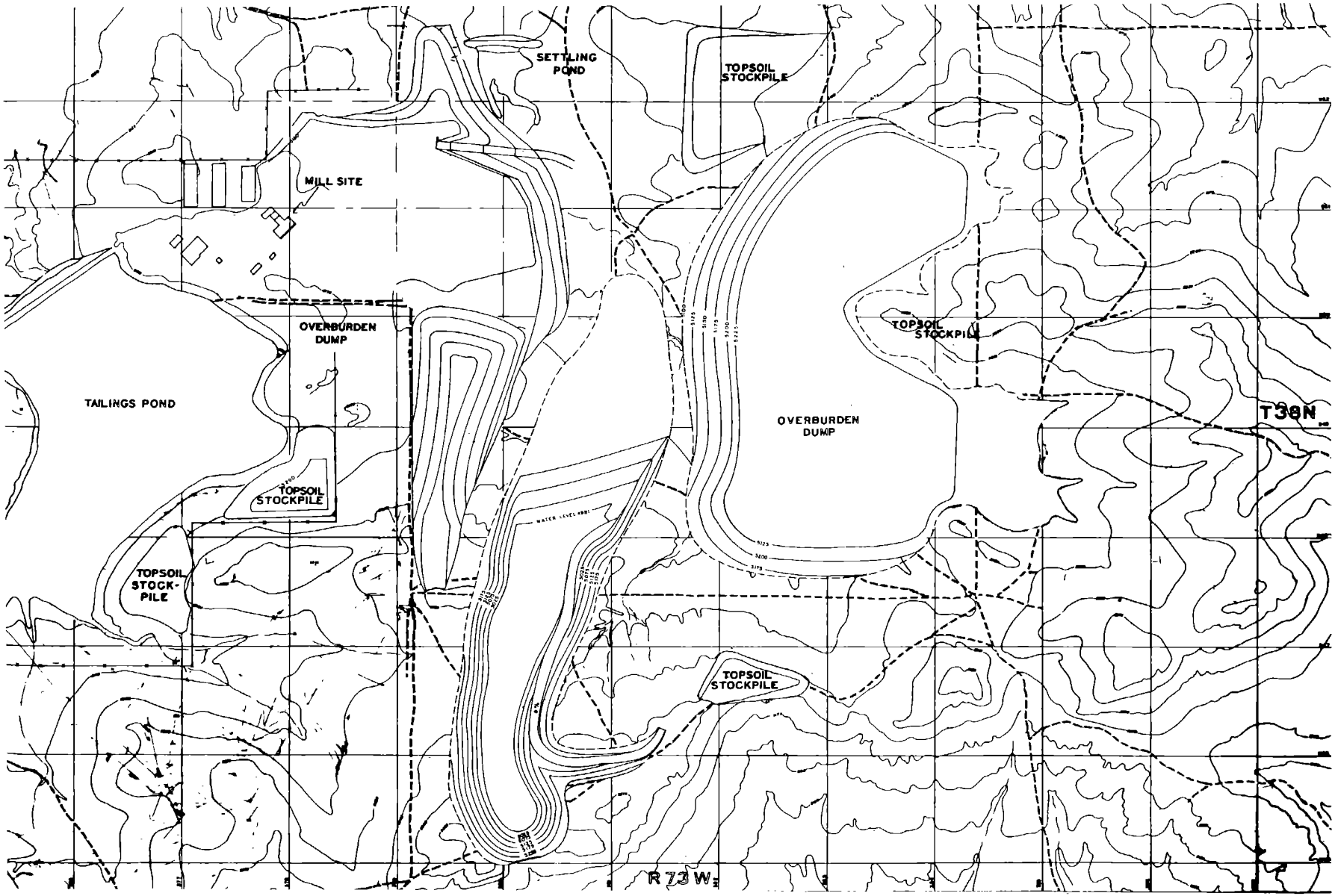


Fig. 3.4. The B-3 Site.



Fig, 3.5 Mill Site, Tailings Pond, B=1 Orebody, and Dump Area before Reclamation



5 Mill Site, Tailings Pond, B=I Orebody, and Dump Area before Reclamation

A

B

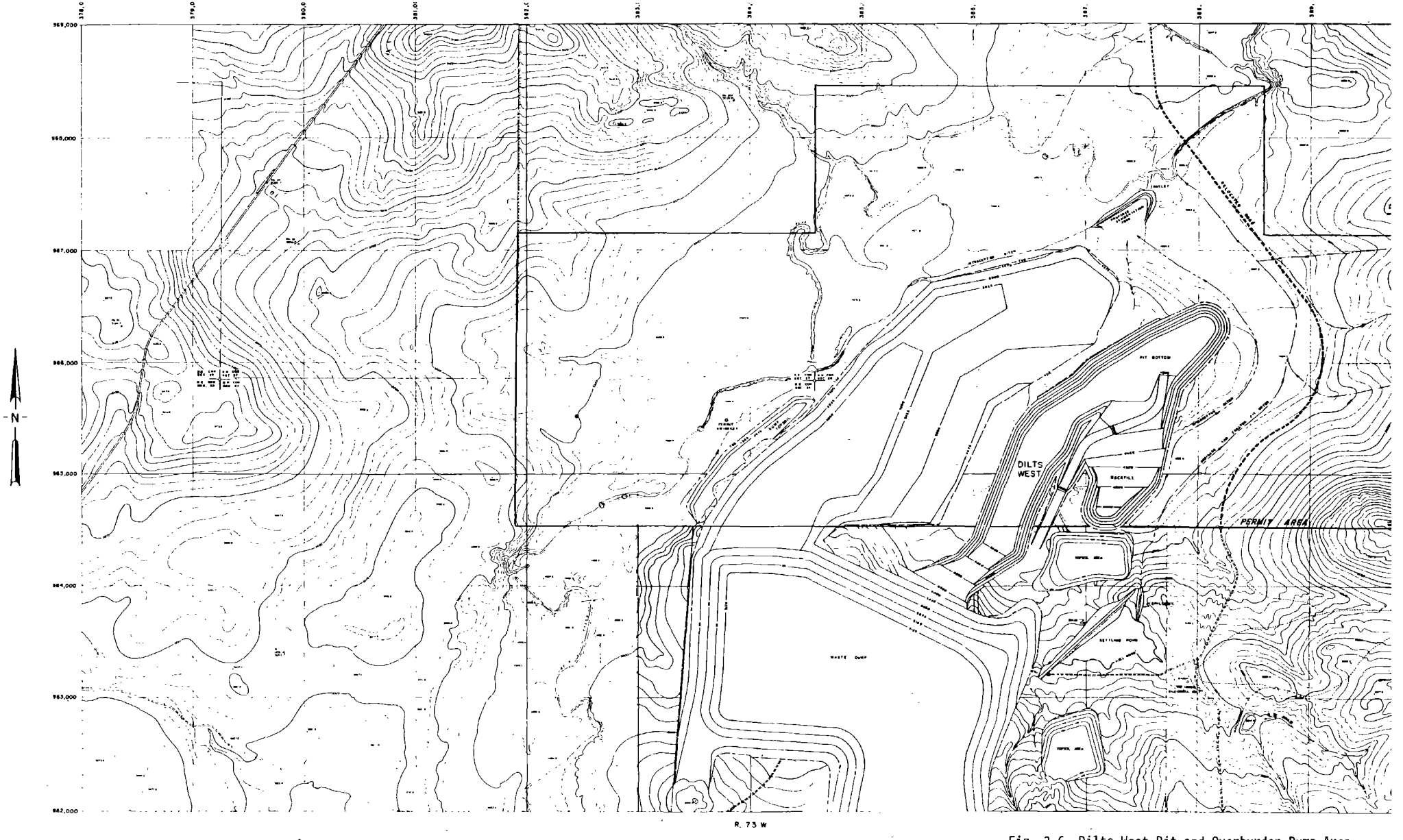


Fig. 3.6 Dilts West Pit and Overburden Dump Area.

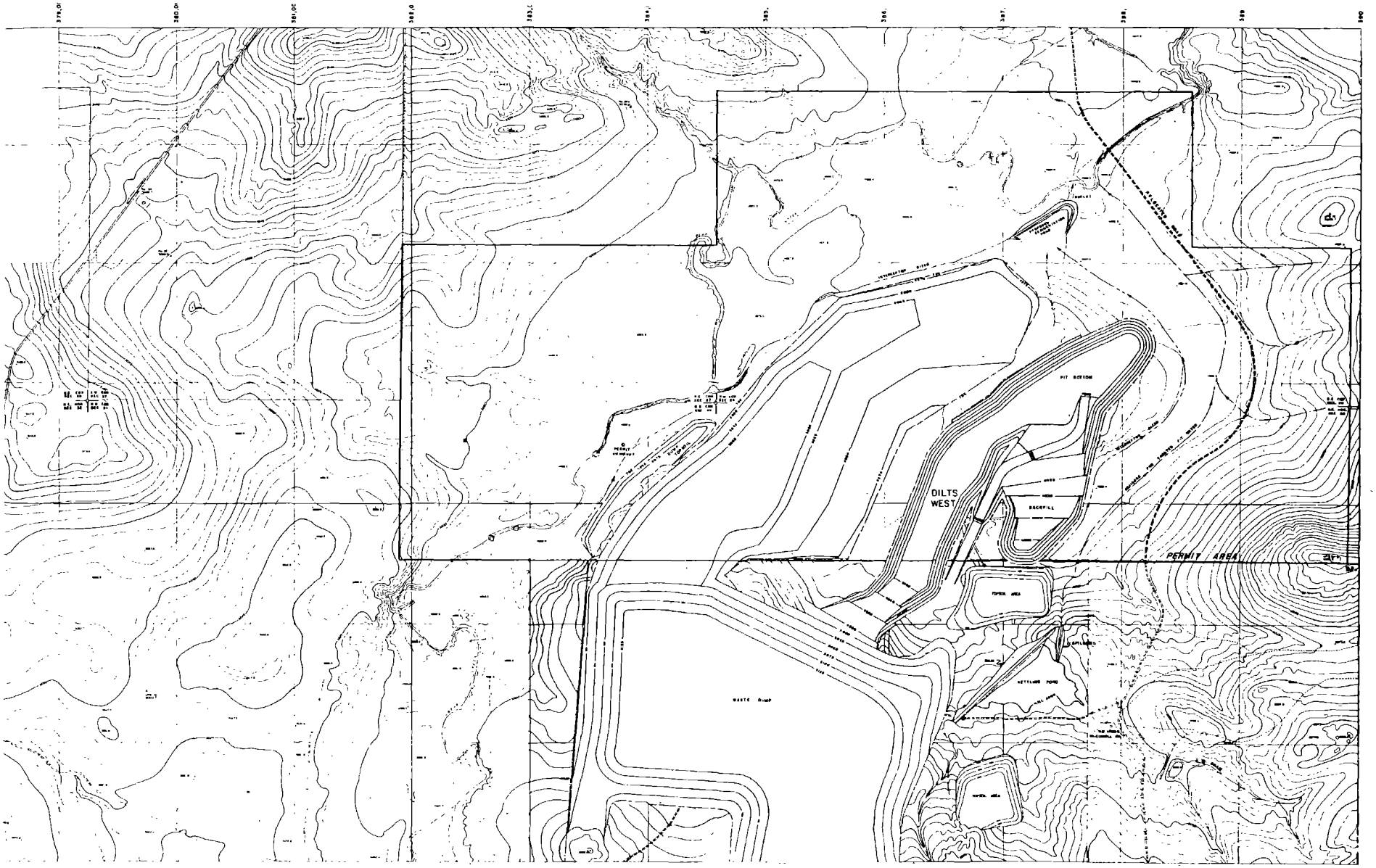


Fig. 3.6 Dilts West Pit and Overburden Dump Area.

as these phases are completed, backfilling will commence with no further material from B-1 going to surface spoil areas.

When mining is completed at the B-1 area, the south end of the pit will not be filled in but left as a water impoundment for livestock and wildlife. In addition, the resulting lake will contain approximately 5800 acre feet of water which has an excellent potential for being an irrigation source. The final pit slopes will be constructed to insure slope stability and safety.

Access to the B-1 water area will be provided by the gentle slope of the backfill material on the north side. Additional access is provided on the south side by an 80-foot-wide haul road that will remain. If practical, all accessible slopes and benches will be seeded and/or planted with suitable grasses and trees.

In approximately seven years, the stripping operations at the B-1 area will be completed and overburden removal will commence on B-6. This will allow ore recovery to begin when mining is completed in B-1.

Overburden from the B-6 operation will not be taken to surface overburden but will be used to backfill the Dilts area to its original landform. Additional overburden will be used to backfill the B-3 pit to restore that area to its original landform.

After the B-6 stripping operations are completed, the operations will shift over to the B-13 areas. The first B-13 pit, B-13E, will contain approximately 3.4 million bank cubic yards of overburden that will be taken to a surface overburden site (Fig. 3.7).

The B-8 pit will come into operation and all of its overburden will be used to backfill the B-6 pit to restore the area to its original contour.

The final B-13 pit will be stripped and the overburden used to partially backfill the B-13E pit area.

After mining has been completed in the final B-8 and B-13 pits, they will be left open as lakes (Fig. 3.8). The water level will rise to within 50 feet of the land surface and the highwall will be graded to a gentle slope that will allow complete revegetation and safe access for livestock.

3.1.2.2 Soil Removal and Deposition

General

Topsoil from all mine and overburden dump areas would be removed with diesel-powered scrapers. Topsoil from each area would be stockpiled initially or, where possible, placed directly on graded and contoured areas in order to reduce the effects of wind and water erosion, loss of soil microorganisms, etc. Topsoil stockpiles would be segregated from overburden materials, the surface of each pile pitted and/or gouged, and the piles then seeded with fast-growing plants to maximize water retention and reduce erosion losses; such stockpiles would be marked in accordance with applicable regulations. Subsoil to be utilized as a "topsoil" medium also would be properly stockpiled and designated.

Specific

Upon initiation of operations, all topsoil materials would be removed from about 141 acres of the proposed pit and overburden dump areas. The topsoil materials are to be stockpiled just to the east of the north end of the pit.

Topsoil materials would then be removed from the approximately 125 acres of the Dilts East pit and overburden dump area followed closely by removal of 160 acres of topsoil materials associated with the B-3 pit and overburden dump areas. Topsoil materials would also be removed from the approximately 100 acres associated with the mill and office complex.

Topsoil materials would be removed from all disturbed lands just prior to the disturbance and stored adjacent to the operation and relatively near the location where it will be needed later. Not all locations will be decided upon until more detailed planning is completed. Wherever possible, to eliminate rehandle, topsoil materials as it is removed will be placed directly in a recontoured area and spread directly over the overburden.

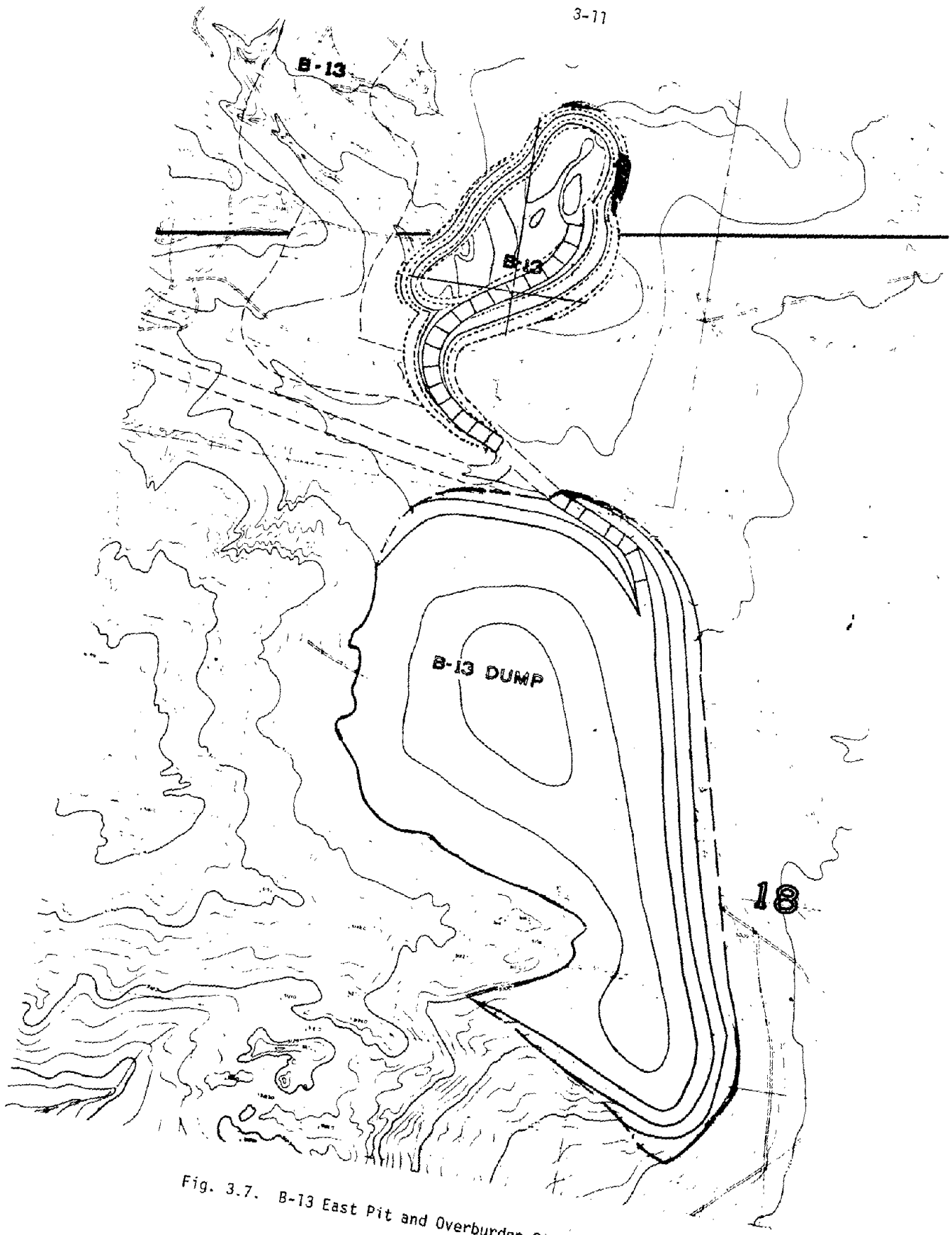


Fig. 3.7. B-13 East Pit and Overburden Site

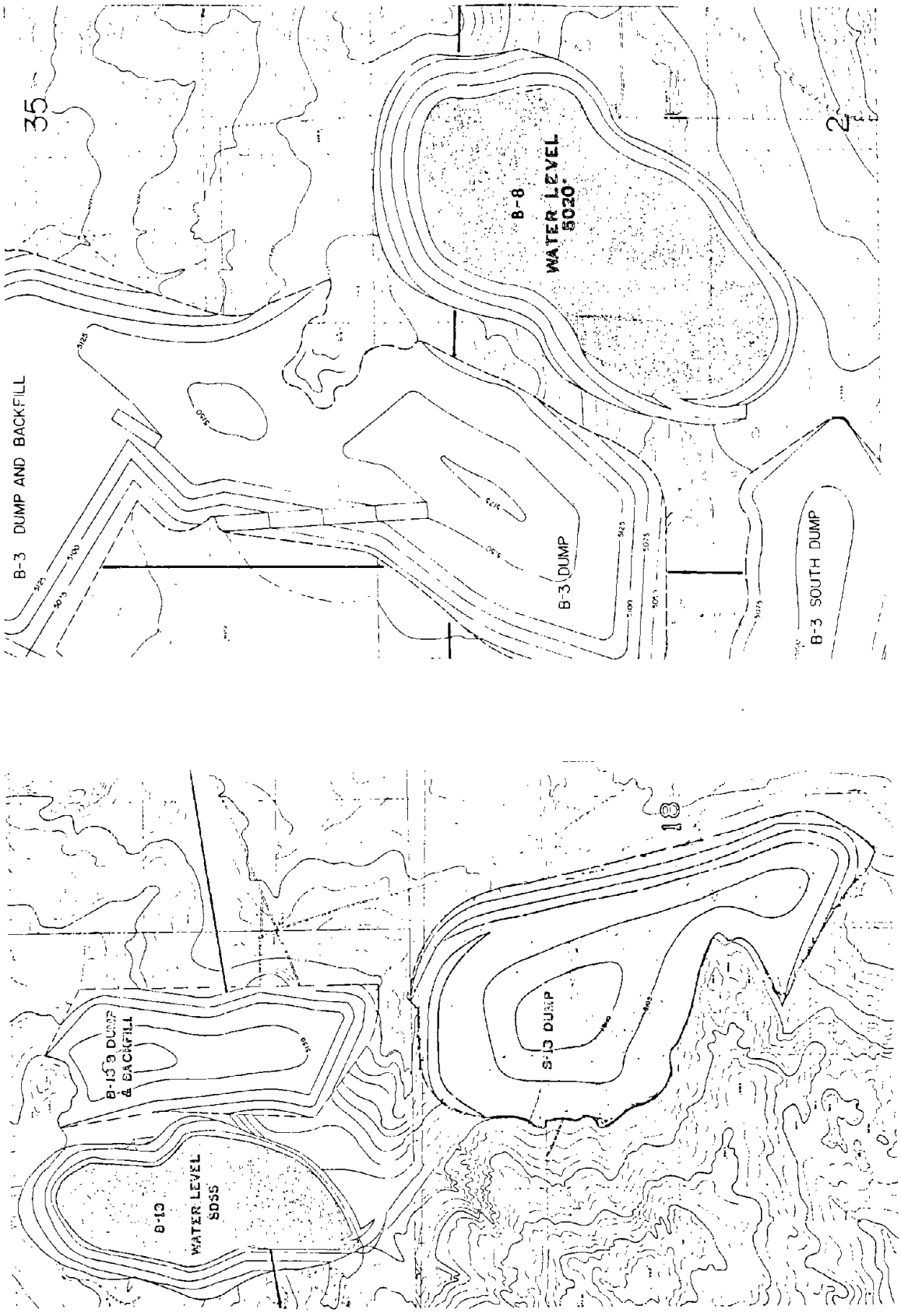


Fig. 3.8. Reclaimed Areas with Lakes.

3.1.2.3 Overburden Removal and Deposition

General

Following topsoil removal, overburden would be stripped from a given area with electric-powered shovels and off-highway haulage trucks; the truck fleet proposed consists of diesel-powered, 120-ton capacity, rear-dump units.

Approximately 80% of the overburden handled by the shovel will be lightly blasted to ease shovel loading. Explosive usage is roughly estimated to be 800 tons of ammonium nitrate fuel oil explosives per year. Blasting will be performed only during daytime hours and will be done in strict accordance with Federal and state regulations.

The mining plan has been developed to minimize the use of overburden disposal sites. Thus, as surface mining progresses, overburden from areas currently being mined would be backfilled into the older pits.

Specific, B-1 and B-4 Ore Deposits

The B-1 orebody is relatively long and narrow, of north-south orientation and the crest of the deposit extends over a distance of 7600 feet (2.3 km), with a maximum width of 1200 feet (0.37 km). The thickness of overburden increases from north to south, and ranges from 100 to 200 feet. Overburden dumps, immediately to the west and east of the mining zone, would be used during the first three years of the B-1 pit operation.

A proposed objective of the mining plan for the B-1 orebody would be to equalize the quantity of material handled per year over the life of the operation. With this approach, about 8.2 million bank cubic yards of overburden material would be stripped and dumped annually. An additional 1.12 million tons of waste occurs within each ore zone, requiring additional stripping each year. At these stripping rates, about 330,000 tons of uranium ore per year would be exposed for surface mining; including preproduction, this would result in an overall stripping ratio of 26.93 bank cubic yards of overburden per ton of uranium ore mined. During overburden removal operations at the B-1 mine, mining of ore will be initiated at the B-3 site (Fig. 3.4). Approximately 14-15 months of excavation would be required at the B-1 site, with an estimated 13.27 million bank cubic yards of overburden material to be removed and dumped at the disposal area east of the pit. Maximum height of this dump would be about 125 feet, situated at a maximum elevation of approximately 5,225 feet above sea level. Access to this overburden site would be provided by a ramp system at an eight-percent slope. The excavation of the B-1 pit would result in an elongated cut about 4300 feet long and 500 to 1100 feet wide, with a maximum pit depth of about 200 feet. Overburden removal would result in a pit side slope of 47 to 49 degrees, with the actual mineralized ore zone excavation planned at 75 degrees.

After about the third year of operations at the B-1 mine, overburden removed from a given mining zone would be backfilled into a portion of the pit that had been previously depleted of uranium ore. Backfilling of the pit would be performed to a practical maximum; however, some additional overburden from the second phase of mining at the B-1 pit would be taken to surface sites because of safety and space aspects relating to backfilling the north end of B-1 where ore mining is being performed. Thus, as soon as mining is completed in the northern portion of B-1, backfilling of this area would commence with no additional overburden from B-1 being placed on the east and west spoil piles. At that time, reclamation would be initiated on the spoil dump to the east of the pit. The dump would be graded and contoured to blend with the surrounding topography. The smaller dump to the west of the B-1 pit would be stabilized with vegetation to reduce erosion. Upon termination of the milling operations, the overburden deposited in this dump would be used to cover the exposed tailings and mill site.

The B-1 mine and processing facilities would disturb a total of about 886 acres. Of this total, 153 acres would be associated with the active mining area, 278 acres would be required for the east waste dump, 155 acres for the west dump, 100 acres for the mill site, about 150 acres for the tailings disposal system, and approximately 50 acres for haul roads and a settling pond. Ramps would be provided on both walls of the B-1 pit to provide access to the waste disposal area to the east of the pit and to the mill site to the west.

The B-1 pit mine would be developed by successive downward stripping cuts to expose the ore zone, with successive pit floors, ore mining horizons, and ramp systems progressing in a southerly direction. Upon completion of mining, this pit would be approximately 900 feet in width at the southern end, with an anticipated depth of about 400 feet.

Initial stripping of overburden from the B-4 ore zones began about September 1976 at a rate of about 667,500 bank cubic yards per month; overburden from the B-4 ore zones is transported to surface dump sites located on the east and west sides of the pit (Fig. 3.2). Approximately nine

months would be required to remove the overburden and expose the ore zones in this mine. Once removed, the B-4 orebody would supply about seven months of mill-feed ore at a production rate of 27,500 tons per month. Approximate acreage to be affected by the B-4 operation would be 42 and 47 acres for the east and west overburden dumps, respectively.

As indicated by the applicant, the pit walls would be graded to a slope that would permit both satisfactory revegetation and safe access for livestock and wildlife.

3.1.2.4 Ore Preparation, Loading, and Transport

The uranium ore is located in poorly consolidated sandstone, which is typically coarse- to fine-grained. Because of the extremely erratic nature of the uranium mineralization in this area, an ore control program would be utilized involving (1) instrumentation for location and semi-quantitative analysis of the uranium content and (2) precise excavation of a given portion of the broken ore in order to minimize rock dilution.

Uranium-mineralized zones would be located by means of instrumented probes that detect gamma and/or x-ray radiation, the rate of which is correlated to the uranium content of the ore. Both hand-held Gieger probes and tower-mounted gamma-beta scanners would be utilized.

Upon delineation, the mineralized zone would be flagged for ore removal. The ore would be loosened by means of single-shank rippers mounted on tractors. Front-end loaders (with rubber tires) or crawler-mounted backhoe units, equipped with 4-cu-yd buckets, would be used to remove the ore from the surrounding waste rock. Additional sampling at this point would be required to determine the uranium content of the mineralized zone for assessing whether it should be processed or discarded as overburden.

Ore transportation would be by 35-ton off-highway ore trucks along haulage roads from each of the open-pit mines to stockpiles located at the mill site; haulage distances would range from less than one mile (northern portion of the B-1 pit) to about 4.5 miles for the B-13 pit (Fig. 1.2).

3.1.2.5 Ore Storage

Three uranium ore stockpiles, high-grade, average-grade, and low-grade, would be maintained at the mill site; the proper stockpile for each truck dumping would be determined by analysis of the uranium content in the truck's load.

Any boulders too large to be handled in the grinding mill, would be sorted out by means of a front-end loader and stockpiled in the vicinity of the ore storage piles; a truck-mounted, portable crusher (contracted several times each year) would be used to reduce these boulders to a size that could be accommodated by the mill's grinding equipment.

3.1.2.6 Mine Dewatering System

Although the following discussion addresses primarily the B-1 mine, similar procedures would be utilized for the control of groundwater in the other mines.

The groundwater level in the B-1 pit would be controlled by establishing a series of water collection channels along the interior perimeter of the pit floor to feed sumps, equipped with submersible pumps, located at the lowest level of the pit floor. This system, together with pipelines extending to the pit rim, would be relocated as the ore cuts advance and lower the pit floor. The pipelines and collection ditches (located on east and west sides of pit) would discharge the water into a settling pond for subsequent treatment prior to discharge into existing drainages; compliance with water quality standards, as specified in the NPDES permit, would be maintained. The settling pond would be located about 500 feet west of the north end of the proposed B-1 pit and would be approximately five acres in size (Fig. 3.5). The applicant indicates that a barium chloride treatment process would be utilized for removing radium from the mine water before discharge. The radioactivity removed from the mine water will be transferred periodically to the tailings retention pond.

Mining dewatering volumes, as reported by the applicant, are estimated to be within the range of 600 to 2000 gpm or 8.6×10^5 to 2.8×10^6 gallons per day; the long-term flow rate is estimated to be about 1000 gpm. Current plans are for the treated water to be withdrawn from the settling pond for use in suppressing dust on the haulage roads.

The tentative locations of the diversion ditches and settling ponds for the other ore deposit areas are illustrated in Figures 3.9 and 3.10.

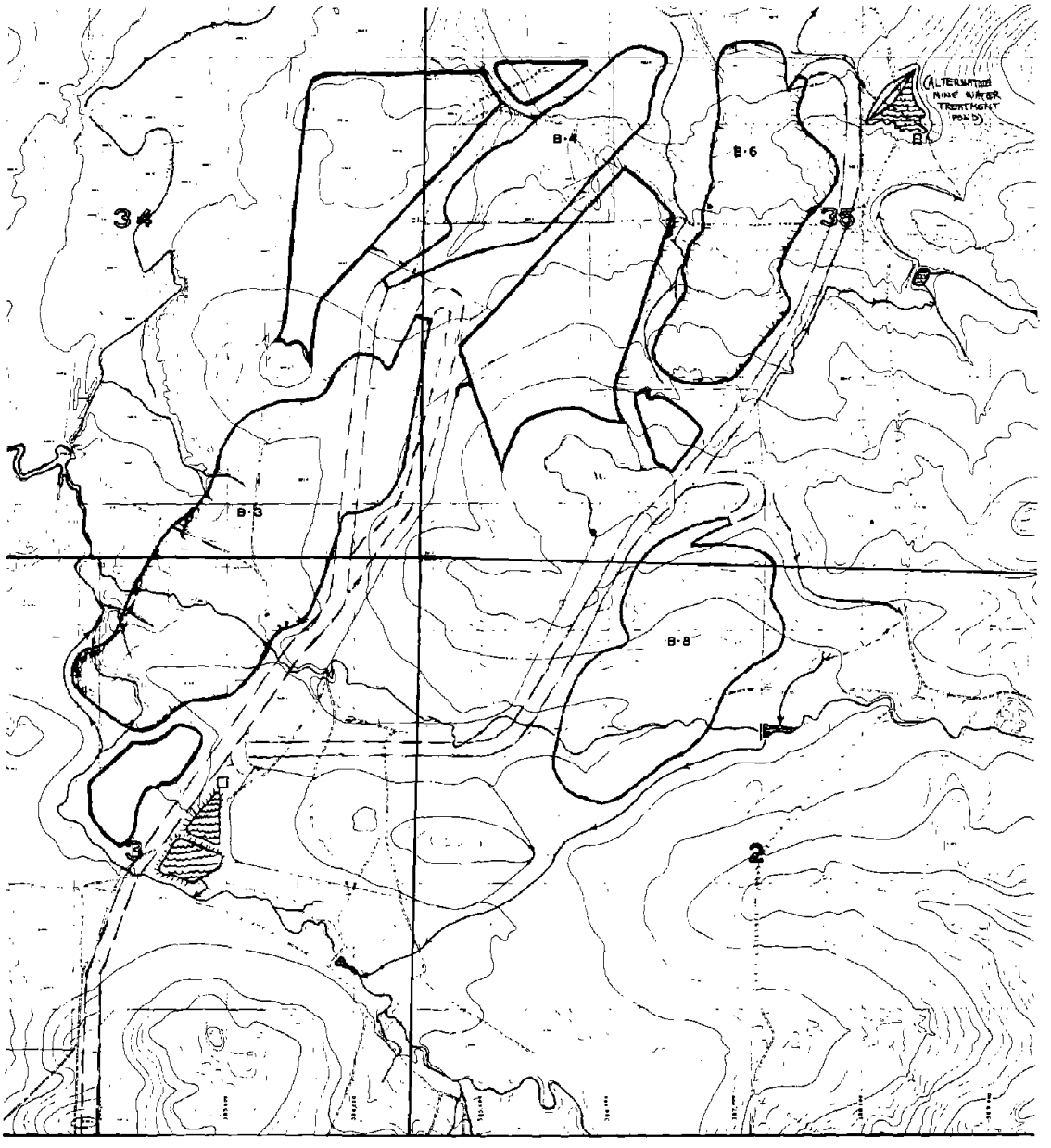


Fig. 3.9. Northern Area of the Project.

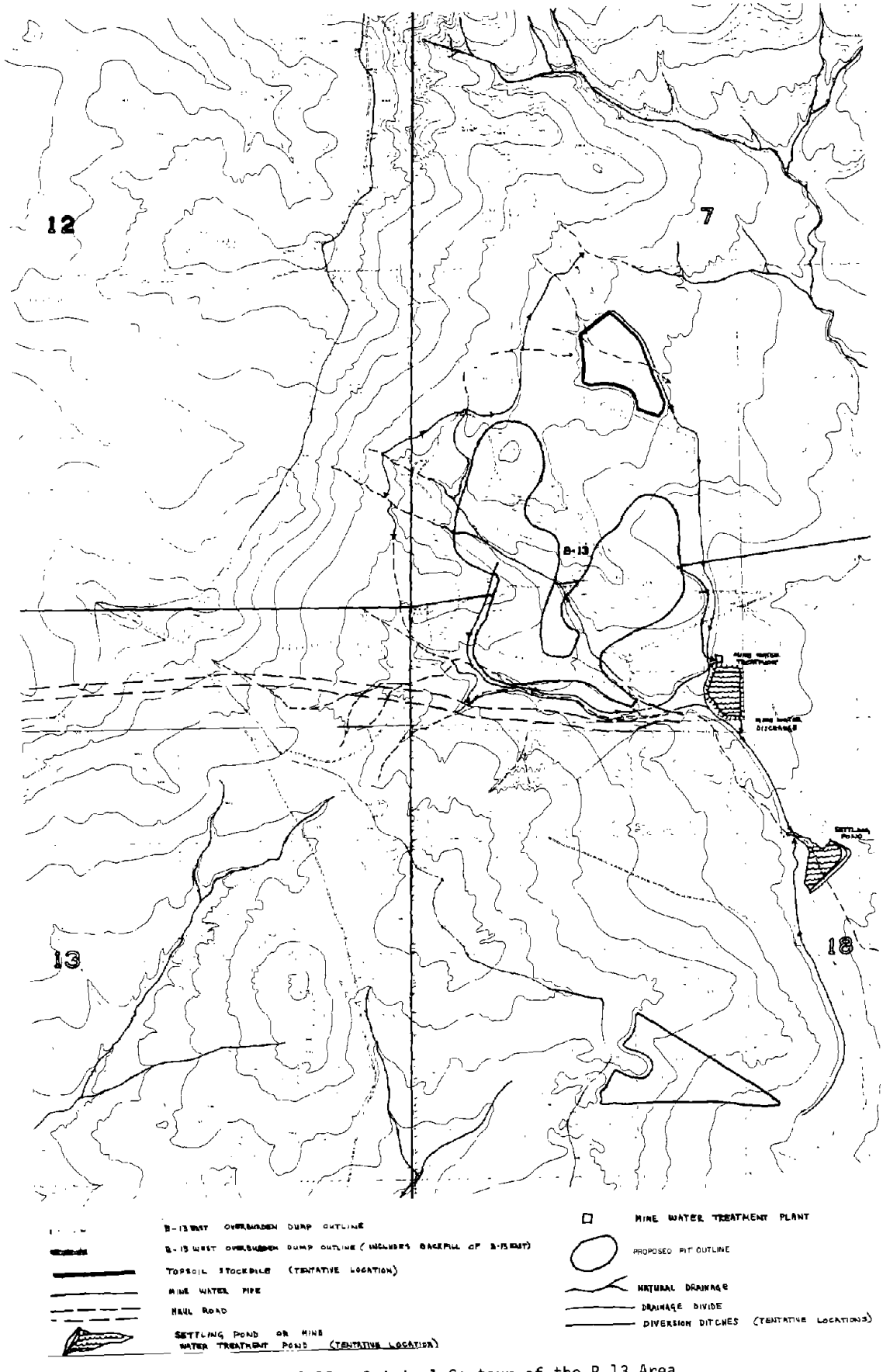


Fig. 3.10. Original Contour of the B-13 Area.

3.1.3 Reclamation Procedures

The following description of reclamation procedures for the disturbed mined land areas refers to the B-1 and B-4 ore deposits; however, the philosophy and procedures would be essentially the same for the other areas.

Land that is disturbed by mining operations would be reclaimed with the goal of returning the area to its present use, i.e., livestock grazing and wildlife habitat. Reclamation would be conducted on a continuing basis throughout the life of the project. All waste dump areas and backfilled portions of the pits would be graded to blend these areas with adjacent topography so as to re-establish the most desirable land form and to restore natural drainage patterns. Where the use of irrigation is feasible, the land form would be contoured so as to provide a gently sloping surface, capable of utilizing circular irrigation systems. Topsoil would be spread over affected land masses after these areas are reduced to slopes of 3:1 or less steep. Contour furrows would be established at the slope toe of overburden and topsoil piles to trap sediment.

3.1.3.1 Grading

After the third year of mining the B-1 ore zones, the extreme northern portion of the pit is expected to be depleted of mineralized material; overburden removed from the next mining zone would be backfilled into the mined-out areas of the pit. As this northern to middle portion of the B-1 pit is backfilled, it would be shaped to approximate the natural topographic contours, i.e., at an elevation of about 5125 feet above sea level (Fig. 3.11), and topsoil would be spread over the spoil material, with revegetation to be completed at the earliest possible date.

Both waste dumps would be reshaped to a slope gradient negotiable by farming equipment, utilizing crawler-mounted tractors (3:1 or less steep). The long, flat-topped overburden dump to the east of the B-1 pit, extending upward about 100 feet, would be shaped and contoured after the third year of mining. The slopes of this dump, established against hillsides on the southern and eastern sides, would range from about 3 to 30 percent. The dump would extend about 5400 feet (1.6 km) in the north-south direction, and would be from 1600 to 3800 feet (0.5 to 1.2 km) in width at its narrowest and widest east-west dimensions, respectively. Upon completion of the grading operations, topsoil would be distributed evenly over the overburden, and vegetation would be established as described in Section 3.1.3.3.

The smaller overburden dump on the west side of the B-1 pit (about 2800 feet by 3100 feet at its longest east-west and north-south dimensions, respectively), would be graded to blend in with the natural topography. The height of this dump, as measured on the east side, would be from 5100 to 5160 feet; the east side of this spoil pile would be graded to slopes of about 25 to 40 percent. This dump site would be established against a hillside on the south, with the northern graded sides ranging in slope from 7 to 28 percent. The dump would remain until completion of the milling operation, at which time it would be eliminated, with the overburden used to bury the tailings pond retention system, mill site, and settling pond.

Haulageways, compacted by heavy mobile equipment, would be ripped prior to reshaping operations.

Upon completion of mining at the B-1 pit, RMEC proposes to leave approximately 50 percent of the original pit length open as a water impoundment for livestock and wildlife and as a potential source of irrigation water (Fig. 3.11). Dewatering pumps would be shut down and the groundwater allowed to fill the pit. Water level in this pit is anticipated to be at an elevation of about 4980 feet. It is estimated that the resulting lake (about 72 acres in area and 80 feet deep) would contain about 5800 acre-feet of water. The backfilled material placed at the north end of the pit would provide a gradual access to the lake, by means of a 75-foot-wide access road at approximately five-percent slope. Additional access would be provided on the southeast side of the pit by 75-foot-wide haul road that would remain at a slope of eight percent. The terraced pit walls would remain at a slope of about 45 to 50 degrees (somewhat less than 1:1, horizontal to vertical distance). A distance of about 220 feet would exist between the top of the pit (south end) and the anticipated water level; this distance would be similar for the west and east sides. A chain-link-type fence, approximately six feet high, together with warning signs, would be provided around the exposed pit wall to prevent entry by human and animal life.

The reasons offered by the applicant for not attempting to slope the final remaining highwalls nor completely filling the B-1 pit are as follows (ER, Supp. "Revised Mining Plan," April 16, 1976):

"1. Approximately 70 additional acres of land would be disturbed to achieve a suitable backslope.

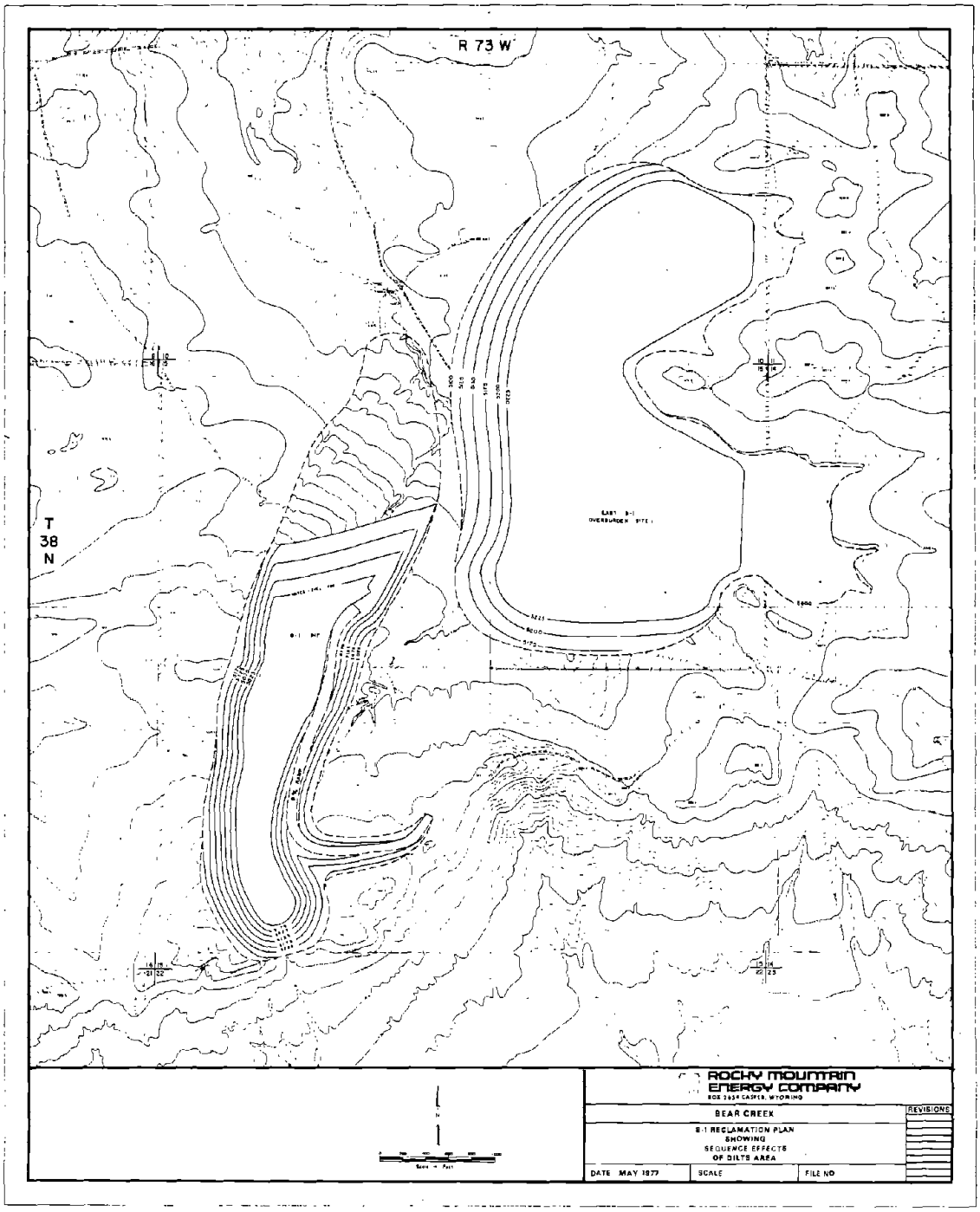


Fig. 3.11. Final Contour of the B-1 Pit.

2. To push the backslope material of approximately 12 million cubic yards into the pit would cover and seal the water-bearing sands and result in a depression that would accumulate stagnant water.

3. To remove the slope material to outside dump areas would require additional surface dump areas. In addition, it would place an unrealistic financial burden of around 10 million dollars on the project.

4. To completely backfill the area with surface dump material would also be financially unrealistic and would disturb previously reclaimed areas."

Upon completion of mining of the B-4 ore deposit, overburden from the B-3 pit would be backfilled into the B-4 pit void and between the B-4 overburden dumps (Fig. 3.2). A description of the B-3 dump and backfill area was described previously under Section 3.1.2.

3.1.3.2 Soil Cover

Studies sponsored by the applicant indicated that "topsoil" suitable for placement over the overburden material is available onsite.[1] The "topsoil" was judged to be a suitable plant growth medium, with the addition of nitrogen and phosphorus fertilizers. Should the reshaped overburden appear to be compacted to such a degree that satisfactory plant growth would be affected, the area would be ripped before the topsoil was spread. Topsoil or suitable subsoil would be placed on disturbed areas using self-loading scrapers. Precautions would be taken to prevent undue compaction of the soil during replacement.

Dames & Moore has conducted a soil study of the entire project area for the applicant.[2] This study provides additional information on physical and chemical parameters of the soils, including depths of topsoil and suitable subsoils within the six ore deposit areas that are available for stockpiling.

3.1.3.3 Revegetation

All surface-disturbed areas, including pits, overburden piles, topsoil stockpiles, mill site, tailings disposal area, and haul roads, would be revegetated in accordance with the plan described below.

The seeding mixture, resolved by evaluating data obtained from 1) soil and overburden study, 2) baseline vegetation study, and 3) discussions with Soil Conservation Service personnel, would consist of western wheatgrass (*Agropyron smithii*), thickspike wheatgrass (*Agropyron dasystachyum*), green needlegrass (*Stipa viridula*), and sweetclover (*Melilotus officinalis*). Species selection may be changed as experience is gained. However, alternative species will only be selected after careful consideration and discussion with District Soil Conservation Service personnel. For loamy soils, seeding rates of 4,4,2 and 2 pounds of pure live seed (pls) per acre of the four above-mentioned plant species would be utilized; these seeding rates would be modified slightly for other soil types. In addition, Indian ricegrass (*Oryzopsis hymenoides*), may be added to the mixture at a seeding rate of two pounds seed (pls) per acre. Four-wing saltbush (*Atriplex canescens*) and possibly big sagebrush (*Artemisia tridentata*), would be planted in certain selected areas to promote a more diverse vegetative cover and to provide browse for wildlife species. Shrubs would be seeded at a rate of two pounds of pls per acre. Seeding would be performed in early spring (preferably before the middle of April), or during late fall, from October 15 to the time when the ground freezes. A drill would be used for the seeding of grasses wherever possible, with the seed planting depth to vary (depending upon soil type and seed size) from 0.5 to 1 inch. Broadcast seeding would be used should small areas be encountered that could not be seeded with a drill. With broadcast seeding, the rates would be doubled to ensure adequate coverage; a harrow or similar drag would then be used to cover the seeds.

Mulch would be utilized where necessary to reduce erosion and to provide a more suitable plant growth medium; prairie hay or small grain straw would likely be the primary mulch used. The straw mulch would be anchored to the soil by discing, to be conducted on the contour; thus the soil surface would be roughened to increase water retention and infiltration and to reduce the eroding effects of wind.

Nitrogen and phosphorus fertilizers would be applied to the soil prior to the time of seeding at a concentration within the recommended rates of 20 to 60 pounds of nitrogen and 15 to 30 pounds P_2O_5 per acre.

When topsoil is stockpiled for periods greater than one year, the soil would be sampled and analyzed prior to seeding to evaluate possible nutrient deficiencies.

A reclamation schedule concerning land that would be disturbed and reclaimed during the ten-year project period is presented in Table 3.2.

Table 3.2. Estimate of Surface Acreage to be Disturbed and Reclaimed during the Operation of the Bear Creek Mining Project

End of Year	Area, acres		
	Disturbed	Reclaimed	Net Disturbed
1976	237	0	237
1977	710	0	947
1978	605	189	1363
1979	0	0	1363
1980	22	66	1379
1981	64	135	1248
1982	0	0	1248
1983	0	595	653
1984	0	0	653
1985	41	0	694
1986	196	67	823
1987	82	101	804
1988	104	72	836
1989	0	156	680
1990	0	172	508
1991	0	204	304
1992	0	304	0
TOTAL	2061	2061	

3.1.4 Deleterious Strata and Control Measures

Chemical analyses of overburden sampled in the vicinity of B-1 ore deposit have shown only minor problems to exist relating to the use of this material as a subsoil. However, it is anticipated that undesirable strata so identified would be buried sufficiently deep below the surface so as not to be subject to substantial groundwater leaching.

3.1.5 Surface Water Drainage Control

For each ore body, a drainage system would be utilized to minimize the accumulation of surface water and to control runoff in a given open pit and around the overburden dumps; the general control system is anticipated to include:

1) Drainage ditches constructed upslope from a given mine pit to divert surface water around these areas.

2) Establishment of ditches at the toes of overburden dumps for the collection of runoff from these piles.

3) Establishment of a series of collection channels to feed the mine sump(s) with water that flows into the mine pit.

4) Sump pump(s) and associated pipeline to remove water from the floor of the mine. The pump(s), together with pipeline extending to the pit rim, would be relocated as the ore cuts advance and lower the pit floor.

5) Pipelines and collection ditches to discharge both surface and groundwater into a settling pond for subsequent treatment prior to discharge into existing drainages.

3.1.6 Roads

The locations of the present and proposed haulage roads are shown in Figure 1.2. These roads would occupy a total surface area of about 104 acres; this includes 15 acres for the B-1 site, 49 acres for the B-3-4-6-8 complex, and 40 acres for the B-13 ore body area.

Current plans are for those roads to be used throughout the duration of the project, to be constructed of compacted overburden and surfaced with coarse sand or other suitable material. Haulage roads would be approximately 60 feet wide, with an average width of 100 feet being disturbed. All roads would have culverts where they cross major drainage channels; in addition, drainage ditches would be constructed alongside the roads. Active haul roads would be adequately maintained.

Those roads anticipated for relatively short-term usage, e.g., those connecting the B-3, B-4, B-6, and B-8 ore zones in the northern pit complex, would be constructed of compacted overburden.

An access road would be constructed from Ross Road (located about 2.5 miles west of the project boundaries) to the mining permit area (Fig. 1.2).

Although the applicant claims no right to mine along the road right-of-way, the road must be considered a part of the mining permit area according to Wyoming regulations. This access road would be designed to provide good drainage and to minimize snow-drifting in accordance with requirments for all-weather roads.

Rocky Mountain Energy Company has obtained an agreement from the surface owner of the land to construct the access road. Moreover, the road would be entirely reclaimed upon completion of the proposed project unless the surface landowner requests that the road remain open.

3.1.7 Personnel

Total employment at the proposed project, including construction workers, and permanent and salaried employees, is estimated to range from about 95 during June 1976, increasing to a maximum of 304 during October 1976, and decreasing to a stabilized figure of about 220 by July 1977.

The personnel to comprise the Rocky Mountain Energy's mine staff during periods of full operation are presented in Table 3.3.

Table 3.3. Bear Creek Mine
Project Personnel

Project Component	Type of Position	Number
Mine	Management	1
	Professional staff	5
	Technicians	2
	Tradesmen	32
	Clerks	2
	Supervisors	13
	Operators	78
	Security	3
	TOTAL	136

3.1.8 Support Facilities

3.1.8.1 Maintenance

Maintenance shop facilities would be constructed to repair, service, and maintain the mobile equipment; these facilities plus the maintenance staff, would be housed in a sizable (100 × 270 ft) warehouse/shop complex equipped with repair bays to accommodate the large equipment (Fig. 3.12). These facilities would be located in Section 3, T. 38 N., R. 73 W., approximately 0.4 mile south of the southern extreme of the proposed B-3 pit. Related shops, e.g., welding, component building and machining, would also be housed in the shop complex. The warehouse would be utilized to supply repair parts to mechanic crews and for the distribution of operating supplies to the open-pit mine.

In addition, the mine shops site (about 1320 × 1360 ft) would be utilized for the change room (40 × 56 ft), mine offices, office and equipment parking lots, vehicle service island, equipment washdown impoundment, and water truck stations. Pit equipment that could not be readily transported to the shop facility would require the dispatching of field repair crews.

3.1.8.2 Water Supply

Potable water (about 1000 gallons per day) would be supplied at the mine office site and assembly area for open-pit personnel. Present plans are for this water to be obtained from a deep well (completed to a depth of about 1600 feet) in the vicinity of the mill site; as indicated in a report[3] prepared for the applicant, local water that meets U. S. Public Health Service (USPHS) standards is generally located in aquifer systems below a depth of 350 feet. Additional cans of drinking water would be distributed throughout the active mine areas. A well north of the maintenance shop facilities to provide additional potable water and also to serve as a source of process water has been completed and tested and found to be of acceptable quality; this well was completed into the Wasatch Formation (400 feet). All potable water is treated and monitored periodically to insure that it meets the standards of the U. S. Public Health Service.

Industrial water required in the subject operation would be supplied by the dewatering impoundment system proposed for the mining area, the shallow well described above, and maintenance shop wastewater.

Several standpipes would be constructed to fill water trucks with tank capacities of 7000 to 10,000 gallons, for use in the suppression of dust on haulage roads; this usage is anticipated to require the largest volume of water--about 10,000 gallons per three miles of road during normal use, for a total of 40,000 to 50,000 gallons per day. Potential sites for the truck fillers would be the water impoundment area and sump(s) located on the active mining floor of a given mining site.

3.1.8.3 Electrical Power Supply

The total electrical power requirement for the mine operation is 6500 kVa. A 34.5-kilovolt primary transmission line was constructed (adjacent to the access road) to the mine and mill sites, with the required stepdown substations installed as necessary; these lines are designed in accordance with Pacific Power and Light Company and modified Rural Electric standards. Power is transmitted to the active mine area (control being by oil-submersed switch boxes) and delivered to the electrical equipment via all-weather, reinforced, 3-conductor trailing cables. Portable lighting units complement this electrical system for industrial lighting wherever needed in the operation. Of the 6500 kVa, approximately 2800 kVa will be utilized by the mine.

3.1.8.4 Diesel Fuel Storage

Two bulk storage tanks of 15,000-gallon capacity each, would be erected for the storage of diesel fuel; these tanks would be buried under the service island at the maintenance area (Fig. 3.12). Additional skid-mounted fuel storage (17,000- to 20,000-gallon capacity) would be located at a given surface mine. All tanks would be protected by an effective "spill prevention countermeasure and contingency plan" as required by Federal and State regulations.

Mobile equipment would be fueled using either spouts adjacent to the tank site or fuel trucks (for distribution of fuel to field equipment).

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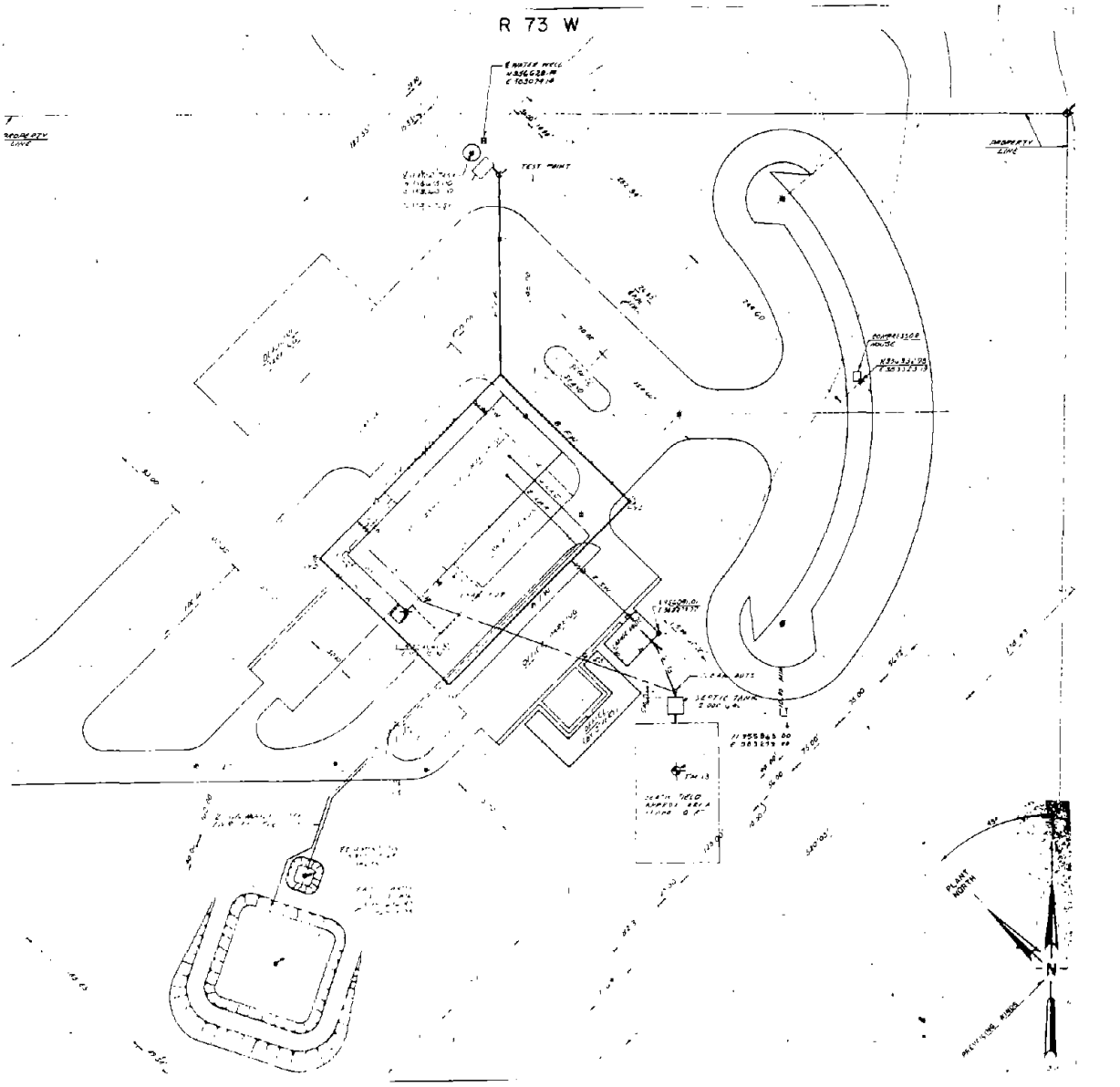


Fig. 3.12. Mine Shops Area, Yard Utilities Plan.

3.1.8.5 Sanitary Facilities

Permanent sanitary treatment facilities would be located at the mine office near the assembly area within the shop/warehouse complex. This approved system would utilize a septic-tank leach-field combination; the leach field, approximately 17,000 square feet in area, would be located immediately southeast of the mine office building. A 2000-gallon-capacity septic tank would be utilized. Although it is not anticipated that fencing will be provided around the leach field, vehicle traffic would be restricted from the southeast side of the office building.

Portable sanitation facilities would be provided at remote locations within the various mine areas for equipment operators and other personnel; these wastes would be trucked by a contractor to a licensed sewage plant for treatment and disposal.

Solid wastes, e.g., trash, rags, and supply containers, would be collected throughout the area of operation and buried in a designated landfill site where overburden is currently being deposited.

3.1.8.6 Powder Magazines

Remote sites would be selected for powder magazines according to screening characteristics provided by the natural topography. Because of the small amount of blasting required, such magazines would be relatively small; one magazine would be reserved for the storage of blasting caps and millisecond delays and a second magazine would be utilized for the storage of explosives (including cartridge dynamite), detonating cord, and cast boosters.

The explosive storage sites would be selected in accordance with the "American Table of Distances", as revised and approved by the Institute of Makers of Explosives.

The chosen sites would be in inactive areas in order to minimize potential danger to personnel in the event of accidental detonation of the magazine contents, the location being in compliance with Federal and State requirements.

3.1.8.7 Fire Protection

Fire extinguishers (Ansel, dry-type), suitable for use with fuel fires, would be placed in all vehicles. Buildings would be protected by a hydrant loop, fed from a 25,000-gallon fire-water reserve, contained in the water storage tank (Fig. 3.12). In addition, Ansel dry-type fire extinguishers would be placed at readily accessible locations throughout the buildings.

3.1.8.8 Mine Office

Administrative, mine scheduling, payroll, and personnel functions, controlled by a salaried staff, would be housed in a small office building erected in the mine shop area complex. Operating records, files, first-aid supplies, and other equipment, would be contained in this building. Also, in the vicinity of this building, an employee and heavy mobile equipment parking lot would be provided.

3.1.9 Proposed Mining Equipment

A tentative listing of equipment to be used in the proposed Bear Creek Mining Project is shown in Table 3.4.

3.1.10 Protective Measures and Fencing

Those areas that could constitute a threat to human safety would be designated with appropriate warning signs. In addition, fences would be constructed and maintained around those areas where possible harm could occur to humans, livestock, and wildlife. In addition, fences would be constructed where needed to protect seeded revegetation areas.

3.2 THE MILL

In milling operations, uranium is extracted from ore and concentrated to a semi-refined product. The product, commonly called "yellowcake" can be any of several uranium compounds. Following industry practices, the product(s) of the Bear Creek Mill will be referred to as "yellowcake" herein.

Table 3.4. Equipment Proposed for the Bear Creek Surface Mining Project

Unit	Capacity	Number Required
Topsoil and Overburden Removal Scrapper/Ripper Stripping		
Scrapers	30 yard	16
Rippers	∿385 H.P.	2
Pushers	∿385 H.P.	6
Water trucks	7,000 to 10,000 gallons	2
Grader	∿240 H.P.	2
Drill	4 3/4-inch holes	1
Service trucks	Light-duty	4
Pickups	3/4 ton	6
Fuel and lube trucks	1,000 gallons	4
Truck/Shovel Stripping		
Shovel	14 yard	1
Trucks	120 ton	7
Rippers	∿385 H.P.	1
Grader	∿240 H.P.	2
Water truck	7,000 to 10,000 gallons	2
Drill	4 3/4-inch holes	1
Service trucks	Light-duty	3
Pickups	3/4 ton	6
Fuel and lube truck	1,000 gallons	2
Ore Removal		
Backhoe	4 yard	2
Trucks	35 ton	5
Rippers	∿385 H.P.	1
Road maintenance	Same units as used by the stripping fleets.	
Drill and blast	" " "	
Service vehicles	" " "	
Pickups (ore sampling)	3/4 ton	2
Wheel loader	6 yard	1
Reclamation		
Self-loading scrapers	Caterpillar 633	4
Caterpillar tractor	D-9	1

The Bear Creek milling operations will consist of a series of unit processes: the ore will be crushed and ground, and the resulting particles leached with sulfuric acid to extract the uranium. The leach liquors are then to be purified and concentrated by solvent extraction, after which the uranium will be precipitated as ammonium diuranate by the addition of ammonia. The yellowcake slurry will be dewatered and calcined to produce a solid product, which will then be pulverized and drummed for shipment.

3.2.1 External Appearance of the Mill

The eventual layout of the physical plant is dependent on material-handling methods and available equipment; the applicant, however, is committed to the consideration of esthetic values (ER, p. 3-1) and it is likely that the actual physical facility will resemble the artist's conception (Fig. 3.13). The plant buildings will be mainly of prefabricated construction and the exterior panels will be earth-toned in color to present an unobtrusive view since the gently rolling terrain precludes effective screening by vegetation.

3.2.2 The Mill Circuit

A schematic flow sheet for the proposed mill processing is shown in Figure 3.14. The Bear Creek mill will process about 1000 tons of ore per day. The average U_3O_8 content of the ore is estimated to be about 3 lb/ton; thus, approximately 1.4 tonnes (metric tons, 1000 kg or 2200 lb) of uranium concentrate are to be produced daily. The following materials will be consumed per day of operation.

	Consumption of Materials	Circuit Inventories
Water	240,000 gal/day	650,000 gal, including storage
H_2SO_4	50,000 lb/day	880,000 lb, including storage
NH_3	800 lb/day	-
$NACIO_3$	4,000 lb/day	-
Flocculents	2,500 lb/day	-
Kerosene	30 gal/day max	40,000 gal
Amine	10 lb/day max	8,400 lb

The ore from the open-pit mining operation will be stored in one of three piles (high-grade, average-grade, low-grade) in accordance with its analytically determined uranium content. For efficient extraction, the different grades of ore are to be blended according to their metallurgical characteristics, then wet-ground to expose the uranium minerals in uniformly sized particles ($\leq$ 0.10 inch, $\leq$ 2.5 mm). The slurry from the wet-grinding process will be mixed with sulfuric acid, sodium chlorate, and steam to produce a leaching solution at a pH of 1.5 and a temperature of 25°C (77°F). It is anticipated that over a period of about eight hours approximately 98 percent of the uranium in the crude ore will be extracted. The uranium-bearing solution will be separated from the barren waste by a process of counter-current decantation, utilizing polymeric flocculants. The concentration of uranium in the decanted leach solution is expected to be less than one gram per liter. The barren waste is to be pumped to the tailings pond.

The concentration of uranium is to be increased by a solvent extraction process carried out in a series of reactor and settling vessels, using kerosene-carrying amine-type compounds that selectively absorb the dissolved uranyl ions. The organic and aqueous phases will be agitated by mechanical means, then allowed to separate in the settling tank. The organic phase will be allowed to overflow and subsequently is to be introduced to the preceding stage, whereas the aqueous solution will be drawn from the bottom to feed the following stage. Thus, the solvent extraction will utilize the counter-flow principle. It is estimated that, after four stages, the organic phase will contain about four grams per liter of uranium, and the depleted aqueous phase (raffinate), about 5 mg/liter. The raffinate will be recycled to the decantation process, whereas the organic phase will be stripped of uranium by contact with aqueous ammonium sulfate. The barren organic solution will be returned to the solvent extraction step and the enriched solution (about 25 g/l of U) will be neutralized with ammonia to precipitate ammonium diuranate. The supernatant solution is to be filtered, conditioned, and returned to the stripping stage; the precipitated concentrate will be subjected to an initial dewatering in a thickener.

The thickened yellowcake slurry will be dewatered further in a centrifuge, which will reduce its water content to about 50 percent. This slurry is to be pumped to a propane-fired dryer (fuel oil may be substituted for propane) where the yellowcake will be dried at 1200°F (650°C). The dried uranium concentrate (about 90% U_3O_8) will be crushed in a hammer mill to produce particles



Fig. 3.13. Artist's Rendition of the Bear Creek Uranium Mill.
Prepared by the Rocky Mountain Energy Company.

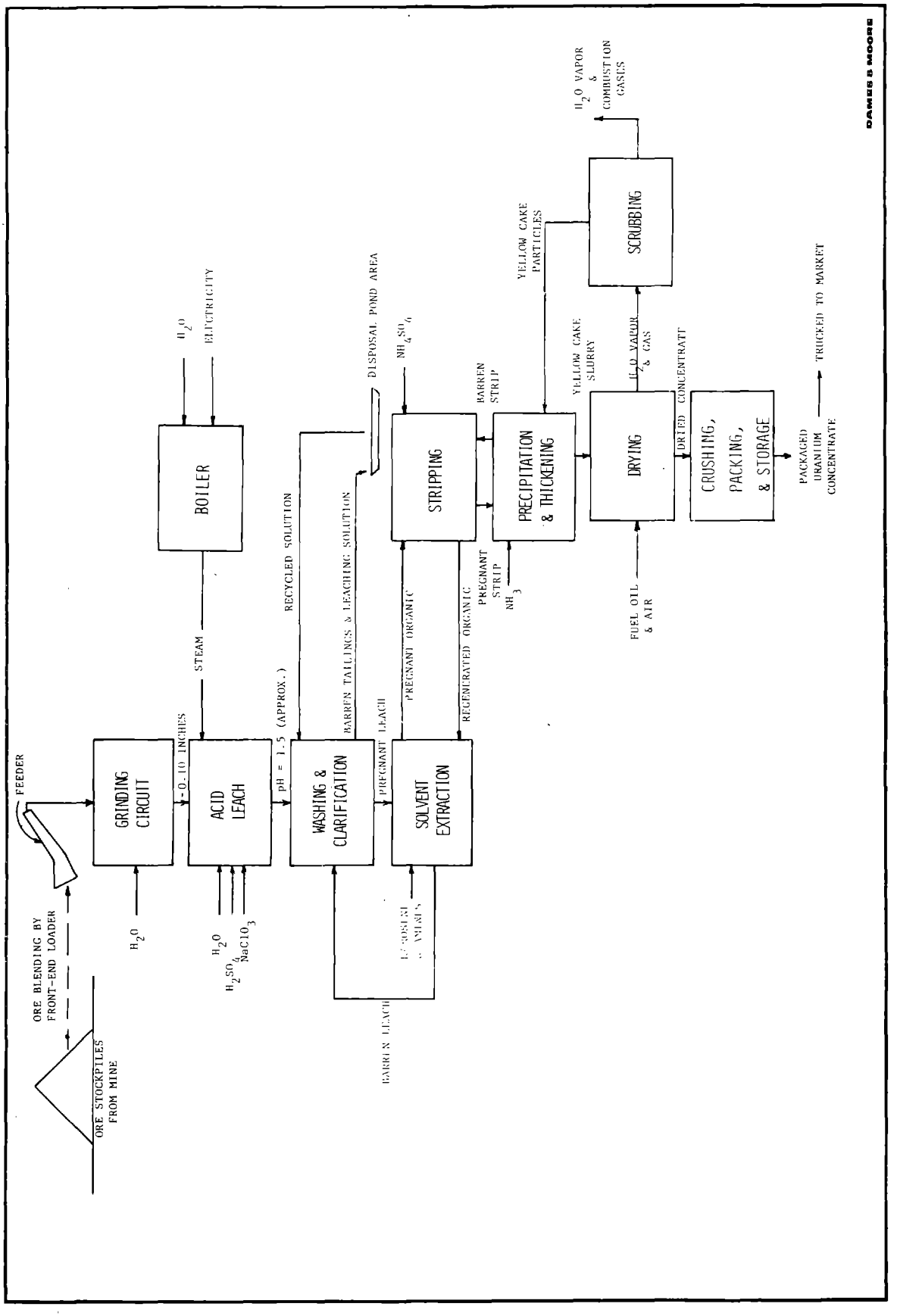


Fig. 3.14. Generalized Flowsheet for the Milling Process. Diagram provided by the applicant.

of less than 1/4 inch (6 mm) diameter. The crushed concentrate is then to be stored for subsequent packaging in 55-gallon steel drums. The entire drying, crushing, storage, and packaging operation will be conducted in an isolated, enclosed building with a negative ventilation pressure to contain and collect (by wet scrubbing) all airborne U_3O_8 particles. This system not only increases the recovery of uranium, but decreases the potential radiation exposure of employees. In addition, the design of the mill will be such that any leaks or spills will be collected and recycled to the appropriate step of the process, thus minimizing product loss and contamination of the surrounding area.

3.2.3 Non-radioactive Mill Wastes and Effluents

3.2.3.1 Gaseous Effluents

Several non-radioactive vapors will be released to the atmosphere during the processing of the ore. The leaching process will release sulfur dioxide (and some sulfuric acid vapor) and chlorine vapors; the maximum rates of release are estimated to be 0.01 lb/hr for each of these (ER, response to question 10). The solvent extraction process will release organic vapor (92% kerosene) at an estimated rate of 0.025 lb/hr (ER, p. 3-21). The concentrate-drying operations will release water vapor (estimated release rate on the order of 500 lb/hr) and combustion products, mainly CO_2 (about 100 lb/hr). Some ammonia and SO_x will also be released; the amounts depend on contemporaneous operating conditions and cannot be estimated, but they are expected to be very small compared to the cited quantities. If, however, fuel oil is burned instead of propane, oxides of sulfur and nitrogen also will be released; the calculated rates of release, on the basis of SO_2 and NO_2, are $\leq$ 1 lb/hr and about 0.25 lb/hr, respectively.

3.2.3.2 Liquid Effluents

The liquid phase of the tailings slurry will contain a portion of the organic phase from the solvent extraction step. The organic residue will be retained in the tails as a film attached to the solid particles. Estimated releases to the tailings pond for kerosene, amine, and alcohol are 6.8, 0.22, and 0.14 lb/hr, respectively (ER, response to question 10).

3.2.3.3 Solid Effluents

Solid effluents, other than the waste tailings, are fugitive dust from the ore piles and ore feeding facility, as well as from the barren tailings, and uranium concentrate particulates carried off in the exhaust gases.

The EPA estimate[4] of 4 lb/ac/hr of fugitive dust introduced into the atmosphere by heavy equipment traffic in a typical construction area is assumed to apply reasonably well to the release of fugitive dust by operations at the Bear Creek mill. The exhaust gases from the drying operation will be scrubbed to remove solid uranium concentrate from the stream; on the basis of a minimum scrubbing efficiency of 98%, the applicant has calculated that the maximum total rate of discharge of uranium should be 0.04 lb/hr (ER, response to question 10).

3.2.4 Control of Mill Waste and Effluents

The major processing buildings and equipment will be provided with ventilation fans, hoods, and ducting adequate to control the concentration of gaseous effluents to levels below the applicable standards, as is discussed in Section 4. The leaching tanks will be equipped with a collection cover to collect and dilute the vapors emitted; 1800 cfm of air will be circulated in this system to provide collection and control of the sulfur dioxide and chlorine emitted during leaching. The ventilation system in the Solvent Extraction Building will discharge air at a rate of 3500 cfm.

Further design work has provided the basis for the current selection of pollution-control equipment. The dryer off-gas scrubber is a venturi-type scrubber followed by an expansion chamber. This scrubber will utilize a recycled solution flow of approximately 9 gpm (34 l/min). The dust control in the product packaging area is accomplished by use of a separate induced draft venturi scrubber requiring a recycled solution flow of up to 150 gpm (568 l/min). The total release rate is estimated to remain at a maximum of 0.04 lb/hr (36 g/hr). The emissions from both scrubbers are routed to the same stack.

Solid yellowcake particles being carried off by flue gases from the dryer will pass through a three-stage impinger scrubber to minimize the discharge rate. About 1.4 gpm of water will be used in this equipment to collect the flue gas particles; the solution will be recycled to the precipitating and thickening section of the mill.

The surface runoff resulting from rain and snowfall on the ore and tailings piles will be collected in ditches and diverted to the tailings pond.

Fugitive dust from ore piles will be controlled by sprinkling water, and the addition of water before grinding will practically eliminate dust releases from this operation.

3.2.5 Sanitary and Other Mill Waste Systems

Current plans call for two sanitary facilities to be constructed at the mill site. The first will be strategically located within the mill complex; the second will be in the mill office. Each facility will be drained to individual septic tank-leach field combinations for treatment of liquid effluents prior to release.

Should future developments indicate the desirability of additional temporary facilities at remote sites, portable sewage units will be utilized. These units will be emptied and cleaned periodically, and returned to service as required.

All applicable State of Wyoming Health and Discharge Standards will be met in the design and operation of all sanitary facilities (ER, p. 3-30). Trash, rags, and other solid debris will be collected, transported to designated areas, and buried with overburden material, using crawler-mounted dozers from the mine. It is estimated that about 8000 pounds per year with a volume of about 180 cubic feet, of miscellaneous solid waste will be generated by mill operations (ER, response to question 13).

Coveralls used by employees in yellowcake product areas will be laundered at the mill. Furthermore, mill personnel will be provided with change facilities to allow them to leave their work clothes at the mill for laundering. All liquid effluents from the laundry will be returned to the mill process stream.

Chemical laboratory wastes normally will be routed to the tailings pond. Those chemical wastes which would be deleterious to the process chemistry and cannot be detoxified or neutralized onsite will be suitably packaged and shipped to a state-approved disposal site.

The only diesel-powered heavy equipment to be assigned permanently to the mill will be the front-end loader used to blend the uranium ore from the stockpiles. This unit will undergo periodic maintenance to ensure that proper combustion of fuel will be achieved and harmful emissions minimized. Exhaust fumes from the gasoline engines of various vehicles will be present at or near the mill. All pollution control equipment, as equipped by the manufacturers of the vehicles, will be maintained in proper operating condition. Emissions from these engines will be monitored periodically to ensure that the control devices are functioning properly.

3.3 RADIOACTIVE EFFLUENTS

The radioactivity released during mining and milling of natural uranium is primarily associated with uranium-238 and its radioactive daughters present in the ore (Fig. 3.15). The average Bear Creek ore will contain about 0.15% U_3O_8 (1.27×10^{-3} g U-238/g ore). Under equilibrium conditions, this ore would incorporate 420 pCi each of the nuclides U-238, U-234, Th-230, Ra-226, and Pb-210 per gram of ore. The concentration of U-235 in natural uranium is 0.72% and its activity in the ore is 19.7 pCi/g. In the U-235 decay series, the only long-lived radionuclide is Pa-231 (half-life 3.43×10^4 years). Compared to the U-238 decay series, the U-235 series contributes negligibly to the quantity of radioactivity dispersed. In Figure 3.16 are shown pathways for dispersion of radioactivity from U-238 and its daughters (Fig. 3.15) to air and to surface and groundwater. In the following sections each pathway is discussed and, on the basis of the available data[5-40] from similar operating plants, the quantity of radioactivity released is estimated. In Section 3.2, the ore handling methods, mining and milling processes, and non-radioactive waste systems were summarized; these systems are discussed in greater detail in the applicant's environmental report and supplements thereto. In the submitted documents, the applicant has presented an analysis of his operations, results of onsite and offsite monitoring, and estimates of the annual release of radioactive effluents.

3.3.1 Radioactive Liquid Waste

Prior to ground stripping and ore extraction, the mineralized zone will be dewatered by pumping water which has collected in pit sumps. If necessary, the mine water will be treated with $BaCl_2$ to precipitate Ra-226 in settling ponds prior to discharge of the water. Some of the treated water will be used to reduce fugitive dust during dry seasons. The long-term mean quantity of water removed during mining operations will be 2×10^6 m^3/yr. The ambient concentration of Ra-226 in groundwater was measured to be 3.3 pCi/l at the Manning Ranch (a nonmineralized area)

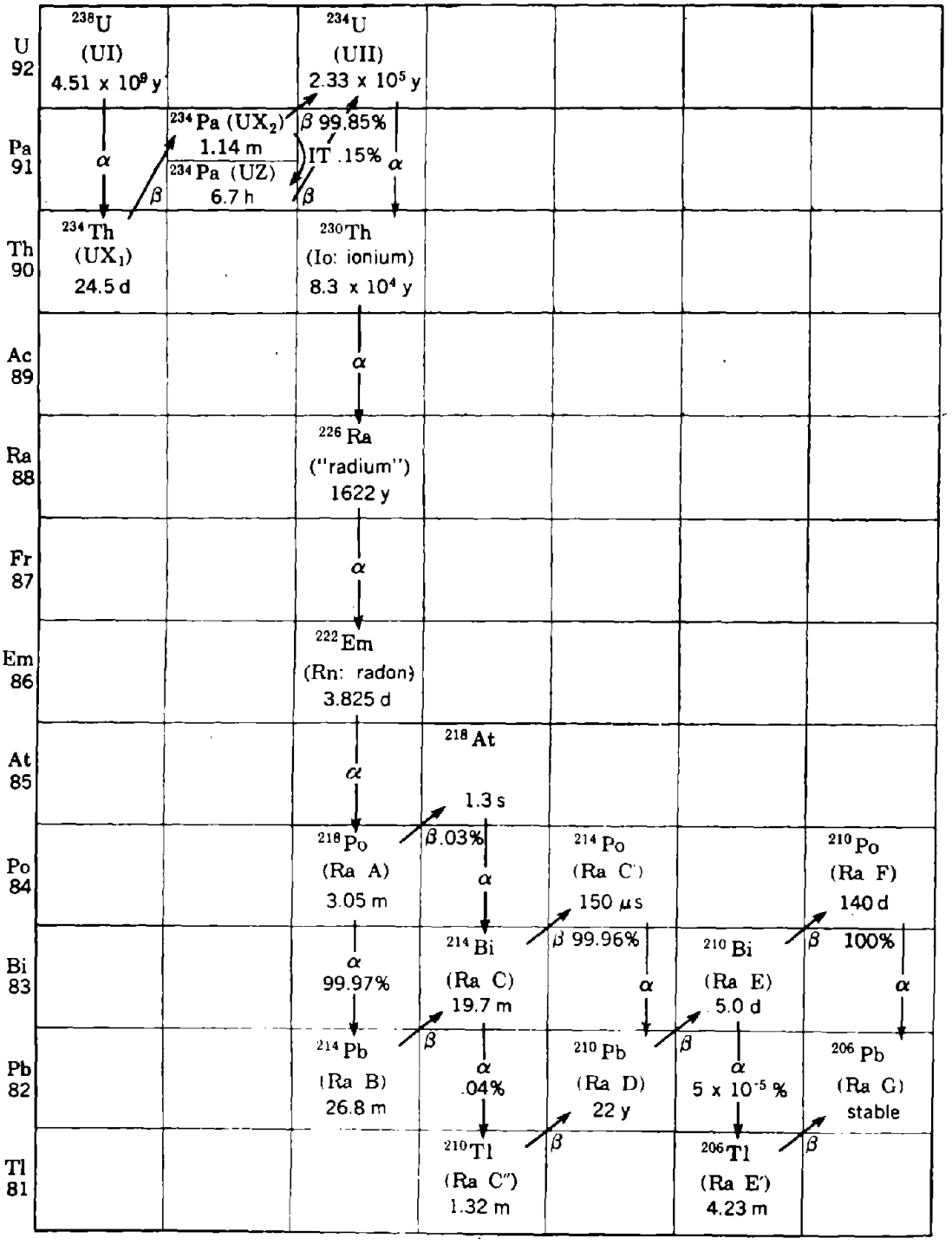


Fig. 3.15. Decay Scheme for Uranium-238

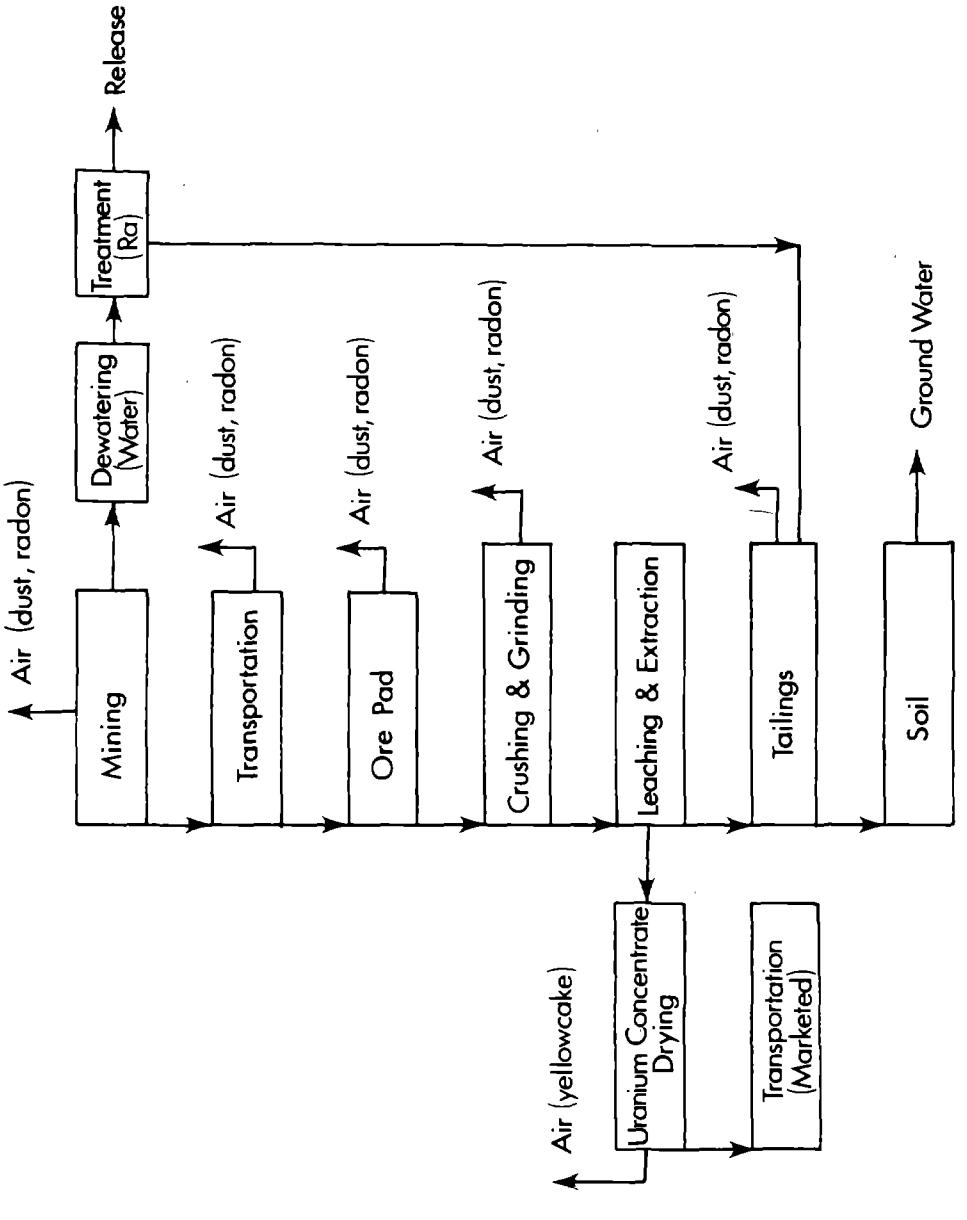


Fig. 3.16. Radionuclide Dispersion via Pathways Relevant to Bear Creek Project Activities

(ER, Table 2-63). However, water extracted from the mineralized zone may contain more radium, and the concentration of radium in several mining areas has been reported to exceed 100 pCi/l. An estimate of the amount of Ra-226 extracted annually with the mine water is about 0.3 Ci. It should be noted, however, that since this radium is extracted from the ore zone, such extraction represents a reduction of the radium concentration in the ore that initially is expected to be at secular equilibrium; it does not alter the overall radium balance. The radium precipitated in the settling ponds will be periodically transferred to tailings retention sites and will not constitute a source of surface water contamination.

A schematic water balance in the mill and mine environment is presented in Figure 3.17. The flow diagram includes liquids used in administrative and laboratory procedures, process equipment, hydrometallurgical processes, liquid losses from the tailings pond, evaporation, and seepage. The overwhelming bulk of the liquid used throughout the plant (5×10^5 m^3/yr) will be routed to the tailings pond, either directly from tailings effluents or indirectly from plant sumps. A very small fraction of water will be utilized for sanitary purposes and will be routed to the sanitary waste system. Water runoff (watershed) from the site during periods of heavy precipitation also will be collected onsite. The eventual disposition of most of these liquid streams will be in retention ponds; a small fraction will enter subsurface and surface waters. The surface runoff resulting from rain and snowfall on the ore and tailings piles will be collected in ditches and diverted to the tailings pond. The liquid discharged to the tailings retention area will be discussed in Section 3.3.7.

3.3.2 Radioactive Release from the Mining Operation

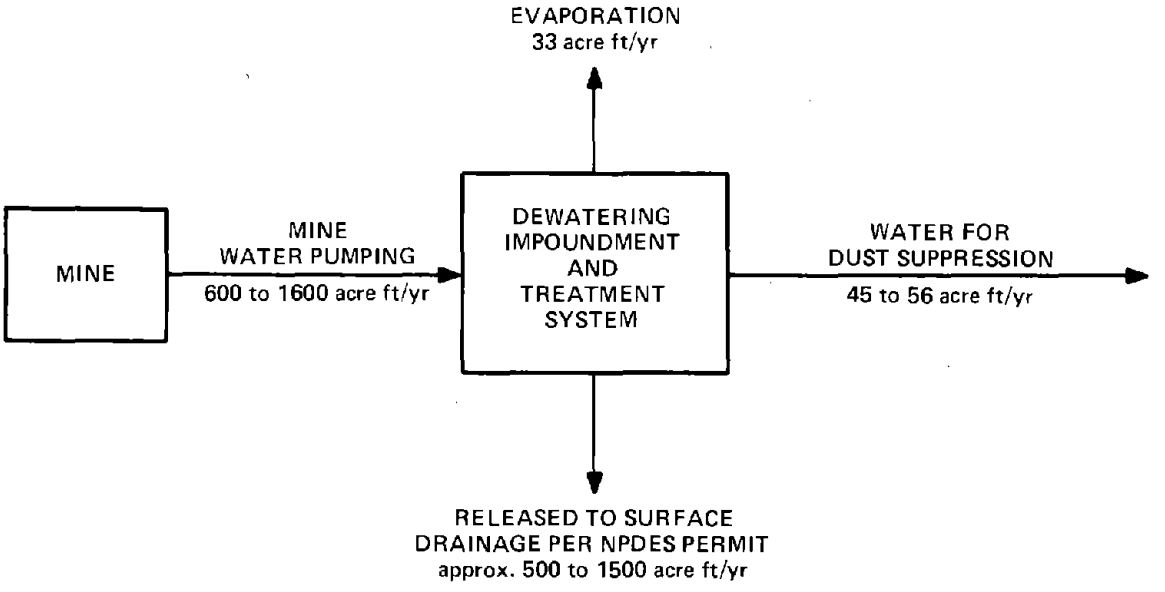
Mining operations will remove 3.3×10^5 tonnes of ore and 3.8×10^6 m^3 of overburden annually; both will be coarse in texture and may contain 10-15% moisture. Mining by stripping is not expected to contribute to the emission of radioactive particulates; however, the exposed surfaces of long-deposited overburden will become dry and subject to wind erosion. Radon-222 is the major radioactive nuclide released into the atmosphere from the mining operations. The annual emission of radon from combined mining activities is estimated to be 7.4×10^3 Ci (see App. K-2). The continuous reclamation process proposed by the applicant to accompany the mining will effectively control dispersion via this pathway (see Sec. 10.4).

3.3.3 Transportion of Ore to Mill

The Bear Creek region is dry and windy during most of the year, and the roads (area about 0.4×10^6 m^2) between mines and mill will be prone to dusting. The applicant plans to spray these roads with treated mine water to control dusting during dry seasons. Ore spilled from truckbeds during transportation will be a source of road contamination, but resuspension of the ore from the road and adjacent areas will be small (see App. K-2). The bulk of the ore deposited on the ground will be massive and, hence, not resuspendable, and weathering processes will mix it into the soil. Since the concentration of the radionuclides in the ore is small and the road surface is well packed by movement of heavy vehicles, resuspension is minimal; the release of particulates to air resulting from transportation of the ore will contribute very little to the overall emission of radioactivity.

3.3.4 Ore Pad, Feed to Mill, and Ore Grinding

The ore to be milled will be stored on pads to provide a continuous supply for blending. During this period of storage Rn-222 depleted ore will generate radon from the decay of Ra-226; storage for ten days results in production of 85% of the secular equilibrium activity of Rn-222, which is partially released to the atmosphere; the disturbance of the ore during feeding and crushing operations will release the remaining radon. Grinding of the ore to a smaller size and the close interface between liquid and solid phases during leaching will increase the emanating power of the ore, but will simultaneously decrease the diffusion coefficient for radon. The NRC staff estimates that the total radon released from the combined operations of ore storage, feed, and grinding will be about 117 Ci/year. In addition, stored ores are readily dehydrated in dry seasons and exposed surfaces will be a source of dust generated by wind action. The use of heavy machinery is expected to produce 0.5 g/m^2/hr (4 lb/hr/acre) of fugitive dust[4] during ore feeding and blending operations. The average annual release from combined action of wind and blending is computed to be 5 mCi for each of the radionuclides Pb-210, Ra-226, Th-230, and U-238. However, most of this radioactivity will be associated with dust of a large diameter and under normal atmospheric conditions will not contribute to the transport of radioactivity outside the mill site boundary (i.e., to an unrestricted area).



MILL

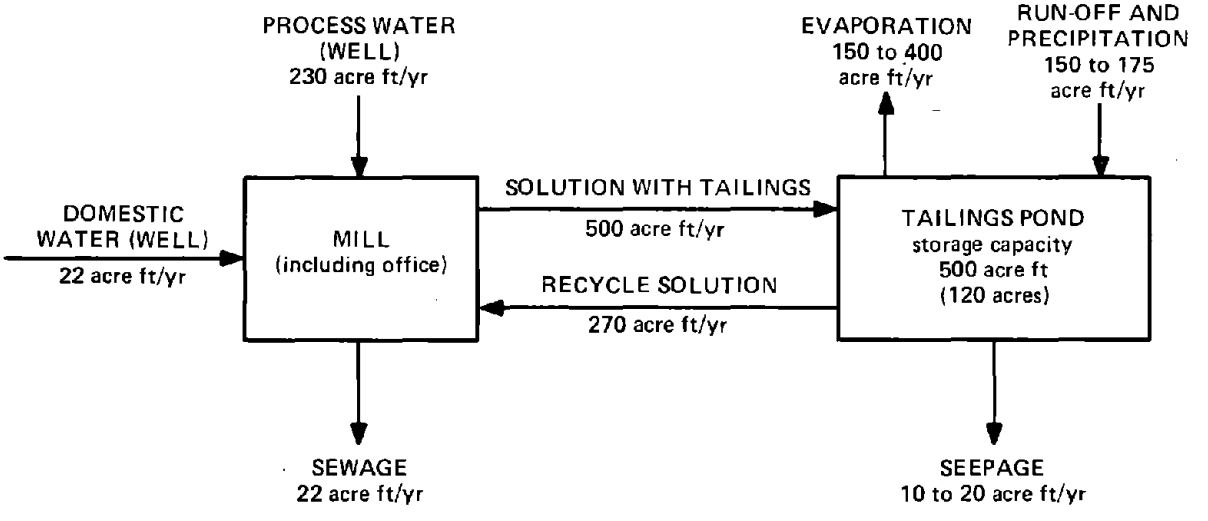


Fig. 3.17. Bear Creek Project Water Balance (see also Appendix K-1).

3.3.5 Leaching Operation

The leaching operation is a wet process and will not contribute to emission of particulates. This pathway also is not a serious consideration in the release of radon due to the less than one-day transit of the ore through the mill circuit.

3.3.6 Uranium Concentrate Drying and Packaging

After extraction, precipitation, and centrifugation, the uranium concentrate (ammonium diuranate) will be dried at 650°C. The product, commonly called yellowcake, will be about 90% U_3O_8 and will contain about 98% of the uranium in the ore. In addition, yellowcake will contain 5% of the Th-230 (21 pCi/g) and 0.2% of the Ra-226 and Pb-210 (0.5 pCi/g each) in the ore. Emission of particulates to air during uranium concentrate drying and packaging will be controlled by a three-stage impinging wet scrubber (98% efficiency). About 1.4 gpm of water will be used in this equipment to collect the flue gas particles; the solution will be recycled to the precipitating and thickening section of the mill. The applicant design projects an estimated release of 36 g/hr of uranium concentrate. The annual release of radioactivity, assuming eight hours of operation each day, will be 31 mCi U-238, 1.6 mCi Th-230, and 31 μCi Ra-226.

Uranium concentrate will be packaged in 55-gallon drums, each containing about 350 kg of the product. This packaging terminates the potential for uncontrolled release of radioactivity under normal operating conditions.

3.3.7 Tailings

The applicant has proposed the construction of a 50-foot (maximum height) earth and rockfill dam to form the impoundment for retention of the tailings from uranium mill operations. The proposed 1500-foot-long dam and 150-acre impoundment, to be located approximately 1000 feet west of the mill, will be within the Bear Creek watershed. The dam will be emplaced in the valley of a tributary of Bear Creek, the intermittently flowing Lang Creek. At the dam site, the streambed elevation is approximately 5100 feet. The valley is surrounded by gently rolling hills that rise to elevations above 5200 feet to form the basin boundaries (Fig. 3.18).

The foundation of the tailings dam will be prepared by removing vegetation, topsoil and loose soils prior to leveling moistening, and compacting the surface materials in anticipation of placing fill for the dam. The dam will consist of a central impervious core with outer shells. A three-foot-thick inclined chimney drain between the downstream core section slope and outer shell will be constructed and horizontally extended to the downstream toe above the prepared foundation surface. The dam side slopes will be 3:1 on the downstream side and 2.5:1 on the upstream side. Embankment materials for the dam will come from borrow excavation of weakly cemented bedrock in proposed mine pits B-3 and B-4. An offsite source will be required to furnish the graded gravelly sand material to be placed in the chimney drain.

The dam will be designed against all anticipated loading conditions, including earthquake, using criteria currently acceptable to the engineering profession.

To improve stability, seepage through the tailings dam foundation will be controlled by excavating a cutoff trench to the top of the bedrock beneath the center of the dam and backfilling with impervious material. An additional measure to contain seepage from the tailings pond is the proposed construction of a 17-foot (maximum height) dike approximately 800 feet downstream of the tailings dam across the existing Lang Creek streambed. Extending upstream from the dike's center there will be a bentonite-filled trench reaching down to bedrock. Seepage collected in this trench will be pumped to the tailings pond.

The tailings pond and beaches will occupy an area of about 6×10^5 m^2. The average depth of tailings will be about 7 m by the end of the conservatively postulated 20 years of operation. The area chosen for tailings disposal and embankment is underlain by some alluvium and the Fort Union Formation, chiefly claystone of relatively limited permeability.

Water-bearing zones underlying the mill site vary between 40 and 50 m below the surface. Radionuclides present in the local aquifers will be routinely monitored in wells, both on and off the site (Sec. 6).

The greatest quantity of waste generated by the uranium milling operation will be the production of barren tailings. Approximately 907 tonnes per day of sand, silt, and clay size particles will result from the leaching of the uranium minerals.

Measurements at several extant tailings piles have yielded average airborne radon concentrations ranging from 3.5 to 16 pCi/l (3500-16,000 pCi/m^3) for samples taken three feet above the surface

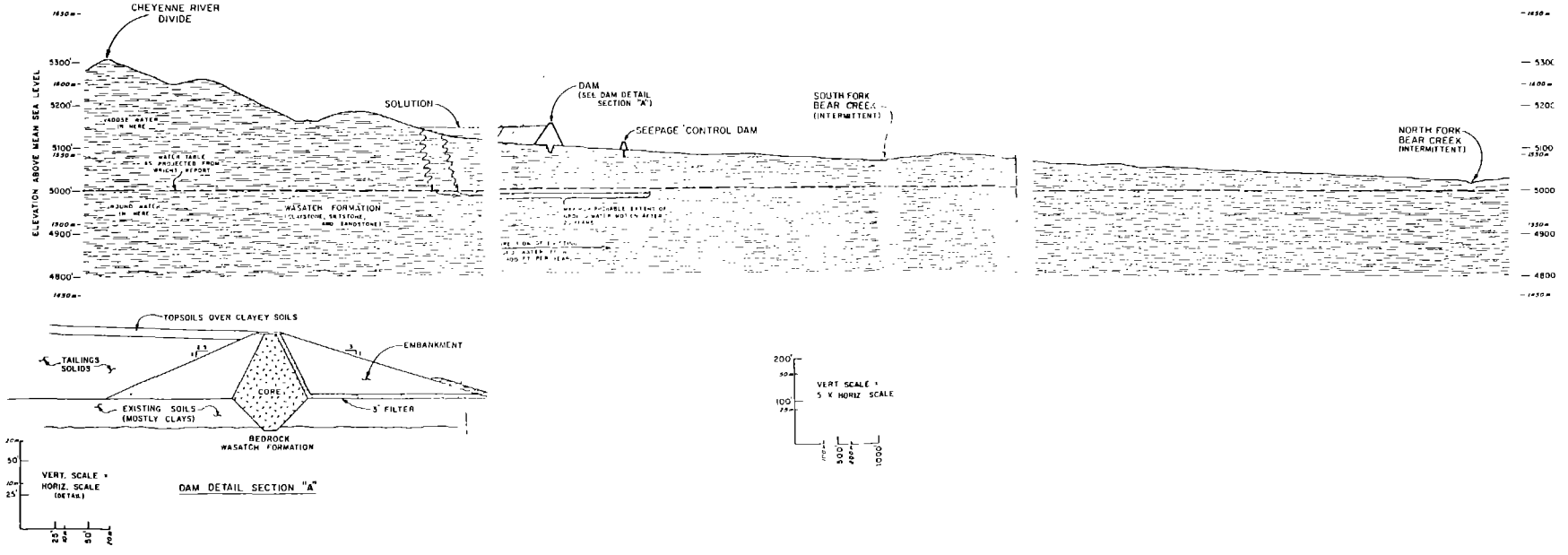


Fig. 3.18. Section Through the Tailings Disposal Area.

and directly over the tailings.[41] Similar concentrations are anticipated over the Bear Creek tailings pile. These concentrations are less than the maximum permissible concentration (MPC) of 30 pCi/l (30,000 pCi/m^3) for workers in a radiation restricted area and only slightly greater than the 3 pCi/l (3000 pCi/m^3) MPC for the general public. Radon released from the ground is dependent on atmospheric conditions, and upon soil porosity, compaction, and moisture (see Sec. 4.8 and App. K-3). The average annual emission is estimated to be 8×10^3 Ci/yr (maximum 1.3×10^4 Ci/yr) at the end of the assumed 20-year period of operation and drying of the pond. During the active period of the mill, the radon emission will be proportional to the relative areas of beach and liquid surfaces and on the depth of tailing deposits. Of the total area of tailings retention (6.1×10^5 m^2), 80% (4.9×10^5 m^2) is estimated to be covered with liquid with the remainder (1.2×10^5 m^2) exposed as dry beaches. Radon is assumed to be released only from the dry beaches (the diffusion length of radon through water is only about 1.5% of that through rock). During the active milling period the average annual emission is estimated to be 1.6×10^3 Ci Rn-222.

3.3.8 Uranium Concentrate Transportation

The uranium concentrate will be transported in 55-gallon drums by truck, carrying about 40 drums in each shipment; about 1000 drums will be shipped out each year. The drums, containing uranium concentrate, will constitute a source of direct radiation and will produce about 2 mR/hr (as measured by the staff) at any edge of the truckbed.

3.3.9 Source Terms

In the previous sections, the parts of the milling process that yield radioactive effluents were described and an analysis was given based on the review of available data from similar operating plants,[8-39] from personal site inspections, and measurements of effects from similarly operating plants. The potential release estimates are adjusted to a 20-year period of mill operation to allow for future expansions and to assure that all estimates are sufficiently conservative. The proposed treatment systems are acceptable, and releases appear to be as low as reasonably attainable within limits of the state-of-the-art mining and milling operations. The principal parameters and conditions used in the computation of source terms previously discussed are given in Table 3.5; the individual source terms are listed in Table 3.6.

3.4 STABILIZATION AND DECOMMISSIONING

In accordance with the Wyoming Environmental Quality Act of 1973, the Forest Service requirements of 36 CFR 252, and the requirements of the U. S. Nuclear Regulatory Commission (Regulatory Guide 3.8), the applicant has prepared a stabilization plan for the tailings area (see Sec. 10.4).

In a document[42] submitted October 7, 1976, the applicant states that the reason for the programs (and alternatives) described therein is the containment, as far as is possible, of all radionuclides, spent reagents, and other noxious materials which will have been deposited in the tailings area as a result of the milling process. The applicant's stated goal is to return the area to its original use, which was grazing.

The applicant proposes containment by burial as a viable solution for reasons of economics and practicality; it is the state-of-the-art solution.

The sequence of the RMEC tailings stabilization effort follows:

1. Preliminary burial of the tailings area with overburden to a depth of two to three feet. This will start in the sixth year of operation and when disposition has reached a point about 600 feet from the crest of the embankment.

2. When milling operations cease, the liquid portion of the tailings will evaporate. After complete evaporation, contaminants will be bulldozed to the edge of the coarse tailings fraction, thus reducing the area occupied by tailings to about 100 acres.

3. The tailings will be covered with a 10-inch compacted clay cap and then with six feet of earth, of which at least the top six inches will be topsoil. The choice of six feet of cover is based on a recent study[43] wherein it is stated that deposition of six feet of earth cover "should eliminate any problems with direct gamma radiation doses". In addition, the applicant uses the estimate that such earth cover will reduce emissions of radon 222 by approximately 50% compared to two feet of earth cover, measured 0.5 mile from the tailings pile.[44] The addition of the prescribed clay cap is expected to further reduce radon emissions by a factor of about one hundred.

4. The area will be revegetated, as described below.

Table 3.5. Principal Parameters and Conditions Used in Radiological Assessment of the Bear Creek Milling Operation

Parameter	Value
Ore quality, U_3O_8	0.15%
Ore activity, Ra-226	420 pCi/g
Ore activity, Th-230	420 pCi/g
Plant factor	1
Ore process rate	3.3×10^5 tonnes/yr
Yellowcake yield	5.5×10^2 tonnes/yr
Yellowcake quality, U_3O_8	90%
Total mine area	6.2×10^5 m^2
Active mine area	6.2×10^4 m^2
Total tailings area	6.1×10^5 m^2
Tailings pond area	4.9×10^5 m^2
Tailings pond depth (20th year)	7.0 m
Tailings density	1.6 g/cm^3
Fraction U to tailings	0.02
Fraction Th to tailings	0.95
Fraction Ra to tailings	0.998
Mill tailings water throughput	5.0×10^5 m^3/yr
Ore pad area	4.0×10^4 m^2

Table 3.6. Average Annual Emissions (in curies) Resulting from the Bear Creek Project During Active Milling and Mining Operations[a]

Source	Nuclide				
	U-238	Th-230	Ra-226	Rn-222	Pb-210
Mine	--	--	--	7.4×10^3	--
Ore pad & feeding	5×10^{-3}	5×10^{-3}	5×10^{-3}	1.17×10^2	5×10^{-3}
Crushing & grinding[b]	2.8×10^{-2}	2.8×10^{-2}	2.8×10^{-2}	2.8×10^{-2}	2.8×10^{-2}
Uranium concentrate	3.1×10^{-2}	1.6×10^{-3}	3.1×10^{-5}	--	3.1×10^{-5}
Tailings[c]	--	--	--	1.6×10^3	--

[a]For releases after stabilization and reclamation see Sections 4.8 and 10.4 and Appendix K.

[b]Based on Highland Mill (Exxon) Environmental Statement (Docket No. 40-8102, p. 37).

[c]Particulate suspension is dependent on the sand-slime ratio, beach area, and specific wind field over the tailings. Estimation of the source term from this pathway is dependent upon mitigating measures and will be discussed in Section 6.

5. The diversion ditches, constructed and revegetated prior to the commencement of use of the tailings area, will be maintained to protect the area from surface water erosion.

6. Fencing, erected prior to the tailings dam construction, will be maintained and posted to prevent ingress by both human land users and livestock until it is determined that surface radiation levels are safe for unrestricted grazing.

The applicant has also coupled monitoring programs, some of which are currently in operation, with the execution of the above steps. Air, soil, and water samples, taken at specified time intervals and places, will be the basis for determining whether the stabilization plan is working. If surface stability is found to be threatened, as indicated by surface inspection and sampling results, steps will be taken to correct the problem.

The staff agrees with applicant that the burial approach to tailings stabilization is the appropriate choice at this time. The staff notes that the stabilization of the Bear Creek tailings pile will not start (other than setting up a borrowing pile from mining) for six to eight years (1982-1984). There is enough time for current and future research results to indicate other approaches to tailings stabilization and for their incorporation into the Bear Creek plan.

The staff also points out that a Generic Environmental Impact Statement on Uranium Milling will be written by NRC. That statement, which will probably be completed in 1978, will contain the results of research already begun to assess the impacts of uranium mill tailings ponds and piles, and the means for mitigating any adverse impacts. The information developed from the generic statement could be used to modify or change the applicant's approach to stabilization if so indicated.

In accordance with Soil Conservation Service recommendations, the applicant plans to revegetate the affected areas with a mixture of native grasses, to include western wheatgrass, thickspike wheatgrass, green needlegrass, and sweet clover. On extremely sandy sites, Indian ricegrass may be added, and in selected areas four-wing saltbrush, and possibly big sagebrush, will be planted to promote a more diverse vegetative cover and to provide browse for wildlife. The piles will be seeded in early spring (before mid-April) or late fall (after mid-October). Where possible a seed drill will be used to apply seed at rates of two to four pounds per acre per grass species. Where broadcast seeding is necessary, seeding rates will be doubled and a harrow will be used to cover the seeds. Mulch will be applied where necessary, and fertilizer will be applied at the time of seeding.

Bonds in amounts acceptable to the NRC, the FS, and the State of Wyoming (subject to periodic review by these agencies) will be posted to cover costs of reclamation of the tailings disposal area. The NRC licensing action will be subject to express conditions that approved waste generating processes and mill tailings management practices will be subject to revision in accordance with the conclusions of the Final Generic Environmental Impact Statement on Milling Operations and any related rule making.

At the present time, the NRC requires that upon termination of the operating license, the land on which the tailings are stored shall be subject to the following specific restrictions:

(1) The holder of the possessory interest will not permit the exposure and release of tailings material to the surrounding area.

(2) The holder of the possessory interest will prohibit erection of any structures for occupancy by man or animals.

(3) Subdivision of the covered surface will be prohibited.

(4) No private roads, trails, or rights-of-way may be established across the covered surface.

At the time of shutdown, the need for construction of permanent fencing around the tailings pile area and installation of permanent warning markers will be decided on the basis of the results of ongoing reclamation and stabilization procedures. Discussions of alternative methods of managing tailings and of alternative reclamation objectives are presented in Section 10.

In addition to the stabilization plan, the applicant has submitted a general plan for decommissioning of the processing facilities and ancillary structures. However, the NRC does not require submission of detailed decommission plans until near the end of the useful life of a project. Prior to termination of the license, the applicant will be required to submit more detailed information. This additional information will include data from radiation surveys taken at the site and plans for any mitigating measures that may be required as a result of the radiation surveys and NRC inspection. Before release of the premises or removal of the buildings and

foundations, the licensee must demonstrate that levels of radioactive contamination are within limits prescribed by the NRC and the then-current regulations. Depending upon the circumstances, the NRC may require that prior to termination of the license, the applicant must submit an environmental report on decommissioning operations.

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4. ENVIRONMENTAL IMPACTS

In the description of environmental impacts that follows, an attempt has been made to separate those impacts due to milling from those specifically attributable to mining. In some cases, however, a clean separation proved difficult, if not impossible. As an example, the transportation impacts from mine to mill cannot be clearly separated, nor can the land use problems associated with truck transportation between mine and mill. Many mining and milling impacts are inseparably interrelated, and, perforce, must be assessed as combined effects.

4.1 AIR QUALITY

4.1.1 Mine

The open pit mining will affect the air quality in two ways. Heavy equipment being operated in the mine and on haulage roads will exhaust diesel fumes. Under similar conditions, these same machines will produce fugitive dust; however, dust loading will vary depending on prevailing weather and character of surface materials. Drilling, blasting and related activities will contribute to dust loading on a sporadic basis.

The exhaust fumes from motor vehicles are expected to have negligible impact on air quality in offsite areas. The dust from the mining operation will also be negligible off site. However, during dry and windy conditions, vehicular movement on haulage roads may generate large quantities of dust that could degrade air quality in areas downwind from project activities.

4.1.2 Mill

The principal impact on air quality resulting from mill operations will be an increase in suspended particulates originating from the tailings piles. The fugitive dust from the piles will be raised and carried by the prevailing winds. Although this dust will consist of particulates larger than those in road dust, the conservative assumption is made that it will be dispersed in a similar manner. Slightly unstable conditions and 11 mph winds were selected to be representative of dust dispersion conditions. Dust release under these conditions is expected to be 4.0 lb/hr/acre (4.5 kg/hr/ha).[1] The area emitting dust at any given time is estimated to be about 15 acres. The average annual suspended particulate concentration at the north boundary (0.15 km) from the tailings piles, the ore pads, the yellowcake drier, and the roads would be about 70 $\mu g/m^3$, at the south boundary (0.9 km) about 9 $\mu g/m^3$, and at the nearest ranch (6 km) about 0.4 $\mu g/m^3$. The concentrations at the nearest residences are well below the current Wyoming state standard[2] of 60 $\mu g/m^3$. Sulfur dioxide and chlorine effluents released to the atmosphere by the leaching process will also have an impact upon air quality. Plant design emission rates for these effluents were used to predict offsite concentrations. From an assumed one-meter height, the release of 0.01 lb/hr SO_2 and Cl_2 would result in a concentration of 0.01 $\mu g/m^3$ at the north boundary, far below the proposed state standard of 60 $\mu g/m^3$ (annual arithmetic mean concentration) of SO_2.[2]

Additional gaseous effluents will include oxides of nitrogen and kerosene. At the north boundary, the concentration of NO_x is predicted to be 0.25 $\mu g/m^3$, while the applicable Wyoming standard is 100 $\mu g/m^3$.[2] It is estimated that 0.025 lb/hr of kerosene will evaporate. With an assumed stack height of one meter, the concentration at the north boundary would be about 0.025 $\mu g/m^3$. But even if all the kerosene released to the pond evaporated ($\sim$ 6.8 lb/hr) the concentration at the north boundary would still be only about 7 $\mu g/m^3$, whereas the applicable state hydrocarbon standard is 160 $\mu g/m^3$.[2]

Radioactive gaseous emissions are discussed in Section 3.3, wherein it is concluded that "as low as reasonably attainable" standards will be met. The resulting doses are well below applicable standards (see Sec. 4.8). The Bear Creek mill is not expected to have a significant radiological impact on the air quality of the region.

4.2 LAND USE

4.2.1 Topography

Construction and mining operations will change the topography of the project area with the creation of pits, water ponds, spoil piles, and a tailings pond and embankment. Mining will cause changes in the drainage pattern and slopes within the area.

Water ponds will be left in the B-1, B-8, and B-13 West pits. The B-1 pit will have 48 acres of steep highwall slopes and flat benches left on the south half of the pit as a final landform. At the extreme south end of the pit, the highwalls will be nearly 300 feet above the water level of the pond. The B-8 and B-13 West pits will fill with water to within 50 feet of the surface.

The mining operation will create new form, line, color and texture that is not in character with the existing landscape. Deep pits, and banks of spoil and stored topsoil, where none now exists, will be in contrast with surface landform that is now of a smooth rolling character. The height of mill site structures will create a focal point in the landscape and the activities of man and machinery will attract attention. The color contrasts between the natural landscape and the buildings and machinery will also attract attention to the site.

4.2.2 Mine

Open-pit mining will involve the removal and temporary storage of topsoil, removal and dumping of overburden in surface piles, removal of ore, and the replacement of the overburden materials and topsoils. At any one time, an average of 805 acres will be in a disturbed condition, over the 15-year life of the project. The proposed mining will leave open mine pits, reservoirs in the bottom of some pits, and spoil piles as landforms. Water pipelines and settling ponds will be used for mine dewatering where needed. Haul roads from the mining pits to the mill will be constructed. The amount of land disturbed by mining will vary from year to year depending upon the progress of the reclamation program, but eventually all of the land, with the exception of the highwalls, will be reclaimed or replaced by ponds.

4.2.3 Mill

The construction and operation of a mill to process the uranium ore will remove 250 acres from production. This area includes not only the land occupied by the mill and tailings retention system but also that occupied by the access road, power lines, septic leach field, parking lots, and the ore storage piles. Virtually all of the disturbed land will be reclaimed after the mill is decommissioned and, with the possible exception of tailings piles, will become available for other uses.

4.2.4 General

4.2.4.1 Agriculture

Grazing will be disrupted for the life of the project on about 3000 acres occupied by the mill site, mine areas, and roads. The estimated loss of AUMs (animal unit months) is shown below:

B-1 pit, mill & access road	10 yr × 366 AUM/yr =	3660 AUM
B-3-4-6-8 pits & haul roads	5 yr × 300 AUM/yr =	1500 AUM
B-13 pit & haul roads	2 yr × 154 AUM/yr =	308 AUM
	TOTAL	5468 AUM

The tailings pond and water-filled pits will be permanently removed from grazing use; an estimated 153 AUM of annual production will be lost.

Fences will be relocated to accommodate mining operations, thereby changing existing grazing patterns and water sources.

Water wells in the vicinity of the mines may be affected by the lowering of water tables due to mine dewatering or other disruptions of local aquifers.

The acreage classified as rangeland will decrease and the potential annual production of 454,000 pounds (200,000 kg) of air dried forage will be lost for utilization by livestock and wildlife due to mine and mill operations, as shown in Tables 4.1 and 4.2. Also indicated, the area suitable for dry farming will increase by 620 acres (250 ha) after the proposed reclamation is completed.

Table 4.1. Potential Change in Soil Capability and Range Sites for All Mine Areas Excluding Roads, Powerlines, Etc.[a]

	Present Condition, acres	Reclamation Proposal, acres	Change, acres
Soil Capability Classes			
Non-irrigated			
IVe	650	1380	730
VIe	1076	361	-715
VIIe	183	12	-171
VIIIe	10	166	156
Irrigated			
IIIe	445	29*	-416
IVe	1124	78*	-1046
IVs	0	1182	1182
Range Site			
Clayey	467	240	-227
Loamy	647	1255	608
Steep loamy	0	216	216
Shallow loamy	133	13*	-120
Sandy	577	28*	-549
Shallow sandy	65	0	-65
Lowland	21	0	21
Rockland	9	49	40
Water	0	117	117

[a]The present and proposed reclamation are related to a common base area for all alternatives analyzed (see Chapter 10.1.3). Acreages marked with an asterisk (*) were adjusted to include the productivity of an increment of undisturbed area to bring the total acreage to a common value.

Note: The range sites and capability classes for the reclamation proposal are estimates based upon the quality and depth of soil materials to be replaced and the expected slope contours.

Table 4.2. Potential Yield Summary[a], Bear Creek Project Site

Suitable Use Soil Capability	Yield Units	Present Potential Acres	Present Potential Total Yield	Proposed Reclamation[b] Acres	Proposed Reclamation[b] Total Yield
A. Non-irrigated[c]					
Wheat	bu	650	13,000	1380	27,600
Oats	bu	650	17,550	1380	37,300
Barley	bu	650	14,300	1380	30,400
Grass-hay or tame-pasture	tons	650	400	1380	860
B. Irrigated					
Alfalfa hay	tons	1569	6,500	1289	2,800
Pasture	AUM	1569	9,900	1289	5,400
Grass-hay	tons	1569	4,100	1289	2,000
Oats	bu	1569	114,300	1289	78,700
Barley	bu	1569	90,700	1289	65,300
C. Native Rangeland (Range Site)		(acres)	(lb)	(acres)	(lb)
Clayey	lb airdry	467	607,100	240*	347,000
Loamy	lb airdry	647	970,500	1255	1,853,300
Steep loamy	lb airdry	0	0	216	101,000
Shallow loamy	lb airdry	133	119,700	13*	11,700
Sandy	lb airdry	577	923,200	28*	44,800
Shallow sandy	lb airdry	65	65,000	0	0
Lowlands	lb airdry	21	52,500	0	0
Rockland & water	----	9	0	166	0
		1919	2,738,000	1918	2,357,800

[a]Does not include haul roads, powerline right-of-ways and other minor disturbances.

[b]The present and proposed reclamation are related to a common base area for all alternatives analyzed (see Sec. 10.1.3). Acreages marked with an asterisk (*) were adjusted to include the productivity of an increment of undisturbed area to bring the total acreage to a common value.

[c]Kinds of crops are non-additive within the non-irrigated and irrigated uses and may not be added to rangeland use.

Land capability classification involves grouping of soils to show agricultural suitability and is based on potentials and limitations of soils, risk of damage when used and an indication of response to management. Capability classes are ranked on a relative scale and designated as Classes I-VIII; Class I lands being suitable for the widest range of intensive uses with minimal maintenance while limitations of Class VIII land preclude use for commerical plant production. Intensive management treatment is not economically feasible and uses are limited to recreation, wildlife habitat, water supply, etc. Land classes I through IV are suitable for the production of cultivated crops, but erosion hazards and/or other limitations of Class V lands are impractical to control or remove and such lands are used for pasture, range and wildlife. The potential for Class VI and VII lands is intermediate between Classes V and VIII.

The capability classification and acreages within classes of the lands to be mined by RMEC are shown in Table 4.1. Comparable information for the area after completion of reclamation is also shown. The net effects of mining and subsequent reclamation are expected to more than double the acreage of Class IV lands. Class VIII lands will increase by approximately 165 acres. Potentially irrigable lands will decrease by about 280 acres, but irrigation water will be made more available by an increase of 117 acres for the three remaining ponds. Table 4.2 (parts A and B) presents potential crop production in the present condition and post-reclamation.

By using the SCS Range Site System, the effects of mining and reclamation may be assessed for rangeland. A Range Site is a distinctive kind of rangeland having characteristic soils, topography and climate regulating its potential production as indicated by a specific group of native plants. Reclaimed land is projected to be primarily a mix of clayey, loamy and sandy. Table 4.2 (part C) gives estimates of potential range production in the present condition and post-reclamation.

4.2.4.2 Transportation

About 20 miles of Ross County Road #31 have been paved to accommodate the anticipated increase in number of vehicles moving to and from the project site. The Jenny Trail County Road #34 may need upgrading to improve access from the northeast via Highway 59.

Numerous other dirt roads and trails in the project area will be disrupted, thereby affecting ranching operations. A new paved road will be completed from the Ross Road to the mill site, 4.5 miles to the east.

Vehicle accidents and littering will increase because of the increase in traffic.

4.2.4.3 Commercial and Industrial

Pacific Power and Light will construct a 34.5-kV powerline to the mill site. Mountain States Telephone will install a buried phone line to the mill site.

4.2.4.4 Recreation

Assuming that no hunting will be allowed on the Bear Creek Project site, there will be an annual loss of approximately 40 hunter days for antelope and six hunter days for deer. No other recreational opportunities will be lost due to the project. Sightseeing and rock-hunting may increase after the project is completed. The large ponds left in the area may be used for fishing if the waters are suitable for fish stocking.

4.3 WATER RESOURCES

4.3.1 Mine

4.3.1.1 Site Preparation and Mine Opening

Impacts on water resources during site preparation and mine operations include construction, mine opening, and mine dewatering.

Existing drainage patterns will be disrupted because of construction activities and overburden removal. The potential for erosion will be increased by the removal of vegetation. This could result in increased amounts of sediment during periods of runoff. Accelerated erosion could cause an adjustment in flow regimen with resultant changes in erosion and sedimentation down gradient. The amounts of change have not been estimated. Because of the low drainage gradients in the area, however, these sediments should not be transported significant distances.

Pumping to dewater the pits and for consumptive use during mining operations will lower water levels in the vicinity of the pumping. The effects will decrease with distance from the pumping. Dewatering will result in the discharge of water into the drainage downstream from the mine area. Water quality is expected to be similar to that of the existing surface water and would be suitable for consumption by livestock and wildlife, the principal use of water downstream from the proposed mine operations.

Although estimates of the effects of pumping on water levels can be made from the analysis of adequate aquifer test data collected from a pumping well in conjunction with nearby observation wells, monitoring of water levels in properly spaced observation wells during actual pumping operations will be necessary to accurately determine the effects of mine dewatering.

4.3.1.2 Mine Operation and Reclamation

Aquifer Disruption

Mining of a proposed 3 million tons of ore and disturbance of 160 to 375 feet of overburden will disrupt aquifers within the disturbed areas. The overburden that is replaced in the mining pit for reclamation will be less permeable, after settling and compaction, than it was before disturbance because the disturbed material will be mixed and thus be more heterogeneous. Because of disruption, the replaced overburden will be less stable, and thus more reactive, and increased leaching of chemical ions could result. In addition to uranium, moderate to high concentrations of vanadium, selenium, and arsenic are present in the ore and overburden; these concentrations, however, appear to be normal for soils in the area.

Recharge and Discharge

Premining recharge and discharge conditions in the mined areas will not be fully restored by reclamation because of the disruption of the natural aquifers. To the extent that depressions on the reclaimed surface are below the reestablished water table, ground water will discharge to the depressions.

Because the disturbed fill area will be less permeable than the undisturbed adjacent deposits, some groundwater flow may be deflected around the reclaimed areas. Where local recharge occurred before mining, destruction of permeable beds conducive to infiltration of rainfall and snowmelt may reduce local recharge somewhat because of the lower permeability. Consequently, increased runoff could cause increased erosion resulting in increased sediment deposition down gradient.

Ore Stockpiles

Precipitation falling in the stockpile area will infiltrate into the ore. If rainfall exceeds infiltration and holding capacity of the ore, however, surface runoff will occur. It is possible that this runoff will contain some radioactive material. This runoff will be diverted into the tailings pond from which no discharge of liquid effluent is expected.

Water Quality

Where a mined area is a point of discharge during mining operations, a reduction of water quality will not occur. After the overburden has been returned to the pit, however, leaching by infiltration of water through the reclaimed areas will occur. Some of the water will eventually move toward discharge points along stream drainages; most of this water, however, will be used by plants or will be evaporated near or along stream drainages.

Surface Drainage

Release of water from dewatering and mining operations could alter flow characteristics, possibly resulting in accelerated erosion of streambeds and banks. The extent of erosion would depend on the amount of water released and the nature and condition of the existing channel.

4.3.2 Mill

Liquid discharge from the mill will be to the tailings pond. The liquid phase of the tailings slurry will contain minor amounts of kerosene, amine, alcohol, and a polymeric flocculent, as well as naturally occurring selenium, arsenic, uranium, thorium-230 and radium-226. The organic residues will be largely retained in the tailings as a film on the solid particles. Some seepage is expected both vertically and horizontally from the tailings pond. Seepage from the pond, however, is not expected to be significant and is expected to be controlled within the local vicinity of the tailings pond.

Radiation exposures to mankind or to animals due to direct ingestion of water or by way of aquatic biota food chains are expected to be negligible. A conceivable indirect pathway is via seepage of radioactive liquids from the tailings into the groundwater and subsequent ingestion of the groundwater or biota which have ingested the groundwater. Seepage is expected to be small and local, nevertheless this pathway has been incorporated into the calculations described in Section 4.8.

4.4 MINERAL RESOURCES

The coal resource on the site is not present in sufficient quantity to be economically mined by itself. However, if the coal that will be stripped along with the overburden is of sufficient quality and quantity to warrant separation from the rest of the overburden, it will be salvaged. Whatever oil and gas that may exist would be thousands of feet below mining depths and could not be affected by the proposed mining and milling operations.

Minerals other than uranium which occur in the ore may become valuable in the future. Should this occur, such minerals will be present (except for minor quantities lost via seepage) in the tailings and overburden piles and can be mined therefrom.

4.5 SOILS

The general impacts associated with both mine and mill activities include disruption of soil forming processes,* mixing of existing soils, destruction of soil structure, soil compaction, and accelerated wind and water erosion.

The removal of natural vegetative cover from construction sites and active mining areas will expose surface materials to accelerated wind and water erosion. Soil compaction, due to operation of heavy construction and mining equipment, will likewise cause increased runoff, erosion and sedimentation.

Stripping and stockpiling of topsoil material will result in disruption of all existing physical, chemical and biological systems of the soil environment. Both fauna and flora of the soil will be variously affected, including micro-organisms which convert organic matter, elements, and compounds to available plant nutrients. The overall impacts of stripping, storing and replacing of topsoil will result in a general reduction in natural soil productivity. Leaching, erosion and anaerobic interactions associated with stored topsoil, and the mixing of soil with sterile materials of the substratum are some of the factors or conditions which will adversely affect soil productivity.

Long-term effects of project activities include destruction of soil structure and related characteristics which have developed over periods of hundreds and thousands of years. Upon completion of project activities, natural soil characteristics such as horizonation and other physical properties will be completely different from those existing prior to initiation of the project.

The total acreage to be disturbed by project activities is about 2020 acres (820 ha), distributed as follows:

Mine pits	575 acres
Overburden dump areas	880 acres
Topsoil stockpiles	148 acres
Hauling roads and settling ponds	130 acres
Mill site area	100 acres
Mine shop	40 acres
Tailings ponds	150 acres
Total	2023 acres

4.5.1 Mine

The development of mine pits, overburden dump areas, topsoil stockpiles, haul roads and settling ponds will disturb about 1730 acres. In addition to the soil materials removed and stored for later use, about 99 million cubic yards (76 million m^3) of overburden will be excavated from pit areas. Effects on soil characteristics will be similar to those just discussed. Toxic or undesirable materials may be exposed during excavation, although chemical tests do not indicate the presence of toxic materials.

Alteration of the intermittent stream channels in the project area will affect downstream portions of creeks and adjoining land areas. Altered drainage patterns may deprive some areas of soil moisture, thereby affecting soil productivity and vegetative growth. Stream channelization and release of mine drainage water will increase flow velocities which, in turn, will increase erosion of stream beds and stream banks of downstream channels.

4.5.2 Mill

Construction of the mill and tailings pond will cause disturbance of about 250 acres (100 ha). An additional 30 acres (12 ha) will be used for stockpiling topsoil removed from the mill and tailings pond areas. The soil types and horizons will be mixed as topsoil material is removed from the mill site and tailings pond. The subsoils in the tailings pond will be compacted to reduce seepage losses.

There will likely be some spillage of chemicals and petroleum products in the mill area. This will result in soil pollution and a lowering of soil productivity in spill areas. Construction and/or maintenance activities will variously affect natural vegetation and topsoils of powerline and access corridors. The total acreage to be used as access corridors is presently unknown.

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*The individual soil forming factors include climate, topography, parent material, time and plant and animal life.

4.6 ENVIRONMENTAL IMPACTS ON VEGETATION

The development of the proposed project will result in the removal of vegetation when open pit mining and the construction of processing facilities is initiated.

Construction of milling facilities, associated roads, tailings pond and the B-1 pit will result in the removal of 950 acres (380 ha.) of vegetation. Of this, the mill site and ancillary facilities will require 250 acres (100 ha.) for the life of the project, 1976-86. The remaining 700 acres (280 ha.) will be disturbed as portions of the B-1 area are progressivley stripped for mining. The B-3, -4, -6, -8 ore bodies underlie about 710 acres (285 ha.) and vegetation will be removed as each of these mines is developed. Mining the B-13 ore body will result in 310 (130 ha.) acres of vegetation disturbance.

Most mining and related activities will occur within Types 1 (grassland) and 4 (sagebrush) vegetation. The acreage of disturbed vegetation will vary from year to year depending upon the development rate for each ore body and the amount of barren land area will depend on reclamation schedules.

Secondary impacts on vegetation resulting from project activities will be caused by gaseous and fugitive dust effluents, dewatering of mine pits and the potential invasion of noxious weeds.

Dust from the milling and mining operations and that from the road surfaces may have an adverse effect on vegetation present in the area. Dust deposits on vegetation may lower plant vigor by slowing the photosynthetic process. Dust will also cause plants to be less palatable to the animals that consume them. Gaseous effluents from the mill operation may combine with atmospheric moisture, forming products which subsequently deposit on and adversely affect vegetation. The magnitude of this potential effect is not known.

Mine dewatering, with water being diverted into Bear Creek, will alter the composition of the meadow vegetation type and small areas of riparian vegetation. Riparian vegetation will increase and vegetation more characteristic of an aquatic environment will be established.

Noxious weeds can be expected to become established on areas undergoing reclamation, along roadsides where soil has been disturbed, and along Bear Creek.

4.6.1 Mine

Open pit mining activities will result in the removal of 1730 acres of vegetation. The B-1 ore body underlies 700 acres; B-3, -4, -6, -8 ore bodies, 710 acres; and B-13, 320 acres.

Most mine areas occur within Type 1 and Type 4 vegetation (see Sec. 2.7). The acreage of vegetation disturbed by mining activities will vary from year to year, depending on the need to strip new areas to expose additional ore. The amount of barren surface will be contingent on progress of the revegetation program. Secondary impacts, as a result of disturbing the vegetative cover, include increased potential for wind erosion and the introduction of noxious weeds and undesirable grasses. Dust from the mine operation and from the haul roads will be variously deposited on local vegetation and may lower plant vigor by slowing the photosynthetic process. Dust may also cause plants to be less palatable to animals and cause increased tooth wear. Mine dewatering, with water being diverted into Bear Creek, will alter meadow-type vegetation which may become more xerophytic in character. Riparian vegetation will increase along Bear Creek and vegetation more characteristic of an aquatic environment will become established.

4.6.2 Mill

Impacts on vegetation, resulting from operation of the mill and other facilities, are the same as identified for the mine. Approximately 250 acres of vegetation will be removed for the life of the project, 1976-86.

Gaseous effluents from the mill operation may combine with atmospheric moisture to form products which deposit on and adversely affect vegetation. The magnitude of this potential effect is expected to be negligible, in view of the low ambient humidity and experience with similar facilities.

4.7 ENVIRONMENTAL IMPACTS ON WILDLIFE

The development of the Bear Creek uranium resource will result in various impacts on wildlife populations.

The following impacts and effects have been identified:

A. Direct destruction of wildlife

Land clearing and excavations for mill facilities and removal of overburden from the uranium ore bodies are actions which will likely be the greatest cause of wildlife mortality. Large, earth-moving machinery will crush, bury and suffocate many small and juvenile animals, primarily those incapable of moving fast enough to escape and those that retreat to burrows for protection. This type of destruction will occur during the life of the project.

B. Project-related destruction of wildlife

Increased ground vehicular traffic due to project employees will result in a proportionate increase in the level of road-killed wildlife. It has been estimated that the maximum average daily traffic flow (1978) in the area will exceed current levels by 280 vehicles and that the maximum peak of vehicular traffic increase (500 vehicles per day) will occur in 1977 (ER, p. 4-22).

An estimated three to five miles (5-8 km) of fence will be constructed around the mill site, tailing pond, and the area B-1 pit during the 1976-80 period. In addition, existing fences will be relocated to accommodate current ranch operations and an unknown amount of fence may be constructed along haul roads. Fences will variously restrict movement of the larger mammals and may result in increased mortality if severe winter storms cause antelope and deer to seek more effective shelter. Impacts may be compounded, especially during spring months when animals prematurely abandon traditional protective habitat, being attracted by newly established grasses and forbs common to revegetated areas and thereby expose themselves to unseasonal spring blizzards.

Power lines associated with the mill site will constitute "in-flight" hazards to birds as well as creating a potential for electrocution of large raptors, unless lines are constructed to prevent this type of accident.

C. Direct destruction of habitat

Project activities will destroy or impair wildlife habitat and this will result in permanent or variously temporary impacts on resident wildlife.

Permanent habitat loss will result from actions such as access road construction and some excavations. The pit excavation activities in areas B-1, -8, and -13 are expected to convert about 75-150 acreas (30-60 ha) of terrestrial habitat to aquatic environments by 1986.

Approximately 3500 acres (1400 ha) of wildlife habitat with some, mostly long-term, potential for recovery will have been disturbed by 1986. Efforts to rehabilitate about half of this disturbed acreage will be undertaken, aimed at establishing a perennial grassland vegetative type.

Most of the habitat disturbances will occur in the sagebrush and grassland vegetative types. The animals in Groups I, II and III, shown in Appendix E, will be most affected.

D. Wildlife interactions with human populations

Increased human population within the project area, approximately 275 in the 1976-81 period, will variously affect wildlife. Human intrusion is tolerated only to a certain point by almost any wild animal. The degree of tolerance varies widely among species. For example, as long as their habitat is intact, insects are relatively indifferent to human activity. Conversely, most of the larger mammals and predators will abandon habitats in close proximity to areas of intense human activity. It appears likely that the combined effects of wildlife and human interactions will result in reduced wildlife production on additional acreage one and one-half to three times larger than the estimated 3500 acres of destroyed habitat resulting directly from onsite project activities as of 1986. From a regional standpoint, impacts associated with Bear Creek operations will be cumulative with those of existing mining activity at the Kerr-McGee, Exxon and Morton Ranch mines, and all other mining and industrial activity in the region.

E. Offsite and secondary impacts

Development of the project area will cause numerous secondary effects on wildlife through the disruption of food supplies, species behavior patterns, and biotic interactions critical to the function and structure of the ecosystem. Animals, especially the larger mammals, displaced from the 3500 acres of habitat disturbed prior to 1986 and the much greater area adversely affected by human activity will compete with resident animals for habitat resources of adjacent areas.

Impacts upon aquatic habitats within and outside the project area must also be anticipated. Dewatering of mine pits and the transfer of water to Bear Creek will increase aquatic habitat in offsite areas. The transfer of water from one mine pit to another, as a method of dewatering, will create lakes which may be utilized by waterfowl and shore birds.

4.7.1 Mine

Open pit mining activities will destroy the smaller, less mobile forms of wildlife on 3250 acres (1310 ha) of land surface. The larger or more mobile forms of wildlife such as antelope and birds will be able to escape. The reduction of the smaller forms of wildlife will affect food availability for the predatory species, both on and adjacent to the mine pits to an undetermined degree. A total 3250 acres of wildlife habitat will ultimately be destroyed during the period 1976-1986. Meaningful recovery of habitat is expected to require two to five years following abandonment. A portion of the disturbed area, about 75-150 acres, will be converted to aquatic habitat, occurring as lakes formed in B-1, -8, and -13 pits.

4.7.2 Mill

The construction and operation of the mill and other supportive facilities will result in destruction and/or disturbance of wildlife and wildlife habitat on 250 acres (100 ha) during the 1976-86 period. About 150 acres will be used for mill tailings ponds during the life of the project. Radioactive and other contaminants occurring in the tailings ponds will render this habitat unsuitable for those species of wildlife which normally would frequent such habitat, such as waterfowl, ground squirrels and mice. Fencing of the mill site will alter the pattern of wildlife movement and may result in increased wildlife mortality.

4.8 RADIOLOGICAL

Estimations of the probabilities of radiological impacts to the ecosystem (Fig. 4.1) from the combined mining and milling operations are based on:

- Identification of the sources of release (see Secs. 3.3-3.4, Fig. 3.16)
- Estimations of the annual average release of each radionuclide (Fig. 3.15) from each source
- Calculation of the probability for transport within the ecosystem (spatial and temporal distribution)
- Identification of exposure pathways (see Fig. 4.1), i.e.:
  (a) inhalation of radionuclides from the air
  (b) ingestion of contaminated food and water
  (c) exposure to gamma radiation from contaminated ground and air
  (d) direct exposure to gamma radiation emitted from the ore, leach solution, and tailings
- Estimations of annual dose rates to tissues at risk (Fig. 4.2)
- Estimations of radiological impacts based on a dose-effect analysis.

These analyses are based on predicted dose rates using the Argonne National Laboratory Steady-State Uranium-Dispersion-and-Dosimetry Code[3] (UDAD) (for details of the code see Appendix K-3) and on Table 2.1. This code is based on conservative modeling assumptions and available parameters for pathways. When the parameters were not known, the calculations were based on conservative estimates. The quantities of the radionuclides (see Sec. 3.3, Figs. 3.15 and 3.16, and Tables 3.5 and 3.6) released are expected to produce concentrations in air and water at the boundary of the controlled areas (lands under direct control of the Rocky Mountain Energy Company) less than the limits specified in 10 CFR Part 20 and are consistent with the present

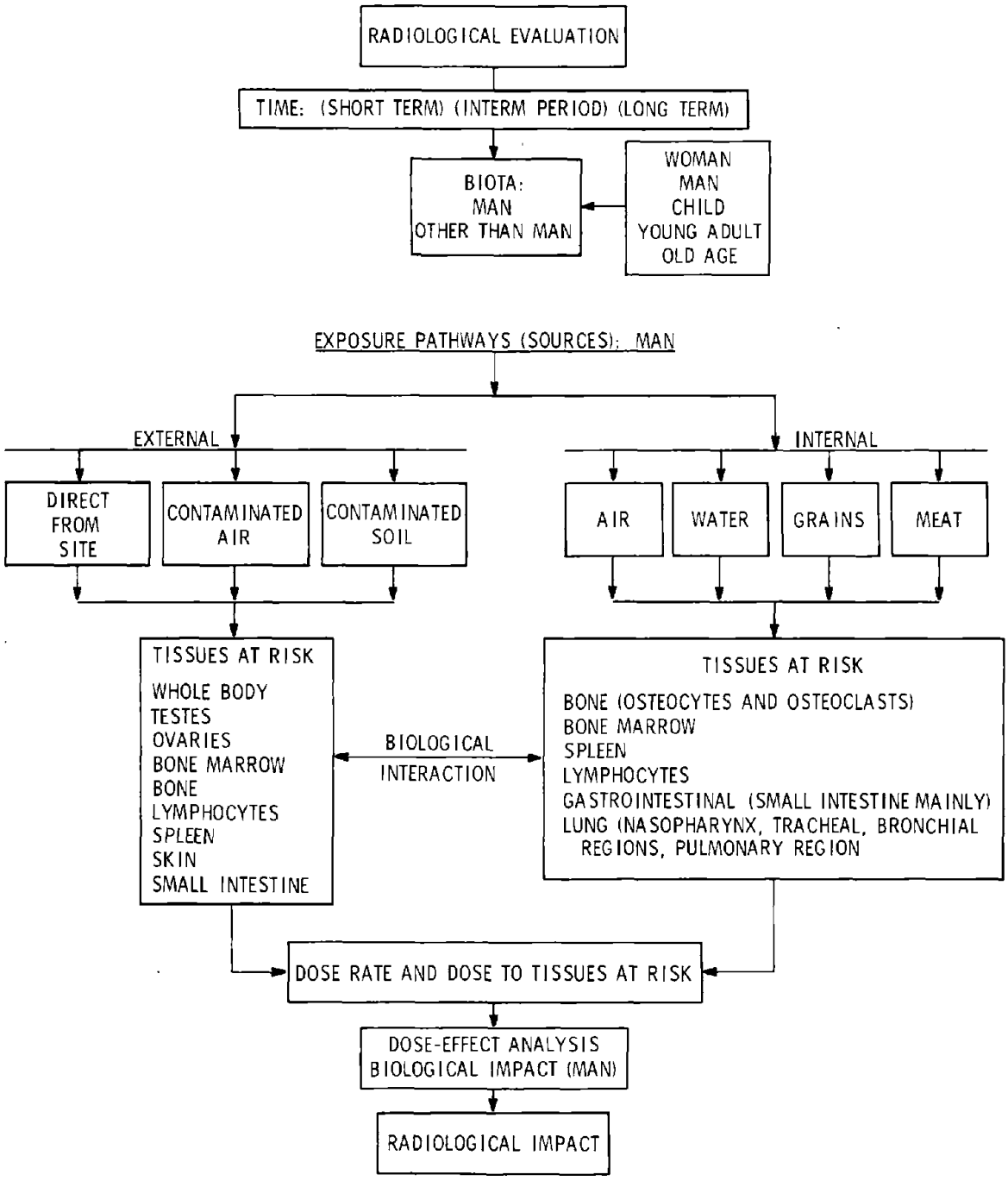


Fig. 4.1. Major Radiation Exposure Pathways.

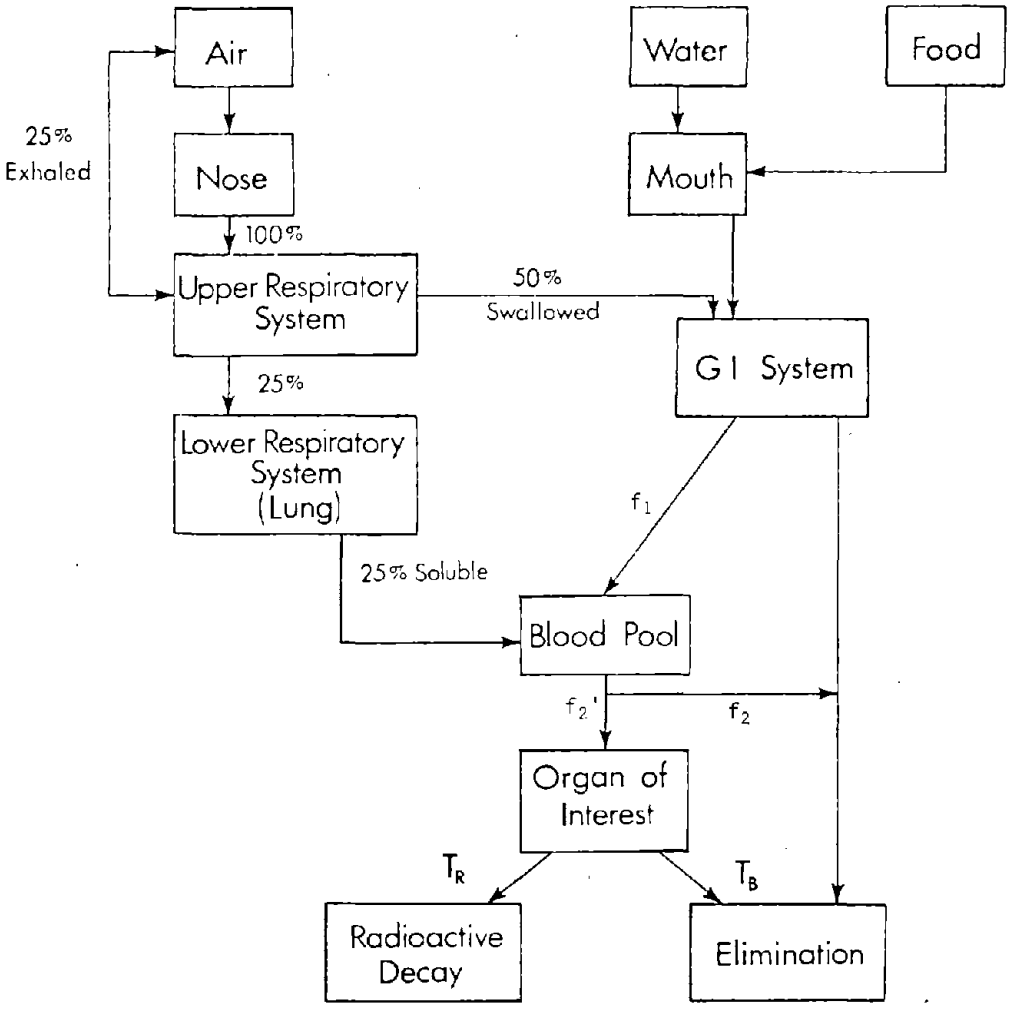


Fig. 4.2. Pathways for Internal Exposure Used for Estimating Annual Dose Rates to Tissues at Risk.

state-of-the-art in the uranium mining and milling operations. It is the NRC staff's opinion, after an independent evaluation of the operation, that the proposed Bear Creek Project satisfies the "as low as reasonably attainable" guides, considering the present state of mining and milling technology. Based on the currently available dose effect data, no deleterious biological effects are anticipated.

4.8.1 Air Exposure Pathways

The average rate of release of airborne radioactivity during the active mining and milling operations is given in Table 3.6. The quantity of radioactivity released from the tailing pond and mine walls is not constant throughout this period. The rate of radon emanation (see App. K-2) is dependent on the exposed surfaces of the tailing pond, i.e., beach areas. The maximum rate of release of radon from the tailing surface is 8×10^3 Ci per year, corresponding to emanation from the entire tailings retention area of $6.1 \times 10^5 m^2$ (see Table 3.5). Mitigating measures carried out concurrently with the tailings beach surface expansion (see Sec. 10.4) should greatly reduce the quantity of radioactivity released. After completion of the mining the source strength from the mine is expected to be reduced to the same emanation rate as from nonmineralized surfaces. Also, the release of particulates and radon from ore pad, transportation, and milling operations is expected to be eliminated. The dose estimates are based on Table 3.6.

Concentrations of U-238, Th-230, Ra-226, and Pb-210 in air during the active mining and milling operations are shown in Figures 4.3 through 4.6 as a function of distance from 0.1 to 80 kilometers for the directions north, east, south, and west. Since the prevailing wind is from the southwest, the maximum concentrations of airborne radionuclides are expected to be in the northeastern (NE) areas of the Bear Creek site. (These maximum airborne concentrations are given in Figs. 4.3 to 4.6) The concentration of radon-222 is given in Figure 4.7 as a function of distance for the same directions.

Figures 1.1 and 4.8 show the boundary (fenced area), ranch headquarters, and towns in the vicinity of the Bear Creek site. For areas shown in Figure 4.8 the concentrations of airborne particulates radon-222, and annual average ambient concentrations of each radionuclide are given in Table 4.3. (For areas shown in Fig. 1.1, see App. K.)

The exposure pathway from air is by inhalation of airborne radioactive particles (soluble and insoluble). The fraction of the radioactivity deposited in nasopharynx, trachea, and the bronchial tree and pulmonary region is dependent upon the particulate aerodynamic size distribution, the physiological state of the body (i.e., active vs. basal or sedentary state affecting the total lung volume and respiratory frequency) and the solubility in the lung fluid (see App. K). The dose rate at the 50th year of continuous inhalation was calculated on the basis of the 1959 recommendations of the International Commission on Radiological Protection (ICRP)[4] and the 1965 report of the task group on lung dynamics for Committee II of ICRP.[5] Tables 4.4 through 4.10 give the dose rate from inhalation for each radionuclide and the total dose rate from all the radionuclides to whole body, bone, lung, gastrointestinal system (soluble and insoluble), liver and kidney at the boundary of the mill and at the nearby residences. After termination of operations of mining, milling, and reclamation, assumed 25 years of operation, the concentrations of radionuclides released to the environment will essentially cease. Therefore, these predicted dose rates, calculated for the 50th year of continuous emission, and the time-integrated dose for the 70-year life span are believed to be conservative. Thus, the dose rates for the years prior to the 50th year would also be less than or equal to the stated values.

Tables 4.4 and 4.5 give the whole-body and bone dose rates from airborne particulates at the site boundaries and populated areas. Table 4.6 gives the dose rate to the lung from combined particulates and to the bronchial epithelium from radon and its daughters at the site boundaries and the populated areas. An estimate of the man-rem per year for any organ can be obtained by multiplying the dose at the location of interest by the population at that location (Table 4.11). The time-integrated doses, the dose accumulating over a 70-year life span from up to a 20-year span of operation, to the critical organs at risk from inhalation of significant particulate airborne radionuclides (cloud) are given in the Appendixes (K-5, K-6 and K-7). For example, the dose to the lungs from inhalation of particulate airborne radionuclides at a distance of 1 km (0.6214 miles) in the northeast direction, 45 degrees, is 24 mrem from U-238, 30 mrem from U-234, 210 mrem from Th-230, 7.5 mrem from Pb-210, for a total of 271.5 mrem to lungs over a 70-year life span.

4.8.2 External Exposure

The concentration of radioactivity deposited on the ground and in water was calculated on the basis of parameters provided in Appendix K. These activities will result in external exposure (i.e., external to human body) and internal irradiation. Both gamma and beta radiation could

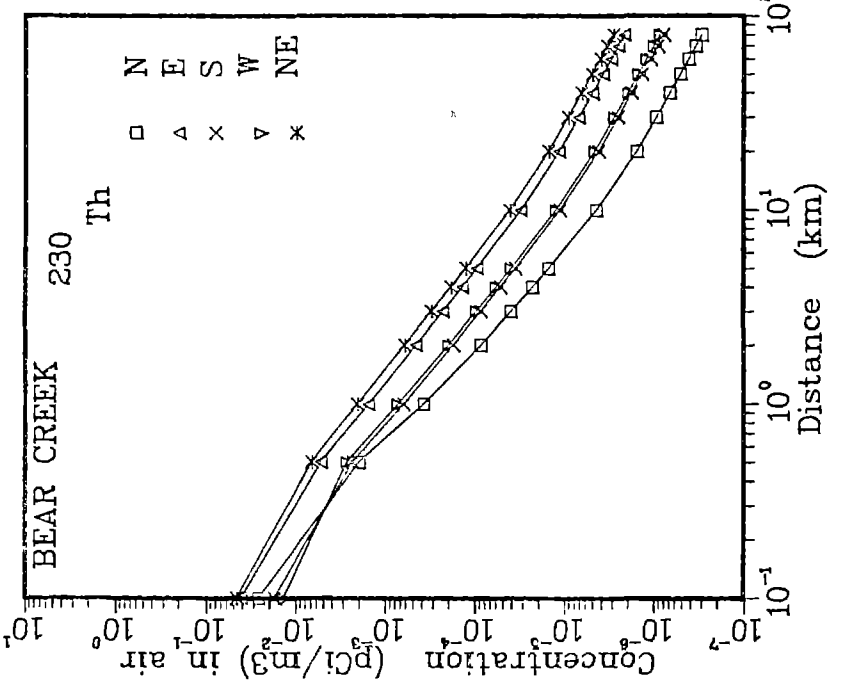


Fig. 4.4. Concentration, from All Sources, of Th-230 in Air Estimated from UDAD Code (1976).

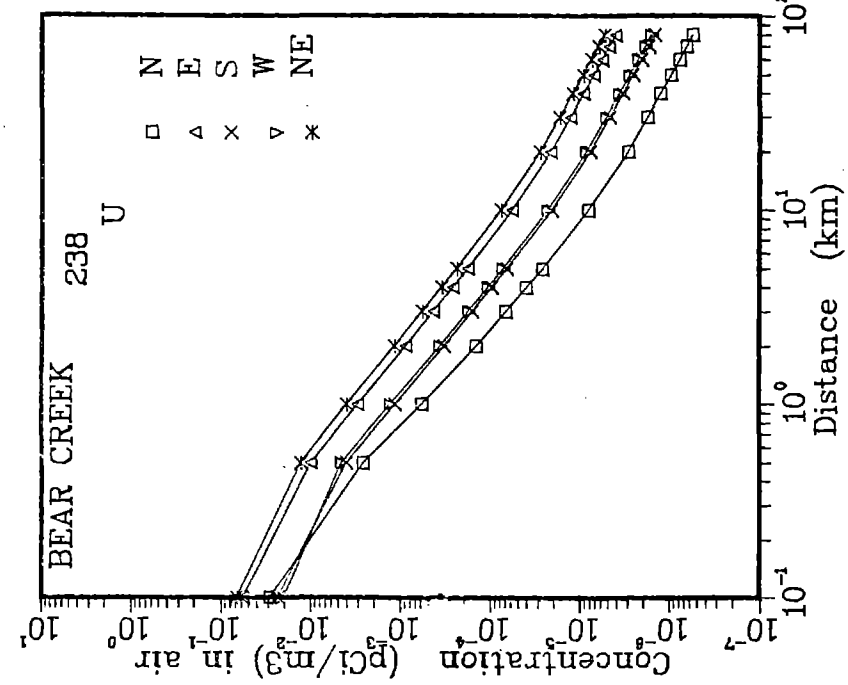


Fig. 4.3. Concentration, from All Sources, of U-238 in Air Estimated from UDAD Code (1976). Northeast (NE) is the direction of maximum deposition.

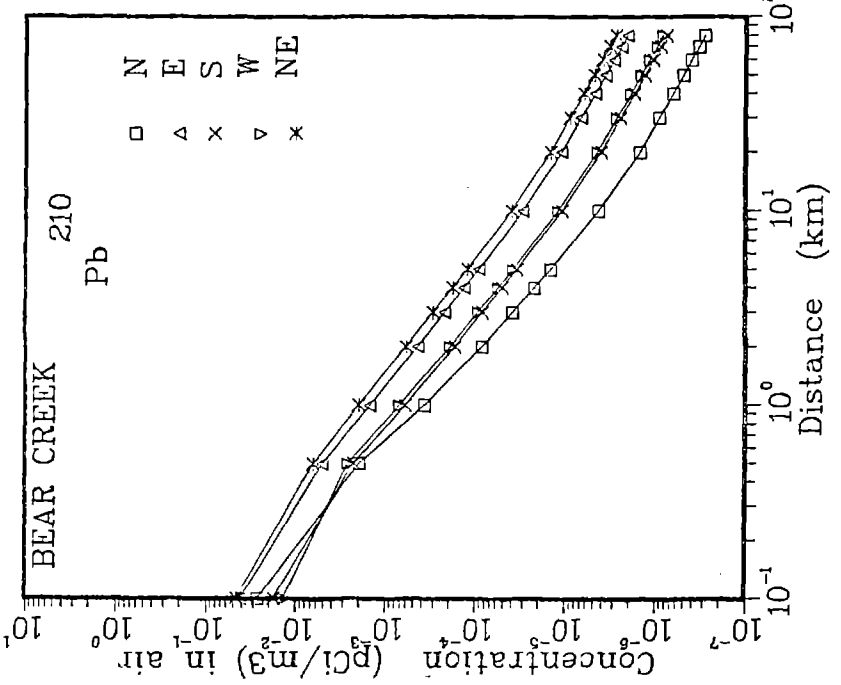


Fig. 4.6. Concentration, from All Sources, of Pb-210 in Air Estimated from UDAD Code (1976).

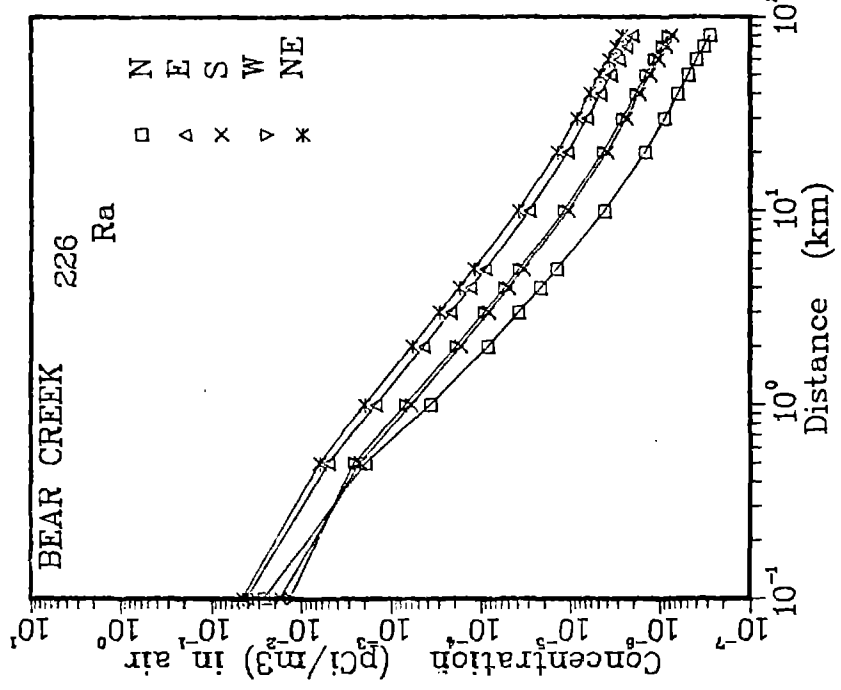


Fig. 4.5. Concentration, from All Sources, of Ra-226 in Air Estimated from UDAD Code (1976).

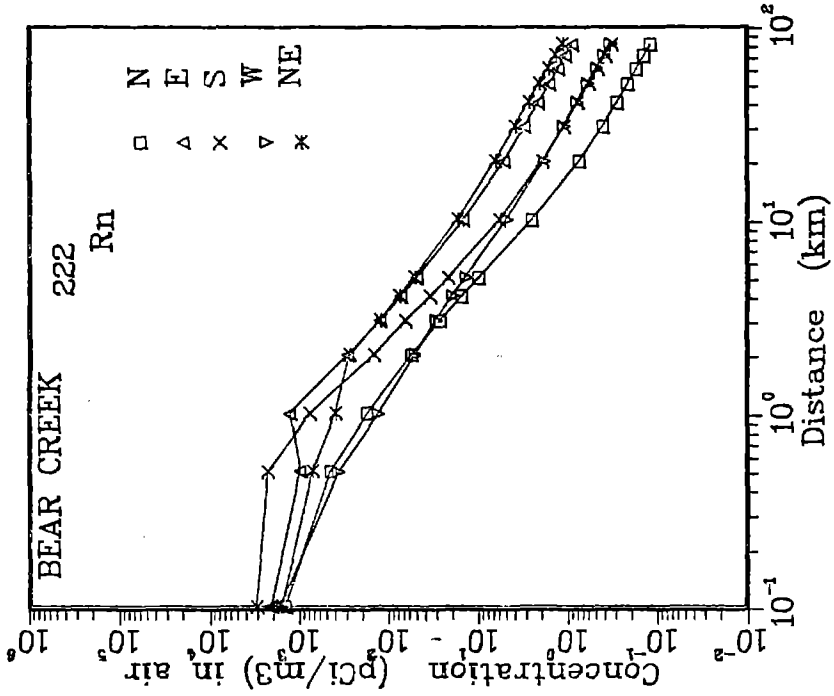


Fig. 4.7. Concentration of Ra-222 in Air from All Sources of Release of Radon Estimated from UDAD Code (1976).

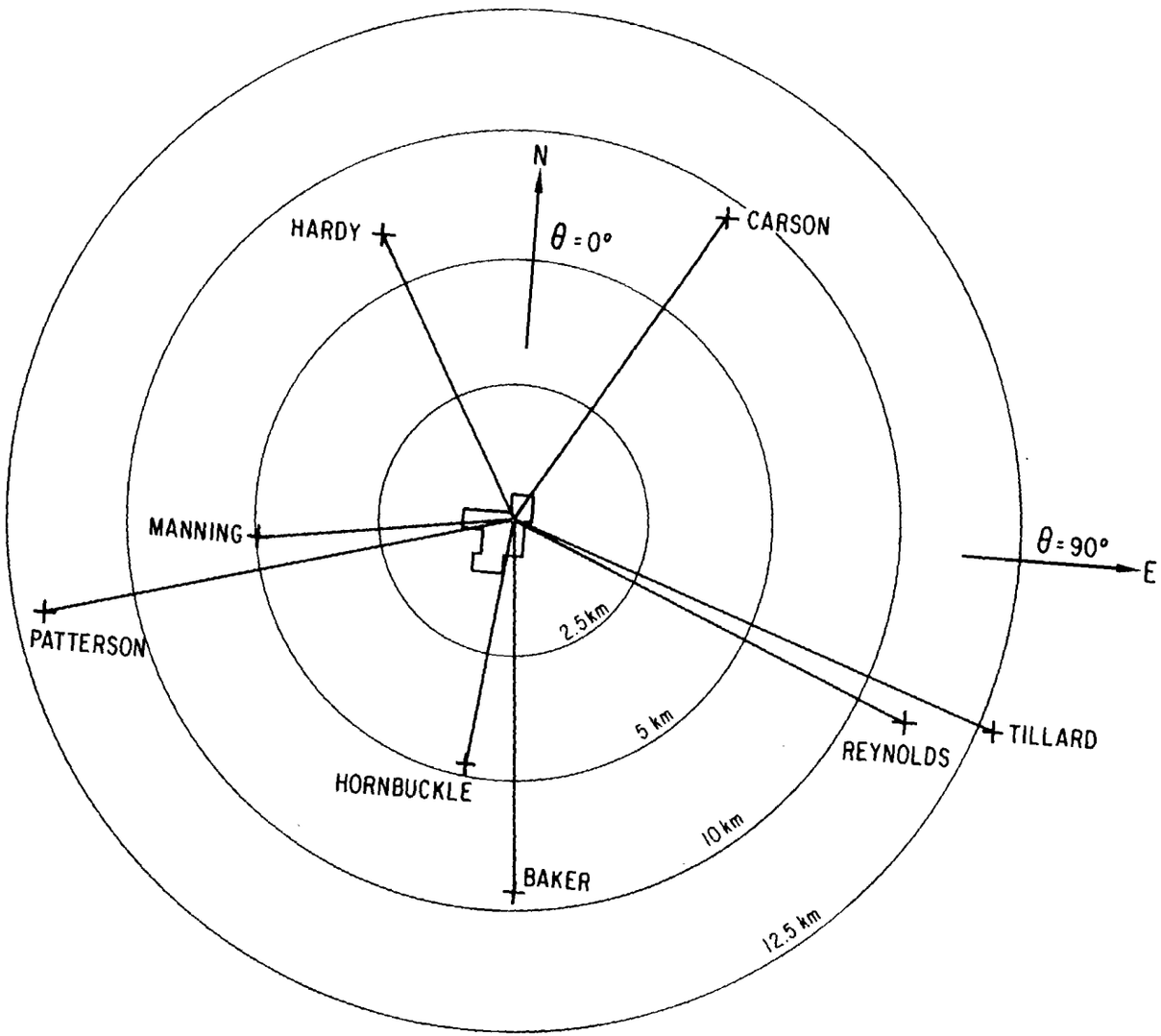


Fig. 4.8. Distance (km) of Nearby Ranches from the Site.

Table 4.3. Total Concentration of Radionuclides in Air (pCi/m^3)

	RECEITOR	U238	TH230	RA226	PB210	RN222	WL
1	South boundary	0.14D-02[a]	0.79D-03	0.75D-03	0.75D-03	0.96D 03	0.22E-05
2	East boundary	0.23D-01	0.13D-01	0.12D-01	0.12D-01	0.15D 04	0.40E-05
3	North boundary	0.19D-01	0.17D-01	0.17D-01	0.17D-01	0.12D 04	0.30E-05
4	West boundary	0.23D-02	0.15D-02	0.14D-02	0.14D-02	0.59D 03	0.11E-05
5	Carson Ranch	0.91D-04	0.49D-04	0.47D-04	0.47D-04	0.20D 02	0.48E-06
6	Reynolds Ranch	0.57D-04	0.31D-04	0.29D-04	0.29D-04	0.15D 02	0.36E-06
7	Tillard Ranch	0.42D-04	0.23D-04	0.21D-04	0.21D-04	0.11D 02	0.28E-06
8	Baker Ranch	0.10D-02	0.54D-03	0.51D-03	0.51D-03	0.59D 03	0.18E-05
9	Hornbuckle Ranch	0.57D-04	0.31D-04	0.29D-04	0.29D-04	0.17D 02	0.31E-06
10	Patterson Ranch	0.13D-04	0.69D-05	0.66D-05	0.66D-05	0.33D 01	0.88E-07
11	Manning Ranch	0.51D-04	0.28D-04	0.27D-04	0.27D-04	0.11D 02	0.21E-06
12	Hardy Ranch	0.11D-04	0.58D-05	0.55D-05	0.55D-05	0.24D 01	0.53E-07
13	Bill	0.46D-05	0.25D-05	0.24D-05	0.24D-05	0.13D 01	0.44E-07
14	Douglas	0.21D-05	0.11D-05	0.11D-05	0.11D-05	0.49D 00	0.18E-07
15	Glenrock	0.41D-05	0.22D-05	0.21D-05	0.21D-05	0.95D 00	0.36E-07
16	Casper	0.12D-05	0.67D-06	0.64D-06	0.64D-06	0.28D 00	0.11E-07
17	Midwest	0.15D-05	0.83D-06	0.79D-06	0.79D-06	0.35D 00	0.13E-07

[a]Both D and E indicate that the number is to be raised to the power following the symbol. Thus, 0.14D-02 = 0.14 × 10^{-2}. D indicates that the computer computation was carried out in "double precision arithmetic;" E indicates "single precision arithmetic."

Table 4.4. Dose Rate to Whole Body from Inhalation of Particulates in Air (mrem/yr)

		WHOLE BODY						
	LOCATION	U238	U234	TH230	RA226	PB210	RN222	TOTAL DOSE
1	South boundary	0.12E-01	0.12E-01	0.79E 00	0.19E 00	0.94E-02	0.0	0.10E 01
2	East boundary	0.19E 00	0.19E 00	0.13E 02	0.30E 01	0.15E 00	0.0	0.16E 02
3	North boundary	0.16E 00	0.16E 00	0.17E 02	0.42E 01	0.21E 00	0.0	0.22E 02
4	West boundary	0.19E-01	0.19E-01	0.15E 01	0.36E 00	0.18E-01	0.0	0.19E 01
5	Carson Ranch	0.76E-03	0.76E-03	0.49E-01	0.12E-01	0.59E-03	0.0	0.63E-01
6	Reynolds Ranch	0.47E-03	0.47E-03	0.31E-01	0.74E-02	0.37E-03	0.0	0.40E-01
7	Tillard Ranch	0.35E-03	0.35E-03	0.23E-01	0.54E-02	0.27E-03	0.0	0.29E-01
8	Baker Ranch	0.84E-02	0.84E-02	0.54E 00	0.13E 00	0.64E-02	0.0	0.69E 00
9	Hornbuckle Ranch	0.47E-03	0.47E-03	0.31E-01	0.73E-02	0.37E-03	0.0	0.39E-01
10	Patterson Ranch	0.11E-03	0.11E-03	0.69E-02	0.16E-02	0.82E-04	0.0	0.88E-02
11	Manning Ranch	0.42E-03	0.42E-03	0.28E-01	0.66E-02	0.33E-03	0.0	0.36E-01
12	Hardy Ranch	0.89E-04	0.89E-04	0.58E-02	0.14E-02	0.69E-04	0.0	0.74E-02
13	Bill	0.38E-04	0.38E-04	0.25E-02	0.59E-03	0.30E-04	0.0	0.32E-02
14	Douglas	0.17E-04	0.17E-04	0.11E-02	0.27E-03	0.13E-04	0.0	0.14E-02
15	Glenrock	0.34E-04	0.34E-04	0.22E-02	0.53E-03	0.26E-04	0.0	0.28E-02
16	Casper	0.10E-04	0.10E-04	0.67E-03	0.16E-03	0.80E-05	0.0	0.86E-03
17	Midwest	0.13E-04	0.13E-04	0.83E-03	0.20E-03	0.99E-05	0.0	0.11E-02

Table 4.5. Dose Rate to Bone (mrem/yr)

	BONE							
	LOCATION	U238	U234	TH230	RA226	PB210	RN222	TOTAL DOSE
1	South boundary	0.21E 00	0.21E 00	0.29E 02	0.23E 01	0.32E 00	0.0	0.32E 02
2	East boundary	0.35E 01	0.35E 01	0.47E 03	0.36E 02	0.52E 01	0.0	0.52E 03
3	North boundary	0.29E 01	0.29E 01	0.63E 03	0.50E 02	0.72E 01	0.0	0.69E 03
4	West boundary	0.35E 00	0.35E 00	0.55E 02	0.43E 01	0.62E 00	0.0	0.61E 02
5	Carson Ranch	0.14E-01	0.14E-01	0.18E 01	0.14E 00	0.20E-01	0.0	0.20E 01
6	Reynolds Ranch	0.86E-02	0.86E-02	0.12E 01	0.88E-01	0.13E-01	0.0	0.13E 01
7	Tillard Ranch	0.63E-02	0.63E-02	0.84E 00	0.64E-01	0.92E-02	0.0	0.93E 00
8	Baker Ranch	0.15E 00	0.15E 00	0.20E 02	0.15E 01	0.22E 00	0.0	0.22E 02
9	Hornbuckle Ranch	0.85E-02	0.85E-02	0.12E 01	0.88E-01	0.13E-01	0.0	0.13E 01
10	Patterson Ranch	0.19E-02	0.19E-02	0.26E 00	0.20E-01	0.26E-02	0.0	0.28E 00
11	Manning Ranch	0.76E-02	0.76E-02	0.10E 01	0.80E-01	0.11E-01	0.0	0.11E 01
12	Hardy Ranch	0.16E-02	0.16E-02	0.22E 00	0.17E-01	0.24E-02	0.0	0.24E 00
13	Bill	0.69E-03	0.69E-03	0.93E-01	0.71E-02	0.10E-02	0.0	0.10E 00
14	Douglas	0.31E-03	0.31E-03	0.42E-01	0.32E-02	0.46E-03	0.0	0.47E-01
15	Glenrock	0.61E-03	0.61E-03	0.83E-01	0.63E-02	0.90E-03	0.0	0.91E-01
16	Casper	0.19E-03	0.19E-03	0.25E-01	0.19E-02	0.28E-03	0.0	0.28E-01
17	Midwest	0.23E-03	0.23E-03	0.31E-01	0.24E-02	0.34E-03	0.0	0.34E-01

Table 4.6. Dose Rate to Lung (mrem/yr)[a]

	LUNG							
	LOCATION	U238	U234	TH230	RA226	PB210	RN222	TOTAL DOSE
1	South boundary	0.43E 00	0.54E 00	0.39E 01	0.0	0.14E 00	0.96E 03	0.96E 03
2	East boundary	0.69E 01	0.86E 01	0.63E 02	0.0	0.23E 01	0.15E 04	0.16E 04
3	North boundary	0.58E 01	0.72E 01	0.84E 02	0.0	0.31E 01	0.12E 04	0.13E 04
4	West boundary	0.69E 00	0.66E 00	0.74E 01	0.0	0.27E 00	0.59E 03	0.59E 03
5	Carson Ranch	0.27E-01	0.34E-01	0.25E 00	0.0	0.88E-02	0.20E 02	0.21E 02
6	Reynolds Ranch	0.17E-01	0.21E-01	0.15E 00	0.0	0.55E-02	0.15E 02	0.15E 02
7	Tillard Ranch	0.13E-01	0.16E-01	0.11E 00	0.0	0.40E-02	0.11E 02	0.11E 02
8	Baker Ranch	0.30E 00	0.38E 00	0.27E 01	0.0	0.97E-01	0.59E 03	0.59E 03
9	Hornbuckle Ranch	0.17E-01	0.21E-01	0.15E 00	0.0	0.55E-02	0.17E 02	0.17E 02
10	Patterson Ranch	0.38E-02	0.47E-02	0.34E-01	0.0	0.12E-02	0.33E 01	0.33E 01
11	Manning Ranch	0.15E-01	0.19E-01	0.14E 00	0.0	0.50E-02	0.11E 02	0.11E 02
12	Hardy Ranch	0.32E-02	0.40E-02	0.29E-01	0.0	0.10E-02	0.24E 01	0.24E 01
13	Bill	0.14E-02	0.17E-02	0.12E-01	0.0	0.45E-03	0.13E 01	0.13E 01
14	Douglas	0.63E-03	0.78E-03	0.56E-02	0.0	0.20E-03	0.49E 00	0.49E 00
15	Glenrock	0.12E-02	0.15E-02	0.11E-01	0.0	0.40E-03	0.95E 00	0.96E 00
16	Casper	0.37E-03	0.47E-03	0.34E-02	0.0	0.12E-03	0.28E 00	0.28E 00
17	Midwest	0.46E-03	0.57E-03	0.41E-02	0.0	0.15E-03	0.35E 00	0.35E 00

[a]Dose rate to bronchial epithelium residing in a house with adequate air ventilation with radon daughter ratios 1/0.9/0.5/0.35.

Table 4.7. Dose Rate (Isoluble) to Gastrointestinal System (mrem/yr)

		GI(INSOL)						
	LOCATION	U238	U234	TH230	RA226	PB210	RN222	TOTAL DOSE
1	South boundary	0.39E-03	0.36E-03	0.20E-03	0.19E-03	0.38E-04	0.0	0.12E-02
2	East boundary	0.62E-02	0.58E-02	0.31E-02	0.30E-02	0.60E-03	0.0	0.19E-01
3	North boundary	0.52E-02	0.48E-02	0.42E-02	0.42E-02	0.83E-03	0.0	0.19E-01
4	West boundary	0.62E-03	0.58E-03	0.37E-03	0.36E-03	0.72E-04	0.0	0.20E-02
5	Carson Ranch	0.25E-04	0.23E-04	0.12E-04	0.12E-04	0.23E-05	0.0	0.74E-04
6	Reynolds Ranch	0.15E-04	0.14E-04	0.77E-05	0.74E-05	0.15E-05	0.0	0.46E-04
7	Tillard Ranch	0.11E-04	0.10E-04	0.56E-05	0.54E-05	0.11E-05	0.0	0.34E-04
8	Baker Ranch	0.27E-03	0.25E-03	0.13E-03	0.13E-03	0.26E-04	0.0	0.81E-03
9	Hornbuckle Ranch	0.15E-04	0.14E-04	0.77E-05	0.73E-05	0.15E-05	0.0	0.46E-04
10	Patterson Ranch	0.34E-05	0.32E-05	0.17E-05	0.16E-05	0.33E-06	0.0	0.10E-04
11	Manning Ranch	0.14E-04	0.13E-04	0.69E-05	0.66E-05	0.13E-05	0.0	0.41E-04
12	Hardy Ranch	0.29E-05	0.27E-05	0.15E-05	0.14E-05	0.28E-06	0.0	0.87E-05
13	Bill	0.12E-05	0.12E-05	0.62E-06	0.59E-06	0.12E-06	0.0	0.37E-05
14	Douglas	0.56E-06	0.52E-06	0.28E-06	0.27E-06	0.54E-07	0.0	0.17E-05
15	Glenrock	0.11E-05	0.10E-05	0.55E-06	0.53E-06	0.11E-06	0.0	0.33E-05
16	Casper	0.34E-06	0.31E-06	0.17E-06	0.16E-06	0.32E-07	0.0	0.10E-05
17	Midwest	0.41E-06	0.38E-06	0.21E-06	0.20E-06	0.39E-07	0.0	0.12E-05

Table 4.8. Dose Rate (Soluble) to Gastrointestinal System (mrem/yr)

		GI(SOL)						
	LOCATION	U238	U234	TH230	RA226	PB210	RN222	TOTAL DOSE
1	South boundary	0.27E-03	0.31E-03	0.17E-03	0.11E-03	0.28E-04	0.0	0.88E-03
2	East boundary	0.43E-02	0.49E-02	0.27E-02	0.18E-02	0.45E-03	0.0	0.14E-01
3	North boundary	0.36E-02	0.41E-02	0.36E-02	0.25E-02	0.63E-03	0.0	0.14E-01
4	West boundary	0.43E-03	0.49E-03	0.32E-03	0.21E-03	0.54E-04	0.0	0.15E-02
5	Carson Ranch	0.17E-04	0.19E-04	0.11E-04	0.70E-05	0.18E-05	0.0	0.56E-04
6	Reynolds Ranch	0.11E-04	0.12E-04	0.66E-05	0.44E-05	0.11E-05	0.0	0.35E-04
7	Tillard Ranch	0.78E-05	0.89E-05	0.48E-05	0.32E-05	0.81E-06	0.0	0.26E-04
8	Baker Ranch	0.19E-03	0.22E-03	0.12E-03	0.77E-04	0.19E-04	0.0	0.62E-03
9	Hornbuckle Ranch	0.11E-04	0.12E-04	0.66E-05	0.44E-05	0.11E-05	0.0	0.35E-04
10	Patterson Ranch	0.24E-05	0.27E-05	0.15E-05	0.98E-06	0.25E-06	0.0	0.78E-05
11	Manning Ranch	0.96E-05	0.11E-04	0.59E-05	0.40E-05	0.99E-06	0.0	0.31E-04
12	Hardy Ranch	0.20E-05	0.23E-05	0.12E-05	0.83E-06	0.21E-06	0.0	0.66E-05
13	Bill	0.87E-06	0.99E-06	0.53E-06	0.36E-06	0.89E-07	0.0	0.28E-05
14	Douglas	0.39E-06	0.45E-06	0.24E-06	0.16E-06	0.40E-07	0.0	0.13E-05
15	Glenrock	0.77E-06	0.87E-06	0.47E-06	0.32E-06	0.79E-07	0.0	0.25E-05
16	Casper	0.23E-06	0.27E-06	0.14E-06	0.96E-07	0.24E-07	0.0	0.76E-06
17	Midwest	0.29E-06	0.33E-06	0.18E-06	0.12E-06	0.30E-07	0.0	0.94E-06

Table 4.9. Dose Rate to Liver (mrem/yr)

	LIVER						
	LOCATION	U238	U234	TH230	RA226	PB210	RN222	TOTAL DOSE
1	South boundary	0.0	0.0	0.17E 01	0.0	0.11E 00	0.0	0.18E 01
2	East boundary	0.0	0.0	0.27E 02	0.0	0.18E 01	0.0	0.29E 02
3	North boundary	0.0	0.0	0.36E 02	0.0	0.25E 01	0.0	0.38E 02
4	West boundary	0.0	0.0	0.32E 01	0.0	0.21E 00	0.0	0.34E 01
5	Carson Ranch	0.0	0.0	0.11E 00	0.0	0.70E-02	0.0	0.11E 00
6	Reynolds Ranch	0.0	0.0	0.66E-01	0.0	0.44E-02	0.0	0.70E-01
7	Tillard Ranch	0.0	0.0	0.48E-01	0.0	0.32E-02	0.0	0.51E-01
8	Baker Ranch	0.0	0.0	0.12E 01	0.0	0.77E-01	0.0	0.12E 01
9	Hornbuckle Ranch	0.0	0.0	0.66E-01	0.0	0.44E-02	0.0	0.70E-01
10	Patterson Ranch	0.0	0.0	0.15E-01	0.0	0.98E-03	0.0	0.16E-01
11	Manning Ranch	0.0	0.0	0.59E-01	0.0	0.40E-02	0.0	0.63E-01
12	Hardy Ranch	0.0	0.0	0.12E-01	0.0	0.83E-03	0.0	0.13E-01
13	Bill	0.0	0.0	0.53E-02	0.0	0.36E-03	0.0	0.57E-02
14	Douglas	0.0	0.0	0.24E-02	0.0	0.16E-03	0.0	0.26E-02
15	Glenrock	0.0	0.0	0.47E-02	0.0	0.32E-03	0.0	0.50E-02
16	Casper	0.0	0.0	0.14E-02	0.0	0.96E-04	0.0	0.15E-02
17	Midwest	0.0	0.0	0.18E-02	0.0	0.12E-03	0.0	0.19E-02

Table 4.10. Dose Rate to Kidney (mrem/yr)

	KIDNEY						
	LOCATION	U238	U234	TH230	RA226	PB210	RN222	TOTAL DOSE
1	South boundary	0.71E 00	0.54E-01	0.59E 01	0.0	0.28E 00	0.0	0.69E 01
2	East boundary	0.12E 02	0.86E 00	0.94E 02	0.0	0.45E 01	0.0	0.11E 03
3	North boundary	0.97E 01	0.72E 00	0.13E 03	0.0	0.63E 01	0.0	0.14E 03
4	West boundary	0.12E 01	0.86E-01	0.11E 02	0.0	0.54E 00	0.0	0.13E 02
5	Carson Ranch	0.46E-01	0.34E-02	0.37E 00	0.0	0.18E-01	0.0	0.44E 00
6	Reynolds Ranch	0.29E-01	0.21E-02	0.23E 00	0.0	0.11E-01	0.0	0.27E 00
7	Tillard Ranch	0.21E-01	0.16E-02	0.17E 00	0.0	0.81E-02	0.0	0.20E 00
8	Baker Ranch	0.50E 00	0.38E-01	0.40E 01	0.0	0.19E 00	0.0	0.48E 01
9	Hornbuckle Ranch	0.28E-01	0.21E-02	0.23E 00	0.0	0.11E-01	0.0	0.27E 00
10	Patterson Ranch	0.63E-02	0.47E-03	0.52E-01	0.0	0.25E-02	0.0	0.61E-01
11	Manning Ranch	0.25E-01	0.19E-02	0.21E 00	0.0	0.99E-02	0.0	0.25E 00
12	Hardy Ranch	0.54E-02	0.40E-03	0.44E-01	0.0	0.21E-02	0.0	0.51E-01
13	Bill	0.23E-02	0.17E-03	0.19E-01	0.0	0.89E-03	0.0	0.22E-01
14	Douglas	0.10E-02	0.78E-04	0.85E-02	0.0	0.40E-03	0.0	0.10E-01
15	Glenrock	0.20E-02	0.15E-03	0.17E-01	0.0	0.79E-03	0.0	0.19E-01
16	Casper	0.62E-03	0.47E-04	0.50E-02	0.0	0.24E-03	0.0	0.60E-02
17	Midwest	0.76E-03	0.57E-04	0.62E-02	0.0	0.30E-03	0.0	0.73E-02

Table 4.11. Projected Population Density for the Year 1997 within an 80-km Radius of the Site

DIRECTION	ANGLE	0.8-2.4	2.4-4.0	4.0-5.6	5.6-7.3	7.3-12.1	12.1-24.2	24.2-40.2	40.2-56.3	56.3-72.5	72.5-80.5
N	= 0.0	0	0	0	0	4	26	105	176	247	316
NNE	= 22.5	0	0	0	0	6	36	112	171	235	298
NE	= 45.0	0	0	0	0	4	26	112	187	229	329
ENE	= 67.5	0	0	0	0	9	27	105	195	239	149
E	= 90.0	0	0	0	0	6	24	107	176	247	235
ESE	=112.5	0	0	0	0	4	36	105	171	258	251
SE	=135.0	0	0	0	0	4	31	107	202	322	150
SSE	=157.5	0	0	0	0	4	24	105	277	3437	225
S	=180.0	0	0	0	0	6	22	105	208	277	276
SSW	=202.5	0	0	0	0	4	18	111	219	1945	338
SW	=225.0	0	0	0	0	4	33	109	176	393	55974
WSW	=247.5	0	0	0	0	6	24	100	187	240	329
W	=270.0	0	0	0	17	9	22	102	195	246	316
WNW	=292.5	0	0	0	0	6	27	105	172	449	263
NW	=315.0	0	0	0	3	4	29	102	176	149	126
NNW	=337.5	0	0	0	0	6	33	[illegible]	148	[illegible]40	254

result in external exposure; beta radiation usually penetrates only the outer layer of tissue, whereas gamma irradiation exposes the whole body. (See Figs. 4.9-4.12.) In these figures the symbols are used to differentiate the lines indicating different directions.

Table 4.12 gives the total predicted external-exposure rates at the mill site boundary (fence) and the ranch headquarters from ground deposition and air particulates. The total external exposures at ranch headquarters are about 0.5 mrem/yr or less to any of the organs. These exposures are less than 2% of the exposure to natural terrestrial irradiation of 32 mrem/yr. The exposure rate directly over the tailings and ore will be about 1.2×10^4 mrem/yr. The exposure rate from the tailings at the boundary is estimated to be less than 300 mrem/yr. Similarly, the 70-year time-integrated doses from exposure from 20-year operations to the external gamma and beta radiations emitted from the ground-deposited radionuclides are given in Appendix K-8. For example, the total whole body dose from the ground deposition at the direction of maximum dispersion (northeast 45°) at a distance of 1 km (0.6214 miles) from the mill site and integrated to a 70-year life span is 10 mrem. The corresponding dose at 40 km (25 miles) in the northeast direction (45°) from the mill is only 0.02 mrem. The nearest occupied area is in the 5.6-7.3 km sector (3.5-4.5 miles) (see Table 4.11) in the western direction (270°) and has a population of 17 people. The total 70-year external dose from the ground-deposited radionuclides at a distance of 5 km (3 miles) to the west is 1.6×10^{-3} mrem (Table K-5___). Finally, the 70-year time-integrated dose from exposure to the external gamma and beta radiation from airborne (cloud) and ground radionuclides is given in Appendix K-7. These dose calculations are for the duration of mining and milling operations, a period of 20 years. The airborne releases are essentially eliminated after the 20th year, upon completion of the projected mining and milling activities. For example, the maximum external dose to the whole body at a distance of 1 km (0.6214 miles) in the direction of maximum dispersion (northeast) integrated over a 20-year period is: 1.3×10^{-7} mrem from U-238; 9.8×10^{-6} mrem from combined Th-234, Pa-234 and U-234; 1.5×10^{-7} mrem from Th-230; 1.9×10^{-6} mrem from Ra-226; 3.2×10^{-2} mrem from Rn-222 and the daughters, for a total dose of 3.2×10^{-2} mrem.

4.8.3 Radioactive Food Pathway

Since the area around Bear Creek is not a cereal-grain producing area, the main pathway to radiation exposure from food is by consumption of meat. The local meat diet is taken to be mostly beef and mutton and, to a much lesser extent, fish, deer, and antelope. The area within 80 km of the Bear Creek Project at present does not produce grain or marketable fruit. In the future, if this agricultural condition changes drastically, this food pathway will be reevaluated.

To demonstrate the insignificance of the dose from the food consumption pathway, it was assumed that the radioactivity emitted from the combined mine and mill operations (see Table 3.6) is all deposited within an area of 80-km radius, and that all the deposited activity is available for forage uptake. Further, it was assumed that the population residing within this area produced the entire intake. Table 4.13 gives the concentration of radionuclides in an average dietary intake in the Bear Creek area. As beef is the only part of the diet produced locally, the mill and mine probably contribute no more than one-tenth of the activities estimated.

The consumption of deer and antelope meats will be much less than that of beef because of limitations on game animal harvesting set by the State of Wyoming. The contribution of sport fish harvested from the North Platte and Cheyenne rivers to man's daily intake of U-238, Th-230, Ra-226, and Pb-210 is also not significant.

4.8.4 Radioactive Water Pathway

The mine and the mill will not release radioactivity directly into surface waters, and the quality of the liquid discharged from mine dewatering will meet State of Wyoming regulations; hence, this pathway will not be considered further.

Internal dosage from ingestion of water containing released radionuclides during normal plant operation is mainly dependent on the concentrations in well waters. Those radionuclides which enter well waters must do so by seepage from the tailings pond (Fig. 3.18). An estimation of the quantities of radionuclides transported from the tailing impoundment into an aquifer (Fig. 3.18) is dependent on a time scale of observation and on such parameters as porosity, permeability, and exchange in vertical as well as horizontal layers of soil.[10-13] Water-bearing zones underlying the mill site are at a depth of between 40 and 50 meters. In the acidic leach mill solution, only 0.4 to 0.7 percent of the total 540 pCi Ra-226/g of ore is dissolved (2.2 pCi-3.8 pCi). Of this dissolved fraction, 80 percent is radium (1.8-3 pCi) carried by the raffinate to the tailings. Sands and slime also carry about 15 percent of the dissolved radium (0.3-0.6 pCi) to the tailings. The remaining 5 percent of the dissolved radium (0.1-0.2 pCi Ra-226/g ore) is finally processed with the yellowcake concentrate. The interaction of the tailings solution (pH 2) with the subsoil in the tailings pond will increase the pH rapidly to near neutrality (pH 7) and some of the dissolved radionuclides will precipitate out.

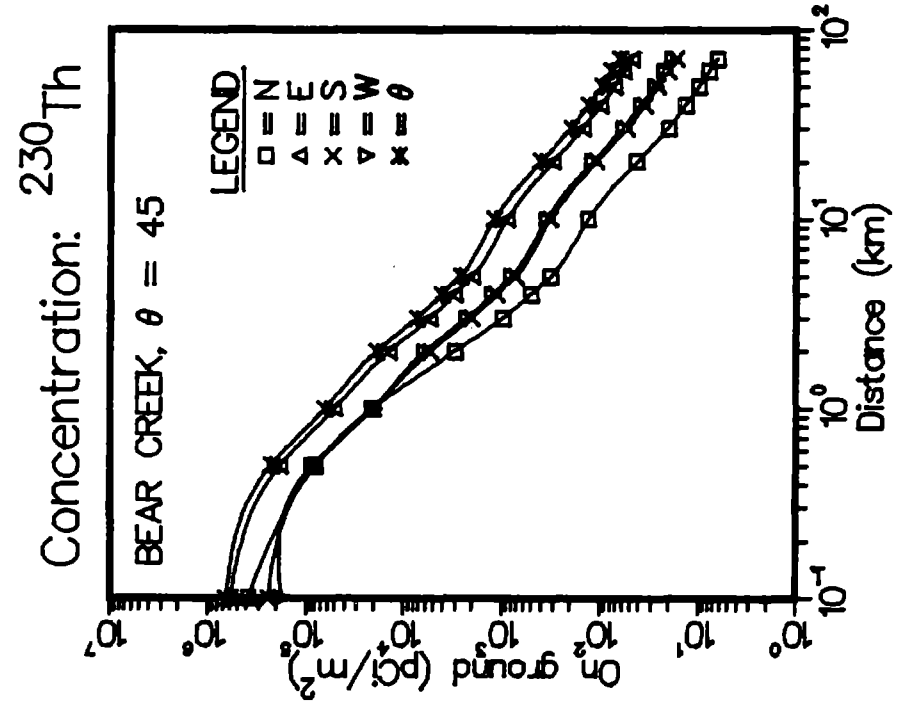


Fig. 4.10. Concentration of Th-230 from All Sources on the Ground (pCi/m^2) Estimated from UDAD Code (1976).

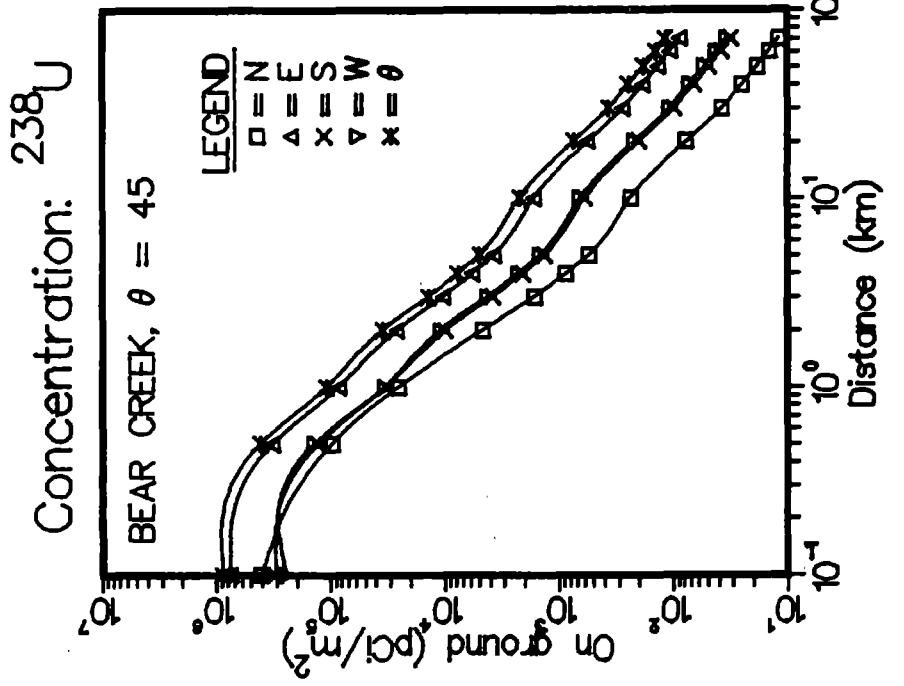


Fig. 4.9. Concentration of U-238 from All Sources on the Ground (pCi/m^2) Estimated from UDAD Code (1976).

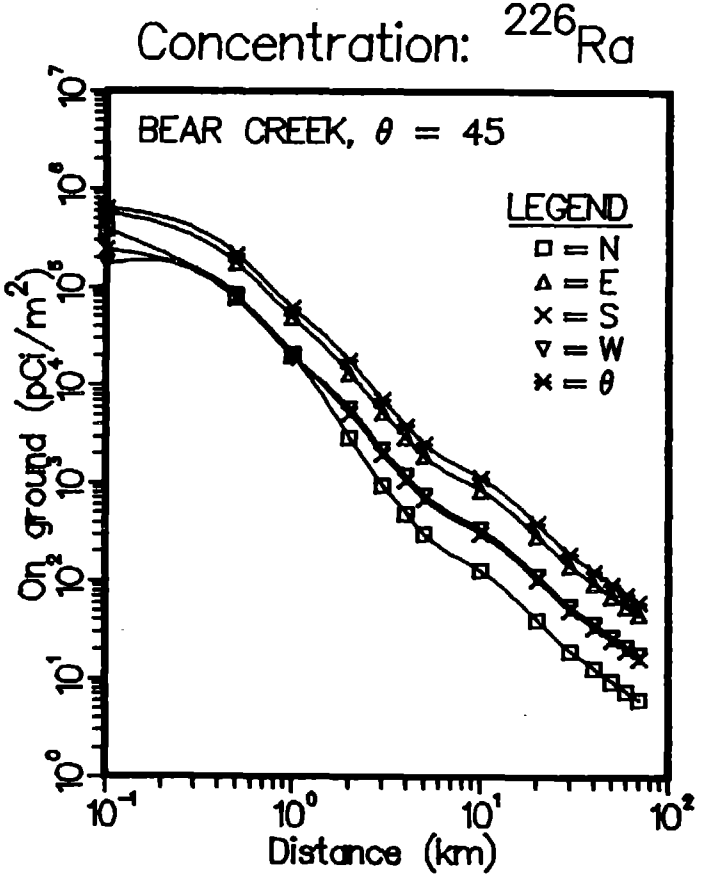


Fig. 11. Concentration of Ra-226 from All Sources on the Ground (pCi/m^2) Estimated from UDAD Code (1976).

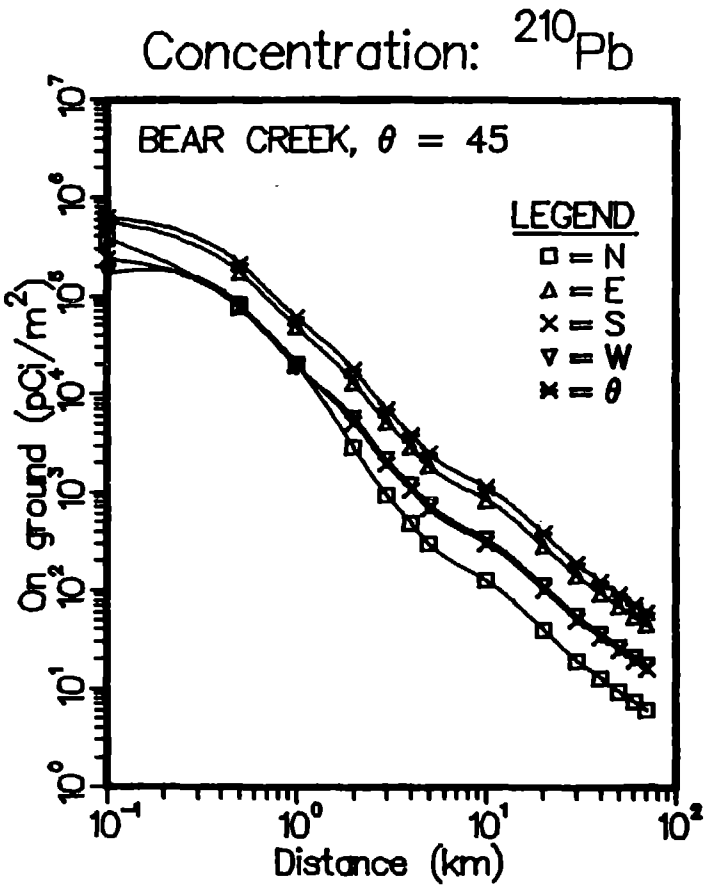


Fig. 12. Concentration of Pb-210 from All Sources on the Ground (pCi/m^2) Estimated from UDAD Code (1976).

Table 4.12. Total External Dose Rate (mrem/yr)[a]

Receptors	Skin	Whole Body	Ovaries	Testes	Small Intestine	Lung	Red Marrow	Skeleton	Spleen
North boundary	29	120	88	42	48	68	3.4	0.1	< 0.01
East boundary	54	230	160	78	73	100	5.1	0.01	< 0.01
South boundary	22	92	66	31	30	42	2.1	0.02	< 0.01
West boundary	18	74	53	25	22	31	1.5	0.01	< 0.01
Carson Ranch	0.02	0.07	0.05	0.02	0.02	0.02	0.01	< 0.01	< 0.01
Tillard Ranch	0.07	0.2	0.2	0.08	0.06	0.08	< 0.01	< 0.01	< 0.01
Reynold Ranch	0.1	0.5	0.4	0.2	0.1	0.15	0.01	< 0.0	< 0.01
Baker Ranch	0.05	0.2	0.13	0.06	0.04	0.05	< 0.01	< 0.01	< 0.01
Hornbuckle Ranch	0.1	0.40	0.3	0.14	0.1	0.1	< 0.01	< 0.01	< 0.01
Patterson Ranch	0.02	0.08	0.08	0.06	0.04	0.05	< 0.01	< 0.01	< 0.01
Manning Ranch	0.1	0.44	0.31	0.15	0.10	0.13	< 0.01	< 0.01	< 0.01
Hardy Ranch	0.03	0.09	0.07	0.03	0.03	0.03	0.02	< 0.01	< 0.01

[a]See Appendixes K-6 and K-7 for details.

Table 4.13. Dietary Component of the Radioactivities Released into the Environment at Bear Creek Mine and Mill

	U-238	U-234	Th-230	Ra-226	Pb-210
U. S. soil background (pCi/g)	2.2	2.2	3.2	1.8	0.85
Bear Creek contribution to soil (pCi/g)	9.5×10^{-4}	9.7×10^{-4}	9.7×10^{-5}	9.3×10^{-5}	0.2×10^{-5}
Percentage of natural soil background after 10 years	0.4	0.4	0.03	0.05	0.0023
Average dietary intake (pCi/day)	0.5	0.5	0	1.4	1.4
Bear Creek contribution* to dietary intake (pCi/day)	0.002	0.002	0	7×10^{-4}	4.2×10^{-5}

*Based on the assumption that the percentage increase in dietary intake of these radionuclides is proportional to the increase in the concentration of these radionuclides in soil over a ten-year period.

Potential lateral and vertical seepage[14-16] of liquids from the tailings (Alternative I, Section 10.4) are also dependent on the water content of the tailings after stabilization. Percolation of rainwater through the overburden ($\sim$ 20%) will continuously mobilize and remove a small fraction of the radium. The leachability of Ra-226 from tailings is dependent on the liquid-to-solid ratio and the chemical composition of the leaching solution[17-20] during processing of the ore in the mill; specifically the mobility of Ra-226 is dependent on Cl ion concentration.[18] Migration of the radioactive ions is inherently dependent on the mineralogy of the absorbent soil beneath the tailing impoundment.

The contribution of these metals to the groundwater concentration is difficult to estimate. A recent analysis by the applicant indicates that an average seepage rate of about 40 liters per minute from the tailings basin can be expected over the postulated 20-year pond life. Seepage through the dam is expected to be negligible. Vertical seepage could extend laterally to a distance on the order of 150 meters beyond the limits of the disposal area. When the groundwater aquifer is reached, contaminants are expected to move with the natural groundwater at a rate of about 2 m/yr and the contaminants may reach a distance of about 180 meters beyond the limits of the area during the design life of the disposal area.

Radium-226 has the lowest suggested maximum permissible concentration in water among all the radionuclides in uranium-238 decay series. The maximum estimated radium concentration in groundwater will be from complete mixing of the total soluble radionuclides in the groundwater. After 150 years, a maximum of 5 μCi Ra-226/day for each 1000 tons of processed ore is anticipated to mix into groundwater (see Stabilization and Reclamation Section 10.4). The concentration of Ra-226 in the groundwater is dependent on the groundwater flow rate (dilution factor). If the present prevailing hydrological conditions persist, the concentration of radium is not likely to exceed 0.1 of the MPC for drinking water, i.e., 3 pCi/l. This is less than the EPA guide of 5 pCi/l for drinking water. The concentration of the other radionuclides will be equal to or less than the Ra-226 concentration (see Section 10.4).

The nearest large body of water is Betty Reservoir, which is located about 18 km in the northeast direction. Estimations of the total increment of concentrations in the reservoir contributed by the Bear Creek Project is dependent on the watershed surface, surface runoff containing the ground deposited radionuclides, and surface water deposition. Bear Creek and its tributaries, a part of the Cheyenne River, drain about 250 km^2. The Bear Creek is impounded at Betty Reservoir, which has a surface area of 25,000 acres and contains an average of 2000 acre-feet of water. Direct surface deposition on water is estimated to be annually about 3 mCi of U-238, about 0.3 mCi of Th-230, and about 0.3 mCi each of Ra-226 and Pb-210. Assuming that there is no withdrawal or release of water from the reservoir in 20 years of operation, the incremental increase in the concentration in the reservoir is estimated to be about 1×10^{-2} pCi/ml of U-238, and 1×10^{-3} pCi/ml each of Th-230, Ra-226 and Pb-210. Estimation of the indirect contribution to the reservoir radioactivity by the watershed surface of 250 km^2 is difficult. It is therefore suggested that the concentrations in the water be monitored periodically.

4.8.5 Radiological Impact on Biota other than Man

Although no guidelines concerning acceptable limits of radiation exposure have been established for protection of other species than man, it is generally agreed that the limits for humans are also conservative for those species.[21-25] Doses to terrestrial biota, such as birds and mammals, due to gaseous effluents are quite similar to those calculated for man, and arise from the same dispersion pathways and considerations. For this reason, both the effluent concentrations and the dose rate computations discussed with respect to man are applicable to other biota.

Concentration of the radionuclides in North Platte River and the Cheyenne River introduced by surface deposition is very small (Appendix K). Exposure to aquatic organisms will be from that fraction of the radionuclide U-238 and its daughters that is water soluble. This is principally a consequence of physiological mechanisms that concentrate a number of elements that can be present in the aqueous environment. Values of relative biological accumulation factors (ratio of concentration of nuclide in organisms to that in the aqueous environment) of water-borne elements for several organisms are provided in the references.[21-28]

4.9 IMPACTS ON THE COMMUNITY

4.9.1 Physical Impacts

4.9.1.1 Pollutants

Construction activities during the early stages of site preparation include clearing of shrub and herbaceous vegetation, grading, and deep excavation. No trees will be removed. These activities will produce a variety of pollutants including noise, smoke, engine exhaust fumes, and dust.

These temporary disturbances will have essentially no impact because of the considerable distance to the nearest offsite human habitation. The remoteness of the project also ensures that pollutants resulting from continuing operation will have little impact on surrounding communities.

4.9.1.2 Vehicular Traffic

Onsite traffic will be managed by the development and regulation of a road system and parking areas that will facilitate smooth traffic flow. Roads in the vicinity of the plant site will be subjected to increased usage. This increase will primarily involve commuting workers but will also include the movement of some construction and operations vehicles. It is likely that some commuting workers will car pool, thus reducing the traffic increase that would otherwise occur.

Three kinds of impacts are expected from increased traffic. First, an increase in accident frequency may be expected, particularly during those periods of heaviest road use. Secondly, local residents will be inconvenienced by periodically heavy traffic on local roads. Thirdly, increased use of local roads and municipal streets, particularly Route 59 and Ross Road, may cause structural damage to these highway systems.

The staff is of the opinion that, because of the low volume of current traffic and the relatively small incremental traffic engendered by the Bear Creek project, this increase of vehicular traffic will cause no generally unacceptable road or traffic conditions.

4.9.2 Employment, Population, and Income

4.9.2.1 Employment

Table 4.14 shows total estimated employment for Converse County, assuming the proposed RMEC development is initiated. This total includes employment from the proposed gasification plant; subsequent figures and analyses also include gasification plant employment unless otherwise stated. Manpower forecasts by RMEC indicate that the final incremental employment due to the Bear Creek project will be relatively small, about 220 permanent operating employees. The following schedule shows the anticipated employment requirements for the project and those project employees assumed to live in Converse County.

	76	77	78	79	80	81	82	83	84
Employees									
Basic Construction	190	80	0	0	0	0	0	0	0
Mining-Processing	40	220	220	220	220	220	220	220	220
Employees living in Converse County									
Basic Construction	130	60	0	0	0	0	0	0	0
Mining-Processing	30	150	150	150	150	150	150	150	160

The capture rates for Converse County employees are assumed to be 70 percent for construction and mining-processing workers. The capture rates were estimated using the criteria outlined in Section 2.10.2.2.

4.9.2.2 Population

Table 4.15 depicts the incremental population for five political subunits, each expected to be affected by Bear Creek project employment. Similarly shown are total estimated population

Table 4.14. Estimates of Converse County Employment through 1985[a]
(includes Rocky Mountain Energy Company employment)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Permanent Basic Employment											
Agriculture	440	440	430	430	420	420	410	410	410	400	400
Mining and Processing	390	220	520	700	960	1,170	1,530	1,530	1,530	1,530	1,530
Other Basic	260	260	270	270	280	280	290	290	290	300	300
	1,090	920	1,220	1,400	1,660	1,870	2,230	2,230	2,230	2,230	2,230
Temporary (Construction)											
Basic Employment	30	870	1,390	1,800	1,930	1,730	900	0	0	0	0
Basic/Nonbasic Multiplier	1.8	1.1	1.0	.9	.9	1.0	1.2	1.5	1.5	1.6	1.6
TOTAL NONBASIC EMPLOYMENT	2,030	2,840	3,220	3,660	4,090	4,310	4,580	4,290	4,440	4,590	4,750
TOTAL EMPLOYMENT	3,150	4,630	5,930	6,860	7,680	7,910	7,710	6,520	6,670	6,820	6,980

[a]Sources: Wyoming Employment Securities Commission data for the first two quarters of 1975. Rocky Mountain Energy Company quarterly estimates of project employment Denver Research Institute projections of County employment.

Table 4.15. Projected Demographic Data for Selected Political Entities, as Influenced by the Proposed Bear Creek Project

Political Entity	1977[a]	1985[b]
Town of Douglas		
Population without proposed development	8,089	10,962
Incremental population with proposed development	337	615
TOTAL	8,426	11,577
Town of Glenrock		
Population without proposed development	2,646	3,455
Incremental population with proposed development	60	103
TOTAL	2,706	3,568
Converse County		
Population without proposed development	11,906	15,792
Incremental population with proposed development	500	741
TOTAL	12,406	16,533
Converse County School District #1		
School enrollments without proposed development	2,296	3,348
Incremental enrollments with proposed development	135	207
TOTAL	2,431	3,555
Converse County School District #2		
School enrollments without proposed development	812	1,104
Incremental enrollments with proposed development	19	36
TOTAL	831	1,140

[a]Rocky Mountain Energy Company peak construction force present.

[b]Anticipated termination of the Bear Creek Project.

increases due to the project and all other existing or planned resources developments. As with employment, the incremental population impacts due to the project are relatively small.

4.9.2.3 Income

Incomes for the employees of the proposed development are expected to be in the same range as those for employees associated with similar energy-related developments (see Sec. 2.10.2.3). This will reinforce the trend toward increased average incomes already noted in the county. By 1981, operations and construction personnel of new development projects will be added to the labor force, and the average weekly wage in Converse County will have increased to an estimated $245 (in 1975 dollars),[29] an increase of 19.4* percent over the 1975 average weekly wage of $205.[30] In 1985, the average weekly wage is estimated to be $221. The development profile used for employment projections does not indicate any major ongoing construction in 1985; if such were the case, the average weekly wage increase would be greater.

4.9.3 Social and Cultural Characteristics

The population influx associated with the proposed development will further contribute to the transition in Converse County from a rural, agriculture-based system to an industrial society. The type and trend of changes should be the same as those summarized in Table 2.23; the magnitudes of change attributable to the RMEC proposed development should be comparatively small. A distinctively unique impact associated with the RMEC development concerns the prospect of abandonment in 12 years--the presently predicted life of the project. This may be perceived as adding risk (and cost) to both public and private borrowing for housing and facilities. However, additional exploration or higher prices for uranium may add to the predicted life of the project.

No cultural resources of significant archeological, paleontological or historic value are known to occur on the project site. However, any undiscovered artifacts that may exist in the area could be disturbed and/or destroyed by project development.

4.9.4 Housing

The influx of project personnel will cause an increase in the number of new housing units needed, from roughly 3000 to 3225 (assuming 3.5 persons per dwelling unit). As discussed in Section 2.10.4, only a portion of these needs are likely to be met by the private housing developments without fundamental changes, e.g., changes in present relationships between production costs, worker incomes, or mortgage terms.

4.9.5 Government, Public Services, and Public Finance

Assessing impacts of a single new development on local public services and public finance is very dependent on (1) baseline assumptions concerning the population growth which would occur without the new development, and (2) the revenue structures of the public entities being impacted. New public facilities are needed (and thus capital outlays are required) only as the total population served by an impacted entity reaches certain "threshold" levels. Depending on their revenue sources and tax rates, local entities may or may not be able to obtain adequate revenues from a development to pay for the costs imposed.

Table 4.16 shows the projected public finance impacts associated with the proposed Bear Creek development.** The projections are based on the baseline population growth described in Section 2.10.2.2. The methodology and assumptions utilized in projecting revenues and expenditures are detailed in the Appendix F.

An indicated deficit or surplus or a net impact of a magnitude of tens of thousands of dollars is unlikely to be significant. The accuracy of the projections is not that precise, and most of

*Note: The 1981 increase in average weekly wages is greatly dependent on the expected presence of construction workers and their higher average incomes. However, the business communities of Douglas and Glenrock may not receive maximum possible benefits from this increased income, because people may travel to larger trade centers to make their purchases, or construction workers, present without families, may spend much of their income elsewhere.

**A degree of uncertainty is inherent in long-range financial projections. The projections described herein are "order of magnitude" estimates. Projections of the impacts of a single facility such as the proposed Bear Creek operation are also dependent on the assumptions of employment and phasing of other developments.

Table 4.16. Projected Financial Status of Selected Political Entities as Influenced by the Proposed Bear Creek Project Development (thousands of 1976 dollars)[a]

Political Unit	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Town of Douglas										
Total surplus or deficit with the proposed development	(1790)[b]	170	40	(180)	(210)	(240)	(220)	(100)	(220)	(220)
Total surplus or deficit without the proposed development	(1790)	150	(30)	(190)	(230)	(270)	(270)	(170)	(290)	(280)
Net impact	0	20	70	10	20	30	50	70	70	60
Town of Glenrock										
Total surplus or deficit with the proposed development	20	30	(70)	(40)	(60)	(70)	(60)	(80)	(100)	(100)
Total surplus or deficit without the proposed development	20	20	(70)	(60)	(60)	(70)	(50)	(60)	(70)	(70)
Net impact	0	10	0	20	0	0	(10)	(20)	(30)	(30)
Converse County										
Total surplus or deficit with the proposed development	(830)	(190)	(590)	(490)	(260)	230	810	1580	1750	1740
Total surplus or deficit without the proposed development	(830)	(140)	(530)	(550)	(310)	190	820	1580	1760	1760
Net impact	0	(50)	(60)	60	50	40	(10)	0	(10)	(20)
Converse County School District #1										
Total surplus or deficit with the proposed development	(330)	(2240)	(3290)	(3460)	(3110)	(1720)	90	2620	3110	3050
Total surplus or deficit without the proposed development	(330)	(2030)	(3080)	(3460)	(2910)	(1510)	300	2820	3310	3240
Net impact	0	(210)	(210)	0	(200)	(210)	(210)	(200)	(200)	(190)
Converse County School District #2										
Total surplus or deficit with the proposed development	(250)	(200)	(360)	(380)	(410)	(550)[c]	(490)	(400)	(360)	(380)
Total surplus or deficit without the proposed development	(250)	(160)	(310)	(380)	(390)	(350)	(310)	(370)	(350)	(350)
Net impact	0	(40)	(50)	0	(20)	(200)	(180)	(30)	(10)	(30)

[a]All figures are rounded to the nearest $10,000.

[b]Deficit is primarily due to water/sewer improvements needed by the Town of Douglas. See: Nelson Engineering, Town of Douglas, Water and Sewer Study, Douglas, Wyoming: City Clerk's Office, 1975.

[c]With the addition of RMEC, the enrollment threshold for building a new school was reached in 1981. The capital costs and the debt service for the new school result in relatively greater deficit for the district in that year.

the entities have large enough ad valorem tax bases to absorb such changes. Even at the county level, a deficit of $100,000 could be accommodated with a tax rate increase of less than one mill. The determination of the threshold beyond which such a deficit and resulting tax increase become a significant negative impact is very subjective.

As mentioned in Section 2.10.2.1, the construction and operation of the gasification plant is a matter of some uncertainty although it has been taken for granted by many in the community. Since its employment makes up such a large part of the increment anticipated in the baseline, the forecasts are quite sensitive to its presence.

Therefore, public finance impacts are also given in Table 4.17 for the RMEC proposed development both with and without a coal gasification project being considered.* The addition of the coal gasification development results in more serious financial problems for all three entities, particularly School District #1. Glenrock and School District #2 are not expected to be impacted by this coal gasification project.

4.9.5.1 Town of Douglas

Table 4.18 shows detailed financial projections for the Town of Douglas, taking into consideration the direct and indirect effects of the proposed RMEC development. The table is directly comparable to Table 2.24, which shows similar projections without effects due to the Bear Creek project.

The estimated population growth, attributable to development of the proposed project, is not sufficient to require major changes in the town's capital improvements program. Currently, capital expenditures by the town would not be affected prior to 1980, regardless of whether or not the proposed project is initiated. Total capital outlays during the period 1976 to 1985 are likely to be the same with or without project development. Thus, no new utilities construction can be attributed to the project, nor should utilities operating costs be affected.

Project related activities should indirectly generate additional town revenues. The most significant increases will be derived from sales taxes, utilities service charges, and utilities tap fees.

4.9.5.2 Town of Glenrock

Annual financial projections for the Town of Glenrock are given in Table 4.19, assuming RMEC project development, and thereby differing from projected values shown in Table 2.25. Project related changes in the town's capital improvement program should be relatively minor--$70,000 in capital expenditures for police and fire facilities and street projects will be needed approximately four years sooner than would otherwise be the case. However, utilities improvements will be needed regardless of whether the RMEC project is initiated. Some project related increases in town revenues should be noted, particularly in sales taxes, utilities service charges, and utilities tap fees.

4.9.5.3 Converse County

Table 4.20 shows financial projections for the County assuming project development and thereby differing from projected values shown in Table 2.26. As discussed in Section 2.10.5, the county is heavily reliant on property taxes as a source of revenue. Because of the time lag between the arrival of construction work forces and the accrual of increased property taxes from project-related home and facility construction, the financial status of the county will be temporarily and adversely affected since the influx of construction workers will necessitate immediate and proportionate increases in county operating expenditures. Annual financial deficits will be alleviated as revenues from project-related taxable properties increase.

The County would not need to build any additional capital improvements as a result of the Bear Creek development. The needed road improvements--namely, the paving of Ross Road to the site--are to be paid for by RMEC. Nevertheless, the lag between needs for additional public services and the delayed receipt of additional tax revenues should result in deficits (adverse impacts) of $190,000 to $590,000 per year (compared to deficits in a range of $140,000 to $550,000 without RMEC's development) until the county population growth rate levels off in 1981. From 1986 on, the budget projections show annual surpluses, which suggests that either taxes might be lowered or facilities and services improved.

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*See footnote in Section 2.10.2.1.

Table 4.17. Projected Financial Status of Selected Political Entities as Influenced by the Proposed Bear Creek Project Development (with and without considerations for a coal gasification development) (thousands of 1976 dollars)[a]

Political Unit	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
IMPACTS WITHOUT COAL GASIFICATION										
Town of Douglas										
Total surplus or deficit with the proposed development	(1790)[b]	100	(90)	(70)	(50)	(60)	(50)	(60)	(50)	(40)
Total surplus or deficit without the proposed development	(1790)	70	(120)	(110)	(80)	(90)	(100)	(100)	(90)	(100)
Net impact	0	30	30	40	30	30	50	40	40	60
Converse County										
Total surplus or deficit with the proposed development	(830)	40	30	20	10	40	80	70	(130)[c]	(160)[c]
Total surplus or deficit without the proposed development	(830)	90	70	30	0	60	50	30	20	0
Net impact	0	(50)	(40)	(10)	10	(20)	30	40	(110)	(160)
Converse County School District #1										
Total surplus or deficit with the proposed development	(330)	(1390)	(1430)	(1380)	(1470)	(1420)	(1400)	(1430)	(1450)	(1500)
Total surplus or deficit without the proposed development	(330)	(1200)	(1240)	(1410)	(1470)	(1420)	(1400)	(1420)	(1450)	(1470)
Net impact	0	(190)	(190)	30	0	0	0	(10)	0	(30)
IMPACTS WITH COAL GASIFICATION										
Town of Douglas										
Total surplus or deficit with the proposed development	(1790)	170	40	(180)	(210)	(240)	(220)	(100)	(220)	(220)
Total surplus or deficit without the proposed development	(1790)	150	(30)	(190)	(230)	(270)	(270)	(170)	(290)	(280)
Net impact	0	20	70	10	20	30	50	70	70	60
Converse County										
Total surplus or deficit with the proposed development	(830)	(190)	(590)	(490)	(260)	230	810	1580	1750	1740
Total surplus or deficit without the proposed development	(830)	(140)	(530)	(550)	(310)	190	820	1580	1760	1760
Net impact	0	(50)	(60)	60	50	40	(10)	0	(10)	(20)
Converse County School District #1										
Total surplus or deficit with the proposed development	(330)	(2240)	(3290)	(3460)	(3110)	(1720)	90	2620	3110	3050
Total surplus or deficit without the proposed development	(330)	(2030)	(3080)	(3460)	(2910)	(1510)	300	2820	3310	3240
Net impact	0	(210)	(210)	0	(200)	(210)	(210)	(200)	(200)	(190)

[a]All figures are rounded to the nearest $10,000.

[b]Parenthesis indicates a deficit.

[c]With the addition of RMEC, the population threshold for building a new hospital was reached. Since the rate of population increase is not maintained, it is unlikely that the county would build a completely new facility when an addition to present facilities would be adequate to provide service for the additional, estimated population in 1984-1985. This savings would be reflected in a lesser projected deficit in 1984 and 1985 than is shown in these numerical outputs.

Table 4.18. Projections of Needed Revenues and Expenditures, Town of Douglas
(includes considerations for the Bear Creek development)
(thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Town of Douglas										
Operating Revenues										
Ad valorem taxes	50	60	120	180	220	260	280	280	220	230
Sales, cig., gas taxes	190	300	400	470	520	540	510	410	410	420
Highway tax alloc.	0	0	0	0	0	0	0	0	0	0
Fed. rev. sharing	30	40	60	60	70	70	70	60	60	60
Utility serv. chg.	240	390	510	600	670	680	650	520	520	530
Other user chg.	40	80	110	120	140	140	140	110	110	110
St., cnty, pvt. con.	40	40	40	40	40	40	40	40	40	40
Miscellaneous	60	100	130	160	170	180	170	140	140	140
Total op. rev.	650	1010	1370	1630	1830	1910	1860	1560	1500	1530
Operating Expenditures										
General admin.	120	190	250	290	320	330	310	250	250	260
Police & Fire	180	280	370	460	510	530	500	380	380	390
Streets	50	90	120	140	160	160	160	120	120	130
Health, welfare, rec.	50	80	110	130	140	150	140	110	110	110
Utilities	290	360	610	660	780	790	770	620	620	620
Miscellaneous	30	50	60	70	80	80	70	60	60	60
Total op. exp.	720	1050	1520	1750	1990	2040	1950	1540	1540	1570
Surplus/deficit	-70	-40	-150	-120	-160	-130	-90	20	-40	-40
Capital Revenues										
Ad valorem taxes	80	90	190	270	330	390	410	420	340	340
Utility tap fees	50	450	390	260	220	60	0	0	20	20
Other cap. rev.	140	0	0	20	20	60	80	80	80	80
Total cap. rev.	270	540	580	550	570	510	490	500	440	440
Capital Expenditures										
Admin.-capital	0	90	0	0	0	0	0	0	0	0
Police & Fire	0	40	70	10	70	0	0	0	0	0
Streets	0	40	20	20	20	0	0	0	0	0
Parks, rec., libry.	0	40	60	0	0	0	0	0	0	0
Utilities	1990	1300	0	2000	0	0	0	0	0	0
Miscellaneous	0	10	400	0	0	0	0	0	0	0
Total cap. exp.	1990	1520	550	2030	90	0	0	0	0	0
Cap. Debt Service	170	330	390	610	620	620	620	620	620	620
Surplus/deficit	-1720	210	190	-60	-50	-110	-130	-120	-180	-180
Total surplus/deficit	-1790	170	40	-180	-210	-240	-220	-100	-220	-220

Table 4.19. Projections of Needed Revenues and Expenditures, Town of Glenrock
(includes considerations for the Bear Creek development)
(thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Town of Glenrock										
Operating Revenues										
Ad valorem taxes	10	10	10	20	20	20	20	30	30	30
Sales, cig., gas taxes	100	120	130	140	140	140	150	150	150	150
Highway tax alloc.	0	0	0	0	0	0	0	0	0	0
Fed. rev. sharing	10	10	10	10	10	10	10	10	10	10
Utility serv. chg.	150	160	170	190	200	200	200	210	210	210
Other user chg.	0	0	0	0	0	0	0	0	0	0
St., cnty, pvt. con.	20	20	20	20	20	20	20	20	20	20
Miscellaneous	40	50	50	60	60	60	60	60	60	60
Total op. rev.	330	370	390	440	450	450	460	480	480	480
Operating Expenditures										
General admin.	70	80	80	90	90	90	90	100	100	100
Police & Fire	80	90	100	100	110	110	110	120	120	120
Streets	30	30	40	40	40	50	50	50	50	50
Health, welfare, rec.	10	10	10	10	10	10	10	20	20	20
Utilities	100	110	120	130	140	140	140	150	150	150
Miscellaneous	10	10	10	10	10	10	10	10	10	10
Total op. exp.	300	330	360	380	400	410	410	450	450	450
Surplus/deficit	30	40	30	60	50	40	50	30	30	30
Capital Revenues										
Ad valorem taxes	10	10	20	20	20	30	30	30	30	30
Utility tap fees	10	30	30	30	20	10	10	20	0	0
Other cap. rev.	0	0	0	0	0	0	0	0	0	0
Total cap. rev.	20	40	50	50	40	40	40	50	30	30
Capital Expenditures										
Admin.-Capital	0	50	0	0	0	0	0	0	0	0
Police & Fire	0	10	0	0	0	0	0	50	0	0
Streets	0	50	0	0	0	0	0	20	0	0
Parks, rec., libry.	0	0	0	0	0	0	0	0	0	0
Utilities	30	50	1000	0	0	0	0	0	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0
Total cap. exp.	30	160	1000	0	0	0	0	70	0	0
Cap. Debt Service	30	50	150	150	150	150	150	160	160	160
Surplus/deficit	-10	-10	-100	-100	-110	-110	-110	-110	-130	-130
Total surplus/deficit	20	30	-70	-40	-60	-70	-60	-80	-100	-100

Table 4.20. Projections of Needed Revenues and Expenditures, Converse County (includes considerations for the Bear Creek development) (thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Converse County										
Operating Revenues										
Ad valorem taxes	1130	1150	1230	1480	1830	2270	2700	3080	3240	3250
Sales, cig., gas tax	100	140	170	200	220	220	210	180	190	190
Royalties	50	60	80	90	100	100	90	80	80	80
Health serv. fee	350	480	600	680	740	760	730	630	640	640
St. welfare fund	0	0	0	0	0	0	0	0	0	0
Grants	20	20	20	20	20	20	20	20	20	20
Fees & misc.	110	160	200	230	250	250	240	210	210	210
Total op. rev.	1760	2010	2300	2700	3160	3620	3990	4200	4380	4390
Operating Expenditures										
General admin.	530	660	770	840	900	910	890	800	810	810
Sheriff, rural fire	180	240	290	320	350	360	350	310	310	320
Library	100	140	170	190	210	220	210	180	180	180
Health & hospital	550	760	940	1070	1180	1200	1160	990	1010	1020
Roads & bridges	390	540	660	750	820	840	810	700	710	720
Welfare	120	160	200	230	250	260	250	210	220	220
Aid-schls/munic.	20	20	20	20	20	20	20	20	20	20
Misc.	70	100	120	140	150	150	150	130	130	130
Total op. exp.	1960	2620	3170	3560	3880	3960	3840	3340	3390	3420
Surplus/deficit	-200	-610	-870	-860	-720	-340	150	860	990	970
Capital Revenues										
Ad valorem taxes	280	280	300	360	450	560	660	750	790	800
Fed. rev. sharing	120	160	200	230	250	250	240	210	210	210
Total cap. rev.	400	440	500	590	700	810	900	960	1000	1010
Capital Expenditures										
Admin./judicial	570	0	0	0	0	0	0	0	0	0
Sheriff & fire	50	0	0	0	0	0	0	0	0	0
Hospl's & ment. hlth	80	0	1440	0	50	0	0	0	0	0
Roads & bridges	240	0	210	0	0	0	0	0	0	0
Other	90	0	230	0	130	0	0	0	0	0
Total cap. exp.	1030	0	1880	0	180	0	0	0	0	0
Cap. debt serv.	20	20	220	220	240	240	240	240	240	240
Surplus/deficit	-630	420	280	370	460	570	660	720	760	770
Total surplus deficit	-830	-190	-590	-490	-260	230	810	1580	1750	1740

4.9.5.4 Converse County School District #1

Like the county, the school district relies heavily on property taxes as a source of revenue. Table 4.21 shows financial projections for the school district budget including considerations for the proposed RMEC development, thereby differing with projected values shown in Table 2.27. The estimated additional enrollment, due to project development, is sufficient to require an additional school be built by the district. The lag between need for increased school operation funding and delayed receipt of revenues from new taxable properties should result in operating deficits for the school district until the population growth rate levels off in 1981, with or without the proposed project. The total annual deficits, including capital costs, is somewhat greater with the development through 1981.

4.9.5.5 Converse County School District #2

Table 4.22 depicts financial projections for Converse County School District #2, taking into consideration the effects of the proposed development, thus differing from the projected values shown in Table 2.28. Increased student enrollments attributed to the proposed development are not sufficient to affect total capital expenditures for the district. The time lag between expenditure needs and delayed receipt of revenues from new taxable properties also affects District #2. Annual deficits, with the RMEC development, range from $200,000 to $550,000 over the period 1976 to 1985 as compared to deficits of $130,000 to $390,000 without the proposed development, over the same time period.

4.9.6 Availability of Other Goods and Services

Expanded provision of public and private (or jointly furnished) goods and services during a period of rapid population growth is often inadequate in small western communities. This has been the case in Gillette, Rock Springs, and Green River, Wyoming.[31] The problem is particularly serious with respect to health services; publicly and/or privately furnished facilities are generally inadequate and numbers of support personnel, physicians and other professionals are insufficient to meet increased needs.

4.9.7 Summary

The total adverse impacts that could result from all ongoing and planned developments in the area--including the proposed Bear Creek development--are potentially substantial. It is not practicable to precisely allocate proportionate shares of these impacts, but the contribution due to the RMEC project is evidently small in relation to the total potential impacts. The financial impacts resulting from RMEC development vary among the public entities having jurisdiction in the area.

Fortunately, most project-related socioeconomic impacts, including those from the RMEC project, are mitigable. However, the allocation of impacts to individual projects (and to individual jurisdictions) is difficult, and the responsibility for mitigation is broadly diffused. The importance of a coordinated, joint effort by incoming industrial developers and other parties-at-interest should be emphasized in order to mitigate the adverse impacts of the aggregate population influx.

Table 4.21. Projections of Needed Revenues and Expenditures, Converse County School District #1 (includes considerations for the Bear Creek development) (thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Converse County School District No. 1										
Operating Revenues										
Ad valorem taxes	2880	3110	3430	4310	5520	7020	8460	9540	10080	10090
St. liqdn fund	0	0	0	0	0	0	0	0	0	0
St. trans. funds	0	0	0	0	0	0	0	0	0	0
Other st. funds	110	180	230	280	310	320	310	250	250	260
P.L. 81-874	0	0	0	0	0	0	0	0	0	0
Other fed. funds	150	0	0	0	0	0	0	0	0	0
Miscellaneous	260	430	570	680	770	790	760	610	620	630
Total op. rev.	3400	3720	4230	5270	6600	8130	9530	10400	10950	10980
Operating Expenditures										
Instruction-op.	1860	3140	4160	4950	5600	5790	5580	4450	4520	4590
Transportation	120	200	270	320	360	370	360	280	290	290
Admin. & misc.	1300	1700	2010	2260	2460	2520	2450	2100	2120	2140
Total op. exp.	3280	5040	6440	7530	8420	8680	8390	6830	6930	7020
Surplus/deficit	120	-1320	-2210	-2260	-1820	-550	1140	3570	4020	3960
Capital Revenues										
Ad valorem taxes	230	230	250	320	420	540	660	760	800	800
Other cap.	0	0	0	0	0	0	0	0	0	0
Total cap.	230	230	250	320	420	540	660	760	800	800
Capital Expenditures										
Capital (school)	470	7600	1600	1600	1600	0	0	0	0	0
Capital (other)	210	30	30	30	0	0	0	0	0	0
Total cap. exp.	680	7630	1630	1630	1600	0	0	0	0	0
Cap. debt serv.	270	1150	1330	1520	1710	1710	1710	1710	1710	1710
Surplus/deficit	-450	-920	-1080	-1200	-1290	-1170	-1050	-950	-910	-910
Total surplus/deficit	-330	-2240	-3290	-3460	-3110	-1720	90	2620	3110	3050

Table 4.22. Projections of Needed Revenues and Expenditures, Converse County School District #2 (includes considerations for the Bear Creek development) (thousands of 1976 dollars)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Converse County School District No. 2										
Operating Revenues										
Ad valorem taxes	1160	1090	1070	1090	1120	1170	1250	1440	1460	1460
St. liqdn fund	0	0	0	0	0	0	0	0	0	0
St. trans. funds	0	0	0	0	0	0	0	0	0	0
Other st. funds	60	60	70	70	80	80	80	80	90	90
P.L. 81-874	0	0	0	0	0	0	0	0	0	0
Other fed. funds	70	30	40	40	40	40	40	40	50	50
Miscellaneous	130	140	160	160	170	170	180	190	190	190
Total op. rev.	1420	1320	1340	1360	1410	1460	1550	1750	1790	1790
Operating Expenditures										
Instruction-op.	770	840	970	1010	1060	1070	1100	1180	1190	1200
Transportation	50	50	60	60	70	70	70	70	70	70
Admin. & misc.	460	490	530	540	560	570	570	600	600	610
Total op. exp.	1280	1380	1560	1610	1690	1710	1740	1850	1860	1880
Surplus/deficit	140	-60	-220	-250	-280	-250	-190	-100	-70	-90
Capital Revenues										
Ad valorem taxes	280	280	280	290	290	290	290	290	300	300
Other cap.	30	30	30	30	30	30	30	30	30	30
Total cap.	310	310	310	320	320	320	320	320	330	330
Capital Expenditures										
Capital (school)	680	1530	0	0	0	1600	0	0	0	0
Capital (other)	20	30	30	0	0	0	0	0	0	0
Total cap. exp.	700	1560	30	0	0	1600	0	0	0	0
Cap. debt serv.	280	450	450	450	450	620	620	620	620	620
Surplus/deficit	-390	-140	-140	-130	-130	-300	-300	-300	-290	-290
Total surplus/deficit	-250	-200	-360	-380	-410	-550	-490	-400	-360	-380

References for Section 4

1. "Investigations of Fugitive Dust--Sources, Emissions, and Control," Publication TD-1582, U. S. Environmental Protection Agency, Research Triangle Park, N. C., 1973.

2. "Wyoming Air Quality Standards and Regulations," Department of Environmental Quality, Division of Air Quality, Cheyenne, Wyoming, 22 pp., 1975.

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5. ENVIRONMENTAL EFFECTS OF ACCIDENTS

The occurrence of accidents related to the operation of the Bear Creek project will be minimized through proper design, manufacture, and operation, as well as a quality assurance program designed to establish and maintain safe operations. In accordance with the procedures set forth in the appropriate regulations, the applicant has submitted applications containing descriptions of the facility design, the organization of the operation, and the quality assurance program. These documents, together with the environmental report and supplements thereto, have been reviewed by the agencies. Moreover, the agencies will maintain surveillance over the project and its individual safety systems by conducting periodic inspections of the facility and its records, and by requiring reports of effluent releases and deviations from normal operations.

Notwithstanding the above precautions, accidents involving the release of radioactive materials or harmful chemicals have occurred in operations similar to those proposed by the applicant. Therefore, accidents which might occur during operations have been conceptualized and the potential environmental impact of these postulated accidents evaluated. Both the nominal consequences and corresponding probabilities of occurrence have been assessed using best available estimates of probabilities and realistic release and transport assumptions. However, where doubt existed or information adequate for realistic evaluations was unavailable, very conservative assumptions were used to compute environmental impacts. Thus, the actual environmental effects from the accidents that are postulated would be, in many cases, significantly less than those predicted by this assessment.

5.1 ACCIDENTS INVOLVING RADIOACTIVITY

5.1.1 Mine Accidents

The Bear Creek project involves open pit mining of uranium ore; radon-222 diffusing from such exposed ore bodies would be rapidly dissipated and diluted in the atmosphere. Open pit mining thus reduces the exposure of mining personnel to radon gas while slightly increasing the exposure of the general public. The radiological exposure to the general public resulting from normal gaseous emissions during routine mining and milling operations was evaluated in Section 4.8. Various mining accidents could result in an increased release of radioactivity, but none of the postulated accidents would approach mill accidents in the quantities released. This results from the segregation of the ore on the mill pads, the concentration of activity in the yellowcake, and the extent of the tailings pond. Mine accidents consequently have been subsumed under mill accidents discussed below.

5.1.2 Mill Accidents

The specific activities of the radioactive materials handled at the mill are very low; i.e., $\sim 10^{-10}$ Ci/gm for the tailings, $\sim 10^{-9}$ Ci/gm for the ore, and $\sim 10^{-6}$ Ci/gm for the refined yellowcake product.* The quantities of materials handled, on the other hand, could be relatively large; i.e., as much as 500 MT of yellowcake per year, representing about 300 Ci of radioactivity.

The very low specific activities require the release of exceedingly large quantities of material in order to be of concern; driving forces for such releases are generally lacking at the Bear Creek mill.

Guidelines have not been published for the consideration of accidents at uranium mills. Therefore, the postulated plant accidents involving radioactivity are considered here in the following three categories:[1]

*In contrast to the relatively high specific activities of a number of prominent radionuclides, i.e., $\sim 10^{-1}$ Ci/gm for ^{239}Pu and $\sim 10^{-3}$ Ci/gm for ^{60}Co.

1. Trivial incidents; i.e., those not resulting in a release to the environment.
2. Small releases to the environment (relative to the annual release from normal operations).
3. Large releases to the environment (relative to the annual release from normal operations).

Trivial incidents include spills, ruptures in tanks or plant piping containing solutions or slurries, failures of the centrifuge used for yellowcake dewatering, and rupture of a tailings disposal system pipe in which the tailings slurry is released into the tailings pond. Small releases include failure of the air cleaning system serving the concentrate drying and packaging area, a fire or explosion in the solvent extraction circuit, and a gas explosion in the yellowcake drier. Large releases include a major tornado strike and releases to the watercourse from the tailings pond or tailings distribution system.

In most cases for which a postulated accident results in a release to the environment, the estimated magnitude of the release, the corresponding maximum individual dose at the site boundary or the closest residence, the total population dose, and the estimated annual likelihood of occurrence are presented below. The likelihoods are estimates based on a diversity of sources, including incidents on record, chemical industry statistics, and failure prediction methodologies. Data and models for the behavior of radioactivity in accident situations were taken from NRC Regulatory Guides,[2] from NRC reports,[3] and from the International Commission on Radiological Protection.[4]

During the three decades of nuclear facility operation, the frequency and severity of accidents have been markedly lower than those in related industrial operations. The experience gained from the few accidents that have occurred has resulted in improved engineering safety features and operating procedures, and the probability that similar accidents might occur in the future is very low. Based on past experience, it is believed that even if major accidents did occur, there would probably not be a significant release of contamination offsite, and radiation exposures would be too small to cause any observable effect on the environment or any deleterious effect on the health of the human population.

5.1.2.1 Trivial Incidents

The following accidents, due to human or equipment failure, would not result in the release of radioactive material to the environment.

Leaks or Rupture in Tanks or Piping

Uranium-bearing slurries and solutions will be contained in several tanks comprising the acid leach, washing and clarification, and solvent extraction stages of the mill circuit. Human error during the filling or emptying of tanks or the failure of valves or piping in the circuit would result in spills which might be expected to occur several times annually during operations. Large spills from tank failures or uncorrected human error might involve the release of several hundred pounds of uranium in the liquid phase to the room. However, the entire content of the tanks would be contained within the mill sumps and therefore would not reach the environment.

Centrifuge Failure

Prior to drying, the thickened yellowcake slurry will be dewatered by the use of a centrifuge. The centrifuge will be located on a cement slab approximately five feet from a small thickener and ten feet from a flocculent surge tank. If the centrifuge rotor were to fail, it could conceivably penetrate the thickener and release yellowcake slurry to the room. However, the entire contents of the thickener would be contained by dikes constructed around the tank and therefore would not reach the environment.

Rupture of a Pipe in the Tailings Disposal System

At the design milling rate of 1000 tons of ore per day, approximately 40 tons per hour of sand, silt, and clay-sized particles will be transported to the tailings pond through the tailings disposal system piping. This material, transported as a slurry ($\sim$ 50% water), will contain mill chemicals and radioactive materials. Ruptures in the piping would be expected to occur; however, the majority of the length of the piping will parallel the tailings pond. Accordingly, the flow of the slurry released from the system would be toward the tailings pond where it would be contained along with the existing tailings material. Should a rupture occur in the length of piping between the mill and the tailings area, the slurry could conceivably reach the watercourse. This case is considered in Section 5.1.2.3.

5.1.2.2 Small Releases

The following accidents, due to human or equipment failure, would release small quantities of radioactive materials to the environment. The estimated releases, however, are expected to be small in comparison with the annual release from normal operations.

Failure in the Air Cleaning System Serving the Yellowcake Drying Area

The off-gases from the drying operation, which contain entrained solid particulates of yellowcake, will pass through a wet scrubber which is expected to collect from 90 to 99+% of the solid material, dependent upon particle size. The emission rate to the scrubber will be approximately 1.4 lb/hr of uranium oxide.[5] Should the scrubber fail completely, the total emissions could be released to the environment. Although stack monitoring for uranium will be performed routinely, the circuit also will be checked every one-half hour as a part of the formal plant procedures.[5] A drop in pressure would indicate failure of the scrubber, in which case operations would be terminated until the scrubber is repaired. If the failure occurred during daylight hours, the plume would be visible to an observer.

For purposes of analysis, it is assumed that the scrubber totally fails to function during the night shift and that the pressure goes unchecked for the entire shift. This would result in the release to the environment of approximately 10 pounds of insoluble uranium oxide particles, assumed to be in the respirable size range. For this magnitude of release, it is conservatively estimated that an individual at the closest residence would receive a 50-year dose commitment to the lung of approximately 6×10^{-5} rem.

Although quantitative data are unavailable, catastrophic scrubber failure will be highly unlikely. Progressive failure, in which case the plugging of vents causes back pressure, will be readily detectable during operational checks and will produce inefficiencies, rather than complete failure.

Fire or Explosion in the Solvent Extraction Circuit

The solvent extraction circuit will be in a separate building and will contain 48,000 gallons of solvent (95% kerosene, 3% amine and 2% isodeconol) and 1300 pounds of yellowcake.[5] Major fires have occurred in solvent extraction circuits of uranium mills in recent history.[6] The tanks containing the solvent will be fitted with sprinkler systems containing an extinguishing agent. According to the applicant, in the event of a fire the solvent would be contained in the tank while the aqueous solution would be allowed to overflow to an emergency containment area.

In the event of a major fire, it is conservatively assumed from previous estimates[7,8] relating to both uranium and plutonium solutions that as much as 1% of the uranium would be dispersed.* This would result in the ultimate release to the environment of approximately 11 pounds of soluble uranium. The maximum individual 50-year dose commitments at the closest residence resulting from this accident are estimated to be roughly 1×10^{-3} rem to the bone and 1×10^{-4} rem to the whole body.

From chemical industry data, the probability of a major fire per plant-year is estimated to be 4×10^{-4}.[7] However, at least two major solvent extraction circuit fires are documented in the literature.[6] There have been approximately 540 plant-years of mill operation in the U. S., or the equivalent of 370 plant-years for mills with the capacity of Bear Creek (330,000 MT ore/yr). Thus, from the historical incidents, the likelihood of a major solvent extraction fire is in the range of 4 to 5×10^{-3}/plant-year. Using these two estimates to bracket the probability, the likelihood of a major solvent extraction fire at the Bear Creek mill is assumed to fall in the range of 4×10^{-4} to 4×10^{-3} per year.

Gas Explosion in the Yellowcake Drying Operation

A propane-fired furnace will be used to remove the water remaining in the yellowcake slurry after the centrifuge operation. The furnace, which will consist of four tiers of hearths enclosed in a 4-1/2 ft diameter cylinder, will be contained in an isolated enclosed area on a concrete slab. The inventory of yellowcake in the drier will be approximately 1600 pounds.[5] The off-gas from the drier, as discussed earlier, will be ventilated through a wet scrubber. An explosion in the drier or the propane piping, however, could blow off the duct work associated with the ventilation system and disperse yellowcake into the room.

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*It is estimated that a smaller fraction of the uranium inventory would be released to the room, and subsequently to the environment, in the event of an explosion.

The consequences of explosion accidents are limited by the concentration of heavy material that can be maintained in the air, estimated to be approximately 100 mg/m^3.[7] Then, for a room volume assumed to be on the order of 10^4 m^3, the quantity of uranium released to the room air is estimated to be approximately 1000 gm. Conservatively assuming that all of the uranium would be swept out into the environment when the room is ventilated, and that 100% of the insoluble particles are in the respirable size range, it is estimated that an individual at the closest residence would receive a 50-year dose commitment to the lung of approximately 7×10^{-5} rem. The corresponding total population 50-year dose commitment is estimated to be roughly 1×10^{-2} man-rem to the lung.

No quantitative data have been found relating either to propane or natural gas furnace explosions. Failure rates observed for piping used in the transmission of natural gas have been converted to equivalent failure rates per plant year.[9] The result of this analysis yields approximately 5×10^{-3} failures per plant year. This is likely to constitute an upper limit of the likelihood of a gas explosion because it is based upon a generous estimate of 170,000 feet of piping per plant and does not take into account the probability of ignition rather than explosion, given a failure.

5.1.2.3 Large Releases

The following accidents might release large quantities of radioactive materials to the environment compared with the annual release from normal operations. By virtue of complex and highly variable dispersion characteristics, however, the individual impacts will not necessarily be proportional to the total amount of radioactivity released to the environment.

Tornado

The frequency of occurrence of a tornado in the 1° square in which the Bear Creek Project is located is approximately 3×10^{-4}/year.[10] The area is categorized as Region 3 in relative tornado intensity.[11] For this category, the wind speed of the "design" tornado is 240 miles/hr, of which 190 miles/hr is rotational and 50 miles/hr is translational. None of the mill structures are designed to withstand a tornado of such an intensity.

The nature of the operation is such that little more could be done to secure the facility with advance warning than without it. Accordingly, a "no warning" tornado was postulated. Moreover, since it is not possible to accurately predict the total amount of material dispersed by the tornado, a highly conservative approach was adopted, in which a total of 5 tons was assumed to be lifted by the tornado.[12] Since the yellowcake product has the highest specific activity of any material handled at the mill, and as much as 20 tons of product may be accumulated prior to shipment, it is assumed that the tornado lifts 10,000 pounds of yellowcake.

A conservative model, which assumed that all of the yellowcake is in respirable form, was used for the dispersion analysis.[13] The model assumes that all of the material is entrained as the vortex passes over the site. Upon reaching the site boundary, the vortex dissipates, leaving a volume source to be dispersed by the trailing winds. The material is assumed to be in a source representative of the velocities of the tornado, and disperses through an arc of 90° containing the maximum population density in the vicinity of the site. Due to the small particle sizes assumed, the settling velocity is assumed to be negligible.

The model predicts a maximum uranium concentration of approximately 5×10^{-8} gm/m^3 for 100 seconds at a distance of roughly two miles from the mill. The maximum exposure, however, is at a distance of approximately six miles from the mill, where 50-year dose commitment to the lung of an individual is estimated to be approximately 2×10^{-7} rem.

Release of Tailings Slurry

The underflow from the fifth thickener of the washing and clarification step in the milling circuit will be pumped to the tailings disposal pond. Approximately 1000 tons per day of sand, silt, and clay-sized particles entrained in approximately an equal weight of solution will constitute the tailings slurry. Over the projected life of the milling operation, approximately 3.3 million tons of barren tailings will be generated and retained on the 150-acre disposal site. Inadvertent release of the tailings slurry to the environment might result from an overflow of the tailings slurry, a rupture in the tailings distribution piping, or a failure of the tailings dam. Failure of the tailings dam could be attributed to a destructive earthquake, flood-water breaching, or structural failure.

For the anticipated rates of precipitation during the life of the mill, the tailings pond could overflow only if the processing system were allowed to operate unattended for several weeks. In

actuality, the pool level will be inspected frequently and the system would be turned off to prevent overflowing.

A minimum of five feet of freeboard will be provided, which is approximately 650 acre-feet of emergency storage. According to the applicant, the predicted runoff, with diversion ditches installed, to the tailings pond from the postulated 100-year storm is 64 acre-feet. Moreover, assuming failure of the diversion ditches and the occurrence of two 100-year storms, the applicant predicts that only 300 acre-feet of water would be input to the tailings pond. An independent analysis[14] of the tailings impoundment concludes that the dam would not be overtopped by the 100-year flood or by one-half of the probable maximum precipitation event.*

Failure of the tailings dam due to an earthquake would be unlikely since the site is in the Zone One, "minor damage" seismic risk category (intensities V to VI on the Modified Mercalli Scale).[15] Test borings and evaluation of soil parameters by the applicant indicate that the dam would have adequate stability under a ground acceleration of 0.05 times gravity. Under the Uniform Building Code, a maximum ground acceleration of 0.05 g is anticipated in Zone 2 (intensities VI to VII on the Modified Mercalli Scale). Within a 150-mile radius of the Bear Creek site, an earthquake of intensity VII on the Modified Mercalli Scale has only occurred once within the past 100 years, centered in Casper in 1897.

From the foregoing discussion, it appears that a natural disaster of sufficient intensity to result in a release of the tailings slurry to the environment would occur on a frequency of less than once in a hundred years. Even if the frequency were known accurately, however, it would be difficult to predict the magnitude of the release. However, tailings slurry releases have occurred in the past, and the consequences associated with these events have been documented to varying levels of detail in reports to the NRC (AEC) and will be used to estimate the nominal Bear Creek release. Table 5.1 contains a summary of recorded incidents in the period 1959 to 1971.[6]**

Table 5.1. Summary of Accidental Tailings Slurry Releases in Period 1959 to 1971

Cause	Solids Released, kg	Liquids Released, liters	Reached Watercourse
Flash flood	14×10^6	1.2×10^7	Yes
Dam failure	9×10^5[a]	9.1×10^5	Yes
Dam failure	5×10^5	4×10^5[a]	No
Dam failure	2×10^5	2×10^5[a]	Yes
Pipeline failure	3×10^5	2×10^5	Yes
Flooding	1×10^6[a]	8.7×10^7	Yes
Pipeline failure	6.4×10^4[a]	6.1×10^4	Small amount
Flooding	2×10^6[a]	1.7×10^6	Yes
Dam failure	$1\text{-}14 \times 10^6$[a]	$1\text{-}11 \times 10^6$	Yes
Pipeline failure	1×10^5[a]	1.3×10^5	Yes
Dam failure	9×10^3[a]	8×10^3	No
Pipeline/dam failure	No quantitative information		No

[a]Assuming equal weights of solids and liquids released and density of liquids approximately 1.1 kg/liter.

*Based on estimates of rainfall, hydrograph shape, peak discharge, and flood volume that will produce the most severe flood that would be reasonably possible.

**A recent release occurred at the United Nuclear/Homestead uranium mill in New Mexico.

From these historical data, the average release from tailings dam failure or flooding was approximately 1.5×10^7 liters of liquids and 1.8×10^7 kg of solids. Nine out of twelve of the releases for which data are available reached the watercourse, and of the total of 12 recorded incidents, eight involved dam failure or flooding. Thus, considering the 287 mill-years of operation in the period, the likelihood of release from the tailings pond to the watercourse is approximately 2×10^{-2} per plant-year. This is a conservative estimate of tailing impoundment failure, since the evaluation of early dike construction led to a determination that dikes need strengthening. Mills having dikes similar in construction to those that failed were required to strengthen the dikes, and new mills are required to conform to strict construction standards.

As discussed in Section 5.1.2.1, most failures in the tailings distribution piping would result in release of the slurry to the tailings pond and not to the environment. However, if the failure were to occur in the length of piping between the mill and the tailings area, the slurry could conceivably reach the watercourse. From the historical data given in Table 5.1, the average release to the watercourse from piping failures was approximately 5.2×10^5 liters of liquids and 6.2×10^5 kg of solids. Furthermore, on the same basis as the dam failure estimate, the likelihood of tailings release from failure of the piping is roughly 1×10^{-2} per plant-year. Since both the historical consequences and likelihood of piping failures are lower than those of dam failures, only releases from dam failures or flooding will be considered in the discussion of the impact of a tailings slurry release that follows.

The solid tailings will be coated with acid solution and are predicted to have a radiological composition of approximately 9.6 μCi/ton of U-238, 9.5 μCi/ton of U-234, 190 μCi/ton of Th-230, and 130 μCi/ton of Ra-226. Because of losses due to seepage, evaporation from the disposal area, and entrapment in the tailings solids, the composition of the liquid phase is difficult to predict. In addition to dissolved minerals from the ore, the tailings solution will contain trace quantities of the components of the organic phase of the solvent extraction step in the milling circuit. Table 5.2 gives the predicted composition of th tailings solution from combined estimates and experiments conducted by the applicant.[16]

Table 5.2. Concentrations of Radionuclides and Chemicals in Tailings Solution[a]

Radionuclide	Concentration, μCi/ml
U-238	2.4×10^{-7}
U-234	2.4×10^{-7}
Th-230	1.2×10^{-4}
Ra-226	1.7×10^{-7}
Chemical	**Concentration, mg/l**
SO_4	700
Fe	1300
Na	280
K	63
Mg	320
Ca	570
Al	240
As	1.1
Kerosene	6.9
Amines	0.42
Alcohol	0.21

[a]Based upon the applicant's measurements in a snythetic raffinate.[16]

The estimated 1.8×10^7 kg of solid tailings released from the impoundment area in the event of an overtopping or failure of the dam would be expected to settle out below the dam. The extent of the area covered would depend upon the details of the failure and is difficult to assess. Scaling from previous estimates[17] on the basis of the total mass of tailings released, the material may be assumed to follow the Bear Creek channel for a distance of approximately 7500 feet, covering a width of approximately 450 feet, and forming a wedge 1-1/2 inches in average thickness.

The main radiological concern associated with the deposition of the tailings material is the small increase in background radiation levels in the affected and adjacent areas, and the eventual transport of these low levels of contamination of wind and rain. These long-term effects may be prevented by removing the contaminated material from the environment. Accordingly, a measure of the impact associated with the release of the solid tailings from the pond is the estimated cost of excavating, removal of the tailings and contaminated soil, and transporting the material back to the tailings impoundment. Estimates of a similar operation have been made in connection with the Vitro mill.[18] Assuming that six inches of contaminated soil would require removal along with the tailings, and that the approximate travel distance back to the tailings impoundment is 1-1/2 miles, the estimated total cost for excavation, removal of tailings and contaminated soil, and the truck transport of the material back to the tailings impoundment is approximately $140,000.

The fate of the estimated 1.5×10^7 liters of tailings solution released with the tailing slurry would depend upon the flow at the time in the Bear Creek basin. Assuming that the basin were not dry, most of the liquid could conceivably find its way to Betty Reservoir, approximately 12 miles downstream from the tailings pond. The annual average volume of Betty Reservoir is approximately 900 acre-feet, whereas the average minimum is roughly 450 acre-feet.[5] Using the minimum value, the dilution provided by the reservoir would be a factor of approximately 2.7×10^{-2}.

Betty Reservoir is used for the watering of approximately 350 to 400 yearling cattle annually and at least an equal number of antelope and deer.[5] Secondarily, the reservoir is used for sporadic irrigation. Referring to the estimated concentrations of chemicals in the tailings solution given in Table 5.2 and assuming the dilution provided by the reservoir at the average minimum volume, the estimated concentration of arsenic in the reservoir from the tailings solution would be well within water quality standards for livestock use,[19] whereas that of aluminum would be slightly in excess of standards. Water quality standards for livestock have not been promulated for the other chemicals.

Of the radioisotopes released to the reservoir only Th-230 is of concern,* resulting in a diluted concentration approximately 50% higher than the MPC (maximum permissible concentration) for unrestricted areas, as specified in 10 CFR 20.[20] The actual concentration of thorium would be expected to be considerably lower than this value, because of absorption onto the streambed sediment and precipitation in the reservoir as the pH of the solution approaches neutrality. Nevertheless, an individual consuming meat derived exclusively from livestock watered from Betty Reservoir could conceivably receive significant bone exposure by virture of the potentially high concentration factors in meat from ingestion of thorium.** However should a release of tailings slurry occur, the NRC must be notified and informed of the approximate time of the accident and furnished estimates of the quantities of liquids and solids that have been released from the tailings pond. If the tailings solution were to find its way to Betty Reservoir, the activity of the water, including its thorium concentration would be monitored prior to its use for the watering of cattle or irrigation. Alternative sources of water would have to be provided for these uses if the concentration of radionuclides were found to be excessive (see Sec. 6).

5.2 ACCIDENTS NOT INVOLVING RADIOACTIVITY

5.2.1 Mine Accidents

Various mine accidents resulting in non-radiological environmental effects are conceivable but none lead to any non-negligible impacts on the general public. Of the potential accidents considered, the largest single impact would result from a major failure of the pit walls. A failure of this nature would endanger men and equipment in the lower mining area, and damage the environment to the extent that additional overburden would need to be removed to rectify the situation.

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*The estimated concentrations of Ra-226 in the reservoir is below the EPA drinking water standard of 5 pCi/liter.

**Reference 21 estimates a thorium concentration factor for the plant/meat pathway of $\sim 2 \times 10^4$ $\frac{\text{Ci}}{\text{gm meat}} / \frac{\text{Ci}}{\text{gm plants}}$. Although no corresponding data are provided for the ingestion of water this estimate would comprise a conservative upper limit.

An accident of this nature would be unlikely, assuming that proper pit design would be utilized. However, a minor failure of the pit walls would be of greater probability, and could result in the removal of additional overburden, thus increasing mining costs, but having little environmental impact.

A second type of man-related accident that could occur involves the accidental detonation of explosives contained in the magazines. The resulting explosion would be violent, resulting in extensive noise and a high-magnitude shock wave. However, injury to personnel or damage to the pit, mining equipment, the mill, or the offsite environment would be very unlikely in an accident of this nature due to the isolated location of the proposed magazines.

Other mining accidents are similar to the mill accidents discussed below, but would be less severe in nature, again because of the concentration of chemicals, etc., at the mill. It should be noted that the postulated mill accidents are themselves trivial in their effects.

5.2.2 Mill Accidents

The potential for environmental effects from accidents involving non-radiological materials at the Bear Creek site will be small. Failure of the boiler supplying process steam to the acid leach stage of the mill circuit could release low pressure steam to the room, possibly causing minor injuries to workers, but would not involve the release of chemicals or radiological materials to the environment. Forced-air ventilation systems will be provided in the acid leach and solvent extraction stages of the process to dilute the chemical vapors emitted and protect the workers from the hazardous fumes. Failure of these ventilation systems might result in the interim collection of these vapors in the building air. Since the vapors would ultimately be discharged to the atmosphere in either case, such a failure would have no effect on the environment.

A number of chemical reagents used in the process will be stored in relatively large quantities on the site. Specifically, storage tanks will be provided for 56,000 gallons of sulfuric acid, 14,800 gallons of sodium chlorate, 8700 gallons of propane, 2600 gallons of diesel fuel (as a backup for the propane), 7100 gallons of kerosene, and 11,000 gallons of ammonia.[5] Each of the tanks containing a liquid reagent will be surrounded by a dike of sufficient capacity to contain the entire contents of the tank. According to the applicant, even if an overflow of a dike were to occur, drainage of the liquid would be toward the tailings pond.

The only chemical which might seriously impact to the environment is ammonia. The anhydrous ammonia storage tank will be located approximately 70 feet from the mill. A break in the tank's external piping would not result in a release, since an internal safety valve would automatically close on a drop in pressure, thus preventing the escape of ammonia.[5] It is possible that the line carrying ammonia to the storage tank from the tank truck could be ruptured, in which case the release rate would be limited to 100 g/sec of the vapor.[14] Assuming the release to be irreversible, the resulting concentration of ammonia at the closest residence is conservatively estimated to be approximately 90 $\mu g/m^3$ over the entire period of release. This concentration is well under the 40,000 $\mu g/m^3$ minimum concentration which produces a detectable odor, and below the 600 $\mu g/m^3$ short-term air quality standard derived from State of Colorado regulations (at 1/30 threshold limit values).[22] Thus the ammonia would not be noticed by offsite residents, and would pose no health risk.

5.3 TRANSPORTATION ACCIDENTS

Transportation of materials to and from the mill can be broken down into three categories. These are: 1) shipments of refined yellowcake from the mill to the uranium hexafluoride conversion facility, 2) shipments of ore from the mine pit to the mill, and 3) shipments of process chemicals from suppliers to the mill. An accident in each of these categories has been conceptualized and analyzed. The results are given in the following discussion.

5.3.1 Shipments of Yellowcake

Refined yellowcake product is packaged in 55 gallon, 18 gauge drums classified by the Department of Transportation as Type A packaging.[23] Type A packaging prevents the loss or dispersal of the radioactive contents of transport. Standards for evaluation and testing of adequacy with respect to normal conditions specified in DOT regulations include temperatures ranging from -40°F to 130°F, all surfaces except the bottom wet for 30 minutes, being subjected while wet to a 4-foot free fall, vibration normally encountered in transport and external pressure reduced to 0.5 atmosphere.

Yellowcake will be shipped by truck an average of 1000 miles to a conversion plant, which will transform the yellowcake to uranium hexafluoride for the enrichment step of the light water-cooled reactor fuel cycle. An average truck shipment will contain approximately 45 drums, or 34,000 pounds of yellowcake. Based upon the projected mill capacity of 1000 tons of ore daily, approximately 25 such shipments will be required annually.

From published accident statistics,[24,25] the probability of a truck accident is in the range of 1.6 to 2.6 $\times$ 10^{-6}/mile. Truck accident statistics include three categories of traffic accidents: collisons, noncollisons, and other events. Collisions involve interactions of the transport vehicle with other objects, whether moving vehicles or fixed objects. Noncollisons are accidents in which the transport vehicle leaves the transport path or deviates from normal operation in some way, such as by rolling over on its top and side. Accidents classified as other events include personal injuries suffered on the vehicle, records of persons falling from or being thrown against a standing vehicle, cases of stolen vehicles, and fires occurring on a standing vehicle. Using an average of the range of probabilities cited, the likelihood of a truck shipment of yellowcake from the mill being involved in an accident of any type during a one-year period is approximately 5 $\times$ 10^{-2}.

Only a small fraction of the accidents in any given mode of transportation would result in the release of the contents of a shipping container. The ability of the materials and structures in the shipping package to resist the combined physical forces arising from impact, puncture, vibration, and fire depends on the magnitude of the forces. These magnitudes vary with the severity of the accident, as does the frequency with which they occur. A generalized evaluation of accident risks by Sandia[26] classifies accidents into eight categories, depending upon the combined stresses of impact and fire. On the basis of this classification scheme, conditional probabilities (i.e., given an accident, the probabilities that the accident is of a certain magnitude) of the occurrence of the eight accident severities were developed. These conditional probabilities for truck transport are given in Column 2 of Table 5.3. Furthermore, Sandia has developed for its classification scheme the expected release fractions for Type A containers, which are given in column 3 of the table. Folding together the fractional occurrence and the release fractions, the expected fractional release in any given accident is approximately 2 $\times$ 10^{-2}. Thus, for a 55-gallon shipping container of yellowcake, approximately 6 kg ($\approx$ 13 lb) of U_3O_8 would be released from the container, on the average, in the event of a truck accident.

Table 5.3. Conditional Probabilities of Occurrence and Corresponding Release Fractions for Type A Containers Involved in Truck Accidents

Severity Class	Fractional Occurrence of Accidents	Release Fractions
I	0.55	NIL
II	0.36	5 $\times$ 10^{-5}
III	0.04	2 $\times$ 10^{-3}
IV	0.028	0.10
V	0.015	0.50
VI	0.004	0.87
VII	0.002	0.97
VIII	0.001	1.00

Most of the yellowcake released from the container would be deposited directly on the ground in the immediate vicinity of the accident. Some fraction of the released material, however, would be dispersed to the atmosphere. Battelle has developed expressions for the dispersal of plutonium oxide to the environment based on actual laboratory and field measurements over several years.[25] The following empirical expression was derived for the dispersal of plutonium oxide to the environment via the air following an accident involving a release from the container:

$$f = 0.001 + 4.6 \times 10^{-4} \left(1-e^{-0.15ut}\right) u^{1.78} ,$$

where:

f = the fractional airborne release,

u = the wind speed at 15.2 meters (50 ft) expressed in m/sec, and

t = the duration of the release, in hours.

In this expression, the first term represents the initial "puff" immediately airborne when the container is failed in an accident. Assuming that the above expression is also valid for U_3O_8 dispersal, that the wind speed is 5 m/sec (10 miles/hr), and that 24 hours are available for the release, the environmental release fraction is estimated to be 9×10^{-3}. The quantity of yellowcake released to the atmosphere in the event of a truck accident is estimated to be roughly 52 grams (2 oz). Assuming insoluble uranium, all in the respirable size range, and a population density of 160 people/mi^2, characteristic of the eastern United States, the consequences of a truck accident involving a shipment of yellowcake from the mill would be a 50-year dose commitment of approximately 4 mrem to the lungs of the general public.

5.3.2 Shipments of Ore to the Mill

Uranium ore will be shipped to the ore stockpiles adjacent to the mill in 35-ton trucks. The average distance from the initial pit to the ore stockpiles is approximately two miles. Based upon the projected mill capacity of 1000 tons of ore daily, approximately 9400 trips would be required annually. Although the ore will be shipped on private roads, it is assumed that the probability of a truck accident is in the range cited in the previous section. Therefore, the estimated likelihood of an ore truck being involved in an accident during a one-year period is roughly 4×10^{-2}; however, because of the low specific activity and ease with which the contaminant can be removed, the radiological impact is not considered to be significant.

5.3.3 Shipments of Chemicals to the Mill

Truck shipments of ammonia and propane to the mill, if involved in a severe accident, could conceivably result in a significant environmental impact. Approximately nine shipments of anhydrous ammonia are expected to be made annually in 5000-gallon tank trucks from Cheyenne, Wyoming, a distance of approximately 150 miles from the mill.[5] Assuming a probability of a truck accident in the range cited in Section 5.3.1, the estimated likelihood of an ammonia tank truck being involved in an accident during a one-year period is roughly 2×10^{-3}. Tank trucks of propane are expected to originate in Casper, a distance of approximately 70 miles from the mill. Approximately nine shipments, each containing approximately 5000 gallons of propane, are anticipated annually,[5] resulting in a likelihood of an accident of approximately 1×10^{-3} per year.

Although the conditional probabilities of release, given an accident, are unavailable, historical data on the consequences of accidents involving shipments of LP-Gas have been compiled and assessed.[27] LP-Gas is a compressed gas, consisting primarily of propane. About 90% of the LP-Gas is transported by tank truck of approximately 4400 gallons in volume. A spill results in the immediate flashing of 30 to 35 percent into vapor. The most important accident consideration is the flash burning of the vapor phase. During the period 1931 to 1961, 37 persons (non-workers) or approximately 1.2 persons per year, were killed in LP-Gas flash fires and explosions from accidents involving tank trucks. For the years since 1961, an exact tally has not been made, but the annual average is believed to be in the range of 1 to 2 per year.[27] For the period 1969 through 1972, an average of roughly 17×10^9 gallons of LP-Gas were transported by truck or a combination of pipeline and truck.

Combining these data, the probability of a fatality resulting from an average shipment of LP-Gas is roughly 3 to 6×10^{-7} per year. This would be expected to be an overestimate for shipments in the vicinity of the Bear Creek project because of the relatively low population density. Nevertheless, accepting this estimate and assuming its validity for the transportation of propane, the likelihood of a fatality to the general public resulting from shipments of propane to the mill is predicted to be roughly 4×10^{-6} per year.

References for Section 5

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6. MONITORING PROGRAMS AND OTHER MITIGATING MEASURES

6.1 AIR QUALITY

Three high-volume air samplers have been installed near the proposed mill at upwind and downwind sites selected under the auspices of the State of Wyoming Department of Environmental Quality (DEQ). The samplers are maintained and operated in conformity with the sampling schedule of the U. S. Environmental Protection Agency (EPA). Sulfur dioxide concentrations were measured in December 1974 and the ambient levels were below the limit of detection. Meteorological information is recorded continuously, and these data are computer-processed to provide input for various predictive models. In addition, the applicant has established the operational radiological monitoring program described in the ER. See Section 6.8 and Table 6.4 for details.

Water will be added to the airstream of the drilling equipment to minimize dust releases; blasted material and haulage roads will be sprinkled as necessary to reduce dust emissions. A summary of measurements of total suspended particulates at the Bear Creek site (background) is given in Table 2.3.

6.2 LAND USE AND TOPOGRAPHY

6.2.1 Mine

During operations, haul roads will be fenced to protect livestock and wildlife. Following reclamation, existing fences, water wells, and reservoirs will be replaced to the extent possible and in locations which will assure optimum grazing use of the reclaimed land. The applicant will reimburse owners for any facilities which cannot be replaced because of mining and related development.

Impacts on grazing resources, both temporary and permanent, will be mitigated. For example, forage production can be improved by altering species composition of plant communities, increasing water developments, fencing to control grazing intensity, eradicating sagebrush, and irrigation. Prompt reclamation will be implemented to restore the productivity of mined land as quickly as possible.

Utilities and transportation facilities serving the area will be so placed in corridors as to localize and minimize the grazing area removed from production on National Grasslands, and to minimize other land-use conflicts.

The B-3, B-4, B-6 pits, the Dilts pits, and the B-13 East pit will be backfilled with overburden, covered with topsoil and revegetated. Water ponds will occur in the bottom of the B-1 and B-8 pits, and the B-13 West pit. If the water in the ponds does not meet Federal and State water quality standards, the pits will be backfilled above the static water level and revegetated. Roads, building sites and remaining spoil piles will be graded to blend with the natural contours of the adjacent undisturbed topography. The steep highwalls of the B-1 pit will be a hazard to humans and animals; therefore, the south half of the pit will be fenced and posted with warning signs.

Procedures which will be considered to blend disturbed areas with natural contours are:

(1) Smooth all cut and fill surfaces to a rounded profile and regrade final slopes to a degree not to exceed those existing in adjacent natural landscape, except that slopes below water surfaces of permanent reservoirs may exceed natural slope gradients.

(2) Dress topsoil over exposed overburden to provide a favorable seedbed, and to avoid color contrasts in soil surfaces of the landscape.

(3) Blend revegetated cuts and fills by interplanting irregular belts (200 to 500 feet wide) of adjacent undisturbed vegetation with the seeding mixture used in site reclamation.

6.2.2 Mill

The mill buildings and ancillary structures will be designed to occupy and disturb the minimum area practicable. Sound construction practices will be followed and erosion, sedimentation, etc., will be controlled by using methods such as those proposed by the EPA.[1] The tailings impoundment will be located to take advantage of the existing topography; seepage may be detected by monitoring wells. Should uncontrolled movement of radioactive nuclides or undesirable chemical species be detected, the applicant will notify the proper authorities and propose a plan for controlling the seepage.

State-of-the-art air effluent abatement equipment will be utilized in the mill process area and dust suppression techniques will be practiced on the roads, and active and unstabilized tailings areas.

The mitigating measures discussed in Section 6.2.1, with respect to grazing, land forms, etc., shall apply, where appropriate, to the construction, operation, and decommissioning of the mill. In addition, the following requirements shall be met:

(1) Power line and road alignments shall be designed to preserve natural landscapes, where possible.

(2) Mill facilities shall be designed with smooth but non-reflective exterior surfaces, and to be attractive in and of themselves.

(3) The use of subdued grays, greens and browns as exterior colors for mill structures will promote harmony with the natural landscape.

6.2.3 Environmental Monitoring Program

The applicant shall establish a monitoring program, acceptable to Federal and State agencies, to ensure that the mitigating measures described herein are carried out. Sufficient records shall be maintained to furnish evidence of compliance with these conditions.

6.2.4 Federal Environmental Approvals and Permits

The applicant's mining and reclamation plan must be approved by regulatory agencies prior to initiation of activities. The development of power lines, telephone lines, roads, etc., on National Grasslands will be authorized by issuance of a special use permit or easement by the U. S. Forest Service.

6.2.5 State Environmental Approvals and Permits

Changes in the usage of State-owned lands will be authorized by the State of Wyoming. The design of the tailings pond embankment must be approved by the Wyoming State Engineer.

6.3 WATER RESOURCES

6.3.1 Mine

The applicant will assess the effects of mining operations on groundwater levels and on water quality by monitoring ten observation wells on a quarterly basis. In addition, five monitor wells will be established around the tailings pond and upland from mine water discharge points in order to provide some baseline data on water level fluctuations and groundwater quality. The presently identified well sites are listed in Table 6.1.

Four surface water stations will be monitored on a quarterly basis. The stations listed in Table 6.2 are located at impoundment sites that, except for Betty Reservoir, are frequently dry.

Groundwater supplies, affected by lowered water levels due to the influence of mine dewatering, will be replaced by water from deeper wells. The water in the deeper Fort Union Formation is generally less mineralized than water in the Wasatch Formation which encompasses the ore body. The yield characteristics of the Wasatch and Fort Union formations are similar. The water wells closest to the proposed mines are small capacity wells used for stock watering purposes. If the capacity of these wells is impaired, replacement wells will be developed.

Water pumped from mine pits will be collected in small storage ponds to allow the settling of suspended solids. If necessary, the water will be treated with barium chloride before being released. The purpose of such treatment is to prevent radium from entering the natural surface drainages.

Table 6.1. Well Sites Included in an Ongoing Sampling Program, Bear Creek Project Area

Site No.	Location			Depth, feet	Owner	Remarks
	Section	Twp.	Rng.			
1[a]	NW¼, SW¼, 15,	38N,	73W	360	RMEC	Fox DH-A1
2	NE¼, SE¼, 15,	38N,	73W	325	RMEC	Fox DH-B
3[a]	NE¼, NW¼, 15,	38N,	73W	270	RMEC	Fox DH-1
4[a]	SW¼, SE¼, 10,	38N,	73W	260	RMEC	Fox DH-H
5	NE¼, NE¼, 34,	38N,	73W	80	Dilts	Windmill
6	NW¼, SE¼, 11,	38N,	73W	265	Carson	Windmill
7	SW¼, NW¼, 14	38N,	73W	322	U.S.F.S.	Windmill
8	NW¼, NE¼, 17,	38N,	73W	515	Manning	Not flowing now, windmill installed
9	SW¼, SW¼, 27,	38N,	73W	410	Hornbuckle	-
10	SW¼, SW¼, 4,	38N,	73W	430	Manning	-

[a]Will be lost as mining progresses.

Table 6.2. Surface Water Sampling Stations in the Bear Creek Project Area

Site No.	Location			Owner	Remarks
	Section	Twp.	Rng.		
11	NW¼, NW¼, S10,	38N	73W	RMEC	Water impoundment in drainage basin where initial mining would occur (Secs. 10 and 15) Drainage goes to S. Fork of Bear Creek
12	SE¼, SW¼, S34,	39N	73W	Carson	Water impoundment on Bear Creek. This is first one below the point where drainage from Secs. 10 and 15 enters S. Fork of Bear Creek. Also, it is downstream of possible tailings disposal area.
13				Carson	Water impoundment on Bear Creek approx. 3 miles down the drainage from site 12. Indicated as a perennial body of water on USGS topographic map.
(Outlet)	SW¼, SW¼, S19,	39N	72W		
(Inlet)	NW¼, NE¼, S25,	39N	73W		
14	S 2,	29N	73W	Dilts	Betty Reservoir receives water from Bear Creek as well as two other intermittent streams.
	S35,	40N	72W		

Surface areas disturbed by mining and mill construction will be isolated from existing surface drainages and surface runoff will be diverted via ditches into seeded areas to promote revegetation and thus mitigate surface erosion.

6.3.2 Mill

Five wells in or near the mill site will be monitored quarterly to detect changes in radiation and water levels, and water quality will be monitored annually. The five observation wells located around the tailings area will be monitored for radiation and water quality on a quartly and annual basis, respectively. The radioactivity of treated mine water retention ponds will be measured monthly.

The wells in the tailings area will enable pumping to be initiated as a safety factor, should monitoring data indicate leakage to local aquifers. If pumping of the monitor wells is required, the State Engineer's initial UW-5 form would permit pumping if the water were returned to the tailings pond. If the water were treated and discharged, however, a surface water discharge permit from the State Department of Environmental Quality, consistent with the 1972 Water Pollution Control Act Amendment (PL, 92-500), would be required.

6.3.3 Environmental Monitoring Program

6.3.3.1 Preoperational

Surface Water

Principal streams in the area, such as Bear Creek, are considered interrupted streams--those consisting of short perennial reaches and intervening intermittent reaches. Four impoundments along the Bear Creek drainage have been selected by RMEC for preoperational monitoring of surface water; see Table 2.7 for water quality data.

Topographic maps (USGS) were used to determine watershed characteristics in order to make flood analyses (ER, Sec. 2.6.2). The frequencies of rains capable of causing 100-year and probable maximum floods were calculated and compared to precipitations recorded at Casper over the last 33 years. The greatest precipitation there, had it occurred in the Bear Creek drainage basin, would have produced a peak discharge of 40% of the estimated 100-year value, roughly a 50-year event. The flood probabilities are not applicable in the event of a heavy rain falling on an accumulated snow cover, with the resulting snowmelt contributing to total runoff. Current plans call for diversion ditches to be constructed to prevent runoff entering the tailings pond. In addition, the freeboard of the pond embankment will be sufficient to contain two 100-year storms, assuming failure of the diversion ditches (ER, Answer to Question 27).

Mining and mill operations will affect flow from approximately 3.5 square miles of watershed in the Bear Creek Basin. Water present on a year-round basis, other than that in occasional potholes and small seepage springs, consists of small impoundments for livestock watering and Betty Reservoir, used for recreation, stock watering, and irrigation. The distance of Betty Reservoir downstream from the mine and mill operations and the comparatively small amount of runoff from the construction sites in relation to total watershed runoff is considered to preclude appreciable changes in the quality of water in Betty Reservoir.

Groundwater

Groundwater hydrology studies at the Bear Creek site were conducted in August 1974. Aquifer tests were made for four production wells using adjacent observation wells to monitor drawdown effects for each production well. Collected data were used in calculations of well yields and estimations of drawdown effects from long-term pumpage at individual wells; water removal that would occur during dewatering of the ore bodies was not considered in the calculations.

In September 1974, a groundwater sampling program was initiated to provide baseline water quality data. The collected data (presented in Table 2.7) were obtained by sampling onsite sources in addition to existing wells in the adjacent areas (ER, Sec. 2.6.1).

6.3.3.2 Operational

Selected offsite wells located downgrade from the mine and mill operations will be sampled quarterly to monitor radioactivity levels. Five proposed wells around the tailings area will be sampled quarterly for radiation and annually for chemical quality. If samples from these wells indicate leakage or movement of contaminants, the wells will be pumped and the water returned to the tailings pond to control further groundwater contamination. These three observation wells

should be located close enough to the pond, and downgrade relative to the normal (local) hydraulic flow to enable early detection of pollution. Recovery pumping must be planned so that recovery may begin soon enough and so that a sufficient proportion of the polluted grownwater is intercepted to make it an effective mitigation measure.

The radioactivity of treated mine water will be monitored monthly to assure that applicable standards are met. Samples will be collected from the retention pond at monthly intervals and checked for radioactivity.

Selected wells on the mining and mill property will be sampled monthly for water levels and annually for chemical quality.

The applicant will conduct an operational radiological monitoring program as described in the amended source material license application. See Section 6.8 and Table 6.4 for details.

6.3.4 Federal Environmental Approvals and Permits

The applicant is required to obtain a National Pollutant Discharge Elimination System permit (NPDES). This was issued by the Wyoming DEQ in September 1976 with the approval of the U. S. EPA.

6.3.5 State Environmental Approvals and Permits

Wyoming water law requires water-right filings for water impoundments and for the general utilization of water from surface or groundwater sources. If the proposed mining activity interferes with existing surface or groundwater rights, the applicant may be required to provide water to satisfy these rights.

Provisions under Wyoming water law make it possible to change the location of a well, a reservoir, or irrigated lands affected by activities such as mining, without affecting these water rights. These provisions prevent loss of rights and could reduce the impact of mining activities.

The appropriation, and the supervision and distribution of groundwater and surface water is under the control of the Wyoming State Engineer and the Board of Control.

The specific permits required are as follows:

(1) Water supply plan approval - Wyoming DEQ

(2) Water appropriation for beneficial use - Wyoming State Engineer

(3) NPDES permit - Wyoming DEQ

(4) Sewage treatment plan - Wyoming DEQ.

The enforcement of all applicable Federal and State laws and regulations concerning water-quality standards will reduce cumulative effects on water quality. These include:

(1) Federal Water Pollution Control Act, as amended in 1972, and as it may be hereafter amended.

(2) Wyoming Environmental Quality Act of 1973.

(3) Water Quality STandards for Wyoming, Wyoming Department of Health and Social Services, State of Wyoming, June 28, 1973.

6.4 MINERAL RESOURCES

The proposed mining and milling operations to occur at the site will not affect the quality or the eventual exploitation of other resources except the coal resource discussed in Section 2.5.2.3. The USGS may require certain provisions for utilizing the coal present in the overburden that would be removed in exposing the uranium ore bodies.

The permits required for the extraction of the uranium resource are:

(1) The Source Material License from the U. S. NRC

(2) The Mining Permit from Wyoming DEQ

(3) The Mining License from Wyoming DEQ.

6.5 SOILS

Topsoil material will be stockpiled previous to and during the mining operations, and replaced on the disturbed areas prior to revegetation. Surfaces of stockpiles will be left in a rough condition to promote moisture retention and to reduce erosion potential. The stockpiles will also be seeded with fast growing grass species to further reduce erosion until the topsoil material is replaced. Prior to soil replacement, the disturbed areas, with the exception of highwalls, will be reshaped to reduce slopes and thus minimize erosion, sedimentation, and prevent landslides to the extent practicable.

Soil compaction will be mitigated by restricting off-road vehicle traffic and by ripping and tilling of surface materials. Self-loading scrapers minimize soil mixing and will be used for stockpiling and replacing soil material. Productive soil will not be buried or mixed with sterile or toxic materials.

Petroleum and other chemical spills will be cleaned up according to EPA specifications.

A soil survey should be conducted after surface reshaping and topsoil replacement, but prior to revegetation of the disturbed areas. It is recognized that genetic soil horizons will be absent and characterization of the replaced soils will be based on physical and chemical properties of the different layers in the upper 60 inches. However, the survey information should be used to designate the kind and distribution of soils in the reclaimed areas. Chemical analysis of the upper 60 inches should be made to determine characteristics of the replaced material and management needs. Soils interpretations and determination of soil capability classes should be used to aid in the management and conservation of the disturbed areas following reclamation.

6.5.1 Mine

The establishment of vegetation on overburden piles and backfill materials will be performed as soon as possible to reduce erosion. Toxic or undesirable materials, if encountered, will be buried below 60 inches.

6.5.2 Mill

Runoff water will be diverted around the tailings pond to reduce erosion in the tailings area. Dikes will be constructed around all storage tanks to prevent spread of chemicals in case of spillage.

The applicant will conduct an operational and radiological monitoring program for soils as described in the amended source material license application. See Section 6.8 and Table 6.4 for details.

6.6 VEGETATION

6.6.1 Mine

Vegetation will be reestablished on virtually all disturbed areas during and following the mining process with the objective of restoring the pre-mining productivity and use of the land.

Mine pits, topsoil, and overburden piles will be vegetated concurrently with mining operations in progress. The applicant plans to vegetate disturbed lands using a mixture of plants such as western wheatgrass, thickspike wheatgrass, green needlegrass and sweet clover. Studies of the existing vegetative cover and soil, along with evaluations of revegetation at other similar project sites, suggest that Sodar streambank wheatgrass be substituted for a portion of the thickspike wheatgrass, and that green needlegrass be eliminated. In place of the needlegrass, blue grama and little bluestem, in varying proportions, are recommended. Browse species can also be successfully established on disturbed sites and may persist for long periods of time. Irrigation of revegetated areas may enhance the reestablishment of vegetation.

Following seeding, the vegetation will be monitored for productivity, ground cover density, and species composition. It has been observed in other reclaimed areas in the same locale, that adequate vegetative cover can be established within 2 to 3 years of the initial treatment.

Noxious weeds and invading annual grasses such as cheatgrass should be treated annually to prevent their establishment and subsequent invasion of other lands.

Fugitive dust from mining operations and haul roads, as it affects vegetation, will be minimized by road watering, spray oiling or graveling of the road surfaces.

6.6.2 Mill

Reclamation and revegetation of the millsite area will occur at the conclusion of the project in 1986. The same mitigation measures identified for the mines will be employed. The 100 acres of tailings area will be covered and revegetated, but it is not certain that this area will be available for use by livestock or human beings, to assure that stabilization and reclamation work will achieve the anticipated results. The applicant has recently submitted a stabilization plan (see Sec. 3.4) and is committed to a monitoring program.

6.7 WILDLIFE

Increasing water developments, the conversion or improvement of species compositions in local plant communities and irrigation of reclaimed areas will partially offset the onsite impacts. Prompt reclamation of disturbed areas will be initiated to restore the productivity of mined lands as quickly as possible.

Utilities and transportation facilities serving the project will be placed in corridors to localize and minimize the habitat area removed from production. Processing plants, buildings, and disposal facilities will also be designed to use a minimum surface area. Solid waste materials and liquid effluents transported into offsite environments will be monitored for deleterious constituents; if detected, deleterious constituents will be removed by appropriate means.

Fencing required during the life of the project will be kept to the practicable minimum. Fence construction and maintenance will be in accord with recommendations of the Wyoming Game and Fish Department. Fences will allow antelope and deer movement whenever practicable.

The applicant will also construct a fence, including signing, around the tailings pond, using design standards acceptable to the NRC. The duration of maintenance period must also be acceptable.

6.7.1 Environmental Monitoring

The applicant intends to conduct an operational radiological monitoring program for fauna as described in the amended source material license application. See Section 6.8 and Table 6.4 for details.

6.8 RADIOLOGICAL

6.8.1 Pre-operational Programs

In October 1974, a program for the collection of environmental data was instituted at the Bear Creek Project site, with analyses done by the Colorado School of Mines Research Institute and other contracting laboratories. This program was initiated after the choice of the site and originally consisted of field meteorology and air quality monitoring. By 1975, monitoring efforts were extended to the analysis of ground and surface water samples as well. Results of such studies are given in detail in the applicant's ER, and are summarized in Tables 2.3, 2.7, and 2.8 which includes some recent analyses for Th-230 and Ra-226. Gross alpha and beta counts for surface water in the Bear Creek region are presented in Table 6.3.

Table 6.3. Representative Surface Water Data for Radiological Monitoring Stations in the Bear Creek Region

Date (year)	Gross Alpha Radioactivity, pCi/liter		Gross Beta Radioactivity, pCi/liter	
	Suspended	Dissolved	Suspended	Dissolved
1965	1.25	16.22	4.50	29.52
1966	0.80	12.38	2.61	25.13
1967	1.46	13.42	4.24	24.88
1968	1.46	12.86	4.10	28.95
1969	0.75	27.00	7.00	34.75
1970	----	-----	----	-----
1971	0.69	6.80	3.20	16.25
1972	0.78	4.52	6.00	11.80

6.8.2 Operational Effluent Monitoring Program

The objectives of effluent monitoring programs are to ensure that mine and mill discharges do not exceed acceptable limits, to develop criteria that can be used in the design of new operational procedures, and to aid in the interpretation of the results of such other studies as the biological monitoring program.

In addition, airborne effluents from the mill will be periodically collected as indicated in Table 6.4. Groundwater samples from ten initial locations will be located from wells shown in Figure 6.1 and analyzed for parameters shown in Tables 2.7 and 2.8. In addition, local soils, flora and fauna will be sampled periodically and analyzed following the program outlined in the NRC license amendments. Following the first year of monitoring, the results will be evaluated to determine which elements of the program will be continued or terminated.

6.8.3 Measurement and Monitoring Programs

Most of the radiological programs noted in Section 2.9 are ongoing programs, and therefore will further contribute to the information base concerning radiological conditions of the region. As additional nuclear facilities are established in the region, radiological and ecological information can be expected to accumulate. In addition, other mines and mills in the region, including those mentioned in Section 2.9, maintain surveillance programs in the area.

6.9 COMMUNITY

Most of the negative impacts associated with the total Converse County energy developments, including the RMEC project, can be mitigated only by the combined efforts of energy firms, governmental entities and agencies, voters, the housing industry, and many others. Most mitigating actions suggested for RMEC can be considered only in that broad context.

Monitoring of impacts and rapid feedback to the parties-at-interest is essential.[2] The timely sharing of information concerning developments and projects is equally important.[3] The Converse County Priorities Board and the Converse Area Industrial Association have already been organized, with advice and leadership from RMEC personnel, and have the capabilitiy to perform these functions.

Mitigation of adverse public finance impacts is primarily the responsibility of local government. Much of the financial deficits described earlier (Sec. 4.9) can theoretically be solved by the enabling mechanisms of the Wyoming Farm Loan Board and the Wyoming Community Development Authority, and by the sharing of tax base through intergovernmental cooperation by Joint Powers Boards.

However, much of the present statutory authorization for such mitigation requires that a community be classified as coal impacted; under present law, abandonment of the proposed coal gasification project would imperil this classification (such abandonment would also greatly reduce the financial deficits forecasted for local governmental units during the late 1970's and early 1980's, as discussed in Sec. 4.9).

Most of the social impacts--the potential conflicts between old timers and newcomers, the requirements for local governments to deal with new orders of problems--are mitigable by active leadership by all of the parties-at-interest to development. The industrial firms plan an important but secondary role in these matters.

The remainder of this section deals with prospective mitigating actions proportionately or wholly specific to RMEC.

6.9.1 Monitoring and Coordination

RMEC and other industrial firms should continue to support and participate in the activities of the Priorities Board and the Industrial Association.

6.9.2 Public Finance

There is no presently definable mitigation required of RMEC or the other firms. However, a failure of state and local government mitigation mechanisms might make needed some financial assistance, beyond taxes, by RMEC or other firms to provide school buildings or other facilities.

Table 6.4. Radiological Monitoring Program

Environmental Element	Sampling Location[a]	Sampling Frequency	Type Measurement
Direct gamma (TLD)	At 8 sites--6 of which are air quality sampling sites	Quarterly	Gross gamma gross beta
Air	Six samples, 3 at current high volume sites and 3 downwind in areas of probable maximum concentration (per wind rose)	Continuous 24-hour sampling. 6-day intervals for particulates at external sites. Continuous at internal site. Quarterly composites for specific radionuclides following one year's monthly data for gross alpha and beta	Airborne particulates, Th-230, Ra-226, and uranium, gross alpha and beta
Air	Stack sampling on yellow-cake dryer	Monthly	Natural U_3O_8
		Semi-annually	Ra-226, Th-230
Air	CCD leach tank ventilation and roof vents from main process building and S-X building	Annually	Natural U_3O_8, H_2SO_4 mist, Ra-226, and Th-230
Air	Ventilation roof vents from S-X building	Annually	Total hydrocarbons
Air	At upwind, downwind and nearest residence See Sec. 5.5.6.2 in NRC license application	Quarterly, following one year's monthly data	Rn daughters
Air	At three internal air quality sites	Continuous for one week per month	Radon
Groundwater	Several on and offsite wells (10 initially) located in the mine and mill site area in including one new well down	Quarterly	Gross alpha and beta
		Annually	Natural U_3O_8, Ra-226, pH, TDS, SWL, conductivity Chemical[b] and Th-230
Groundwater	4 or 5 wells around tailings impoundments and tailings ponds	Quarterly	Natural U_3O_8, Ra-226, gross alpha and beta, pH, TDS, Conductivity and SWL
		Annually	Th-230 and chemical[b]

Table 6.4. Continued

Environmental Element	Sampling Location[a]	Sampling Frequency	Type Measurement
Surface water	4 sites--surface impoundments	Quarterly	U_3O_8, Ra-226, gross alpha and beta, pH, TDS, conductivity and SWL
		Annually	Th-230 and chemical[b]
Mine water	Project settling ponds	Refer to NPDES Permit	Cd, Zn, As, pH, oil and grease U, Th, Ra, TSS
Soils	Six sites--air quality monitoring sites	Annually	Natural U_3O_8, Ra-226, Th-230 and gross alpha and beta
Biota	Six sites--air quality monitoring sites. Vegation, small mammals	Annually	Natural U_3O_8, Ra-226, Th-230 and gross alpha and beta
Meteorology	As described in text	Continuous	Temperature, relative humidity, wind speed and direction, precipitation
Sediment	Surface impoundments and affected drainages	Annually--following spring runoff event	U_3O_8, Ra-226, Th-230, and gross alpha and beta

[a]Locations are shown on Fig. 6.1.

[b]Chemical parameters to be analyzed for will be determined from an analysis of a sample taken from the tailings pond once operations (mill) have begun.

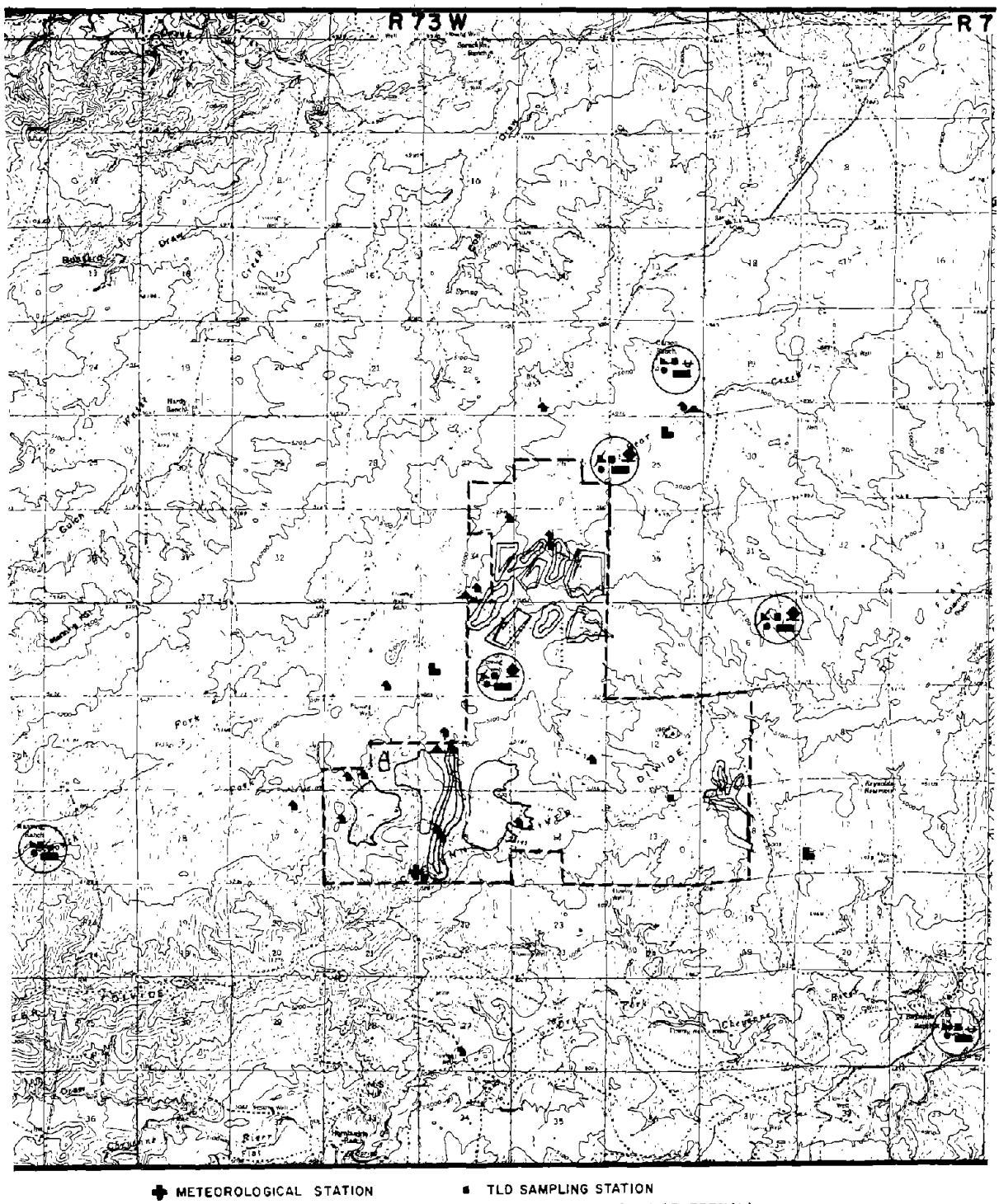


Fig. 6.1. Environmental Monitoring Stations.

6.9.3 Other Goods and Services

The recruitment of physicians may need support from RMEC and other industrial firms.

6.9.4 Housing

The potential impacts of undue rural sprawl, poor housing, or excess worker commuting time can be mitigated by company assurance of housing in an appropriate location. RMEC is giving consideration to providing a guarantee to a local developer to build about 50 single-family homes in Douglas, the homes for sale to RMEC employees.[4]

6.9.5 Cultural Impacts

Both federal and state antiquities acts regulate excavation and/or collections of cultural resources, and both protect historical values on public lands. The applicant will be required to adhere to applicable legislative regulations and maintain vigilance for signs of archeological or paleontological artifacts in daily mining operations. If any cultural resources are encountered, the operation in the area will be suspended immediately and the Area Mining Supervisor notified within 24 hours. Operations will not resume until the cultural discovery has been evaluated and/or salvaged by an archeologist.

The National Register of Historic Places, published in the Federal Register on February 1, 1977, and subsequent monthly supplements, have been consulted. No National Register-listed properties are affected at this time. No additional sites have been determined eligible for, or are pending, nomination to the National Register. If any cultural resources or sites are found, during any activities, that meet the criteria for the National Register, they will be protected in compliance with the Advisory Council on Historic Preservations Precedures for the Protection of Historic Cultural Properties (36 CFR, Part 800).

6.10 CHANGES IN THE MONITORING PROGRAMS AND MITIGATIVE MEASURES

As data from the various monitoring programs are accumulated, some objectives of the programs will be realized in whole and in part. When this happens, it will be desirable to modify the existing programs. Proposed modifications will be submitted to the appropriate agencies for evaluation.

References for Section 6

1. U. S. Environmental Protection Agency, "Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity," EPA-430/9-73-007, October 1973.

2. M. H. Wakelin, "Approaches to Impact Management," Supervisor of Construction Impact Planning, Bechtel Power CO., Norwalk, California.

3. J. S. Gilmore and M. K. Duff, "Boom Town Growth Management: A Case Study of Rock Springs, Green River, Wyoming," Boulder, Colorado, Westview Press, 1975.

4. Interview with Ned Davis, Director of Administration, Rocky Mountain Energy Co., August 17, L976.

7. UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

7.1 AIR QUALITY

The unavoidable impacts of the mine and mill upon the air quality of the area will be slight. Some increase in suspended particulates from mining operations, vehicular traffic on the haulage roads, and fugitive dust from the tailings piles will occur, but the resulting impact upon the air quality will be minor. The anticipated small chemical emissions will have a negligible impact on the air quality of the area.

7.2 LAND USE AND TOPOGRAPHY

7.2.1 Topography

Some destruction of the natural features of the area and changes in some drainage channels cannot be avoided. The exact shape and contours of the present topography is unrestorable. The final highwalls of the B-1 pit are considered by the applicant to be unavoidable because of the very high cost (4.4 to 15.7 million dollars estimated by the applicant) to slope the final highwalls as well as other considerations discussed in Section 3.1.3.1 and in Chapter 10.

The topography will be altered after the milling operation is completed. The tailings impoundment area is unavoidable and will remain, containing the tailings (about 100 acres) that were deposited during the course of the operation. The mill will be a focal point in the landscape regardless of measures taken to blend or harmonize the structures with the natural landscape.

7.2.2 Land Use

There will be a temporary change in land use of about 2000 acres from livestock grazing to mineral extraction during mining and milling operations. There is a possibility that some new water sources will have to be provided for livestock. The potential for mortality and molestation of cattle and sheep will increase. Ranchers will be inconvenienced by changes in access and land-use patterns. Changes in land capability of reclaimed areas are expected.

The project area is presently of low potential for intensive recreation use and development, and no unique scenic or natural features are present. There are no existing recreation facilities within the project area. Although big game species (antelope and deer) are found in the area, hunting has been limited because access across private lands is controlled. For these reasons, it is considered unlikely that any unavoidable adverse environmental impacts will occur, except some possible loss of hunting opportunities.

The increase in daily traffic flows to and from the project area will result in increased maintenance costs for roads, and the potential for accidents will be raised. It is difficult to estimate the extent of these impacts since the increase in traffic is unknown.

7.3 WATER RESOURCES

Water consumed in mine and mill operations will be unavoidably lost from the area; however, the amount cannot be quantified at this time. The adverse impact resulting from the disruption of aquifers in the disturbed areas of mining cannot be avoided.

Some local deterioration of water quality will occur and may result from infiltration of rainfall and snowmelt in reclaimed areas, thereby leaching fill materials of salts and other chemicals which subsequently enter surface and subsurface drainages. Additionally, removal of protective vegetative cover and other soil disturbance will cause increased water erosion during construction and mining activities.

Lowering of water levels in local wells will occur within the area influenced by mine dewatering operations. After mining ceases and pumping stops, water levels will return to pre-mining levels, so this is a temporary effect. Dewatering operations will also cause an increase of

streamflow in Bear Creek during the life of the project. The quality of this water will be monitored before release and treated as necessary to meet state water quality standards.

Lakes of an estimated 5 to 10-acre size (2-4 ha) may be left at the terminal ends of mining excavations. These lakes could provide water in an area where surface water supplies are scarce. On the other hand, the lakes may be sufficiently contaminated so as to adversely affect domestic livestock and wildlife consuming the water, or otherwise utilizing such habitat.

Some leakage of radioactive contaminants from the tailings disposal pond is expected. Horizontal leakage can be detected, monitored and controlled. Detection of vertical leakage will not be possible but vertical movement will be slower, and consequently less than horizontal movement. Planned control measures should limit dispersion of contaminants to tolerable levels. Some contaminated water may discharge into springs and seeps along surface drainages in the nearby area.

7.4 MINERAL RESOURCES

No unavoidable adverse effects on mineral resources are expected, other than the extraction of the uranium ore. In addition to the environmental effects of uranium mining and milling discussed herein, other subsequent and related impacts will occur, the kind and intensity of such impacts being dependent on disposition of the refined ore. Assuming that the uranium will be used to fuel steam-electric systems, the environmental effects associated with the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transport of radioactive materials and management of radioactive wastes are relevant to the proposed Bear Creek project. The nature of these environmental effects is presented within the scope of the AEC report entitled, "Environmental Survey of the Uranium Fuel Cycle", and in NUREG-0116 - "Supp. 1 to WASH-1248," October 1976.[1]

7.5 SOILS

The alteration of soil horizons, parent materials and other soil characteristics which have developed over long periods of geologic time cannot be avoided. Disturbance of soils may lower, to some degree, the natural soil productivity because of soil compaction, accelerated erosion and mixing of natural soils. The present soil biota and soil forming processes will be affected. Soil development will commence after the disturbed areas are reclaimed, but the developing soils will likely have characteristics unlike those existing prior to mining.

7.5.1 Mine

Soil disturbance on 1730 acres (700 ha) (see Table 3.2) of mined area, overburden dump areas, topsoil stockpiles, settling ponds and haul roads cannot be avoided. The mined area will be the most severely disturbed since the entire soil profile and overburden will have been removed.

7.5.2 Mill

Soil disturbance on the 250 acres (100 ha) used for the mill site, tailings pond and stockpiled topsoil cannot be avoided. The soil disturbance at the mill site will not be severe since only a few inches of soil material will be removed and stockpiled. Soil disturbance for the tailings pond will consist of stripping and stockpiling topsoil, and compaction of subsoils to reduce permeability.

7.6 VEGETATION

7.6.1 Mine

Vegetation on approximately 1730 acres (700 ha) (see Table 3.2) will be removed over the life of the project; about 75-150 acres (30-61 ha) will be converted to permanent lakes. Plant species composition and diversity will be altered due to the disruption of the natural vegetation and subsequent revegetation. Fugitive dust from haul roads will affect remaining vegetation, but the extent of the impact cannot be quantified.

7.6.2 Mill

Vegetation on about 250 acres (100 ha) will be removed during the life of the project. Revegetation will be initiated when mill facilities are removed, but some 150 acres will be committed to the tailings pile.

7.7 WILDLIFE

7.7.1 Mine

Loss of habitat and reduction in most wildlife populations will occur as a result of mining. It is estimated that all operations will result in an annual loss of 10% of the antelope population (40-50 animals) and a similar loss of deer (4-5 animals) between 1976 and 1986. Habitat removal and severe disturbance will result in a loss or displacement of avian species. Total population numbers are unknown so actual losses cannot be quantified.

7.7.2 Mill

The mill and other structural facilities will contribute to the adverse effects described in 7.7.1. The tailings pond may contain radioactive and other contaminants that will harm, to some extent, all forms of wildlife that may come in contact with it. In cases where the magnitude of the effect could be computed, it turned out to be negligibly small (Sec. 4.8).

7.8 RADIOLOGICAL

Radioactive emissions from the excavated ore will directly affect the local environment as compared to current conditions whereby the surface environment is variously shielded by earth materials overlying the radioactive ore deposits. Since emissions from excavated ore are more direct, the level of radioactivity in the surface environment will also increase.

7.9 COMMUNITY

General

The disruption of the local labor market and the bidding up of wage rates are attributed to ongoing energy-related developments, and are causes of increasing concern that will be further stimulated by the RMEC project. This is related to the higher per employee income forecast earlier, and will be perceived as a negative impact by both public and private employers. This situation will likely contribute to higher consumer prices.

7.9.1 Public Finance

Even with energetic mitigation efforts, institutional friction will force some choices to be made between higher taxes and a lower quality of public facilities and services for several years. Either will represent negative impacts.

7.9.2 Abandonment

The RMEC development, with a short forecasted operating life (10 years), may add to costs of public and private capital for some borrowers. Socially, it will introduce another stress in a growing, changing community which has been relatively stable and predictable for several decades prior to the beginning of energy development.

7.9.3 Social Impacts

There are two major unavoidable adverse impacts to the previously existing societal relationships. The first involves a change from a ranching community to a more heterogeneous industrialized construction-and-mining community. This transition is underway as a result of present and potential energy resource development.

A second major area of concern is the relatively high proportion of retired individuals living in the Douglas area (32.4% of the oldtimers, people living in the community 5 years or more, 65 years of age or older).* This segment of the population is particularly vulnerable to the rising cost of living associated with rapid economic development.** The RMEC project will contribute to the adverse effects of such development.

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*As a group, they comprise most of the individuals with income under $9000/yr, with Social Security payments being their primary source of income.

**Julie M. Uhlmann, Robert Kimble and David Throtmorton, "A Study of Two Wyoming Communities Undergoing the Initial Success of Energy Resource Development in Powder River Basin: Buffalo and Douglas Wyoming - 1975," Laramie: U. of Wyoming, Dept. of Anthropology, 1976.

7.9.4 Cultural Impacts

If buried prehistoric cultural materials or sites exist, they may be damaged or destroyed during project development, and possibly more losses will occur due to increased human activity in the vicinity of the project site.

References for Section 7

1. "Environmental Survey of the Uranium Fuel Cycle," U. S. Atomic Energy Commission, Directorate of Licensing, Fuels and Materials, WASH-1248, April 1974, and Supp. to WASH-1248, October 1976.

8. RELATIONSHIP BETWEEN SHORT-TERM USAGE AND LONG-TERM PRODUCTIVITY

8.1 AIR QUALITY

The short-term increases in suspended particulates and chemical emissions associated with project activities is expected to have no effect upon the long-term quality of the atmosphere in the project area.

8.2 LAND USE AND TOPOGRAPHY

Project operations will cause a short-term reduction in carrying capacity of the local grazing resource and a reduction in hunting opportunities. Use of sprinkler irrigation may increase forage yield, and thus the amount of forage available to livestock and wildlife. Transportation routes in the area will be improved by upgrading existing roads and constructing new ones. The greater than 200% increase in capability Class IV lands, created during site reclamation, will increase the potential productivity of about 730 acres (290 ha) on a long-term basis. The 165 acres (66 ha) of highwalls and surface water expected to result from planned mining activities represents a permanent loss of agricultural productivity. The increased amount of surface water represents a change in use to include recreation activities, a source of livestock and wildlife water and/or opportunities to irrigate adjacent lands for greater agricultural yields.

A decrease in the potentially irrigable land of about 390 acres (150 ha) will occur within the disturbed areas; however, water for irrigation would be available within the remaining impoundments.

The short-term disruption of the landscape will not adversely affect the long-term esthetics if the proper mitigating measures are applied. The mill will be a focal point in the landscape from almost any point within a mile of the site. The mill structures can be designed to be interesting and in harmony with the site for the short-term usage of the site. Removal of mill facilities and appropriate site restoration could enhance landscape esthetics in a long-term time frame.

8.3 WATER RESOURCES

If water pumped from the active pits is treated and released into the existing stream channel, the resulting increased flow in the stream may create a temporary riparian habitat along the channel. Also, this water would be available to the downstream ranches for agricultural use throughout the duration of mining activities.

8.4 MINERAL RESOURCES

The extraction of the uranium ore (short-term usage) precludes future mining activities since the uranium is the only mineral resource known to exist in the project area. The proposed action does not preclude extracting minerals of current or future economic importance, should such minerals unexpectedly occur in association with the uranium deposits. Reworking of tailings piles or reopening of the strip mine could be effected as necessary.

8.5 SOILS

8.5.1 Mine

The long-term productivity of soils on approximately 2000 acres (800 ha) (see Table 3.2) in the mined areas is expected to be improved, according to predicted land capability potential, by the reclamation practices proposed by the applicant. The acreage of Class VIII land will increase from the present 10 acres (4 ha) to an estimated 165 acres (66 ha) of highwalls and water. The production potential on these acres will be lost, for agricultural purposes.

8.5.2 Mill

The possible long-term soils productivity on 150 acres (60 ha) of tailings will be improved to a predicted Class IV capability. The estimated forage production potential of reclaimed soils overlying the tailings deposits will increase compared to the present production levels, but may not be available because of excessive radiation levels.

8.6 VEGETATION

8.6.1 Mine

The existing vegetative cover on about 1000 acres (400 ha) will be systematically removed as each ore body, or portions thereof, are excavated over the next ten year period (see Table 3.2). Reclamation and revegetation of the mined areas will be initiated concurrent with cessation of mining activities in a given area. A satisfactory vegetative cover can be reestablished within a two to three year period and should be available for use by livestock and wildlife within four years after the ore has been extracted.

Conversion of planted vegetation to communities comprised of original species compositions, through natural plant succession, may require as much as 50-100 years. Some species, such as sagebrush, upon which wildlife rely heavily for food requirements may be reestablished at lesser frequency and/or density. Consequently, the productivity of these food plants may limit populations of browsing species that can be supported in the area.

8.6.2 Mill

Vegetation would be removed from about 250 acres (100 ha) for 10-12 years, after which the 250 acres would be available for revegetation. Long-term productivity and successional implications are the same as in Section 8.6.1.

8.7 WILDLIFE

8.7.1 Mine

Existing wildlife habitat on 3250 acres (1300 ha) will be destroyed or otherwise altered by strip-mining activities during the 1976-1986 period, with varying portions being revegetated and reclaimed during the life of the project. The planted vegetation will undergo natural successional changes and much of the character of the original vegetation may be restored. This, however, will occur over a long period of time, perhaps 50 to 100 years.

8.7.2 Mill

Development of the 250-acre (100-ha) mill site and related facilities will have the same effect on the local productivity as discussed above. The 100-acre (40-ha) tailings area may not be available for use following site reclamation.

8.8 RADIOLOGICAL

The buried tailings deposit may constitute a radiation hazard that is minor but continuous far into the future, particularly if the cover is removed or diminished. Depending upon the amount of radiotoxicity that accumulates in the water, the lakes that form in the abandoned mine pits may have either a positive or negative effect.

8.9 COMMUNITY

No significant long-term impacts on the socioeconomic character of local communities can presently be attributed to the RMEC project with certainty. The nature of such impacts will depend on the prevailing community conditions when operations of this RMEC development cease:

1. If the local economy and population continue to grow when the RMEC operation terminates and project personnel migrate from the area, the additional housing and public facilities built to accommodate RMEC and project related personnel will help to accommodate needs of the expanding economy.

2. If, at project termination, the economic activity and populations of communities are declining, and surpluses of facilities and housing exist, some of the resources initially invested to accommodate RMEC needs will have been wasted. This situation could be aggravated if bonds used to finance public facilities directly attributable to this development have not been amortized during the operating (or other taxpaying) life of the project.

The short-term usage of the site for mining and milling operations will likely preclude any future discoveries of archeological or other artifacts. However, any artifacts within the project area should be found and salvaged before or during project related activities. Thus, no long-term effects on archeological resources are expected, except for artifacts that might be buried under overburden or tailings. A loss of long-term productivity, which is intangible and difficult to assess, accrues from the fact that any site discovered must be evaluated by currently available techniques before destruction; the option of preserving the site for future study by improved techniques is foreclosed.

9. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

9.1 AIR QUALITY

Because air is not "used up" in the mining or milling operations, and because the atmosphere is self-cleaning of pollutants at the anticipated low concentrations, no irreversible or irretrievable commitments of air quality are expected.

9.2 LAND USE AND TOPOGRAPHY

The 48 acres of highwall area at the B-1 pit will be permanently lost to grazing use by livestock and by game animals. This area will consist of sandstone cliffs and probably very little vegetation will ever become established. These highwalls and the water ponds in the bottom of the B-1, B-8, and B-13 West pits will be an irreversible commitment of the topography and land use opportunities.

9.3 WATER RESOURCES

In areas where uranium ore is strip mined, water-bearing zones will be permanently altered, and infiltration of rainfall and snowmelt may be reduced. If recharge is reduced, runoff will increase and erosion and stream alterations will occur. The commitment of water resources necessary for the construction of facilities and mining of ore are believed to be small in comparison to the benefits obtained from the uranium that will be mined.

9.4 MINERAL RESOURCES

Other than the uranium that will be mined (about 4500 tons) the three million gallons per year of fuel oil consumed, and those fuels consumed to produce the eighty million kWh per year used in the mining and milling operations, no irreversible or irretrievable commitment of mineral resources is anticipated.

9.5 SOILS

9.5.1 Mine

The change in productivity potential of about 1730 acres (690 ha) of reclaimed soils is a commitment of the soil resource. The productivity of the 165 acres (66 ha) committed to highwalls and water bodies will be lost, although this may be partially compensated by increased productivity in the surrounding area.

9.5.2 Mill

The development and use of 150 acres (60 ha) of the project site for the tailings pond is an irretrievable commitment of the soil resource, but 50 acres (20 ha) may be recovered by decreasing the size of the tailings pile after operations are concluded.

9.6 VEGETATION

Removal of vegetation during construction and operation commits the applicant to the reestablishment of satisfactory vegetative cover when mining is concluded. This will involve substantial human and financial resources for an undetermined period of time.

Research and current reclamation projects of this nature indicate that vegetation can be reestablished in most of the area. Therefore, project activities will not result in a total irreversible or irretrievable commitment of the vegetation.

9.7 WILDLIFE

Mine activities will essentially preclude the use of 3250 acres (1300 ha) of land by wildlife for the duration of the project. Ultimately, species of wildlife will return when suitable habitat is restored. However, short-term loss of some wildlife species will occur.

9.8 RADIOLOGICAL

No irreversible or irretrievable commitments of radiological resources have been identified.

9.9 COMMUNITY

Any destruction of archeological or paleontological sites or materials will be an irreversible loss of the resource to the extent that the artifacts or fossils are not recorded and/or salvaged in an appropriate manner. The loss of sites for future study by improved methods is irretrievable.

10. ALTERNATIVES

10.1 ALTERNATIVES TO PROPOSED MINING AND RECLAMATION PLAN

The Federal action is viewed as basically one mining and reclamation plan covering the entire operation. Approvals by the Secretary of the Interior with respect to the lease will be with the concurrence of the Forest Service.

10.1.1 Alternatives on the Federal Lease Area (Lease W-4416)

Pursuant to implied covenants of both the Federal mineral leasing laws and the existing lease agreements, the Secretary of the Interior is obligated to respond to a legitimate application to conduct mining operations on a valid lease provided all terms and conditions thereunder have been met. His response may be approval as proposed, rejection on various legitimate grounds, approval in part and rejection in part, or approval subject to such additional conditions and requirements as he may impose under the laws. He may also defer decision, based on proper grounds, as described below.

10.1.1.1 No Action

"No action" on mining proposals for the initial development of existing lease would equate to maintaining the status quo on the lease. The impacts of taking no action in these cases would be the same as described in Section 10.1.1.3.

10.1.1.2 Defer Action

For proper cause, the Secretary may defer final action on a proposed mining and reclamation plan. These could include, but are not limited to, the need and time required for:

1. Modification of the proposal to correct administrative or technologic deficiencies.
2. Redesign to reduce or avoid environmental impact.
3. Acquisition of additional data to provide an improved basis for technical or environmental evaluation.
4. Further evaluation of the proposal and/or alternatives.

The principal effect of deferring action on a proposed mining and reclamation plan on these grounds would be a comparatively short-term delay in the imposition of all related impacts of the proposal--both adverse and beneficial, as previously described in Section 4 of this statement.

Once a mining and reclamation plan is approved, however, the regulations and lease terms do require that all subsequently proposed departures and deviations therefrom be approved in advance by the USGS. The regulations [30 CFR 231.10(e) and (f)] also permit the USGS to direct that changes be made in previously approved operations. For example, changes could be ordered to accommodate new, improved, or revised administrative requirements, technological improvements, environmental concerns or requirements, or revisions of prior evaluations thereof in the light of experience or previously unknown factors. Such changes have been ordered routinely in USGS mining supervision practice.

10.1.1.3 Prevent Development on the Existing Lease

The only alternatives to allowing the proposed development of an existing lease is to prevent such development or to impose additional conditions and restrictions on the operations. The several apparent means of preventing full development are discussed below.

If prevention of further development of the existing lease were accomplished, significant quantities of uranium, known to be present, would be left in place and not recovered for use. To

replace the resources foregone by this alternative course of action, other comparable quantities of uranium would be required to meet national needs. The development of other sources and the related impacts are discussed later.

Cancel the Lease

The Secretary does not possess authority to unilaterally cancel the lease except on the grounds defined therein (Appendix C, Section 9 of the lease terms--"Proceedings in case of default"). The authority to cancel on other grounds would require Congressional authorization for such action as well as for the requisite funds for compensation of the lessees as may be necessary. The Administration has not entered a request for such legislation, and the Congress has not initiated such action in the matters considered in this statement. The possibility of such actions is a matter for further consideration by the Administration and the Congress in the light of this environmental statement and other relevant nonenvironmental concerns. Such legislative proposals have been initiated by the Administration and/or the Congress in recent years in several other instances, but such legislation has never reached the voting stage. Should such cancellation be legislated, litigation by the present lessee would be likely. The ultimate effects would be several and would relate directly to the litigatory actions taken, the decision thereof, and the time required for their resolution.

To the extent that uranium production from the existing lease would be curtailed or halted, alternative sources of uranium would be required to meet present needs and demands. The time required to replace the resource foregone could range from scant to a number of years, depending on the specific alternative(s) selected. The direct monetary cost of such action to all parties involved could range from comparatively modest sums to millions of dollars. Indirect costs to producer, government, and consumer occasioned by contract abrogation, delay in replacement or substitution, loss of governmental taxes and royalties, loss of employment income, etc., could be substantial in the aggregate.

Federal Acquisition of Lease

The leasehold interest could be acquired by the Secretary. The ability to acquire the leasehold interest is not granted by the existing relevant statutes and would require Congressional authorization for such action as well as for the requisite funds for compensation of the lessee. To date, the Administration has not requested such action, and the Congress has not initiated or considered such legislation; the possibility thereof is thus conjectural at best. The major effects of such Congressional authorization would be similar to those of cancellation of the lease as previously discussed under the heading, "Cancel the Lease".

Reject the Mining and Reclamation Plans

Rejection of the proposed mining and reclamation plans would result in no environmental impact on the leased lands, and they would continue in their present condition, subject to modification by natural processes and by the continuation of other existing activity and uses--and to further modification by the surface owner to meet other uses.

The Secretary may reject any individual proposed activity that does not meet the prescriptions of applicable law and regulations under his authority, including the potential for environmental impact that could be reduced or avoided by adoption of a significantly different designed course of action by the lessee (operator). The Secretary cannot under present circumstances reject the proposed plans to the extent that a de facto cancellation of a lease results unless he seeks and obtains additional authority from Congress. Viability of this option is dependent upon timely legislative action; the option of rejecting the proposed plans pending legislation remains available. Impacts of this alternative would be similar to those described above under heading, "Cancel the Lease."

10.1.1.4 Restrict Development on the Existing Lease

The subject lease conveys without constraint as to time, location, or rate, the unequivocal right to develop, produce, and market the Federal uranium resource thereon, if all other terms and conditions have been met by the lessee. In general, the Secretary does not possess the authority to constrict development per se unilaterally and out of hand. Various measures, which may tend to restrict development, may be taken by the Secretary at any time in the interest of conservation of the resources or in the protection of various specific environmental values in accordance with existing law; for example, the National Historic Preservation Act of 1966, the Endangered Species Act of 1973, etc.

Thus, under present conditions, a general effort to restrict or regulate development of an existing lease for most other reasons would constitute a selective application of the "prevent development" alternative already discussed; that discussion, as it relates to impacts, possible litigation, and the need for authorizing legislation, would be relevant in this instance.

10.1.2 Mining Alternatives

Selection of a mining method adaptable to recovering a mineral resource is based upon (1) the spatial characteristics of the deposit (size, shape, attitude, and depth); (2) the physical (or mechanical) properties of the mineral deposit and surrounding rock; (3) ground-water and surface-water conditions; (4) economic factors, including grade of the ore, comparative mining costs, and desired production rates; and (5) environmental factors, such as the preservation of the surface overlying the mine and the prevention of air and water pollution. Of these factors, the spatial characteristics of the deposit and the physical (or mechanical) properties of the mineral and surrounding rock technically and economically limit the methods that can be employed to mine it. Cursory review of readily available modern textbooks will quickly reveal that only open-pit and solution (in-situ leaching) mining are viable methods of mining these uranium deposits under the existing state of technology and the existing geologic conditions in the area.

10.1.2.1 Open-Pit Mining

The open-pit method is most effective and most used where ore bodies are at or near the surface and where there is ample suitable location for disposal of overburden within the economic constraints of haul distance. The earth surrounding the ore body is removed to expose the ore. As the ore is mined at depth, the overburden and middle waste are removed, creating a depression or pit. The ultimate limit of depth of an open-pit mine is an economic limit. The limit is that point at which the cost attributable to a ton of ore plus the company's profit per ton of ore is equal to the net market value of that ton of ore.

10.1.2.2 Solution Mining

In-situ leaching, a relatively new technique for uranium extraction of a commercial scale, involves the drilling (from the surface) of injection and recovery wells into the ore body. An acidic or alkaline solution is pumped down the injection wells into the ore-bearing strata; this solution dissolves the uranium minerals associated as a coating over the sandstone grains. The uranium-containing leach solution is then recovered by pumping it to the surface through the recovery wells. The disposal of the leaching solution and/or contamination of the aquifers is the primary environmental impact area risk. Uranium deposits, which are small, isolated, and too deep to be mined economically by other methods, may be recovered by in-situ leaching under the following general conditions:

1. The ore is generally horizontal and is underlain by relatively impermeable stratum.

2. The ore is in a saturated stratum below the static water table.

3. The fluid transmissivity and storage capability of the ore-bearing sandstone and the mineralogy of the ore are known.

4. A maximum recovery of the acidic or alkaline leach solution is possible (a primary impact of concern involves an incomplete recovery of the leachate).

The applicant conducted an in-situ leaching pilot study north of the B-4 ore body area. Results of this study were considered in the applicant's decision to utilize conventional mining methods rather than the solution leaching method.

In evaluating the results of this study, RMEC stated:

> "The state-of-the-art of in-situ extraction is such that dependable prediction of the time, rate of production, and ultimate recovery of uranium could not be made. The fact that in-situ leaching is very site specific would mean that each of the seven Bear Creek deposits would need to be tested to develop the optimum in-situ leaching design for the respective deposits. Normally, such optimization is an evolving process which can require years to complete because of the slow rate at which uranium is recovered by this means. The state of the art of conventional mining and milling is such that dependable production of uranium recovery can be made based on laboratory testing of ore samples obtained by core drilling.

The geology of the Bear Creek deposits is not too well suited for in-situ leaching. The deposits are very long and narrow and often over 100 feet thick vertically. The edges tend to be poorly defined with the thick sands pinching out into multiple thin layers. This would make recovery of the uranium around the edge of deposits--a significant portion of the total pounds--very tricky and unpredictable by in-situ means."

10.1.3 Surface Reclamation Alternatives

This section discusses various alternative methods (including those proposed by the applicant) for reclaiming land that has been disturbed by mining and milling operations. A brief consideration is given to reclamation problems associated with alternative methods of mining, but major attention is given to the assessment of alternative methods of reclaiming land disturbed by open-pit mining. The considerations herein apply to surface reclamation in both the lease and claims areas. The present land capability potentials provide a quality standard for reclamation and the natural resources provide the raw materials for future potentials and capabilities in land use. A variety of potential land uses can be considered for development within the project area as uses after mining. They are uses such as livestock grazing, wildlife habitat, recreation, cropland and multiple-use combinations. Methods of reclamation are chosen with a specific set of land use goals in mind (see Table 10.1) considering the expected capability of the land to support the selected uses and the public need. It was assumed that the primary land use objective of reclamation would be a return to livestock grazing and wildlife habitat in the immediate future. [However, the potential capability of the reclaimed land for other potential uses is a necessary consideration in view of the long-term productivity of the sites to be disturbed. (See supporting data in Appendix D)].

Table 10.1. Land-Use Goals

Reclamation Alternatives[a]	Grazing	Wildlife	Recreation	Cropland
Topography - Landform				
1) Flat - gently rolling	1	2	2	1
2) Rough - significant relief	3	1	2	4
3) Highwalls (reclaimed)	3	2	3	4
4) Lakes and reservoirs	1	1	1	2
Soil				
1) Surface with topsoil	1	1	1	1
2) Surface without topsoil	4	4	3	4
3) Rebuild soil structure	1	1	1	1
4) Fertilize and mulch	1	1	1	1
5) Mechanical surface treatment	1	1	2	1
Revegetation				
1) Native species	1	1	1	4
2) Introduced species	2	2	2	1
3) Irrigation	1	2	2	1

[a]Alternatives may be selected singly or in combination.

Legend: 1 = Desirable alignment of reclamation with land use.
2 = Acceptable alignment of reclamation with land use.
3 = Undesirable alignment of reclamation with land use.
4 = Unfeasible alignment of reclamation with land use.

Surface reclamation options, with respect to viable extraction methods discussed in Section 10.1.2, differ widely in magnitude between solution and open-pit mining methods.

10.1.3.1 Reclamation for Solution Mining

The reclamation techniques which may be associated with solution mining are primarily one of plugging drill holes, clean-up of chemical spills and the later revegetation of disturbed area. Although little experience is available in reclamation of solution-mined areas for uranium, the practices and methods are believed to be similar to those used for oil fields.

This would involve the stripping and stockpiling of the topsoil, on areas to be disturbed, which would later be spread back into the surface and revegetated. There are no estimates regarding the possible number of locations required for the maximum economic and conservation recovery of uranium from this method within the project area. It is known, however, that this method would disturb the surface and the underlying geologic material to lesser degree (by several orders of magnitude) than the other viable methods. This method was dismissed by the applicant as stated in Section 10.1.2.

10.1.3.2 Reclamation for Open-Pit Mining

A considerable amount of information is available concerning open-pit mining, since this is the most commonly utilized mining method in the region. This is also the method of mining the applicant proposes.

Open-pit mining would disturb the most surface acreage of all mining methods considered and would completely alter the underlying geologic material. The company has reviewed in depth five principal reclamation alternatives identified as A through E. Several other alternatives were considered but eliminated from detailed review since they were found to be unacceptable by considerations of environmental, economic or statutory factors. Alternative A, as discussed previously and summarized below, is the applicant's proposed reclamation plan.

Alternative A

According to the mining and reclamation plan, B-1 pit overburden will be placed in two surface dumps east and west of the pit. The overburden from the south half will be backfilled into the north end resulting in approximately a 46.5% backfill of the pit. A total of 21.0 million bank cubic yards (BCY) of overburden will be moved to surface dumps. The tops of the dumps and the mill facility areas would be shaped to a rolling topography with slopes ranging from 0 to 10 percent. This part of the disturbed area is approximately 618 acres including the tailings pond. The sideslopes of the spoil dumps would range in slopes of 10 to 30 percent covering an estimated 78 acres. Salvaged topsoiling material would be spread to a thickness of approximately 21 inches on these areas.

A lake of 31 surface acres would remain in the south end of the pit after reclamation. Access to the lake will be on the south and north ends at grades of approximately 8 and 30 percent, respectively. The soft sandstone highwalls would remain on both sides of the lake. The highwalls amount to approximately 48 surface acres with an overall slope in excess of 60 percent. These slopes would be benched and planted to trees and shrubs as planned.

Overburden from the B-4, Dilts-E, and half of the material from the B-3 pit will be taken to surface overburden sites. The remaining overburden from the B-3 pit will be backfilled into the B-4 pit, with excess going to two B-4 surface overburden sites. The overburden from Dilts-W will be placed as backfill in Dilts-E and the B-3 pit. B-6 overburden will be backfilled into Dilts and B-3 to achieve the original landforms in those areas. All of B-8 overburden will be backfilled into the B-6 pit to restore original contours. The B-8 would remain open and serve as a 51-acre lake with the highwalls reduced to about 3:1 slopes to provide for access and revegetation.

The backfilled pits and dump tops in the northern area would be shaped to slopes ranging from 0 to 10 percent on approximately 539 acres. The dump and pit slideslopes would range from 10 to 30 percent on approximately 138 acres. Salvaged topsoiling material would be spread to a thickness of approximately 33 inches on these areas.

Overburden from the B-13 east pit would be placed to the south and overburden from the B-13 west pit would backfill the eastern part. A 35-acre lake would form in B-13 west with highwalls reduced to about 3:1 slopes.

The backfill pits and dump top in the east area would be shaped to slopes ranging from 0 to 10 percent on about 175 acres. The backsloped pit and dump sideslopes would have slopes of 10 to 30 percent on about 73 acres. Salvaged topsoiling material would be uniformly spread to a thickness of approximately 30 inches on these areas.

The restored surfaces would be revegetated with approved species using the necessary fertilizers and soil amendments to assure expected plant growth. Structural practices are planned, additionally, to insure soil stabilization from erosion and to provide watershed protection.

Alternative B

Alternative B is identical to Alternative A with the exception that the highwalls of the B-1 pit which lie on Federal lands would be reduced to a maximum of 3:1 slopes. The slopes would be reduced during stripping operations by removing 9.3 million cubic yards of additional material and placing the material in the east B-1 surface overburden site.

The final B-1 lake would expand by approximately 438 acre-feet, of which 68 percent of the increased volume would be on Federal land. An additional 48 acres of surface around the B-1 pit and an additional 66 acres would have to be added to the east B-1 overburden dump.

Topsoil salvaging, replacement and revegetation would be the same as described in Alternative A.

Alternative C

Alternative C is similar to Alternative A with the exception that the highwalls on Federal land surface of the B-1 pit are reduced to a maximum of 3:1 slopes. The method of achieving the slope reduction differs from Alternative B in that 2.4 million cubic yards of backslope material is dozed into the B-1 pit after the B-1 mining operations are completed.

Compared to Alternative A, this alternative results in an additional disturbance of approximately 20 acres and a reduction in the size of the final B-1 lake from 2463 acre-feet to 1058 acre-feet, with none of the remaining lake on Federal land.

Topsoil salvaging, replacement and revegetation would be the same as described in Alternative A.

Alternative D

Alternative D, like B and C, is similar to Alternative A with the exception that the B-1 highwalls are reduced around the entire pit to a maximum of 3:1 slopes. This is achieved by dozing approximately 8.7 million cubic yards of material into the B-1 pit from the sidewalls after mining operations are completed.

Original contours are not achieved by this alternative in the B-1 pit but all highwalls are eliminated. The resulting depression would be similar to a playa condition. Approximately 68 acres of additional land would be disturbed in this option relative to Alternative A.

Topsoil salvaging, replacement and revegetation would be essentially the same as described in Alternative A.

Alternative E

Alternative E consists of complete backfill of all mine pits to achieve approximately the original elevations.

Relative to Alternative A, the total fill of the B-1 pit would require an additional 21 million BCY of overburden from surface dumps to be rehandled. The reclaimed surface of Mining Area I would consist of approximately 673 acres having slopes of 0 to 10 percent and about 50 acres between 10 and 30 percent. Replaced soils would be spread to an approximate average thickness of 21 inches.

Backfilling the B-8 pit involves rehandling an additional 12 million BCY of overburden. The reclaimed surface of Mining Area II (north area) would include about 643 acres of 0 to 10 percent and about 85 acres in the 10 to 30 percent range. The replaced soil would be about 33 inches thick.

Filling the B-13W pit would require rehandling 5.4 million BCY of overburden. The final landform of Mining Area III (east area) would consist of about 278 acres having less than 10 percent slopes and approximately 5 acres within the 10 to 30 percent range. Replaced soil would be about 30 inches thick.

Other Alternatives

Other alternatives which were evaluated included:

(a) no backfill of any pits,

(b) 50% backfill of the final pit in each mining area and 100% backfill of all other pits in each mining area.

These alternatives, as well as numerous other mining sequences and methods, were discarded as being unacceptable either environmentally, economically or technically.

10.1.4 Impacts and Effects of the Five Alternatives

Alternatives A, B, C, D, and E disturb a comparable acreage. The reduction of highwalls and rehandling of overburden materials discussed in Alternatives B, C, D, and E would disrupt site stabilization of overburden dump achieved during the process of mining and reclamation, increasing the likelihood of accelerated soil erosion and water quality degradation due to additional land disturbance. Interim use by livestock and wildlife would be limited and the total reclamation phase would be extended over a longer period of time. Reclamation costs are heavily related to material handling. These estimated costs are shown in Table 10.2.

Table 10.2. Relative Costs of Reclamation Alternatives

	Alternatives				
Mining Area	A	B	C	D	E
I. B-1 area	--	$7 million	$1.2 million	$4.4 million	$15.7 million
II. B-3, B-4, B-6, B-8, Dilts area	--	0	0	0	$ 9.0 million
III. B-13 area	--	0	0	0	$ 4.1 million
Project total	--	$7 million	$1.2 million	$4.4 million	$28.8 million

Note: All cases are relative to Alternative A.

The analysis of alternatives was based upon the existing potential capability of the land and predicted potential capability of the land according to each reclamation alternative. (See Tables 10.3, 10.4a, and 10.4b.)

The significance of the variations between alternatives (see Table 10.5) is primarily in the amount of lands that would be disturbed by the process of mining and reclamation, the opportunities for enhancing the long term productivity of the site, and the amount of lands removed from productive potential. The possible change in use potential offered by the various alternatives is not necessarily a loss in total benefits. For example, the creation of lakes and ponds would have an influence upon the esthetics of the area, could be associated with recreation, and could provide for a fishery. The surface water could have beneficial effects upon the distribution of water for wildlife and livestock utilizing the reclaimed and adjacent areas. The water storage also represents an opportunity which could support irrigated agriculture.

The areas left as highwall represent a net loss in long term productivity. (See Appendix D for supporting data.)

10.1.5 Summary

Alternative A represents the least costs in reclamation of the five alternatives while returning the land to a wide variety of uses. Alternative B is similar to A in returned benefits and values. B would increase the opportunity for water resource development and reduce the highwalls on National Grassland surface at a higher cost than A. Alternative C is similar to B but would reduce the amount of water resource development while returning the greatest surface area to a wide range of productive use at a lesser cost than Alternatives B, D, or E.

Table 10.3. Summary of Existing and Predicted Soil Capability Classes and Range Sites for All Disturbed Areas, by Alternatives[a,b]

Soil Capability Classes or Range Sites	Present Acres	Reclamation Alt. A		Reclamation Alt. B		Reclamation Alt. C		Reclamation Alt. D		Reclamation Alt. E	
		Acres	Change Acres	Acres	Change Acres	Acres	Change Acres	Acres	Change Acres	Acres	Change Acres
Non-irrigated											
IVe	650	1380	730	1364	714	1433	783	1433	783	1699	1049
V	0	0	0	0	0	0	0	0	0	0	0
VIe	1076	361	-715	369	-707	336	-740	400	-676	207	-869
VIIe	183	12	-171	2	-181	4	-179	0	-183	12	-171
VIIIe	10	166	156	184	174	146	136	86	76	1	-9
Irrigated											
IIIe	445	29*	-416	4*	-441	11*	-434	0	-445	29*	-416
IVe	1124	78*	-1046	11*	-1113	29*	-1095	0	-1124	78*	-1046
IVs	0	1182	1182	1207	1207	1265	1265	1283	1283	1501	1501
Range Sites											
Clayey	467	240*	-227	184*	-283	199*	-268	175	-292	343*	-124
Loamy	647	1255	608	1259	612	1322	675	1331	684	1403	756
Steep loamy	0	216	216	286	286	237	237	327	327	130	130
Shallow loamy	133	13*	-120	2*	-131	5*	-128	0	-133	13*	-120
Sandy	577	28*	-549	4*	-573	10*	-567	0	-577	28*	-549
Shallow sandy	65	0	-65	0	-65	0	-65	0	-65	0	-65
Lowland	21	0	-21	0	-21	0	-21	0	-21	0	-21
Rockland	9	49	40	47	38	41	32	0	-9	1*	-8
Water	0	117	117	137	137	104	104	86	86	0	0

[a]All alternatives and present case are compared on a common total area to facilitate comparison. The base case is Alternative D which has the largest total disturbed area. Acreages marked with an asterisk (*) were adjusted to include the productivity of an increment of undisturbed area to bring the total acreage to a common value.

[b]Acreages do not include haul roads, powerline right-of-ways and other minor disturbances.

Note: Soil capability and range site correlations are according to the USDA-SCS Soil Survey for present conditions; the predicted reclaimed potentials are based upon the same format, but modified for disturbed lands. The range site and capability potentials for reclamation alternatives were developed by Hayden D. Rounsaville and Darwin D. Hoeft, Soil Scientists, USDA-Forest Services.

Table 10.4a. Potential Yield Summary for Areas to be Disturbed[a] - Non-irrigated Potentials[b]

Agricultural[c] Potential	Estimated Production, yield/acre	Present		Alternative A		Alternative B		Alternative C		Alternative D		Alternative E	
		Acres	Total Yield	Acres	Total Yield	Acres	Total Yield	Acres	Total Yield	Acres	Total Yield	Acres	Total Yield
Non-irrigated Crops													
Wheat	20 bu	650	13,000	1380	27,600	1364	27,300	1433	28,660	1433	28,660	1699	34,100
Oats	27 bu	650	17,550	1380	37,260	1364	36,700	1433	38,700	1433	38,700	1699	45,900
Barley	22 bu	650	14,300	1380	30,360	1364	30,000	1433	31,500	1433	31,500	1699	37,300
Grass, hay or tame pasture	0.62 ton	650	403	1380	856	1364	846	1433	890	1433	890	1699	1,050
Range Sites													
Clayey	1300	467	607,100	240*	347,000	184	274,200	199*	293,700	175	262,500	343*	501,500
Loamy	1500	647	970,500	1255	1,853,300	1259	1,859,300	1322	1,953,800	1331	1,967,300	1403	2,104,500
Steep loamy	1100	0	0	216	101,000	286	178,000	237	124,100	327	223,100	130	143,000
Shallow loamy	900	133	119,700	13*	11,700	2*	1,800	5*	4,500	0	0	13*	11,700
Sandy	1600	577	923,200	28*	44,800	4*	6,400	10*	16,000	0	0	28*	44,800
Shallow sandy	1000	65	65,000	0	0	0	0	0	0	0	0	0	0
Lowlands	2500	21	52,500	0	0	0	0	0	0	0	0	0	0
Rockland	0	9	0	49	0	47	0	41	0	0	0	1*	0
Water	0	0	0	117	0	137	0	104	0	86	0	0	0
TOTAL		1919	2,738,000	1918	2,357,800	1919	2,319,700	1918	2,392,100	1919	2,452,900	1918	2,805,500

Note: All alternatives and present case are compared on a common total area to facilitate comparison. The base case is Alternative D which has the largest total disturbed area. Acreages marked with an asterisk (*) were adjusted to include the productivity of an increment of undisturbed areas to bring the total acreage to a common value.

[a]Acreage of disturbance calculated does not include haul roads, powerline right-of-ways, and other minor disturbances.

[b]Yield estimates are based on U. S. Dept. of Agriculture, Soil Conservation Service, Wyoming Technical Guides VB for crops (Table D-4.1). Range site yield estimates are based upon data from Table D-1.2.

[c]Only Capability Class IV or better was considered as having crop potential.

Table 10.4b. Potential Yield Summary for Areas to be Disturbed[a] - Irrigation Potentials[b]

Agricultural Potential[c]	Estimated Production, yield/acre	Present		Alternative A		Alternative B		Alternative C		Alternative D		Alternative E	
		Acres	Total Yield	Acres	Total Yield	Acres	Total Yield	Acres	Total Yield	Acres	Total Yield	Acres	Total Yield
Irrigated IIIe													
Oats	80 bu	445*	35,600	29*	2,320	4*	320	11*	880	0	--	29*	2,320
Barley	65 bu	445*	28,925	29*	1,885	4*	260	11*	715	0	--	29*	1,885
Hay (grass)	3 tons	445*	1,335	29*	87	4*	12	11*	33	0	--	29*	87
Alfalfa hay	4.5 tons	445*	2,002	29*	130	4*	18	11*	49	0	--	29*	130
Irrigated pasture	7 AUM	445*	3,115	29*	203	4*	28	11*	77	0	--	29*	203
Irrigated IVe													
Oats	70 bu	1124*	78,680	78*	5,460	11*	770	29*	2,030	0	--	78*	5,460
Barley	55 bu	1124*	61,820	78*	4,290	11*	605	29*	1,595	0	--	78*	4,290
Hay (grass)	2.5 tons	1124*	2,810	78*	195	11*	27	29*	72	1	--	78*	195
Alfalfa hay	4 tons	1124*	4,496	78*	312	11*	44	29*	116	0	--	78*	312
Irrigated pasture	6 AUM	1124*	6,744	78*	468	11*	66	29*	174	0	--	78*	468
Irrigated IVs													
Oats	60 bu	0	--	1182	70,920	1207	72,420	1265	75,900	1283	76,980	1501	90,060
Barley	50 bu	0	--	1182	59,100	1207	60,350	1265	63,250	1283	64,150	1501	75,050
Hay (grass)	1.5 tons	0	--	1182	1,773	1207	1,810	1265	1,897	1283	1,924	1501	2,252
Alfalfa hay	2 tons	0	--	1182	2,364	1207	2,414	1265	2,530	1283	2,566	1501	3,002
Irrigated pasture	4 AUM	0	--	1182	4,728	1207	4,828	1265	5,060	1283	5,132	1501	6,004
Total Irrigated Potential		1569		1289		1222		1305		1283		1608	
Oats	bu		114,280		78,700		73,510		78,810		76,980		97,840
Barley	bu		90,745		65,275		61,215		65,560		64,150		81,226
Hay (grass)	ton		4,145		2,055		1,849		2,002		1,924		2,534
Alfalfa hay	ton		6,498		2,806		2,476		2,695		2,566		3,444
Irrigated pasture	AUM		9,859		5,399		4,922		5,311		5,132		6,675

Note: All alternatives and present case are compared on a common total area to facilitate comparison. The base case is Alternative D which has the largest total disturbed area. Acreages marked with an asterisk (*) were adjusted to include the productivity of an increment of undisturbed area to bring the total acreage to a common value.

[a]Acreage of disturbance calculated does not include haul roads, powerline right-of-ways, and other minor disturbances.

[b]Yield estimates are based on U. S. Dept. of Agriculture, Soil Conservation Service, Wyoming Technical Guides VB for crops (Table D-4.1). Range site yield estimates are based upon data from Table D-1.2.

[c]Only Capability Class IV or better was considered as having crop potential.

Table 10.5. Acreage Available for Potential Use According to the Reclamation Alternatives Considered[a]

Potential Uses	Alt. A, acres	Alt. B, acres	Alt. C, acres	Alt. D, acres	Alt. E, acres
Approximate area of disturbance[a]	1786	1900	1870	1919	1786
Adjusted total area for alternative comparison[b]	1919	1919	1919	1919	1919
Agricultural Opportunities[b]					
A. Non-irrigated crops	1380	1364	1433	1433	1699
B. Irrigated crops	1289	1222	1305	1283	1608
C. Wildlife and livestock range	1753	1735	1856	1833	1919
Recreational Opportunities[b]					
A. Hunting[c]	1871	1872	1878	1919	1919
B. Fishing	116	137	104	86	0
Non-use[b,d]	48	47	41	0	0

[a]Unadjusted approximate total disturbed area exclusive of certain minor disturbances such as haul roads, powerline right-of-ways, etc.

[b]Alternatives and present case are compared on a common total area to facilitate comparison. The base case is Alternative D which has the largest total disturbed area. Acreages marked with an asterisk (*) were adjusted to include the productivity of an increment of undisturbed area to bring the total acreage to a common value. Acreages do not include haul roads, powerline right-of-ways, and other minor disturbances.

[c]Includes total surface disturbed less highwalls and considers large game and waterfowl.

[d]Refers to highwalls which would serve no purpose other than sight-seeing interest and potential avian nesting, resting, and launching sites.

Alternative D would reduce all highwalls and eliminate the water development associated with the B-1 pit at next to the highest reclamation cost. D is otherwise similar to A. Alternative E would return the disturbed land to approximate original contour, yield the highest ratio of improved use potential, and re-establish the primary use of range for livestock and wildlife at the highest reclamation cost.

10.2 ALTERNATIVE SITES FOR MILL AND MILL TAILINGS DISPOSAL FACILITIES

The applicant has investigated three sites for the Bear Creek Mill and four sites for mill tailings disposal facilities.* The main considerations involved in the final selection of the mill site were as follows:

1. The proximity of the site to mining operations.
2. The site should not be underlain with mineable ore.
3. Topography; i.e., mill site should be flat and as free as possible from sharp relief.
4. The position of the tailings effluent system from the mill should be on an uphill gradient from the tailings disposal area.
5. Subsurface ground conditions must permit adequate support for mill building foundations.
6. The mill site should have adequate drainage and not be subject to flooding by surface runoff.

*Potential mill sites are located in Sections 1, 3, and 9, and tailings disposal sites are in Sections 16, 8, 9, 1. See Figure 1.2 for the location of these sites relative to the total project area.

7. Clear title to the land is possible; i.e., the applicant has control of the surface.

8. Condition of tailings: if they are treated with barium, a more permeable basin would suffice than with untreated tailings.* The economics of treating tailings is still under study.

The site in Section 8 includes a prime meadow, hence the environmental impact of using this site would be relatively large. This consideration, in addition to potential drainage problems, resulted in the applicant eliminating this site. The site in Section 9 would result in a tailings impoundment that would divide the Manning Ranch into halves. This fact, in addition to anticipated problems in obtaining clear title because of the mixed ownership of the land resulted in elimination of the site. The site in Section 1, although apparently acceptable on other grounds, was withdrawn from serious consideration because of its remoteness from the selected mill site.

Two possible sites for the disposal of treated tailings were evaluated by the applicant but were not studied in detail because the economic cost of the treatment was considered as far outweighing the environmental benefits.

In view of the considerations outlined above, the applicant chose the disposal site in Section 16. The surface of Section 16 is owned by the State of Wyoming and the applicant was able to obtain a long-term lease only after satisfying the Land Commissioners of the state that no mineable deposits of coal or minerals exist under the tailings impoundment site.

The NRC staff has evaluated the applicant's site alternative analysis and finds the sites selected are suitable for the proposed operations.

10.3 ALTERNATIVE MILL PROCESSES

There are eight main steps in the milling of uranium ore to produce yellowcake. They are:

Crushing of ore (primary)

Grinding of ore (secondary)

Production of water-ore slurry (sometimes combined with secondary grinding)

Leaching of ore

Separation of leach liquor from tailings (waste)

Concentration and purification of leach liquor

Precipitation of uranium values from leach liquor

Drying and calcining of precipitate to form U_3O_8

The specific manner in which each of these steps, singly or in combination, is accomplished, is ore and site specific. Usually, decisions are based on overall process economic considerations including the costs of controlling chemical and radiological effluents to water, air, and land.

Crushing and grinding of ore are needed to prepare run-of-mine ore for slurry formation and to reduce overall particle size to insure efficient contact with the uranium dissolving reagent. When the ore is loosely consolidated (as is expected to be the case for Bear Creek) it lends itself readily to wet grinding in a ball or rod mill. The material from the wet grinding operation will also have been slurried, and ready for contact with the dissolving medium. This combination of two steps (slurry manufacture and grinding) into primary treatment of ore also minimizes dust generation, eliminates bin storage of ground ore (which can have variable moisture content) and reduces costs.

Methods for leaching the ore-water slurry are dependent on ore characteristics. If the ore has a high content of chemically basic materials, leaching with sulfuric acid would be relatively costly. In such a case, hot autoclaving with sodium bicarbonate-carbonate could be used. The Bear Creek ore is expected to be somewhat acid and loosely agglomerated. For these reasons the applicant has chosen sulfuric acid leaching process.

The separation of the leach liquor (which contains 90+ percent of the uranium in the ore) from the barren undissolved waste (tailings) can be accomplished by thickening, filtration (usually very difficult with most ores), settling, or counter-current decantation. The applicant has chosen to accomplish this separation by counter-current decantation.

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*Two sites were considered; the Spook Pit and the B-1 mining pit. See Figure 1.2 for these locations.

There are two commonly used methods for concentrating and purifying the leach liquor, and they are similar in that each involves an interchange of ions between an aqueous solution (leach liquor) and either a solid resin (resin ion exchange) or a liquid organic solvent (solvent extraction). In the latter case, a kerosene-amine mixture is usually used for uranium. The applicant has stated that the Bear Creek process will employ the latter method because:

Its simplicity allows continuous, automated handling and control.

Most resin-based processes require a finishing solvent extraction to assure maximum yields.

The solvent extraction system has a lower capital cost (the special resin required for resin ion exchange is expensive).

The solvent extraction method requires less water.

The milling process, even if carbonate leaching is used, generally concludes with precipitation of the uranium values from an acid solution by addition of ammonia, although in some operations hydrogen peroxide is used. The complex precipitate is filtered, washed, dried, and calcined to produce oxides of uranium.

The NRC staff has considered the employment of the various alternative process steps mentioned above, and considers that none of the alternatives is clearly superior to those chosen by the applicant. Further developments, such as changes in the characteristics of the ore or unexpected changes in the relative costs of reagents, may result in applicant-initiated changes in the process. When such changes are suggested, the staff will assess the environmental impacts of the changes and weigh the relative merits of the viable alternatives.

The applicant considered the construction of a sulfuric acid plant at the mill site to supply the Bear Creek and other area mill requirements for this reagent but has decided to purchase the necessary quantities from existing suppliers.

10.4 ALTERNATIVE METHODS FOR TAILINGS MANAGEMENT

10.4.1 Introduction

For the purposes of this section, tailings management is defined as the disposition of the tailings and waste leach solutions following extraction (separation) of the uranium-bearing solutions. Engineering techniques to control pollutants from tailings storage, both during operational and postoperational stages of a milling project, have been demonstrated. The unique characteristics of each facility must be identified, and then appropriate environmental controls must be applied. Alternatives presently available or feasible (i.e., potentially available with existing technology and within legal constraints) are discussed in Section 10.4.2. In Section 10.4.4 is a list of alternatives that have not been considered in detail because the staff has concluded that they are not viable with existing technology or legal constraints. The staff has examined numerous sources of information[1-5] in preparing this analysis of alternatives.

10.4.2 Viable Alternatives

Alternative I - Tailings Pond with Natural Foundation

Alternative I consists of creating a tailings impoundment in an existing natural basin with a dam close to the mill. The impoundment would be of sufficient size to hold a lifetime output of the mill (see Sec. 3 for construction details and design basis). The bottom will be scarified and recompacted. Water from the tailings pond will be recycled to the mill. All surface water will be routed around the impoundment area. The entire area will be fenced. Prior to reclamation, blowing sands and dust which might impact offsite areas will be stabilized by use of chemicals or other methods. Reclamation will be staged, with the initial efforts beginning as soon as an area has reached sufficient depth and dryness (probably within six years). Five and a half feet of overburden will be placed on top of the dried tailings, the pile will be contoured and shaped, and six inches of topsoil material will be spread over it. Soil amendments (e.g., fertilizer, organic matter) will be added as necessary. The area will be revegetated with appropriate plant species. A monitoring and maintenance program will be established following reclamation to ensure stability of the pile.

Physical properties of tailings material are such that tailings will provide minimal seal against water seepage. The applicant states that 80% of the tailings material is coarser than 200 mesh. Only 15% is finer than 325 mesh. Because of the coarse tailings, scarification and recompaction cannot be expected to prevent all seepage. The applicant's data indicate that at least a portion of the tailings basin is permeable. It is common practice to recycle water from the tailings pond in order to reduce freshwater requirements at the mill; however, approximately 12 to 27%

(see Fig. 3.17) of the water pumped to the pond will be lost through seepage. Therefore, under this alternative, some migration of tailings liquid into groundwater and surface drainageways (which receive water from local groundwater flow systems) can occur. The degree to which this will occur will be determined by geochemical equilibrium considerations and by the precise permeability values discussed in Section 4.8.4. However, under Alternative I, some contamination of groundwater and probably of surface water will take place. The applicant states that mill discharge water can be expected to contain up to 12 g/l of total dissolved solids, including sulfate, radium, selenium, and vanadium. It is likely that some of the sulfates and selenium will reach the groundwater; however, the major portion of the radium and vanadium will be held in place in the soil because of the ion exchange process. (For a more detailed discussion of seepage and resulting distribution of radioactive nuclides see Section 4.8.) Monitoring to determine any contamination caused by tailings seepage into groundwater is described in Section 6.3.3.

The applicant proposes to minimize the effects of dust during operation by the use of appropriate measures to keep the particles within the property fence (see Sec. 3). Without appropriate control measures, wind erosion of tailings would result in a reduction of air quality and deposition of radioactive particles on the soil and vegetation and into aquatic systems. Such deposition can introduce radioactive material into the food chain via foraging animals. The presence of solid particles, particularly sand, on vegetation may increase wear on the teeth of these animals and could reduce productivity through the shielding of sunlight by the dust layer on the leaves of plants. Monitoring to determine any contamination by materials blown from the tailings pile onto the surrounding environment is described in Section 6.1.

The exposure rate from the gamma radiation at the surface of uncovered tailings is estimated by the staff to be 12 R/year. The reduction of the gamma exposure rate after an application of six feet of topsoil and overburden is dependent upon the degree of compaction and the mass-stopping power of the overburden. The staff has estimated that six feet of packed earth will reduce the 12 R/year exposure rate to 12 μR/year. The natural terrestrial radiation background in the Bear Creek area is 32,000 μR/yr.

The flux of radon at the surface of the unreclaimed tailings is estimated to be 25 mCi/y-m^2 for dried tailings. An application of six feet of packed earth with a moisture content of about 10% will reduce the radon flux to 2.3 mCi/yr-m^2. The natural radon flux from the nonmineralized soil is 0.04 to 0.05 mCi/yr-m^2. Thus, a combined six feet of topsoil and overburden will effectively reduce the radon release to about 50 times the natural background level.

The six feet of overburden and soil above the tailings will substantially reduce the radiation hazard, but may be inadequate to prevent penetration of plant roots into the tailings. Such penetration would result in uptake of radionuclides and toxic elements into aerial portions of the vegetation, thus providing a pathway into the food chain. Additionally, there is evidence that certain plants can remove radon from soil and release it above the ground,[6] perhaps via the transpiration stream of the plant. The depth of overburden and soil necessary to permanently isolate the tailings from the biosphere will depend on the plant species used to revegetate the pile. For example, roots of big bluestem (*Andropogon gerardi*), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*), can extend downward to 7 feet, 11 feet, and 9 feet, respectively.[7,8] The species in the seed mixture proposed by the applicant for revegetation includes Western wheatgrass (*Agropyron smithii*), the roots of which can reach depths of up to seven feet.[7] It is presently unclear whether plant roots will cross the overburden-tailings interface and penetrate the body of the tailings; the material may be sufficiently hostile to preclude such penetration.

The estimated cost of this alternative is $3.3 million (1976 dollars).

Since this alternative calls for only six feet of overburden covering the tailings pile, future recovery of mineral values would be relatively easy. Therefore, this alternative does not foreclose future options.

Alternative II - Tailings Pond with Clay Liner

As with the first alternative, Alternative II would involve creation of a tailings impoundment large enough to hold the lifetime output of the mill by damming a natural basin close to the mill. However, under Alternative II, after scarification, these areas of the basin requiring addition of clay for a liner would be covered with clay and then compacted to produce a minimum thickness of three feet so as to reduce seepage to the extent practicable.

Following construction of the impoundment, procedures for management and eventual reclamation would be the same as were discussed for Alternative I.

Since Alternative II is the same as Alternative I, except for the clay liner, the impacts would be the same except as follows: A compacted clay liner should reduce seepage by a factor of ten

providing liner integrity is maintained, but complete elimination of seepage is not likely. Compacted clay can be expected to have permeabilities of 10^{-6} to 10^{-7} cm/sec. The effectiveness of clay is determined largely by the installation process and thickness of the liner. If suitable clay is distributed uniformly over the tailings basin to a suitable depth (to be determined by standard soil tests), the adverse environmental impact of seepage will be greatly reduced.

Radiation exposure from gamma radiation and the radon flux for this alternative would be identical to those of Alternative I. Potential for seepage of liquids and movement of radioactive material would be reduced because of the compacted clay liner.

The estimated cost of this alternative is $3.4 million (1976 dollars), which includes the cost of additional clay ($130,000 per foot thickness of liner in the tailings pond basin) and six feet of cover as part of the reclamation program. Costs for overburden and corresponding reduction in releases of radioactivity are as follows:

Total Cover, ft (overburden* + topsoil)	Cost of Cover (1976 dollars)	Fraction of Radon Emitted
0	0	1.00
6	750,000	0.09
7	875,000	0.06
8	1,000,000	0.04
9	1,125,000	0.03
10	1,250,000	0.02

In addition to reducing releases of radioactivity, additional increments of overburden would reduce the possibility of plant root penetration into the tailings and the associated problems of root uptake of radionuclides and toxic elements (see Alternative I). A thicker overburden layer on top of the tailings would increase the cost of future recovery of mineral values; however, this alternative does not foreclose the option of recovery in the future.

Alternative III - Tailings Pond with Addition of Clay to Bottom and Cap

Alternative III consists of creating a tailings impoundment in an existing natural basin with a dam close to the mill. As with the previous alternatives, the impoundment would be of sufficient size to hold the lifetime output of the mill. The bottom will be scarified, covered with clay, where necessary, to produce a minimum thickness of 3 feet and recompacted so as to reduce seepage to the extent practicable. The water from the tailings pond will be recycled to the mill. All surface water will be routed around the impoundment area. The entire area will be fenced. Prior to reclamation, blowing sands and dust which might impact offsite areas will be stabilized by use of chemicals or other methods. The tailings in a given area will be allowed to dry out sufficiently to move equipment over the pile and then capped with a layer of clay. Reclamation will be staged, with the initial efforts beginning as soon as an area has reached sufficient depth and dryness (probably within six years). Five and a half feet of overburden will be placed on top of the dried tailings, the pile will be contoured and shaped, and six inches of topsoil material will be spread on top. Soil amendments (e.g., fertilizer, organic matter) will be added as necessary. The area will be revegetated with appropriate plant species. Following reclamation, a monitoring and maintenance program will be established to ensure stability of the pile. Since Alternative III is the same as Alternative II, except for the clay cap, the impacts of this alternative are the same as for II except as follows: The staff believes that a compacted clay cap should reduce radon emanation to near background levels and reduce the level of any perched water table inside the tailings if a sufficient thickness is provided and if the integrity of the cap can be maintained.

Since the staff has not completed a detailed study of the reduction of radon emanation as a function of cap thickness, specific composition, and degree of compaction, an illustrative calculation using a thickness of 25 centimeters (ten inches) will be discussed. The staff has estimated that this thickness of a typical montmorillonite clay with a moisture content of 30% will reduce the radon emanation by a factor of approximately 100. The resulting radon flux at the surface of the tailings (after passing through ten inches of compacted clay, 5-1/2 feet of overburden, and six inches of topsoil) would be 0.08 $mCi/yr\text{-}m^2$ (less than twice the natural background). The problems discussed under Alternatives I and II concerning plant root penetration would also apply to this alternative.

The estimated cost of this alternative is approximately $3.6 million.

Recoverability of mineral values is approximately the same as for Alternatives I and II.

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*This is for the type of soil found in the Bear Creek area.[1]

Alternative IV - Tailings Pond with Artificial Liner

Alternative IV is the same as Alternative I except that the bottom will be graded and covered with an artificial liner (asphalt, 20 mil-polyester reinforced PVC, or some other type of plastic).

Artificial liners, if installed without damage and properly maintained, can be expected to eliminate seepage during the 10-year operating life of the mill. Even after that period, seepage should not be a problem. Therefore, any infiltration of radioactivity and toxic substances to groundwater discussed in previous alternatives should not occur if an artificial liner is used, and if its integrity can be maintained. Environmental impacts (including radiological impacts) to the above-ground terrestrial and aquatic environment will be the same as for Alternatives I or II. Future availability of the resources would also be the same.

The estimated cost of Alternative IV, including pond construction and reclamation, is $5.9 million.

Alternative V - Tailings Pond with Artificial Liner and Cap

Alternative V is the same as Alternative IV except that the tailings in a given area will be allowed to dry out sufficiently to move equipment over the pile and then be capped with an artificial and impervious material (e.g., asphalt or PVC). Reclamation will also be staged, with the initial efforts beginning as soon as the area has been covered with the capping material. Sufficient overburden will be placed on top of the cap to meet state approval and will be contoured and shaped. Six inches of topsoil material will be spread on top. Soil amendments (e.g., fertilizer, organic matter) will be added as necessary. The area will be revegetated with appropriate plant species. A monitoring and maintenance program will be established following reclamation to ensure stability of the pile.

Seepage from the tailings to the environment should not occur if the liner integrity is maintained. Environmental impacts resulting from airbrone contaminants from the tailings (including radon) would not occur following complete placement of the cap. It should be noted, however, that the gamma radiation will penetrate these artificial caps and the resulting dose will depend upon the thickness of the overburden covering the cap. In view of the discussion given under Alternative I, the amount of material required for reclamation will be sufficient to reduce gamma irradiation to very low levels. The net result should be a radiation level almost the same as the natural background level.

The problems discussed under Alternative I regarding plant root penetration of the covering material would become of greater import. Additional problems to be considered are possible sliding of the overburden off the cap and frost-heaving effects on the cap.

The estimated cost of this alternative, using two inches of asphalt for the liner and cap, is $8 million. The cost would be much greater if PVC were used instead.

This alternative would not decrease the future availability of mineral resources in the tailings.

Alternative VI - Slurry Pipeline to Pit

The tailings slurry would be transported via an above-ground pipeline to a RMEC mine pit (which would not be lined with artificial materials) or to a pit dug especially to receive the tailings (and lined with an impervious material as in Alternatives II through V). The bottom of any pit considered would be above the water table--either naturally or as a result of backfillings. Excess or standing water in the pit would not be returned to the mill. Pipeline right-of-way (ROW) and pit area would be fenced. Pipeline spillage resulting from pipe freeze-up, stoppage, or other problem would be cleaned up and transported to the pit. As the tailings dry, appropriate measures would be taken to prevent blowing of tailings material outside the fenced area.

Reclamation will be staged, if possible, and initial efforts will begin as soon as a section of the pit has been filled to the appropriate depth. At least 5 1/2 feet of overburden will be placed on top of the tailings, and then contoured and shaped so that no depressions which can hold standing water are created over the tailings. Six inches of topsoil will be spread over the top. Soil amendments (e.g., fertilizer, organic matter) will be necessary. The area will be revegetated with appropriate plant species. Following reclamation a monitoring and maintenance program will be established to insure stability of the pile. After completion of the project the pipeline will be dismantled and the pipeline ROW will be reclaimed.

Routing tailings to an existing mine pit would reduce the required land area by eliminating the tailings pond. Digging a new pit especially for tailings could reduce required land area to the extent that a special pit would be deeper and therefore cover less surface area.

As a prerequisite for disposal of a slurry in one of the applicant's mine pits, the site must have a clay, or other relatively impervious, layer above the water table. The pit must then be backfilled with overburden to this layer and a clay bottom liner emplaced, resulting in a hole with

a relatively impervious bottom, but possibly permeable sides. Adverse environmental impacts could result from lateral seepage. In the Bear Creek area clay beds are usually lenticular in form; thus, lateral movement of contaminated water from the pond could result in eventual contamination of the water table.

The environmental impacts of a specially dug and lined pit on the groundwater would not be markedly different from those of Alternative II.

Above-ground environmental impacts from utilizing either an existing mine pit or a specially dug pit would not differ from those discussed in Alternative II* except that additional impacts would result from the construction, fencing and maintenance of the pipeline ROW.

Cost estimates for utilizing one of the applicant's existing mine pits range from $3.3 million to $4.3 million, depending upon pit characteristics (e.g., location, depth). Estimates for excavating a pit especially for tailings disposal range from $8.7 million to $10.9 million, depending on pit location and liner.

Burial of tailings in pits may decrease the availibility of minerals for future recovery--depending upon the depth of overburden utilized.

Alternative VII - Temporary Holding Area and Dry Transport to Pit

Under this alternative an "intermediate" tailings impoundment would be created close to the mill. This impoundment would be of sufficient size to hold approximately eight years worth of tailings. The bottom of this impoundment will be scarified, recompacted and lined with clay where necessary to insure a clay depth of at least one foot. Slurried tailings will be routed to this area from the mill. Surface water will be returned to the mill (recycled). The area will be fenced. As the tailings dry, blowing dust, sand, etc. will be prevented from leaving the site (by use of chemicals or other means). When the tailings are sufficiently dry in any area of the impoundment, they will be loaded onto trucks and transported to either a RMEC mine pit (via returning ore trucks) which would not be lined with any artificial materials or to a pit especially prepared to receive tailings and lined with an impervious material. (This pit could be either below grade or in the clay portion of an overburden pile.)

Reclamation will be staged, if possible, initial efforts beginning as soon as a section of the pit has been filled to the appropriate depth. At least 5 1/2 feet of overburden will be placed on top of the tailings, and the overburden will be contoured and shaped so that no depressions which can hold standing water are created over the tailings. Six inches of topsoil will be spread over the top. Soil amendments (e.g., fertilizer, organic matter) will be added as necessary. The area will be revegetated with appropriate plant species. Following reclamation a monitoring and maintenance program will be established.

The environmental impacts of the temporary holding area would be similar in kind to those discussed in Alternative II; however, the land area would be reduced and the tailings would be completely removed within six years after the mill stopped production. The impacts of placing dried tailings into either an existing pit or specially constructed pit would not be greatly different from those discussed in Alternative VI except that the impacts of the longer pipeline would not occur. Greater impacts from airborne tailings and dust will occur, especially during movement.

Cost estimates for this alternative range from $6.6 million to $10 million when utilizing an existing pit. Utilization of a specially dug pit would raise the costs to an estimated $12.1 million to $15.5 million, depending on pit characteristics.

Future availability of mineral resources is the same as in Alternative VI.

Alternative VIII - Slurry Pipeline to Pit and Stabilize Tailings with Asphalt or Concrete

Under this alternative, the tailings slurry would be transported via pipeline to either a RMEC mine pit (which would not be lined) or to a pit dug especially to receive the tailings. The bottom of any pit considered would be above the water table--either naturally or as a result of backfilling. Prior to releasing the tailings to the pit, asphalt or concrete would be added to the slurry. Pipeline right-of-way (ROW) and pit area will be fenced. Pipeline spillage resulting from freeze-up, accidental stoppage or other problems will be cleaned up and transported to the pit.

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*If an existing mine pit were used there is a high probability that backfilling and contouring to prevent standing water would result in overburden depths in excess of six feet. Therefore, the radon emanations would be reduced below those in Alternative II as a function of increasing overburden depths (see discussion in Alternative II).

Reclamation will be staged, if possible, initial efforts beginning as soon as a section of the pit has been filled to the appropriate depth. At least 5-1/2 feet of overburden will be placed on top of the tailings, and the overburden then contoured and shaped so that no depressions which can hold standing water are created over the tailings. Six inches of topsoil will be spread on top. Soil amendments (e.g., fertilizer, organic matter) will be added as necessary. The area will be revegetated with appropriate plant species. A monitoring and maintenance program will be established following reclamation to ensure stability of the pile. Following project completion, the pipeline will be dismantled and the pipeline ROW will be reclaimed.

This alternative would require large capital investment in extra equipment and substantial operating costs resulting from increased labor requirements and large amounts of scarce fossil fuels (e.g., natural gas or fuel oil) to operate evaporation units between the end of the pipeline and the disposal pit.

No adverse impacts to groundwater or the above-ground environment should occur from the tailings after the addition of asphalt or concrete. Pipeline ROW impacts would be same as in Alternative VII.

Estimated costs of this alternative range from $34.3 million (using asphalt) to $42.3 million (using concrete).

Future availability of mineral resources would be decreased--especially if the asphalt option were chosen.

10.4.3 Evaluation of Alternatives I through VIII

Alternative I may provide an adequate tailings disposal program. Scarifying and compacting the basin floor should result in a seepage rate of 32 gal/min. This could result in some pollutants reaching the groundwater. The staff estimates that the tailings covering proposed in this alternative should result in a 90% reduction of radon emanation to 50 times natural background.

Alternative II provides more assurance against seepage of tailings liquid. The addition of clay proposed in this alternative should reduce the seepage rate to 3 gal/min and, in addition, serve as an ion exchange medium. The staff estimates that the additional 4 ft overburden of tailings covering proposed by this alternative, compared to Alternative I, should result in a 98% reduction of radon emanation to 10 times natural background.

Alternative III, while providing the increased seepage control of Alternative II, also provides greater reduction of radon emanation (98.6% resulting in two times natural background) than Alternatives I and II at approximately the same cost.

Alternative IV would provide approximately the same benefits as Alternative III, but at an additional cost of at least $2.4 million. In addition, the long-term integrity of artifical liners is questionable.

Alternative V, which includes both an artifical liner and cap, reduces the direct radon emissions from the tailings, but is judged to be undesirable because of small environmental benefits accrued from large ($\sim$ $4.4 million) costs above Alternative III. The question of long-term integrity of the liner and cap is unresolved.

Alternative VI involves the transportation of the tailings via a pipeline to a disposal site. The monetary cost of the cheaper options of this alternative may be comparable to that of Alternative III; however, because of the unknown, but potentially great, risks of groundwater pollution from lateral leakage around lenticular clay beds it is the staff's opinion that this alternative is too likely to result in unacceptable adverse environmental impacts, and the options which reduce these potential impacts are several million dollars more expensive than Alternative III.

Alternative VII would combine the impacts of Alternatives II and VI. Although the magnitude of each component of impact would be reduced, it is the opinion of the staff that the combined impacts would exceed those of other, more economical, alternatives.

Alternative VIII is at least $30 million more expensive than is Alternative III. Although it does further reduce adverse environmental impacts, it is the staff's opinion that the marginal costs are unjustified. In addition, it would require the unjustified use of scarce fossil fuel resources and could render future extraction of mineral resources in the tailings impracticable.

Based on the above discussion, it is the staff's opinion that Alternative III represents the most environmentally sound, reliable, and reasonable method of tailings management using existing, commercially available technology. It appears likely that use of a clay liner and cap, and an

appropriate quantity of overburden will obviate the necessity of long-term monitoring and maintenance, except that measures (such as appropriate entries in the land deed) must be taken to ensure that the tailings pile will not be disturbed, or used for any purpose. If the Generic Environmental Impact Statement on Uranium Milling currently being prepared by NRC shows that a different amount or type of cover is appropriate, the requirement for cover of the Bear Creek tailings will be modified accordingly.

10.4.4 Other Alternatives

The alternatives listed in Table 10.6 were also considered in the staff's evaluation. The reasons for the rejection of these alternatives are also listed.

Table 10.6. Tailings Management Alternatives Rejected

Alternative	Reason for Rejection
Raise pH of slurry with lime, treat with barium chloride to precipitate radium & thorium.	Technology not demonstrated on tailings slurry. Would not allow water recycle, therefore more water would be required to operate mill, more water would have to be disposed of, and there would be additional health hazards to workers.
Segregate (chemically) the toxic components of the tailings and dispose of these small quantities as low-level waste. Treat "clean" tailings as overburden.	Technology not developed to implement alternative on Bear Creek ores.
Slurry or truck tailings to Spook Pit (abandoned mine pit not under RMEC control)	Legal problems of acquisition, etc. (see ER, Supplement B).
Pump slurry to a regional (i.e., Powder River Basin) tailings disposal area	Logistical and legal problems will not be resolved within the time frame under consideration (i.e., 10 years).
Precipitate radioactive and toxic elements to bottom of the tailings pond and consider top of tailings as cover.	Technology not developed (would require a selectively permeable bottom liner).
Install drains below pond to collect and discharge to a local waterway.	Technology not available to allow seepage water treatment sufficient to attain water which is environmentally and legally acceptable for release.
Filter tailings, cake the sands and transport to a landfill.	Filters of sufficient size and efficiency are not commercially available.

10.5 ALTERNATIVE OF USING AN EXISTING MILL

Where the deposits of uranium are close together, the construction of a centrally located milling operation to process ore from several mines might be feasible. Such an arrangement would centralize environmental impacts, and could conceivably produce economies of scale from the greater throughput per mill.

The option of utilizing existing mills for processing ore entails consideration of numerous factors. The method and distance of mine-to-mill transport are the principal factors. Other variables include, but are not limited to, consideration of variations in grade and the quality of haul roads, total tonnage to be transported, hauling schedules, traffic and weather conditions, possible interim transfer and storage costs, and handling and milling costs. Environmental costs must also be considered.

For larger operations, hauling costs of five to six cents per ton mile are commonly quoted. Hauling distances may range up to 200 miles; however, the longer hauls are primarily a result of mining small deposits where the construction of milling facilities is not feasible.

The applicant has considered both onsite processing and use of existing mills. The road distance between the Bear Creek site and the nearest existing mill is 35 miles. By comparing mill construction and milling costs at the Bear Creek site with trucking and processing cost associated with use of an existing mill, the applicant has concluded that adopting the latter option would result in greater costs--a differential equivalent to \$2.50/lb of U_3O_8 concentrate produced.

The use of the existing mill facilities would preclude the environmental costs that would accrue from construction and operation of a Bear Creek mill. On the other hand, increased production at an existing mill will intensify operational impacts on the local environment. Additionally, the existing mill and tailings pond would likely have to be expanded to accommodate the increase in processing capacity, thereby contributing to increased environmental costs.

In consideration of the foregoing, the applicant has elected to erect a mill near the Bear Creek ore bodies.

10.6 ALTERNATIVE ENERGY SOURCES

10.6.1 Fossil and Nuclear Fuels

The use of uranium to fuel reactors for generating electric power is relatively new historically. Coal was the first fuel used in quantity for electrical power generation. Coal use was reduced because of the ready availability and low price of oil and natural gas, which are cleaner burning than coal and easier to use as well. Uranium fuel is even cleaner (chemically) than oil or gas, and at present is less expensive, on a thermal basis than all other fuels used to generate electric power. The following discussion concerns the relative availability of fuels for power generation over the next 10 to 15 years, since availability will be the key factor in the choice of fuel to be used.

Table 10.7 shows the disparity between availability and usage of energy resources in the U. S. Although these data are for 1974 (final figures for 1975 are not yet available) estimates for 1975 indicate little difference. Gas usage in 1975 decreased slightly ($\sim$ 1%); oil, coal, and nuclear usage increased slightly.[9]

In 1975, the U. S. consumed about 71 q of energy (1 q = 10^{15} Btu); of this total, 20 q consisted of electric energy. An estimated 8.6% of this electric energy was generated using nuclear fuels, but within ten years the percentage is expected to increase to 26%.

Table 10.7. Reserves and Current Consumption of Energy Sources[9]

	Percent of Proven U. S. Energy Reserves Economically Recoverable with Existing Technology (1974)	Percent of Total U. S. Energy Consumption Contributed by Each Energy Resource (1974)
Coal	90	18
Oil	3	46
Gas	4	30
Nuclear	3	2
Other	0	4

Coal was used for producing 59% of the electric energy generated by combustion of fossil fuel in 1975; the percentages for oil and gas were 20 and 21, respectively. Use of oil and gas to generate electric power has decreased about ten percent over the last three years, a reflection of high oil prices and gas unavailability.[9]

Current and projected requirements for electric energy (1975-1985) and relative changes in resources used for generation, as estimated in "Project Independence,"[10] are shown in Table 10.8. All information available to date indicates that coal and uranium must be used to generate an increasing share of future U. S. energy needs, because of decreasing supplies of oil and gas available for electric power generation. The U. S. does not have sufficient oil and gas reserves to insure long-run supply but coal and uranium resources are adequate for foreseeable needs. Currently rising prices for oil and gas are a reflection of increasing competition for these two resources which will be severely depleted in the next few decades.

Expanding industrial capacity for increasing coal production to meet projected requirements must occur in the next decade (total requirement is 1040 million tons in 1985 vs. 603 million tons in 1974). The major expansion of coal production will likely be in the west (from 92 million tons

Table 10.8. Estimated Relative Changes in Resources to be Used for Generation of Projected Energy Requirements[10]

Fuel Resource Used	Percent of Thermal Energy Required in Year: 1970[a]	1974[b]	1980[b]	1985[c]
Coal	45	45	45	46[c]
Oil and gas	38	34	25	16
Nuclear	2	4[d]	17	26
Hydro, waste, etc.	15	17	13	12
Total q's of energy required	15.6	20	25.5	34

[a]Actual.

[b]Estimated (Ref. 9).

[c]Coal usage must increase 77% by 1985 to attain this level.

[d]Uranium fueled reactors furnished 9.9% of the total U. S. production in January 1976.

in 1974 to 380 million tons in 1985) because of the low sulfur (low air pollutant) content of most western coals. The potential for environmental damage (due to disturbance of generally fragile ecosystems) in the western U. S. will be increased. Since the major markets for the coal produced are located hundreds of miles from the mines, transportation costs will be high, as will the environmental impacts associated with transportation systems. Transportation costs for bringing western coal to the eastern U. S. currently accounts for the major portion of the market price.

For a given thermal content transport facilities for U_3O_8 are minimal compared to those for coal because of the much higher energy content of uranium fuel. Approximately 250 tons of U_3O_8 per year are required for a 1000-MW nuclear plant operating at a plant factor of 80%. Annual western coal requirements for an equivalent 1000-MW coal plant would be more than three million tons, or the load capacity of at least one unit-train (100 cars of 100 tons each) per day of plant operation.

The evidence available at this time indicates that, of the resources currently used in electric power generating stations (coal, uranium, oil, gas, and hydro), only coal and uranium have the potential for increasing long-range reliability in domestic energy production. Because of the time lag between initial extraction and the consumption of the resource for energy production (3-5 years from mine to generation plant for uranium and coal; 5-7 years for construction of a coal generating plant and 7-10 years for construction of a nuclear generating plant), the exploitation of both coal and uranium resources must be integrated with contemporary energy needs. Neither the coal nor uranium producing industries are considered capable of singly supporting the energy requirements projected over the next few decades; major expansion of both industries will be required to fill projected needs.

The determination of availability of uranium in large enough quantities to fuel the projected nuclear generating capacity (for 1985) is currently a matter of study.[11] Results of those studies are given below.

Estimates presented in the National Energy Outlook[9] indicate that 140,000 to 150,000 MWe of nuclear generating capacity will be needed to supply 26% of the total electrical energy used in 1985. The first "Project Independence"[10] report indicated that nuclear capacity could increase to more than 200,000 MWe by 1985. A more recent and lower estimate resulted from lower projections of electricity demand, financial problems experienced by utilities, uncertainty about government policy, and continued siting and licensing problems. The more recent projections of uranium requirements are given in Table 10.9.

Known reserves of uranium (as U_3O_8), as of January 1976, were an estimated 640,000 tons, as compared to 600,000 tons estimated in January 1975.[12] These reserves could be mined and milled at a cost of $30/lb of U_3O_8 produced. The price of U_3O_8 in April of 1976 was $40/lb for delivery in 1976, and $48/lb for delivery in 1980.

ERDA has estimated total U. S. uranium resources as shown in Table 10.10.[12] The total of all variously known categories of uranium resources is equivalent to 3,560,000 tons of U_3O_8. Reserves are in known deposits; drilling and sampling have established the existence of these

Table 10.9. Uranium Requirements[9]

MWe Operating by 1985	Lifetime U_3O_8 Requirements, tons	
	at P.F. of .8[a]	at P.F. of .6
142,000	960,000	704,000

[a]P.F. = Plant factor, or capacity factor.

Table 10.10. U. S. Uranium Resources[12]

Cost $/lb U_3O_8	Tons U_3O_8			
		Resources		
	Reserves	Probable	Possible	Speculative
$30	640,000	1,060,000	1,270,000	590,000

deposits beyond reasonable doubt. Probable resources have not been drilled and sampled as extensively as reserves. The speculative and possible resource categories have been estimated by inference from geologic evidence and limited sampling.

Historically, resources of uncertain potential have become established reserves at an average rate of 7% per year since 1955.[10] If this rate were to persist over the next decade, total reserves would exceed requirements (1,250,000 tons of reserves vs. a maximum 960,000 tons required for lifetime nuclear generating capacity rated at 142,000 MWe) by about 300,000 tons. Assuming no transfer of possible resources into the probable category, probable resources would still contain 450,000 tons.

10.6.2 Solar, Geothermal, Synthetic Fuels

Estimates reported in the "National Energy Outlook"[9] indicate that solar and geothermal sources will each supply about 1% of U. S. energy requirements by 1985 and about 2% by 1990. Supplies of synthetic gas and oil derived from coal will probably not exceed 1% of U. S. energy requirements as of year 1990. These projections are based on many considerations. The technology exists in all cases, but not in a proven, commercially viable manner. The potential for proving these technologies on a commercial scale is great, but timely development will require a favorable market as well as governmental incentives. A maximum of 6% of projected 1990 energy requirements is expected to be derived from solar, geothermal, and synthetic fuel resources combined.

10.6.3 Byproduct Uranium

Uranium reserves recoverable as a byproduct of phosphate fertilizer and copper production are expected to increase from 90,000 tons (U_3O_8) in 1974 to 140,000 tons in 1976. These reserves are in addition to the 640,000 tons available from conventional mining and milling sources.

From Reference 10, page 106, the following discussion of byproducts as a source for uranium is cited.

> "Like all byproducts commodities, byproduct uranium is entirely dependent upon production of the primary commodity, is limited in amount by the level of production of the primary commodity, and is unresponsive to the demand for uranium. Byproduct uranium could be obtained from the mining of phosphate, copper and lignite.
>
> "Much phosphate is treated with sulfuric acid to produce fertilizer and goes through a phosphoric acid step. Uranium in the phosphate can be recovered from the phosphoric acid. ... It has been estimated that about 2,500 ST U_3O_8 per year could be recovered from Florida phosphate mined for fertilizer. The Bureau of Mines studied the sulfuric acid leaching of low grade dumps at 14 porphyry copper mines and concluded that about 750 ST U_3O_8 per year could be recovered. This would be recovered from rocks whose uranium content ranges from 1 to 12 ppm.

The Bureau thought that other porphyry copper deposits might also be possible sources of byproduct uranium.

"This possible byproduct uranium totals 3,250 ST U_3O_8 per year which is only slightly less than the initial annual production planned for the Rossing deposit in South West Africa.

"Another source of byproduct uranium could be mine-mouth electrical generating plants that burn uranium-bearing lignite as fuel. The uranium is concentrated in the ash. Some lignite contains as much as 0.30 percent U_3O_8. Bieniewski estimates that about 1500 ST of U_3O_8 is contained in about 500,000 ST of high grade lignite. More recently reserves in lignite were estimated to be less than 5,000 ST of U_3O_8 and resources to be about 50,000 ST. Low BTU lignites seem to be richest in uranium. Good quality coals usually contain less than 0.001 percent U_3O_8. If lignite is burned at too high a temperature the uranium enters the ash in a form that is not easily leachable and for which an economic recovery system has not yet been developed."

0.6.4 Conservation of Energy

The NRC staff has examined available information concerning the potential reduction in energy usage that could be achieved by 1985 and concludes that incremental savings in total energy consumption could be achieved in all major consumption sectors: residential, commercial, industrial, and transportation. Actions which improve the thermal efficiency of automobiles, homes, and office buildings would have the greatest conserving effect. However, in the case of electrical energy, demand is expected to increase (during the next decade) at a rate about twice as great as that for total energy.[9] It will be more difficult to conserve electrical energy since it will probably be a viable alternative for oil and gas use in residential heating and for some industrial applications. Conservation will not materially change the need for increased dependence on coal and uranium as fuels for generating electric power during the next decade.

10.7 ALTERNATIVE OF NO LICENSING ACTION ON MILL

Among the alternative actions available to the NRC is the denial of a source material license to the applicant. Classifications of source materials are discussed in 10 CFR 40.13(b); these classifications are based on Section 62 of the Atomic Energy Act of 1954, which specifically exempts "unbeneficiated ore" from control. Under these regulations RMEC could mine the ore at Bear Creek but could not process it, should the NRC deny the source material license. Exercise by the NRC of this option would thus leave the applicant with three possible courses of action: (a) mine the ore and have it processed at an existing mill possessing a source material license; (b) postpone the project while attempting to remove the objections that led to the denial of the license; or (c) abandon the project. Alternative (a) has been discussed in Section 10.5. Alternative (b) is essentially the applicant's proposal (merely shifted in time), which is the subject of this statement. Alternative (c), therefore, is the only alternative discussed herein.

If the applicent were not awarded a source material license, the uranium concentrate it intends to produce would not become available for use as fuel in nuclear reactors in as timely a manner. The relationship of electrical energy produced by nuclear reactors to the total U. S. energy requirement has been discussed in Section 10.6. Appendix H discusses the need and timeliness of the project and the basis for the NRC evaluation thereof.

The U_3O_8 produced by the Bear Creek Project will be used as fuel in nuclear reactors which are either operating or under construction (in 1976). These reactors will produce electric power for sale to U. S. consumers. Lack of fuel would require those reactors short of fuel to reduce their output, and could conceivably result in the shutdown of some of them.

The applicant has indicated the effects of losses of local and regional economic benefits that would occur if the Bear Creek Project were not licensed, and has also pointed out the environmental costs that would not be incurred should no license be issued. The NRC staff has examined the applicant's tabulations of benefits and costs and made an independent assessment of benefits and costs of the proposed project (see Sec. 11), and has concluded that the overall benefit-cost balance is favorable.

References for Section 10

1. ER Supplement, Bear Creek Uranium Project, "Analysis of Alternatives for Mill Tailings Disposal," 1976.

2. Sears et al., "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing 'as Low as Practicable' Guides - Milling of Uranium Ores," ORNL-TM-4903, Vol. 1, 1975.

3. A. D. Ryon and R. E. Blanco, "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing 'as Low as Practicable' Guides - Appendix A. Preparation of Cost Estimates for Volume 1, Milling of Uranium Ores," ORNL-TM-4903, Vol. 2, 1975.

4. C. L. Aplin and G. O. Argall, Jr., "Tailings Disposal Today," Miller Freeman Publ., San Francisco, 1975.

5. R. E. Williams, "Waste Production and Disposal," Miller Freeman Publ., San Francisco, 1975.

6. J. E. Pearson, "Natural Environmental Radioactivity from Radon-222," Public Health Service, U. S. Dept. Health, Education, and Welfare, 1967.

7. J. E. Weaver, "Prairie Plants and Their Environment," Univ. of Nebraska Press, 1968.

8. Phillips Petroleum Co., "Pasture and Range Plants," 1963.

9. "National Energy Outlook," Federal Energy Administration, Feb. 1976.

10. "Project Independence," Federal Energy Administration, Nov. 1974.

11. "Mineral Resources and the Environment," Supplementary Report: "Reserves and Resources of Uranium in the U. S." National Academy of Sciences, 1975.

12. Report ERDA 76-94 Energy Research and Development Administration. April 1976 - Latest estimate of U. S. Uranium Resources.

11. NRC BENEFIT-COST SUMMARY FOR THE BEAR CREEK MILL

11.1 GENERAL

The need for additional uranium milling capacity was established when the decision, based on alternatives addressed in site-specific nuclear power generating EIS's, was made to utilize nuclear fuel. In the reactor evaluation the benefits of the energy produced are weighed against all the related environmental costs, including a prorated share of the environmental costs of the uranium fuel cycle. These incremental impacts in the fuel cycle are justified in terms of the benefits of energy generation. However, because these costs and benefits are not localized, it is appropriate to review the specific site related benefits and costs for an individual fuel cycle facility such as the Bear Creek Mill.

11.2 QUANTIFIABLE ECONOMIC IMPACTS

Section 4.0 of this statement treats the quantifiable economic impacts for the Bear Creek Mill. On the one hand there are the many monetary benefits which accrue to the community from the presence of the mill such as local expenditures of construction and operating funds, as well as state and local taxes paid by the mill. Against these monetary benefits are the monetary costs to the different communities involved, such as costs for new or expanded schools and other community services. It is not possible to arrive at an exact numerical balance between these benefits and costs for any one community unit or for the mill overall because of the ability of both the community and mill to alter the benefits and costs. For example, the community has its various taxing powers to redress any perceived imbalance in favor of the mill. The mill, on the other hand, can create larger revenues through increased product price to redress any imbalance it suffers through direct or indirect taxation.

11.3 THE BENEFIT-COST SUMMARY

The benefit-cost summary for a fuel cycle facility such as the Bear Creek Mill evolves to a comparison of the societal benefit of an assured U_3O_8 supply (ultimately provided energy) to the local environmental costs for which there is no directly related compensation. For the Bear Creek Mill these uncompensated environmental costs are basically two, the radiological impact and the disturbance of the land. As shown in Section 4.8 of this statement, the radiological impact of the Bear Creek Mill is minimal. The disturbance of the land, as shown in Section 4.2, is also a very small short-term environmental impact. The mill will temporarily disturb about 250 acres. Virtually all of the disturbed land will be reclaimed after the mill is decommissioned and, with the possible exception of the tailings burial area, will become available for other uses.

11.4 STAFF ASSESSMENT

The staff concludes that the adverse environmental impacts and costs are such that the use of the mitigative measures suggested by the applicant and the regulatory agencies involved would reduce the short- and long-term adverse impacts associated with the project to acceptable levels.

The Bear Creek Project, along with other energy related projects in the area, will create a short-term stress on the political and social systems (including housing) of the area. The quantity of total tax money appears (to the staff) to be adequate but the distribution may not. (See discussion in Section 11.2.) This aspect of the project is currently receiving attention by the institutions directly concerned, and mitigation appears possible.

In considering the energy value of the U_3O_8 produced, and the minimal radiological impacts and long-term disturbance of land, as well as the mitigable nature of the societal impacts, the staff concluded that the overall benefit-cost balance for the Bear Creek Project is favorable, and the indicated action is that of licensing of the Bear Creek Mill.

12. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

12.1 INTRODUCTION

Pursuant to 10 CRF 51 the Draft Environmental Statement (DES) was transmitted in January 1977, with a request to comment, to the Federal, State, and local agencies listed in the summary of this statement. In addition, the NRC requested comments on the DES from interested persons by means of a notice published in the *Federal Register* (42FR 2140) on 10 January 1977, and the Forest Service solicited comments from the local populace during public meetings held on 8 and 9 February 1977.

Letters in response to these requests were received from the following:

Department of the Army (DTA)
Representative Teno Roncalio (RTR)
First National Bank of Casper (NBC)
Department of the Interior (DOI)
Office of the Governor, Wyoming (WOG)
Department of Transportation (DOT)
John C. Dilts (JCD)
Southern California Edison Company (SCE)
Department of Health, Education, and Welfare (HEW)
The Converse County Bank (CCB)
Kenneth A. Kosterlitzky (KAK)
San Diego Gas and Electric Company (SGE)
Department of Agriculture (DOA)
MATO
Green Construction Company (GCC)
Arthur G. McKee and Company (AGM)
Thomas C. Woodward (TCW)
Richard T. Hornbuckle (RTH)
Advisory Council on Historic Preservation (ACHP)
G. Eugene Hardy (GEH)
Department of Agriculture, Wyoming (WDA)
Office of the Governor, Utah (UOG)
Department of Natural Resources, Utah (UNR)
David F. Harrald (DFH)
Environmental Protection Agency (EPA)
Chen and Associates, Inc. (C&A)
Game and Fish Department, Wyoming (WGF)
Energy Research and Development Administration (ERDA)
Robert O. Pohl (ROP)

In addition to these letters, brief comments (PMC) were obtained from attendees at the public meetings held at Casper and Douglas. The letters and brief comments are reproduced in Appendix A of this statement. The staff's consideration of the issues raised in the comments is presented in this section and by changes in the text. The abbreviations and associated page numbers refer to specific comments received from the various agencies, organizations, and individuals.

Although several comments were received well after the expiration of the standard 45-day comment period on 28 February 1977, they were considered by the staff and are included in Appendix A.

12.2 RESPONSES TO COMMENTS

12.2.1 Importance of Bear Creek Project to Local Economy
(NBC, A-3; CCB, A-9; MATO, A-12; GCC, A-13; AGM, A-14; PMC, A-47-57)

The staff recognizes the importance of the project to the local economy and that its relative importance has increased with the delay of the Panhandle Eastern Project. See Sections 2.10 and 4.9.

12.2.2 Passage of Antelope and Deer
(DOI, A-37)

The staff agrees and an appropriate text change has been made (Sec. 6.7).

12.2.3 Flora to be Used in Revegetation
(DOI, A-38; DOA, A-18; WGF, A-35; PMC, A-45-47, 52)

Species proposed for use in revegetating the area, and the recommended substitutions, have proven to be successful in other areas of close proximity to the Bear Creek Project and in the same precipitation zone. While some species are not "native" flora in the strictest sense, their use is recommended because they produce more herbage matter and are better soil holders. Consultation with livestock operators in the Bear Creek area indicated that green needlegrass (*S. virisula*) and thickspike wheatgrass (*A dasystachyum*) are not desirable species for consumption by sheep.

The problems of revegetation, soil conservation, and management of the disturbed land are considered within the land capability evaluations. Tried and proven USDA-Forest Service and Soil Conservation Service Conservation practices will be considered, applied to the appropriate situations, and monitored for success.

12.2.4 Topography of Reclaimed Areas
(DOI, A-38; WGF, A-36; PMC, A-45, 53)

The staff does not agree that restoration will be directed toward flat, level topography. The intent is to ensure that the majority of reclaimed sites will maintain the rolling topography characteristic of the Powder River Basin.

12.2.5 Preservation of Raptors
(DOI, A-38)

The powerline design will be in accordance with the guide "Suggested Practices for Raptor Protection on Powerlines," "Edison Electric Institute," 1975, and REA Bulletin 61.10, Figs. 6 and 7). Also, see footnote to Table 10.5.

12.2.6 Fish and Wildlife Habitat
(DOI, A-38; WGF, A-35, 36; PMC, A-46, 56)

Fish and wildlife habitat on National Grasslands can be adequately handled under Forest Service administration. Suitable habitat on private land may be made available to Wyoming Game and Fish for management if it is agreeable with the parties involved.

At this point, only the possibility of a fishery can be considered. Current water-quality data suggest that wildlife and livestock watering and irrigation are suitable uses for the water in the reclamation ponds. It is realized that the shape and depths of the ponds will have a significant effect upon the establishment of an aquatic habitat. It is also not known if the water quality would limit fish life. According to the Company's environmental assessment, the water quality will be suitable without treatment and there is little risk of caustic poisoning since no areas will have open caustic materials. Available prediction techniques are not believed to be reliable enough to determine the fish sensitive range which might result. Water quality will be monitored to determine the feasibility of a fishery in the lakes.

12.2.7 Effect of Mine Dewatering on Water Table
(JCD, A-6; RTH, A-17; DOA, A-18; GEH, A-19; DFH, A-24; EPA, A-26, 27, 29, 32; PMC, A-45-48, 50)

Pumping of groundwater to keep the mine pits free of water during mining operations will lower water levels and cause flowing wells in the vicinity of the mine to cease flowing. Well water supplies lost because of mine dewatering will be replaced as stipulated by Wyoming water law administered by the State Engineer and the Board of Control. Provisions of the law make it possible to change the location of a well, a reservoir, or irrigated lands affected by activities such as mining without affecting water rights.

When an area is dewatered, the area of influence extends well beyond the dewatered zone, but the drawdown decreases with distance. Estimates of maximum drawdown may be made from the graphs on

p. 12-4. The upper figure is constructed with an assumed storage coefficient of 0.001 (a reasonable estimate for a sandstone 1000 feet thick); the lower figure is constructed with an assumed storage coefficient of 0.0001 (a reasonable estimate for a sandstone 100 feet thick). Both graphs are drawn for a pumping rate of 1000 gpm. Drawdown is directly proportional to discharge; thus, the drawdown at other pumping rates can be estimated from the graphs.

When dewatering ceases, water levels and pressures will return to static levels, which should be very near to those existing before dewatering was instituted. Recharge to the formations affected by mining comes from local precipitation - principally rainfall and snowmelt. Pre-mining recharge and discharge conditions in the mined areas will not be fully restored by successful reclamation because of disruptions of natural aquifers. Overall long-term change in recharge to the general area, however, will be minor.

12.2.8 Use of U_3O_8 Production from Bear Creek
(SCE, A-7; SGE, A-11; ROP, A-41; PMC, A-52, 53, 55)

The U_3O_8 produced (an estimated 3000 tons over the lifetime of the mill) at Bear Creek is sufficient to provide fuel for thirty years for a 500-MWe nuclear generating plant (assuming: average lifetime plant factor = 0.65, enrichment factor = 6.11, and the conversion, 1.29ST U_3O_8/MTU). During that lifetime, the plant would generate 8.5×10^{10} kWh, which would be worth (at $0.025/kWh) more than two billion dollars.

12.2.9 Long-Term Surveillance of the Tailings Area
(HEW, A-8; UNR, A-23; PMC, A-47, 56)

As indicated in Section 3.4, the NRC requires submission of decommissioning plans prior to the termination of the license. At that time additional control and surveillance procedures for the tailings storage area could be specified if necessary. At present, the general restrictions of Section 3.4 apply.

12.2.10 Environmental Monitoring
(HEW, A-8; EPA, A-30-32)

The monitoring plan has been revised in response to these comments. Section 6 has been updated; see Table 6.4 for a summary of the monitoring program.

12.2.11 Location of Irrigated Lands
(DOA, A-12)

The text is amended to indicate that no irrigated lands lie within the project area. All land within the project area is considered as rangeland.

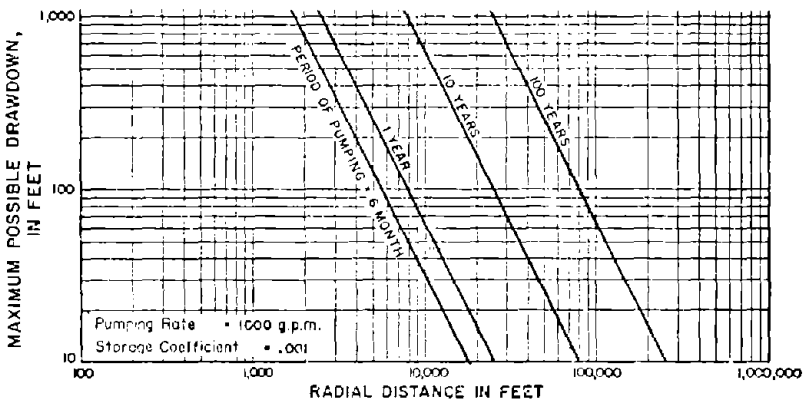
12.2.12 Designation of Soils
(DOA, A-12)

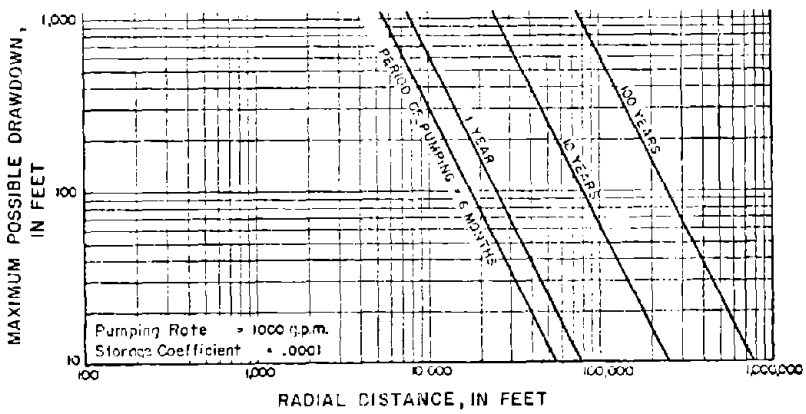
Changes in the text have been made to correct the errors.

12.2.13 Backfilling of Mine Pits
(AGM, A-15; GEH, A-20; DFH, A-24; EPA, A-26; PMC, A-45, 53, 56)

The Forest Service is charged with land management responsibilities for the National Grassland under its administration within this project area. The responsibilities associated with the administration of the laws applicable to these public lands involve the public good including not only those citizens adjacent to the project but of the entire country. The Forest Service was neither entirely supportive of the Company's reclamation proposal nor the possibility of complete backfill. Both the alternative desired by the company and the one preferred by the Forest Service provide for stockwater ponds. Refer to Appendix I for the current Forest Service position.

The reduction of unproductive highwall, amounting to an estimated 48 acres, to 3:1 slopes would disturb an additional 70 acres of land. All 70 acres would be reclaimed to a land capacity class of VIe with a potential native range production capacity of 1100 lb per acre per year. This would amount to an estimated 77,000 lb of annual forage production. The ten acres referred to was the net difference between the additional disturbance and the proposed unreclaimed highwall. (The acreage base for the alternatives is slightly different between the DES and FES.)





Maximum possible drawdown for a given distance and time
(Modified from Water-Supply Paper 1536-F, fig. 48)

Evaluations of restoration costs have not shown highwall reduction to be unreasonable in terms of the potential long-term productivity of the reclaimed land. Additionally, esthetics and recreational opportunities are social values within the responsibility of Forest Service administration and therefore cannot be separated from the other factors of the environment.

The regulations pertaining to coal are not in concert with those applicable to uranium mining. We agree in principle, that for purposes of uniformity in environmental control, it should be handled the same; however, the differences between open pit and strip mining should be kept in mind. The backfilled material in the pits would create the stagnant pool if the aquifer were sealed around the pit perimeter.

12.2.14 Preservation of Other Mineral Resources
(AGM, A-14; TCW, A-16)

The USGS may require certain stipulations related to conservation of mineral resources. If economical coal is discovered during the actual stripping operation, the lessee could be required to stockpile it for sale to an appropriate market. Existing logs indicate that the probability of finding economical coal is very remote. Analyses of core samples taken in the 1974 drilling program indicate that the coal seams located above the uranium bearing zones may be more properly classified as carbonaceous shale. Geologic information available in the files of the Area Mining Supervisor show thin, discontinuous beds which would have questionable economic value. Even if coal existed in sufficient quality in the dump area, the stripping ratio for a bed of coal only 2-2 1/2 feet thick would make economic recovery prohibitive. Analyses available at this time indicate that the carbonaceous zones have, on the average, very high ash content (50-80%) and very low calorific content (500-5000 Btu/lb) which would classify these zones as non-commercial.

12.2.15 Interaction of Labor Force with Local Ranch Operations
(RTH, A- 17; GEH, A-20; PMC, A-47-50, 53)

Although there will be a discernible increase in the number of vehicles traveling to and from the Bear Creek area, the traffic volume will not exceed that which is normal for a typical Wyoming secondary road. In general, landowners are compensated for the use of their land during mining as per surface owner agreements, and all land disturbed will be reclaimed in a timely fashion. More specifically, property damages and schedules to avoid lambing and calving pastures at sensitive times are detailed in the surface owner's agreement negotiated by the operator and landowner before any work commences on private land. Litter and garbage problems are not unique to a mining operation. The constant winds in the Bear Creek area make the solution to this problem difficult; however, RMEC is making every effort to control the indiscriminate scattering of trash generated by its operations.

12.2.16 Disruption of Usage by Livestock of Land, Forage, and Water
(RTH, A-17; GEH, A-19; PMC, A-48, 50)

Thic concern is addressed in the FES in various places. The disruption of usage by livestock can be mitigated somewhat by the timing of certain mining operations so as to interfere as little as possible with livestock activities. Also, traditional grazing patterns may have to be changed, if possible, to reduce interference.

Loss of forage will be unavoidable while mining operations are active and until restoration of disturbed areas is accomplished.

Loss or disruption of water use may be mitigated to some degree by additional wells and diverting water from the mining operation.

12.2.17 Likehood of Man-Caused Fires
(RTH, A-17)

With increased activity the potential for man-caused fires is expected to increase. This potential will be reduced somewhat by an active fire prevention and law enforcement program.

12.2.18 RMEC Contact with Landowners
(WDA, A-21; PMC, A-45, 47, 49, 50)

All ranchers in the area of activity were notified of plans and questions and comments were solicited. Mining and milling operations on private and Federal land are subject to State and

Federal regulations. Under Wyoming DEQ regulations each landowner whose land was directly affected or disturbed was required to give written approval to the mining plan. Several items, not required by DEQ, were requested by ranchers, and these requests were granted by RMEC. Personal contact by various RMEC personnel has been maintained with all local people affected. This contact and exchange is expected to continue throughout the life of the project.

12.2.19 Requirements Imposed on the Tailings Facility
(UNR, A-23; EPA, A-27-29, 32, 33; WGF, A-35; PMC, A-47, 57)

The Bear Creek requirements represent an effort to meet the performance objectives developed by NRC. These objectives, which are enumerated below, may be modified as results of the Generic Environmental Impact Statement on Uranium Milling Operations become available, but are considered appropriate for the interim.

Siting and Design

1. Locate the tailings isolation area remote from people such that population exposures would be reduced to the maximum extent reasonably achievable.
2. Locate the tailings isolation area such that disruption and dispersion by natural forces is eliminated or reduced to the maximum extent reasonably achievable.
3. Design the isolation area such that seepage of toxic materials into the groundwater system would be eliminated or reduced to the maximum extent reasonably achievable.

During Operations

4. Eliminate the blowing of tailings to unrestricted areas during normal operating conditions.

Post Reclamation

5. Reduce direct gamma radiation from the impoundment area to essentially background.
6. Reduce the radon emanation rate from the impoundment area to about twice the emanation rate in the surrounding environs.
7. Eliminate the need for an on-going monitoring and maintenance program following successful reclamation.
8. Provide surety arrangements to assure that sufficient funds are available to complete the full reclamation plan.

12.2.20 Public Involvement in the Decision-Making Process
(DFH, A-24; PMC, A-46)

In addition to the normal channels for public participation provided by NEPA (see Foreword), the Forest Service sponsored, and the US Geological Survey and the Nuclear Regulatory Commission participated in, two local public-involvement meetings. They were held in Douglas on February 8, 1977, and in Casper on February 9, 1977. Input from local people was encouraged and sought.

12.2.21 Assessment of Radiological Impacts
(EPA, A-27-29; WGF, A-35; ERDA, A-40, 41; ROP, A-41; PMC, A-48)

In view of the comments above, Sections 4.8 and Appendix K have been revised and expanded. The specific typos, errors, ambiguities, omissions, etc. pointed out have been corrected by appropriate text changes, and the suggested amendments have been achieved by rewriting and expanding the text, tables, and figures.

12.2.22 Exemption by NRC and Conditional Approval by FS
(EPA, A-26; PMC, A-51)

By letter dated January 20, 1976 Rocky Mountain Energy Company requested an exemption from 10 CFR 40, Sections 40.31(f) and 40.32(e) for the purpose of early initiation of certain construction activities on the Bear Creek Uranium Mill in order to meet scheduled uranium delivery commitments.

The scope of the exemption encompassed the following activities:

1. Extending an existing electrical transmission line to a substation near the site of the proposed mill.

2. Building of fence on private lands.

3. Mining of sand and gravel 35 miles south of the proposed mill and hauling the gravel to a stockpile on private land near the site of the proposed mill.

4. Construction of access road to the mill area.

5. Hook up power from substation to well and install pump to provide water to project area as well as extending power to mining area.

6. Begin field mobilization, i.e., establish a field office (trailer), tool shed, etc.

7. Remove topsoil from proposed mill area and stockpile for future use in reclamation work.

8. Begin grading and excavation work in mill site area and establish surface drainage diversion dikes around disturbed area.

9. Begin work on activities such as building foundations and shells for mill buildings, offices, change house, mining field offices, shops and warehouses.

The conditions that this exemption was granted under, dated April 1, 1976, are:

1. Construction activities shall be conducted in a manner designed to minimize the impact on the environment and shall be limited to that work described by the statements and representations contained in the January 20, 1976, application.

2. On the finally approved site, the applicant agrees to pump tailings slurry to the tailings disposal area, if necessary, without regard to the financial costs or other impacts resulting from work completed under the exemption.

Conditional approval by FS for access to the mill construction site was based upon the Exemption granted by NRC for Mill Construction pending the satisfactory completion of the FES.

12.2.23 Distance to Highland Mill
(EPA, A-26, 33)

The road distance, appropriate for hauling considerations, to the Highland Mill, is 35 miles; the air distance, appropriate for dispersion calculations, is 13 miles. The appropriate text change has been made.

12.2.24 Rate of Flow of Wasatch and Fort Union Wells
(EPA, A-26)

Most flowing water wells in the vicinity of the Bear Creek Project flow at rates of from about one gallon per minute to about ten gallons per minute. One well near the mine property flows about 25 gpm. Most wells are drilled for stock watering and yields of a few gallons per minute are generally adequate. Somewhat higher flows would be possible at some locations by drilling deeper wells.

12.2.25 Removal of Settling Basin Sediments to Tailings Pond
(EPA, A-26)

The accumulated sediments are to be removed from the mine settlement basin with a front end loader, truck haulage system. The material will be finely textured and will contain 20-40% moisture. Dusting will not be a problem during the removal and haulage operations. Deposition is scheduled for the tailings disposal basin at the mill site where the finely sized material can be buried so that dusting will not become troublesome in the future.

12.2.26 Quality of Water in Impoundments
(EPA, A-27, 29, 32; WGF, A-35; DOI, A-38; PMC, A-56)

It is true that it can not be determined at this time what the quality of the water will be in the residual lake at the B-1 pit. If the water is unused, it will become stagnant, and because of high evaporation, the water will become more mineralized as it is evaporated and the minerals in the water remain. However, if enough water is used from the lake, such as being pumped out for irrigation as proposed, replacement of water by discharge of groundwater into the lake will tend to keep the water much fresher and of better chemical quality. Dissolved solids of about 1000 milligrams per liter are common in the groundwater in the vicinity of the Bear Creek Project. It seems probable that dissolved solids could be kept at about 2000 milligrams per liter if the water from the lake is used as proposed by the applicant.

12.2.27 Definition of "Topsoil"
(EPA, A-26)

"Topsoil" as used in the FES refers to soil materials suitable for plant growth. All suitable soil materials as defined and evaluated within the FES will be salvaged and replaced upon the contoured surface. The total acre feet of this suitable material will restore soils 20 to 33 inches thick on the reclaimed sites. We disagree that the detailed soils information should be added to the report. In our opinion, little would be gained and it would amount of about three inches of additional report thickness. The integrity of the original A horizon will not be maintained in salvage.

12.2.28 Chemical Analyses of Overburden
(EPA, A-26)

The answer to this question can be found in Section 2.6.2, General Chemical Properties of Onsite Soils. Overburden sampling and analysis were done by the Colorado School of Mines Research Institute on three cores drilled in Sections 10 and 15, T38N, R78W. Their studies found deficiencies of nitrogen and phosphorus. A 10-in. clay cap and a minimum of six feet of suitable material will be required to cover toxic or deleterious strata on the tailings.

12.2.29 Solvent Interference in Leaching Process
(EPA, A-26)

Interference with the leaching operation is unlikely, but some difficulty in flocculation reaction could be experienced in CCD. However, there exists a skimming capability in the surge vessel receiving the returning aqueous flows. In this manner, organic inclusives in the CCD wash flows should be held at acceptable levels.

12.2.30 Dust Suppression at Ore Pads and in Grinding Operations
(EPA, A-27; PMC, A-48)

Dust suppression in the ore pad operations is currently addressed with the water truck coverage of the main haulage roads to the ore stockpile area. This coverage protects the route that is frequently used by the loader in the tramming of the ore to the ore receiving grizzly. Stockpile sizes are also planned to be of a size such that they are fed before extensive drying of the ore piles occurs. It has been felt that the wet nature of the ore with moisture contents of 12-20% will not present a serious dusting problem in the stockpile area. Consideration has been given to wetting of stockpiles in case a problem of this nature occurs. However, the maintenance of an implace sprinkler system in such a cold climate is judged to be impractical. It is felt that the water truck coverage provides a better assurance of dust suppression when and where it may be needed.

The concepts of size reduction applied in the Bear Creek milling circuitry are specifically designed to generate a minimal amount of ore dust. The single large diameter, wet, semi-autogenous mill is used to cover the crushing and grinding operations in such a manner that the normally wet ores (12-20% moisture) need no drying. Additionally the storage of ore is accomplished in a wet mode after the size reduction rather than in the dry state as found in the more conventional circuits. Existing plants having this design have adequately displayed these advantages.

Po-210 has traditionally not been tested for due to the analytical difficulties encountered and the costs involved. Additionally Po-210 has an allowable maximum permissible concentration in air to unrestricted areas (MPC) of 2×10^{-11} $\mu Ci/cm^3$ compared to 3×10^{-12} $\mu Ci/cm^3$ for Ra-226 and is 20 times less harmful to the critical organ than Ra-226. Po-210 may be considered for analysis on a one-time basis to determine the disequilibrium ratios of this isotope.

12.2.31 Compacted Clay Cap
(EPA, A-28)

The text in Section 3.4, item 3, has been updated to include the clay cap.

12.2.32 Treatment of Mine Water
(EPA, A-29; DOI, A-38; PMC, A-46)

Prior to minewater being discharged for livestock use, it will be pumped into a settling pond which will have an approximate retention time of five days. This treatment will effectively remove any suspended solids present. If radium becomes a problem (i.e., weighted concentrations become greater than 3 pCi/l per the NPDES permit) the mine water will be treated with barium chloride prior to its release into the settling pond.

12.2.33 Properties of Overburden and Backfill
(EPA, A-29)

Although some studies of permeability rates for open-pit mine overburden before stripping versus permeability rates for backfill after placement and reclamation are now being undertaken by the USGS and private industry, the results are not yet available to determine exactly what the changes in the permeability rates will be. The rocks at the Bear Creek Project consists, in general, of alternating layers of sand and shale, and consequently do have some degree of sorting. Some rock layers are predominantly sand, other layers are predominantly shale, and some layers are a mixture of sand, shale, and/or silt. Movement of water is mostly horizontally along sandy layers with only minor vertical movement through the interbedded shale layers. When the overburden is removed for stripping of the uranium ore, the bedding will be destroyed. After the pits have been backfilled with the original overburden, the backfill will be much more heterogeneous. Water that formerly moved laterally along the pre-mining sand layers will tend to infiltrate vertically through the backfill as new flow paths are established in the backfill with the principal permeability being vertical. The backfill will constitute a greater volume due to less compaction and consequently porosity should be somewhat greater, depending on the compaction.

Leaching studies are being made in some coal-mine soils in the northern part of the Powder River Basin, but the results to date are not conclusive.

Water that moves through the backfill deposits will probably be of relatively poor quality. This water will be dispersed and diluted, however, as it moves down gradient away from the backfill deposits.

12.2.34 Chemical Contamination Seepage
(EPA, A-29, WGF, A-35)

A discussion of the possible effects of leached chemical contaminants is given in Section 10.4.2, but, in view of the low seepage rate, this is not expected to be a problem at Bear Creek. The operations at the mill are such that only sulfate levels are raised substantially; it is expected, however, that most of the sulfate will precipitate as $CaSO_4$ within the tailings impoundment area.

12.2.35 Radon Sampling Program
(EPA, A-32)

RMEC has agreed to forward a copy of the radon sampling program when it is in final form.

12.2.36 Leakage of Chemical Contaminants from Tailings Pond
(EPA, A-32; WGF, A-35)

It is correct that any leakage from the tailings disposal pond would include chemical contaminants. Radioactive contaminants, however, should be detected first and corrective measures would be taken at that time. The corrective measures to be taken to monitor and control possible leakage from the tailings disposal pond are discussed in various sections of this environmental statement.

12.2.37 Success of Reclamation Effort
(WGF, A-35; PMC, A-45-48, 52)

The expected success of reclamation is based upon the present land capability classification, the predicted land capability after reclamation, and the experience of various mines adjacent to

the area such as the Amax Coal Mine south of Gillette, Wyoming. Good results have been achieved with land capability predictions during the last 30 years of its use. The tailings area will be monitored for safety of use.

12.2.38 Temporary Riparian Habitat
(WGF, A-35)

Temporary riparian habitat, as used in the text, is in reference to an aquatic situation which includes Typha, Juncus, Carex and similar species.

12.2.39 Loss of Big Game Populations
(WGF, A-36)

The estimate in the FES is based on the best information available at this time.

12.2.40 Dry-land Farming
(WGF, A-36)

The analysis involving dry-land farming served the purpose of comparing soil and land potentials before and after mining as well as manageability. Potentials for dry-land farming are displayed as marginal.

12.2.41 Effects of Movement and Storage of Overburden on Wildlife
(WGF, A-36)

The staff agrees that the loss of small mammals is an unavoidable impact. Although most wildlife numbers will be reduced through loss of habitat, some will be destroyed by earthmoving activities. Please also refer to Section 7.7.1.

It is recognized that there will be distruction of small burrowing species when overburden covers the habitat. There will also be a temporary loss of habitat for most all species until revegetation has occurred.

12.2.42 Restoration of Wetlands and Dryland Habitat
(WGF, A-36; PMC, A-46, 47, 52, 53)

The staff agrees that it is the responsibility of the company to restore these habitats to the extent reflected in the Mining and Reclamation Plan.

12.2.43 Seasonal Variations in Faunal Densities
(WGF, A-36)

Seasonal fluctuations do occur (see Sec. 2.8.1). These fluctuations may be seasonal changes in population densities resulting from the normal dynamics of species or as the result of seasonal migrations. Since an operational area of about 3500 acres is involved, some species may exhibit population fluctuations on a daily basis.

12.2.44 Downstream Sedimentation
(DOI, A-38)

The increased erosion and consequent sedimentation are not expected to effect any reservoirs downstream of Betty Reservoir. The distance from the mining and milling operations to Angostura Reservoir plus the intervention of Betty Reservoir render highly unlikely any deposition of Bear Creek sediment in Angostura Reservoir.

12.2.45 Preservation of Cultural Resources
(DOI, A-39)

All activities on Federal lands are subject to termination if and when antiquities are found during the operations until a professional archeologist has an opportunity to survey, preserve, or otherwise protect the artifacts of historical, archeological, or paleontological value. Only when this is accomplished can the activity be resumed.

The final statement shows confirmation of consultation with the Federal Register of Tuesday, February 1, 1977 and subsequent monthly supplements.

12.2.46 Productivity of Soils
(DOI, A-39)

The increased production potential is not considered to be an unavoidable adverse environmental impact. The staff recognizes the variance in the magnitude of disturbance to soils within the operating area. The semiquantitative prediction of soil capability as presented is its best estimate and represent an aggregate of soil properties and characteristics.

The "why" of improved soil productivity is described in Section 10.1.3 and further supported in Appendex D. The procedures are displayed in the applicant's Mining and Milling Operations (revised plan) discussed in Section 3.

Those particular soils referred in Section 9.5.2 will be buried under several feet of tailing materials.

12.2.47 Fuel Consumption in Mining and Milling Uranium Ore
(DOI, A-39; PMC, A-53, 54)

The requested information is given as a text change (Sec. 9.4).

12.2.48 Adequacy of Benefit-Cost Analysis
(WGF, A-36; DOI, A-39)

The NRC staff considers the benefit-cost summary to be adequate.

12.2.49 NPDES Permit
(ERDA, A-40)

The NPDES Permit has been reproduced as Appendix L.

12.2.50 Occupational Exposure
(ERDA, A-40)

Special studies at selected mills showed that the workers' exposures are normally below 25% of the allowable concentrations[1] and that external exposures are normally less than 25% of the 10 CFR 20 limits.[1,2]

References for Section 12

1. J. R. Metzger, "Nuclear Regulatory Commission Occupational Exposure Experience at Uranium Plants." In "Conference on Occupational Health Experience with Uranium," p. 205 ERDA-93, April 1975.

2. "Manual on Radiological Safety in Uranium and Thorium Mines and Mills," IAEA Safety Series No. 43.

APPENDIX A. COMMENTS

COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT.

COMMENTS RECEIVED AT PUBLIC MEETINGS.

Meeting at Douglas, Wyoming.

Meeting at Casper, Wyoming.

DEPARTMENT OF THE ARMY
OMAHA DISTRICT, CORPS OF ENGINEERS
6014 U.S. POST OFFICE AND COURT HOUSE
OMAHA, NEBRASKA 68102

MROPD

25 January 1977

Director, Division of Fuel Cycle and
Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

This responds to your letter of 10 January 1977 with which you inclosed the Draft Environmental Statement for Bear Creek Uranium Mining and Milling Project for review and comment.

We have reviewed the draft EIS and find there will be little, if any, impacts to any Corps of Engineers project or on-going study. Our review also indicates that this project will not require either a Section 10 or Section 404 permit under the Federal Water Pollution Control Act as amended. This is based on the assumption that there does not appear to be any fill activity planned in any stream which flows more than 5 c.f.s. 50 percent of the time; any natural lake larger than 5 surface acres; or any adjacent or contiguous wetlands.

We appreciate the opportunity to review and comment upon the draft.

Sincerely yours,

JOHN E. VELEHRADSKY, P.E.
Chief, Planning Division

TENO RONCALIO
THE STATE OF WYOMING

(202) 225-2311

COMMITTEES:
INTERIOR AND INSULAR AFFAIRS

PUBLIC WORKS AND TRANSPORTATION

JOINT COMMITTEE ON ATOMIC ENERGY

CHAIRMAN
SUBCOMMITTEE ON AGREEMENTS FOR COOPERATION

Congress of the United States
House of Representatives
Washington, D.C. 20515

January 26, 1977

Dr. Clifford Smith
Director
Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Director Smith:

I have reviewed the Draft Environmental Impact Statement for the Bear Creek Uranium Mill and Mine complex proposed by Rocky Mountain Energy Company and Mono Power Company for Converse County, Wyoming.

It would appear that proceeding with the mill and mine would be a positive step for Wyoming and I would hope that the NRC would proceed with the Final Environmental Impact Statement and expedite the granting of permits and the source material lisence necessary for the operation to move ahead.

Respectfully yours,

Teno Roncalio
Congressman for Wyoming

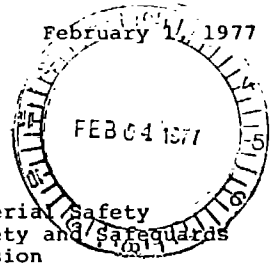
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A-2

First National Bank of Casper

HENRY A. HITCH
PRESIDENT

February 1, 1977



Director
Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

This bank is one of Central Wyoming's oldest business institutions, and one of Wyoming's two largest banks, founded in 1889, and I have lived in Central Wyoming for the past twenty-one years.

This letter is for the purpose of responding to the Commission's request for comment concerning the Bear Creek Uranium Project, proposed by Rocky Mountain Energy Company. This bank and I personally have been concerned that the form of comment very often received by responsible agencies such as yours are from persons and organizations that are opposed to development of any kind. We feel it is

first at wolcott / p. o. box 40 / casper, wyoming 82601 / 307/235-4243

incumbent upon us as responsible community leaders to demonstrate, through this letter, that there are those who believe that proper balancing of energy development and environmental protection can be accomplished and that projects, such as the Bear Creek Project where such balance is achieved, should be allowed to proceed forthwith.

We have become acquainted with Rocky Mountain Energy Company through our full service banking business activity in Central Wyoming and view its Bear Creek Project as an important addition to the regional economy.

Sincerely,

HENRY A. HITCH
President

first national bank of casper

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

DOCKETED
USNEC
FEB 14 1977
REGULATORY
MAIL SECTION

TO Director, Geological Survey, Dept. of Interior
Washington, DC

DATE: Feb. 2, 1977

FEB 1 1977

FROM : ACTING Area Manager, U.S. Fish and Wildlife Service
Billings, MT

SUBJECT: Draft Environmental Impact Statement, Bear Creek Project Uranium Mining in Converse County, Wyoming (ER #77-38)

We have reviewed the subject DES which was sent to us for reply. Our comments follow:

The treatment of potential impacts on fish and wildlife resources and the related environment appears generally adequate. However, certain mitigation potentials should be further considered and implementation prospects presented in the final impact statement.

1. Fenced areas should specifically provide for antelope and deer movement, especially escape passage from newly fenced areas.

2. Reclamation efforts should be designed to re-establish native flora that will survive in the semi-arid climate having a mean annual precipitation of 12.0 inches.

3. Land reclamation directed towards creating a flat, level topography best suited to a monoculture purpose like domestic livestock grazing will result in a permanent loss of wildlife habitat. Restoring the topography to its original form might best mitigate damages to existing wildlife habitat.

4. Power lines and their supports should be designed to prevent the electrocution of raptors.

5. Besides having sight-seeing values (10.1.4), highwalls left after the mining operation might provide valuable nesting sites for raptors.

6. Fish and wildlife habitats suitable for future management and public use could be made available to the Wyoming Game and Fish for management after the project is terminated.

We have no comments on specific language of the draft.

John G. Wood

cc: Chief, Branch of Environmental Coordination, FWS, Washington, DC
Regional Director, FWS, Denver, CO (ES)
Dale Strickland, Wyoming Game and Fish Dept., Cheyenne, WY
Kent Keenlyne, FWS, Casper, WY

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CHEYENNE

ED HERSCHLER
GOVERNOR

February 8, 1977

Director
Division of Fuel Cycle and
Material Safety
Office of Nuclear Material Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

This will advise that the review of the Bear Creek Project Draft Environmental Statement has been completed and that it sufficiently addresses the impacts expected to result from the proposed uranium mining and milling operations.

In view of previous energy projects in Wyoming related to the Rocky Mountain Energy Company, and the adequacy of this draft statement, I strongly support this proposed operation and recommend that the required federal approvals and permits be granted as soon as possible.

Thank you for the opportunity to review the draft statement. We are looking forward to the realization of the Bear Creek Project.

Yours sincerely,

Ed Herschler

EH:trc

cc: D. Thomas Kidd

A-4

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (G-WS/73)
WASHINGTON, D.C. 20590
PHONE: (202) 426-2262

8 FEB 1977

FEB 10 1977

Mr. L. C. Rouse, Chief
Fuel Processing and Fabrication
Branch
Division of Fuel Cycle and
Material Safety
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Rouse:

This is in response to your letter of 10 January 1977 addressed to Captain W. R. Riedel concerning a draft environmental impact statement for the Rocky Mountain Energy Company's Bear Creek Project, Converse County, Wyoming.

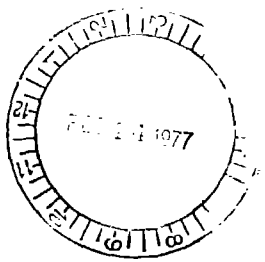
The Department of Transportation has reviewed the material submitted. We have no comments to offer nor do we have any objection to this project.

The opportunity to review this draft statement is appreciated.

Sincerely,

D. J. RILEY
Captain, U. S. Coast Guard
Deputy Chief, Office of Marine
Environment and Systems
By direction of the Commandant

DOCKETED
USNRC
FEB 11 1977



Box 707
Douglas, Wyoming 82633
February 8, 1977

Mr. John Kendig
Division of Fuel Cycle and Material Safety
Office of Nuclear Materials Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Kendig:

I have reviewed the draft Environmental Impact Statement, NUREG 0129, related to the Bear Creek Project in Converse County, Wyoming. I am a rancher in the area and have land leased to Rocky Mountain Energy Company under an agreement for uranium mining.

It is my opinion that this project should move forward in order that additional energy resources can be obtained at an early date. I know that the operation as proposed, or any way that it is carried out, will change things from what they have been in the past, but I feel that we who live in the area should not stand in the way of progress.

It seems to me that the delay in development of other energy projects caused by the Sierra Club, the Powder River Basin Resources Council and government red tape costs everyone more for future energy resources and further contributes to the country's inflationary pattern.

I have been concerned that the mine de-watering will lower the water table in the area. However, if the Impact Statement is correct, it appears that considerable study was given to this matter and that the long term effects on the groundwater are expected to be minor.

All in all, it appears that when the bad effects are weighed against the benefits of the Bear Creek Project that the project is environmentally sound. It further appears that the Federal agencies involved and Rocky Mountain Energy Company have done and are doing a good job in evaluating the various alternatives.

Very truly yours,

John C. Dilts

John C. Dilts

Southern California Edison Company

P. O. BOX 800

2244 WALNUT GROVE AVENUE

ROSEMEAD, CALIFORNIA 91770

JACK K. HORTON
CHAIRMAN OF THE BOARD

TELEPHONE
213-572-2262

February 8, 1977

FEB 15 1977

Mr. Clifford V. Smith, Director
Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Gentlemen:

This letter is in response to the Nuclear Regulatory Commission's request for comments on the Bear Creek Project uranium mine and mill Draft Environmental Statement, NUREG-0129. Southern California Edison Company urges the timely approval of the licensing for the Bear Creek Project, as being in the public interest and necessary for achieving the energy independence goals of the country.

Southern California Edison is an investor-owned electric public utility that supplies essential electric service to nearly 8,000,000 people in an area encompassing approximately 50,000 square miles of central and southern California. Edison owns and operates a number of hyroelectric and steam electric generating plants. Among these is the San Onofre Nuclear Generating Station consisting of one 430-megawatt unit currently in operation and two 1100-megawatt units under construction. This plant is owned 80% by Edison and 20% by San Diego Gas & Electric Company. As part of its on-going efforts to secure fuel supplies for these units, Edison, through its wholly-owned subsidiary, Mono Power Company, has a 50% ownership interest in the Bear Creek Project, together with its partner, Rocky Mountain Energy Company.

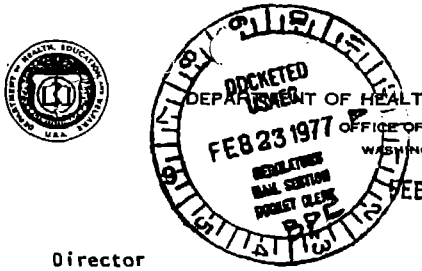
We are concerned that the need for U_3O_8 production from the Bear Creek Project as a substantial source of fuel for the generation of electric energy at the San Onofre plant was not adequately emphasized in the draft statement. We believe that it is important that those who review the final Environmental Impact Statement are made aware that the U_3O_8 produced from the Bear Creek Project is expected to be an essential part of our fuel procurement program, and represents approximately 35% of the total fuel required through 1990 at San Onofre for the production of clean, reliable electric energy. Use of the U_3O_8 in this manner will have the effect of reducing oil consumption on our system by approximately 120 million barrels. A reduction of the

country's dependency upon foreign oil supplies of this magnitude represents a significant contribution to the energy independence objectives established by the President of the United States.

Your consideration of these comments is appreciated, and we again respectfully request timely approval of the license for this project.

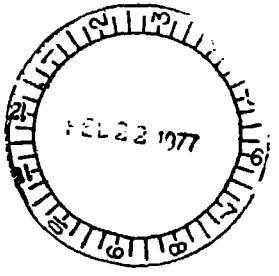
Sincerely,

JKH:br



DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

FEB 18 1977



Director
Division of Fuel Cycle and Material
Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Thank you for the opportunity to review the Draft Environmental Impact Statement concerning the Bear Creek Project in Converse County, Wyoming.

The document, as written, is relatively complete and comprehensive. However, we have the following comments to offer:

1. There is no discussion of the control of the areas in which the tailings will be stored subsequent to abandonment of the operation. Because of the presence of radium in the tailings and the emanation of radon and thoron from this material, it is recommended that the statement state specifically what control measures will be employed to prevent use of these areas for the construction of domestic dwellings, schools or similar structures that would be inhabitated for prolonged periods of time.

2. The statement indicates that crops of various types are being produced in the area, but there is no indication of what sampling and analysis will be performed on these crops. This should be added to the final statement.

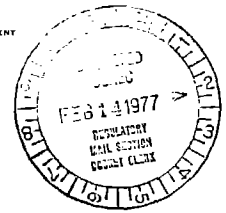
3. There is a prevalence of wild game, both animals and birds, in the area. There is no indication that these will be sampled and analyzed for radioactivity. A monitoring program for both the crops and the game should be conducted for the duration of the project.

Sincerely,

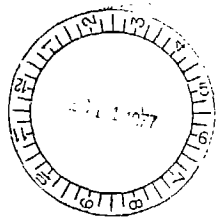
Charles Custard
Director
Office of Environmental Affairs

The Converse County Bank

CECIL J. COE PRESIDENT



February 9, 1977



Director
Div. of Fuel Cycle & Material Safety
Office of Nuclear Material
Safety & Safeguards
Washington, D.C. 20555

Dear Sir:

I am writing to you to give you some of my thoughts with regard to the Bear Creek Uranium Mill, a joint venture of Rocky Mountain Energy Company and Mono Power Company. This mill/mine complex will be located to the north of Douglas, County Seat of Converse County, Wyoming; and when it becomes operational, will be mining and milling some 1,000 tons of ore per day.

I am sure you are aware of all of the technical aspects of this operation, so my comments will not be in that direction. Often times today we hear so many comments about the adverse effects of an operation of this type and of the harm that it will do to the terrain and environment. We have had in operation for several years the Exxon Uranium Mine and Mill not too many miles distance from the site of Bear Creek. We have been very impressed with the manner in which they returned the grasslands to a state, in many cases, better than they were prior to being disturbed. Of course, the Bear Creek Uranium Company will follow the same methods in restoring these conditions so that it will, in fact, be a benefit to the ranching interest which will eventually take it over.

We are also looking forward to the many benefits that a mill of this type will have to our county inasmuch as it will pay many millions of county and state taxes plus, of course, the payroll which will be of an advantage to our town as well as to neighboring communities.

It has been our experience that the operators and employees of the uranium companies are highly paid and highly skilled individuals who contribute much to the community and become a very integral part of it.

Drawer 689 • Douglas, Wyoming 82633 • Phone 358-3543

In short, what we are attempting to do here is to stand up and be counted for this development. We feel very strongly that the people of this country need the energy that this mill will produce and we in Wyoming need the economic benefits. We hope that your office will approve of this operation as well as other pending mills and consider the positive side as well as the environmentalists opinions.

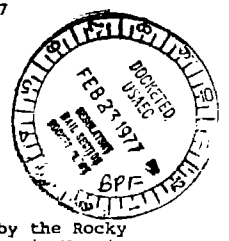
Very truly yours,

Cecil J. Coe
President

CJC:rb

cc: W. F. Baumann
Resident Manager
Bear Creek Uranium Co.
P.O. Box 2654
Casper, Wyoming 82602

February 14, 1977



The Director
Division of Fuel Cycle & Material Safety
The Office of Nuclear Material Safety & Safeguards
The U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

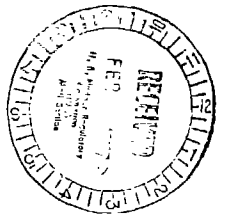
Dear Director:

I have recently learned of the delays encountered by the Rocky Mountain Energy Company's Bear Creek Uranium Project in Wyoming. As an interested citizen of the United States, in our energy independence, I feel that it is extremely important that we develop alternative sources of energy during the years to come. Having worked with many of the uranium oxide mines and mills in the Rocky Mountain area, I feel that it is justified for our economy and country to proceed with the development of these uranium oxide projects to ensure that there is available fuel for nuclear reactors during the 1970's and 1980's.

I honestly believe the environmental impact statement of the Bear Creek Uranium Project accesses the impact of the Bear Creek Project and shows that these impacts are minimal and temporary because measures have been incorporated in the plan to mitigate them.

I would like also to mention that I honestly believe that with the measures taken by Rocky Mountain Energy to ensure little or no impact to the environment, that we are further guaranteed that no harm will come to this environment. I am also very much for any and all projects that provide new opportunities for jobs in the area and bolster the national economy by providing the alternative sources of fuel for the future.

I should like you to know that I am very much for the project and do hope that you will give it a speedy passage, and allow for development of this project very soon.



Respectfully,

Kenneth A. Kosterlitzky

Kenneth A. Kosterlitzky

SAN DIEGO GAS & ELECTRIC COMPANY
[illegible] SAN DIEGO, CALIF. 92112
[illegible] 232-6252

R. E. MORRIS
PRESIDENT

FILE NO. MSH 300

February 15, 1977

FEB 17 1977

Mr. Clifford V. Smith
Director, Division of Fuel
Cycle and Material Safety
Office of Nuclear Material
Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Smith:

This letter is in response to the Nuclear Regulatory Commission's request for comments on the Bear Creek Project draft environmental statement NUREG-0129. San Diego Gas & Electric Company considers the licensing for the Bear Creek Project to be in the public interest and necessary for achieving the energy independence goals in the country. We urge the project's timely approval.

San Diego Gas & Electric Company is an investor-owned gas and electric public utility supplying essential electric service to over 635,000 electric customers in an area encompassing approximately 4,100 square miles, primarily in San Diego County, California. SDG&E owns and operates a number of steam electric generating plants. Among these is the 20%-owned San Onofre Nuclear Generating Station consisting of one 430 Mw unit currently in operation and two 1,100 Mw units under construction. As part of its ongoing efforts to secure fuel supplies for San Onofre, the operating agent, Southern California Edison Company, through its wholly-owned subsidiary, Mono Power Company, has a 50% ownership interest in the Bear Creek Project Uranium Mine and Mill together with its partner, Rocky Mountain Energy Company.

SDG&E is concerned that the draft environmental impact statement did not adequately emphasize the need for the U_3O_8 production from Bear Creek as a substantial fuel supply for the San Onofre Plant. It is important that those who review the final environmental impact statement understand that the U_3O_8 produced from the Bear Creek Project will provide approximately 35% of the total nuclear fuel required through

1990 at San Onofre for the production of clean, reliable electric energy. Use of U_3O_8 in this manner will have the effect of saving approximately 120 million barrels of fuel oil. A reduction of the country's dependency upon foreign oil supplies of this magnitude represents a significant contribution to the energy independence objectives established by the President of the United States.

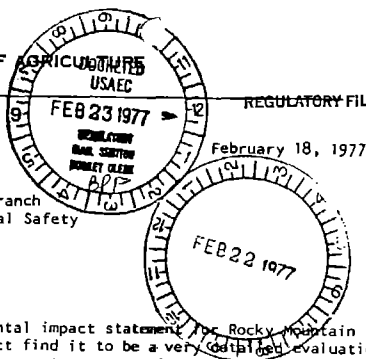
We appreciate your consideration of these comments; we respectfully request timely licensing of this project.

Sincerely,

R. E. Morris
President

REM:kp

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. Box 2440, Casper, WY 82601



February 18, 1977

Mr. L. C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
Nuclear Regulatory Commission
Washington, D.C20555

Dear Mr. Rouse:

Our review of the draft environmental impact statement for Rocky Mountain Energy Company's Bear Creek Project find it to be a very detailed evaluation of the existing situation and an accurate presentation of environmental impacts and adverse effects. We commend the people responsible for the preparation of the statement.

We have only a few minor comments to offer for your consideration.

Page 2-5, section 2.3.3 Agriculture. This section is not clear, in that it talks about irrigated lands located 2 miles west-northwest and 12 miles to the northeast. The reader does not know whether this is in the project area or not. Some mention of acres of irrigated cropland, dry cropland, and rangeland within the project area would be desirable.

P. 2-29, table 2.10 - Column entitled Soil Series. The names used for the mapping units are not all soil series names. For instance, Rock outcrop or Aeric Haplaquents are considered a land type and a soil subgroup name, respectively. Therefore, the heading of this column should probably be Soil Series, Land Types, and Subgroups.

P. 2-33, table 2.12, last column in table is called Range Site Class. Associating class here, as well as at many other locations in the EIS with Range Sites, is incorrect. Only the term Range Site should be used.

Page 4-3, table 4.1. This table lists Land Capability Sub-Classes VI_e, VII_e, VIII_e under dry cropland. We do not agree with this and suggest that the heading "Dry Cropland" be deleted from this table. Only Sub-Class IV_e is considered as potential dry cropland in table 4.2, Potential Yield Summary.

Thank you for the opportunity to review this EIS.

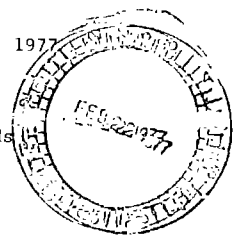
Sincerely,

Blaine O. Halliday
State Conservationist

cc: Council on Environmental Quality (5 copies)
722 Jackson Place, N.W., Washington, D.C. 20006
Attention: General Counsel
R. M. Davis, Administrator, SCS, Washington, D.C. 20250
Office of Coordinator of Environmental Quality Activities
Office of the Secretary, USDA, Washington, D.C. 20250

MATO
4605 Holly Street
Denver Colorado 80216
303 320 6615

February 18, 1977



Director
Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

In the course of our construction related business activities, we have become sensitive to the construction activities in the coal mining regions of Wyoming. Our most recent involvement with such a mill/mine complex was with the project known as Bear Creek in Converse County Wyoming.

Although we have sucessfully completed our portion of the construction work, we are still monitoring this project as well as others which are similar because of it's import and impact on our country's energy requirements.

The joint venture of Rocky Mountain Energy Company and Mono Power Company has now completed the intital stages of their mill/mine activities. It is our understanding that the Environmental Impact Statement for this project is now before your agency for review.

During this review period, we ask that your agencies give consideration to the expedicious approval for this project and allow it to proceed. We also take this opportunity to ask your agencies to work toward establishing procedures that will enable your agency to work with others involved to increase the efficencies of EIS statement evaluation.

Our country's critical need for energy of all types is becoming more apparent every day. The solutions to our energy problems are complex and the responsibility is upon all Americans to do their part. We therefore respecfully ask you to endorse programs for responsible energy development, keeping in mind that time is of the essence.

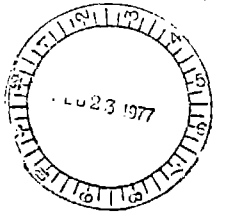
Very truly yours,

MATO, INC.

Pete Owens
Sales

PO/lf

GREEN CONSTRUCTION COMPANY



February 17, 1977

Director
Division of Fuel Cycle and Material Safety
Office of Nuclear Material and Safeguard
U. A. Nuclear Regulatory Commission
Washington, D.C. 20055

Gentlemen:

Draft Environmental Statement
Bear Creek Project

The Bear Creek Project falls within the framework of a number of industrial business and governmental interests in the Powder River Basin of Wyoming. This area has a history of intensive site specific and regional planning efforts primarily related to coal development. The Draft Environmental Statement (DES) is an excellent example of the continuing comprehensive planning for the region. As such, the preparation of this DES and its dissemination, together with the public discussion surrounding the environmental analysis of the Bear Creek Project, undoubtedly constitutes a major mitigation force for the project. The early planning and interagency coordination and cooperation has provided the opportunity to incorporate specific mitigation measures for anticipated environmental impact, for the mine construction and operation plan. This has obviously been accomplished in great detail and presented in a lucid and effective manner.

One major area of long-standing concern to industry and government has been perceived adverse socioeconomic impacts related to industrial development and induced population influx into low density areas such as Converse County. The DES has clearly addressed these concerns through in depth documentation of the community services needs and by stating "most of the social impacts are mitigable by active leadership by all the parties at interest to development" (Pages 6 through 8).

A concerted effort among citizens, governmental and industrial leaders to implement the Bear Creek Project and the described socioeconomic mitigation measures can be effective if continued throughout the life of the project.

2015 GRAND AVENUE • DES MOINES IOWA 50312, U.S.A. • 515/244-7251
CABLE ADDRESS GREENCO • TELEX 478463

Using the projected rates of uranium exploration and development requirements provided by agencies of the U.S. Government, the production capability of the nation must be increased to meet uranium fuel requirements for 1985 (see Section 10.6 and Appendix H). This requires accelerated exploration and mine mill facilities development in the near future. Therefore, we recommend that the DES be accepted and processed on schedule. We believe it meets the requirements of the National Environmental Policy Act, and we believe further that the mining and reclamation plan is well conceived and should be approved as submitted.

Green Construction Company appreciates this opportunity to comment on the DES for the proposed plan for mining and milling uranium ore at the Bear Creek Project in Converse County, Wyoming.

Very truly yours,

GREEN CONSTRUCTION COMPANY

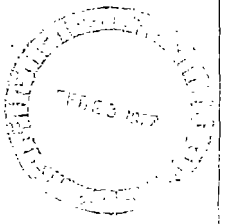
J. A. Judge
Vice President, Construction

JAJ/sr

McKee
WKE
ENGINEERS AND CONSTRUCTORS

TWX 510-374-2855, TLX 34-9358 RCA 278311 CABLE ARECO

February 15, 1977



Director
Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Wasnington, D.C. 2055

Reference: Docket No. 40-8452
Draft Environmental Statement,
Bear Creek Project of Rocky
Mountain Energy Company

Dear Sir:

Comments have been requested from various agencies and interested parties on the subject environmental statement and I am pleased to submit herewith the views of the Arthur G. McKee and Company, a leading engineering design and construction company based in Cleveland, Ohio. We are currently constructing the ore processing mill for the Bear Creek Project.

1. The entire environmental statement has been reviewed by our staff, with particular attention to those sections concerned with the stripping, mining, processing of the ore and impoundment of the tailings therefrom, which functions in the Bear Creek Project are well understood by McKee.

2. The quality and completeness of the study is most impressive and reflects well on the experts from the U.S. Forest Service, the U.S. Geological Survey and the U.S. Nuclear Regulatory Commission, who performed the studies and analyses and prepared the report.

3. A review of the contents of the statement shows that there are 12 major divisions, 15 appendixes and 49 maps and figures, all related to the proposed Bear Creek Project in matters concerning the environment. Certainly, the data are most complete and should suffice to answer all practical and reasonable questions regarding the effect of the project on the environment. The extensive references in each major division testify to the thoroughness of the studies.

ARTHUR G. McKEE & COMPANY · WKE DIVISION · 2855 CAMPUS DRIVE, SAN MATEO, CALIF. 94403 · PHONE 415 573-3372

McKee
WKE
ENGINEERS AND CONSTRUCTORS

4. The authors are to be commended for the condensed Summary and Conclusions and it is gratifying to note that the position of the agencies is to issue a source material license to the applicant, subject to certain minor provisions. In view of the serious energy shortage facing the U.S. and the high unemployment rate, the need for uranium demands that we utilize the resource at Bear Creek and take advantage of the employment and economic benefits to the region and nation. Those benefits should greatly outweigh any socioeconomic stress that may be associated with the project.

5. The Rocky Mountain Energy Company enjoys a good corporate reputation, is well staffed and financed and can be relied upon to carry out the mining and processing plans which are so completely explained and detailed in the statement. One is impressed by guarantees offered by RMEC in the form of the $2,200,000 bond, pledged to assure completion of the tailings stabilization plan (Appendix J).

6. In assessing the statement, it must be remembered by the various agencies involved that ore deposits of any kind are a rarity in the earth's crust, and must be utilized for the national benefit, even if there are some adverse effects on the local environment.

7. In reference to the "five criteria" described in Section 1.6, the statement recognizes that:

   a. every ore deposit is an individual one and that some deposits cannot stand significant economic penalties imposed by unrealistic regulations and,

   b. a deferral of licensing actions could result in substantial harm to the public interest because of the uranium fuel requirements of our existing reactors and reactors now under construction. The U.S. simply must decrease its reliance on imported energy fuels and conserve our domestic petroleum reserves.

We fully support the view expressed by the agencies in Item 5, namely "Such a shortfall of electrical energy is generally construed to be harmful to the public interest". This is underscored by the recent energy crisis in the mid-west due to the winter cold wave.

8. Referring to Appendix I and the major Forest Service surface management responsibilities with respect to the Bear Creek Project, various alternatives were considered including one which requires complete backfill of all mined pits. We support the present Forest Service attitude which approves of the RMEC mining plans and rejects the requirement for complete backfilling. If complete backfilling of all open pit mines were forced upon the U.S. mining industry, most operations would become uneconomic and paralysis of our raw materials industries would result.

9. We respectfully suggest that in the interest of reducing the volume of data in the statement, Appendix K, Detailed Radiological Assessment, could be deleted because of its highly specialized nature. A reference to such data and a summarizing statement by a recognized expert should suffice.

10. In regard to Item 3-C under Summary and Conclusion, the first sentence states, "There will be no discharge of liquid or solid effluents from the mill". Technically, this statement could be questioned because the mill tailings definitely are a slurry of solids in liquids and are discharged to the tailings pond. Perhaps the authors could clarify this item. The intent, we believe, was to include the tailings pond with the mill, and the sentence referenced might better refer to the tailings impoundment area than the mill.

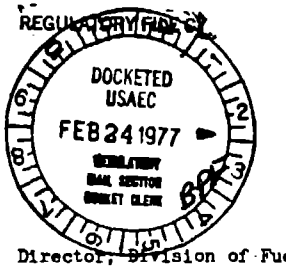
Summarizing, on the basis of the extensive experience of Arthur G. McKee & Co. in the field of uranium mining and milling, the draft environmental statement for the Bear Creek Project represents a thorough, impartial investigation into the principal effects the project will have on the site, the region and the nation. We agree with the proposed position of the agencies and urge that a source material license be issued without delay to the Rocky Mountain Energy Company for the Bear Creek Project.

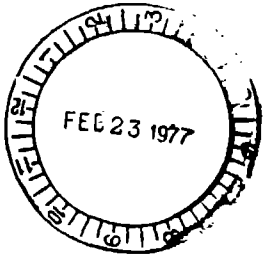
Respectfully submitted,

ARTHUR G. McKEE & COMPANY
Western Knapp Engineering Division

R. J. Verner
Sr. Vice President and
General Manager

THOMAS C. WOODWARD, PH.D.
GEOLOGIST
828 TOWNSEND BUILDING
CASPER, WYOMING 82601
OFFICE PHONE: (307) 234-4262
HOME PHONE: (307) 237-7130





February 18, 1977

Director, Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Comment, NUREG-0129
Bear Creek Project
Rocky Mountain Energy Company
Converse County, Wyoming

Dear Sir:

I wish to comment on the above draft environmental statement concerning the protection of the environment at the Bear Creek Uranium Project in Converse County, Wyoming proposed by Rocky Mountain Energy Company.

My main concern is the protection of the minerals other than the uranium in the area of the Bear Creek mining project. Damage will be done to other minerals, particularly coal, by the proposed uranium mining operation. Coal is present at the site of Pit B-1 and recovering that coal will increase the value of the land. The result will be a greater return of value in terms of the royalty income to the Federal government and ultimately to the taxpayers of the United States.

The draft environmental statement in Paragraph 2.5.2.3. titled "Coal" states that coal deposits have been discovered in Sections 10 and 15, T. 38 N., R. 73 W. The coal is in the Wasatch formation and in Section 15 underlies the following area: $SE\frac{1}{4}$, $W\frac{1}{2}SE\frac{1}{4}$, $S\frac{1}{2}NW\frac{1}{4}$. This is the site of Pit B-1 and associated facilities. The coal ranges in thickness from two feet to almost three feet and lies at depths from zero (or outcrop) to around 80 feet. Within the area of the proposed uranium mining operation as much as 160 acres of this coal will be either lost by placement of overburden dumps or destroyed by strip mining, i.e. removal of overburden material to reach the uranium deposit. The estimated amount of coal reserves destroyed in this manner is approximately 0.6 to 0.7 million tons.

The coal rights to all of this coal are owned by the Federal government, and in planning the overburden removal, the Federal government has the power to save this coal by requiring that it be strip-mined and recovered. Once it is recovered, it can be sold to local markets either for electric power generation or for space heating.

The value of this shallow coal deposit must be considered. Coal in this part of the Powder River Basin sells in the market at a price of around $5.00 per ton, in which case the coal in this deposit under Section 15 is worth between $3,000,000 and $3,500,000. Under the Federal coal leasing regulations, the royalty to be paid to the Federal government is $12\frac{1}{2}\%$ of the F.O.B. mine price of the coal. Therefore the value of this coal deposit in terms of the Federal government's royalty is between $375,000 and $437,500.

The draft environmental statement in Paragraph 9.4 titled "Mineral Resources" states: "Other than the uranium that will be mined, no irreversible or irretrievable commitment of mineral resources is anticipated." This statement is not true. If this uranium mine goes forward as planned, as much as 160 acres of coal deposits will be destroyed, and the Federal government will lose valuable royalty income.

As part of the total environmental considerations, these coal values should be protected.

Very truly yours,

Thomas C. Woodward

Thomas C. Woodward

TCW/llw

RICHARD T. HORNBUCKLE
HORNBUCKLE RANCH
ROUTE 3
DOUGLAS, WYOMING 82633

February 19, 1977

DIRECTOR
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
U. S. NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555



RE: ROCKY MOUNTAIN ENERGY COMPANY
BEAR CREEK PROJECT
CONVERSE COUNTY, WYOMING

I am a livestock rancher upon whose land a portion of the Bear Creek Project is located.

I have devoted all of my life to being the second generation operator except for some university education in Geology and a successful ten year Uranium mining operation, known as B & H Mines, Inc. This exploration drilling and mining experience which evolved on and near my ranch, gave me some awareness of the ground water tables in this area. The thousands of old unpluged holes can possibly have affected the ground water.

The agriculture industry in this area is facing a change caused by energy development somewhat reminiscent of that caused the Indians by the Agriculture Industry years ago. This present dile could have been less painfull if the homestead laws would have alocated the minerals with the surface.

I believe that my livestock operation along with others in the area willnot suffer execessively from the Bear Creek Operation if these two major concerns are studied and regulated.

#1- The ground water tables in this area need study and possible supervision.

The artesion aquifers unique to this area are the most valuable asset the farmers and ranchers have. They require no pumps,heaters or maintenance and consist mostly of a good potable water. Some of these aquifers appear to be rather delicate as to pressure and recharge.It is quite possible that an execessive amount of water drawn from these sands would deplete the pressure and volume of these flowing wells for some distance. This could be caused by the wells for milling, dewatering and water pumped from the pits of the Bear Creek Operation. This problem could be compounded by similar operations in this by water wells for oil development and possible future coal development . The mixing of water tables from different levels could mix any unpotable water with good water. It is quite obvious that grazing land in this area is worthless without wells; as stock ponds are two often dry.

There is not enough information on the ground water tables in this area to alleviate my concern on this matter. The State Engineer Dept. should be consulted of this problem.

#2- Heavy traffic and concentration of workers in the immediate area will cause problems of trespassers on the nearby ranch properties and danger to livestock on the main road to the Bear Creek Operation which crosses open grazing range. This problem can probably be alleviated by a co-operative security and policing program between Rocky Mountain Energy, the local law enforcement and the ranchers.

I have had a good relationship with Rocky Mountain Energy and found them to be co-operative with the ranchers problems.I feel they should be given their license to continue with their operation with a recommendation to give strict attention to the ground water situation in this area.

I would hope to realize an advantage from the Bear Creek Operation in the future,by aquiring water which will probably be taken frombeneath my land; to supplement the Hornbuckle #1 through #5 irrigation project on the Dry Fork, which seems to be omitted in the enviromental statement.

SINCERLY

Richard T. Hornbuckle

C.C.
W.G. Van Bebber
Rocky Mountain Energy Co.
Lakeside National Bank BLDG.
4707 Harlan St.
Denver, Colorado 80212

A rancners view point of damages to a livestock operation which may be caused by Energy Development.

A large percentage of livestock operations are on land under which the operator does not own the minerals. The livestock operator is unable to receive any compensation from the minerals for damages and added expense while mineral exploration and development is being conducted.

1. Loss of forage for the livestock.
2. Possible damage to water for livestock,either through surface ponds and streams or water tables in wells. Many companies do not properly plug different sands in drill holes,endangering all wells in the area.
3. Damages to fences controlling livestock. Anytime a fence is taken down and put up again the wires are loosened for a great distance. Wire gates wear out from excessive use due to metal fatigue. Auto gates become full of dirt dropping from vehicles.
4. Nuisance Value- This one gets to us the most and actually cost the most.
   A. Requires the livestock operator to use increased labor patrolling livestock water and checking for gates left open as breeding or mixing of livestock at the wrong time of year can be disastrous.
   B. Any access road opened to traffic and activity tends to attract unauthorized visitors who are not affilated with the company operating in the area. these trespassers can use the company activity as a cover for questionable purposes.
   C. Any activity around new born lambs in the pastures tends to orphan them,resulting in a death loss. Traffic and activity in any area with range livestock tends to keep the livestock nervous and disrupts their natural habits. Most livestock are trained to come to a vehicle for their feed during the winter and spring months. These same livestock will also follow energy development vehicles, disrupting their normal feeding and water programs.
   D. No company can completely control the actions of its employees and there are few who have little regard for personal property of others; such as littering, discharging fire arms and injuring or killing livestock on roads or range trails.
   E. Some company employees tend to want to tour the livestock operators property on their time off either with or without permission hauling away souviniers, such as petrified wood, Indian artifacts, and items of historical value.
   F. Damage to existing trails,and roads. Heavy trucks tend to erode and depress range trails which makes them rough and impassable at the expense of the ranchers light equipment. The livestock operator has an expense of maintaining these trails and roads.
   G. Extreme danger of men and equipment causing prairie fires at certain times of the year.These can destroy hundreds or thousands of acres of grass and forage besides improvements.
   H. The accidental spilling of injurious substances and materials to livestock which could result in their sickness or death. leaving the livestock operator a costly problem of finding the reason and care of their ailment.
   I. The livestock operator has to spend a great deal of his time and travel keeping informed of the energy Companys operations and plans which may affect his operation and land. The operator usually has to travel to distant cities to negotiate with the energy company to protect his interest. This added chore may require hiring additional labor to perform his regular work.
   J. Last but not least, is the worry and concern by the livestock operator over what may be happening in the area a company is working and its effect on his operation. Due to the distance required in a livestock operation, the ranch personnel are unable to keep abreast of these activities.
   There is always the threat of condemnation proceedings for right of ways for roads, railroads, power lines, pipe lines etc: eben though the energy operation may not be on or near the livestock operation.
   The worry that his livestock operation, life style, and even the life style of the community will have to undergo drastic changes.

Rick T. Hornbuckle

Advisory Council on
Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005

February 18, 1977

Mr. L. C. Rouse, Chief
Fuel Processing and
Fabrication Branch
Division of Fuel Cycle
and Material Safety
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Rouse:

This is in response to your request of January 10, 1977 for comments on the environmental statement for the Bear Creek Project, Converse County, Wyoming. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969, the Advisory Council on Historic Preservation has determined that your draft environmental statement appears adequate regarding our area of expertise and we have no further comment to make.

Sincerely yours,

Louis S. Wall
Assistant Director, Office
of Review and Compliance

The Council is an independent unit of the Executive Branch of the Federal Government charged by the Act of October 15, 1966 to advise the President and Congress in the field of Historic Preservation.

AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250
OFFICE OF ADMINISTRATOR

February 22, 1977

Mr. L. C. Rouse
Division of Fuel Cycle and
Material Safety
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rouse:

This is in response to your letter of January 10, 1977, to [illegible] Carlson requesting comments on the draft environmental statement related to the operation of the Bear Creek Project.

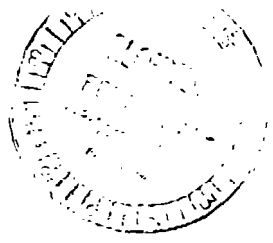
Ranching is the major land use in the Bear Creek area and involves both sheep and cattle production. Cropland is limited to irrigated land which depends on surface runoff from the Bear Creek drainage. During the period of the project the National, State, and private lands affected by the mining operations should not exceed more than 3,200 acres. Much of this land area will be reclaimed. Grassland occupies 36.8 percent of the project, meadow 3.5 percent, and sagebrush the remaining 59.7 percent. With proper management, any losses associated with the reduction in rangeland could be offset by the increased productivity of the cropland resulting from topographic changes.

The impact on groundwater has been considered but the time required for a new equilibrium to be reached has not been estimated. Changes in the water transmission properties of the disturbed areas have been alluded to, but quantitative information is apparently lacking. The low rainfall of 12 inches and the moderate evapotranspiration of 40 inches suggest that the response time of the groundwater system could be several years. Nevertheless, the rangelands are probably primarily dependent on annual rainfall for their establishment and productivity and the 2 to 3-year estimate seems reasonable. The problem of revegetation under such low rainfall has presumably been considered though specifics on the special requirements are lacking. The possibility of serious wind erosion prior to revegetation should be considered.

We appreciate having the opportunity to review this statement.

Sincerely,

H. L. Barrows
Deputy Assistant Administrator



Hardy Ranch Co.
Route 3
Douglas, Wyo.

February 20,1977

Mr. John Kendig
Division of Fuel Cycle and Material Safety
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Bear Creek Uranion Project
Rocky Mountain Energy Co.
Docket No. 40-8452

Dear Mr. Kendig:

On three different occasions you have heard my oral testimony in regard to the Bear Creek Project of R.M.E.C.

I still feel it necessary to offer written comments pertaining to my concerns about the overall aspects of said project.

First I wish to clearly state my position that I am aware of the need for energy developement and am not attempting to delay or interefere with the developement of the project as long as said developement is conducted in such a manner as to minimize or alleviate conflict with my ranching operation which encompasses over 2000 acres of the Bear Creek Project.

I feel that Agriculture,like energy, is a necessary and critical commodity to the United States and as such must also be given adequate consideration to ensure a continued supply of food and fiber for the public.

I intend here to address only briefly any comment as to social or economic impact relating to either County or Municipal governments. Other people are better versed in addressing these problems, so consequently my comments will relate more directly to the immediate physical impact upon the ranching community surrounding the project area.

My primary concerns could be briefly itemized as follows:

1. Disruption of normal livestock useage of land, forage and water.

2. Possible permanent loss of ground water because of damage to continuity of aquafers and associated dewatering operations of mine pits.

3.Litter and garbage of all types.

4. Ambient dust pollution of available forage caused by traffic and stripping.

5. Change in the community life style brought about by the influx of a labor force comprised to a sizeable degree by people who historically come from an unstable, uncaring and undesirable catigory of individuals.

6. Loss of recreational useage, basically hunting.

7. Damage to wildlife habitat.

8. Adverse stress factors imposed upon agricultural operators when attempting to continue their normal life style after their operation has become intermingled with, disrupted by, and generally harrassed by the project and its' infinite multitude of decisions, phone calls, time consuming meetings and other factors all associated with the landowner.

I have not necessarily listed these concerns in any order of importance but would feel that loss of ground water, land and forage use would have to head the list.

The productivity of a ranch operation, and consequently its' profit, is dependent not only on the grass available for livestock grazing but by the availability of livestock water within close proximity of the grass and the suitability of the terrain for shelter in the event of winter storms. All these factors are determinants which dictate the useage of any given piece of range land. Often the loss of use of a pasture has a more far reaching effect on the overall ranch operation than would at first seem apparent, since it necessitates a complete revamping of all the seasonal and rotational use of remaining lands.

It is an admitted fact by R.M.E.C. that mine dewatering will beyond any doubt have some temporary detrimental effect on ground water in the immediate area. Wells in the breached aquafers will be at least temporarily destroyed. I have proof at this time that one artesion well located two miles diatant from the Bear Creek Mill was depleted within two weeks after R.M.E.C. began pumping from their mill supply well in June of 1976.

While I have written assurances from R.M.E.C. that they will replace any source of water which they destroy, the fact still remains that it could be a physical impossibility to

adequately or economically restore damaged wells.

The litter and garbage generated by an operation of this nature is an ever present, ugly eyesore which I find to be excessively repulsive since I have spent my life time enjoying the simple beauty of the Wyoming range land. It is all the more revolting to me because the root of the problem lies with the labor force who cause it because of their "don't give a damn" attitude. Wyoming would be eternally blessed if these people could live and throw their beer cans somewhere else. There is little value in commenting further on the undesireable element of people within the labor force. I will only observe however that ranchers will see increased pilfering, livestock rustling, game poaching and general trespassing. The towns will experience a corresponding increase in all types of crime.

Dust is controllable if R.M.E.C. will live up to the provisions of their mining permit and I have found from past experience with them that frequent monitoring must be provided to accomplish this goal.

The population influx will create additional pressures for recreational usage of land. The increased demand for hunting coupled with a reduction of game habitat and more game poaching will prove to be a complex problem not only for the State Game and Fish Commission but for ranchers who directly provide the game and available land upon which to hunt. There will be an adverse effect upon all sportsmen, both in State and on a national level, since many of them travel from all over the U.S. to hunt Wyoming antelope.

In looking toward the future and ultimate termination of any mining project we are led to believe that the land will eventually be returned to productivity as good as or possibly better than its' original state. This potential would exist if we can be assured that reclamation is not only adequate but possible. There are too many variables of nature that reclamation practices will always be productive. I wish to stress at this point that if the availability of large amounts of ground water does occur in mining pits upon the termination of the operation or better yet, during the interim time of the mine reclamation, then I feel that a concerted effort should be directed toward beneficial use of this water in the reclamation process by R.M.E.C., State of Wyo., effected ranchers and all Federal Agencies which are involved.

There has been some input into the reclamation plan of the B-1 pit by the U.S. Forest Service which would tend to indicate a higher priority would be placed on esethic values and recreational accessibility to lakes than might

be placed on productive use of the water. I feel ~~costs~~ increased costs should be considered when proposing the moving of several million cubic yards of overburden in order to achieve a 3:1 slope and weigh this advantage against the possibility of productivity on the reclaimed land through the use of irrigation practices etc.

I sincerely thank you for your time and hope that in some way my comments may be helpful in the final formulation of a workable mining plan.

Very truly yours,

G. Eugene Hardy, President
Hardy Hardy Ranch Co.

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Wyoming Department of Agriculture

TELEPHONE: (307) 777-7321 CHEYENNE, WYOMING 82002

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COLLEGE OF AGRICULTURE
UNIVERSITY OF WYOMING, LARAMIE

RECEIVED
MAR 2 1977

February 22, 1977

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attn: Director, Division of Fuel Cycle and Material Safety

Dear Sir:

We appreciate the opportunity to comment on the Bear Creek Project.

Overall, it is a well-prepared document. Anytime that agriculture has to give for other industries it cuts down the production of food and fiber. A balance between the needs of industry and agriculture must be equalized. A recovery of the grazing lands by reclamation after the mining, with water storage left intact, would meet with our concurrence. Attached are the comments of Dan Hartley, Ag Economist with the Department of Agriculture, for your perusal.

It would appear that the man-years spent preparing E.I.S.'s is getting absurd. When, in reality, the company should be making the deals with the landowner and both would benefit dollar-wise.

Sincerely,

Don Daiss

Don Daiss, Assistant Commissioner
Wyoming Department of Agriculture

DDjh (gf)

cc: Commissioner Bourret
State Planning Coordinator

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Wyoming Department of Agriculture

TELEPHONE. (307) 777-7321 CHEYENNE. WYOMING 82002

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COLLEGE OF AGRICULTURE
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February 22, 1977

M E M O R A N D U M

TO: Donald I. Daiss, Assistant Commissioner of Agriculture

FROM: Daniel R. Hartley, Ag Economist, Division of Ag Planning and Development Daniel R. Hartley

SUBJECT: EIS, BEAR CREEK PROJECT

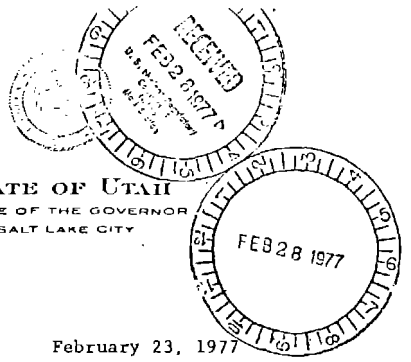
I have reviewed the draft copy of the Environmental Statement for the Bear Creek Project. The draft copy is well written and put together. Most of the technical data used for support is left in the appendix for the reader to reference.

Agriculture will be effected only on an individual basis within the area. Approximately 800 AUM's of livestock grazing will be effected. Meadow hay and small grain production will be effected along the Bear Creek Drainage.

I would suggest the Rocky Mountain Energy Company contact each individual rancher involved near the mine and milling operation. By a personal contact, questions could be answered by the individual rancher and later problems may be avoided. The ranchers may want to seek compensation due to loss of income and change in operations due to mining and milling operations. By a personal contact, a better relationship can be established between the ranchers and mining company.

DH/mn/dj

"AGRICULTURE—the backbone of Wyoming"



SCOTT M. MATHESON
GOVERNOR

STATE OF UTAH
OFFICE OF THE GOVERNOR
SALT LAKE CITY

February 23, 1977

Mr. Leland C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rouse:

On behalf of Governor Matheson, the enclosed response on the draft environmental impact statement for the Bear Creek Project, Rockey Mountain Energy Company, Converse County, Wyoming, is submitted to your agency.

These comments have been developed in consultation with the Utah Division of Oil, Gas and Mining, reviewed at the department level and endorsed by the Governor. I hope they will recieve your prompt and serious consideration, and that they are helpful in your work on this project.

We appreciate the opportunity to comment. If I can be of further help, please let me know.

Sincerely,

Kent Briggs
Administrative Assistant for
State/Federal Affairs

KB:JJ

Enclosure
cc: Milo Barney
Janet Jenson

Scott M. Matheson
Governor

GORDON E. HARMSTON
Executive Director,
NATURAL RESOURCES

CLEON B. FEIGHT
Director

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS, AND MINING
1588 West North Temple
Salt Lake City, Utah 84116
(801) 533-5771

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February 18, 1977

Mr. Leland C. Rouse, Chief Fuel
Processing & Fabircation Branch
Division of Fuel Cycle and
Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: D.E.I.S. Bear Creek Project

Dear Mr. Rouse:

We have reviewed the Enyironmental Statement for the Bear Creek Project and do not wish to address any comments specifically to this operation. We are concerned that the design and reclamation standards described in this report may be incorporated as nationally applied standards by the NRC. Of particular concern to us are the siting and reclamation of the tailings facility.

Locating a tailings pond in a natural drainage depression is a common practice and often the most economical alternative. However, each proposed tailings facility must be judged on it's own merits both structurally and economically. Where locating the tailings pond in a drainage would involve costly dam design, seepage control and upstream drainage diversions, other alternatives such as side-hill or isolated, heaped designs should be acceptable.

The reclamation plan of a tailings pond should be tailored to the past and future use of the land and the cost benefit considerations related to the future land use. In the case of the Bear Creek Project, it is obvious that the objective of reclamation is to provide for future grazing use. This use indicated a relatively low unit land value yet the reclamation plan calls for a very high unit area expenditure. A stabilization plan that provides for decreasing the direct gamma radiation rate to well below background and the radon emanation rate by 99% to twice the background levels may be justified in an area of high resident human population, but to do this in an unpopulated, low value area, seems uncalled for.

It is our belief that in remote areas with low unit land values the reclamation of uranium mill tailings should primarily provide for the mechanical stability of the deposit and the physical containment of the water and air mobile particles. To cover the facility with enough overburden and soil to prevent water and wind erosion should be the prime consideration. Also, seepage control measures should be designed in accordance with the relative hazards posed by seepage at each site.

We do not view the reclamation measures as outlined in the E.I.S. as comprising a permanent tailings impoundment facility. At this point, the ultimate disposition of uranium tailings is unknown to those in the waste disposal field. The specifications as outlined in this plan seem to direct operators to go to great length and expense to achieve the same temporary impoundment standards as previously achieved under other plans.

Thank you for allowing us the oppurtunity to comment on this document.

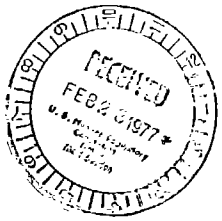
Respectfully,

DIVISION OF OIL, GAS, AND MINING

Brian W. Buck

BRIAN W. BUCK
ENGINEERING GEOLOGIST

600-1 North Fifth Street
Douglas, Wyoming 82633



February 23, 1977

Mr. John Kendig
Division of Fuel Cycle, and Material Safety
Office of Nuclear Materials, Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Reference:
Bear Creek Project
Rocky Mountain Energy Company
Draft Environmental Statement
Docket No. 40-8452

Dear Sir:

As a result of attending the public meeting on subject project in Casper, Wyoming on February 9, 1977, and because of my interest in this project as an employee of one company involved in the site development, I submit the following comment:

Persunal observation of the project over an eight month period shows no serious opposition to the work from landowners or citizens of the area. The Owner (Rocky Mountain Energy Company) and the area ranchers have achieved a reasonable harmony in this venture as expressed at this NRC public meeting and at other meetings between the parties.

It is quite disturbing then to find a federal agency, the United States Forest Service, proposing alternative grading schemes for reclamation when, in fact, none of the alternatives are as desirable to the area landowners or to Rocky Mountain Energy Company as the plan set forth by Rocky Mountain Energy Company.

It appears that the United States Forest Service did not seek out the opinions of the people locally involved and as a matter of fact, has been reluctant to talk with involved parties. This appears to be another example of a federal government uncontrolled by the people and unresponsive to local needs.

Following is a review of some facts stated during the discussions at the Casper Public Meeting:

1. Alternative reclamation plans for excavating 3:1 pit slopes are not feasible because of the costs involved which would result in higher fuel bills. To slope the B-1 Pit would require nine million cubic yards of grading at a cost of ten million dollars, resulting in a net gain of only ten reclaimed acres. Disposal of additional overburden is proposed on private land, and the land-owner involved is opposed to any such alternative. The Forest Service is proposing a plan opposed by the local land-owner. This is totally unresponsive to local data input. Moreover, the higher costs cannot be reasonably justified.

2. Alternative reclamation plans which would backfill the ponds proposed in Alternate "A" are not acceptable to local landowners because of their great concern with maintaining groundwater continuity. It is also very desirable to local interests to leave stock water ponds after reclamation. Complete backfill of the pits would eliminate stockwater ponds and interrupt groundwater flows and as a result water would be lost to beneficial use subsequent to mining. Any gain in reclaimed acreage cannot justify the loss of usable water in this dry region.

United States Forest Service offers reasons of aesthetics and recreational gains for proposing alternatives which are not consistant with the goals and values of local ranchers and citizens and are certainly not justified against the loss of valuable beneficial water and the additional costs involved.

For the important reasons detailed here, it is extremely disturbing to a local citizen to find the United States Forest Service acting in a manner uncooperative with other federal agencies and unresponsive to local needs and values. This is uncontrolled bureaucracy working against the citizen rather than for him, and it cannot be allowed to interfere with local goals. It would be most distressing if the Forest Service were allowed to delay this project.

Very truly yours,

David F. Harrald

DFH/gar

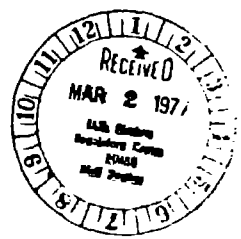
XC: Representative Teno Roncalio
Senator Malcolm Wallop

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VIII
1860 LINCOLN STREET
DENVER, COLORADO 80203

REF: 8AH-WM

FEB 28 1977



L. C. Rouse, Chief
Fuel Processing and
Fabrication Branch
Division of Fuel Cycle and
Material Safety
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rouse:

We have completed reviewing your agency's recently-issued Draft Environmental Statement (DES) on the Bear Creek Project (NUREG-0129).

In general, there are no major problems with this document. We have found it to be a well-researched and well-prepared DES. The planned long-term stabilization of the mill's residual sand tailings appears to represent a major change in the "state-of-the-art" methodology now being used by the uranium milling industry. As you may be aware, EPA Region VIII has had the opportunity to work with the Rocky Mountain Energy Company on their pre-DES environmental reports. This effort apparently has avoided any major conceptual differences over environmental factors between the company and the EPA Regional Office.

In view of the U.S. Department of the Interior's (DOI) participation with the NRC in preparation of the DES, I would like to call your attention to the DOI, Bureau of Mines (BM), Report of Investigations 8099, "Radium Removal from Uranium Ore and Mill Tailings". The document makes the statement that:

> "Controlled containment of radium-bearing tailings would be a very expensive and probably an ultimately unsuccessful undertaking. Considering the 1,600-year half-life of radium, 10,000 years of controlled storage are necessary to reduce the radium in uranium tailings from 700 picocuries per gram to 20 picocuries

> "per gram through natural decay. Although controlled containment seems the only feasible method, it involves high costs of continuous monitoring, maintenance, and loss of property usage for thousands of years."

We did not find any reference to the above in the Bear Creek DES. In many respects, DOI in their BM Report has offered a challenge to regulatory agencies and industry on the question of radium-bearing tailings control. We feel this should be pursued in future environmental statements, particularly since related decisions could very well provide the basis for an "ultimate" disposal methodology that has been sought after for a number of years now.

The Bear Creek Project, with minor changes, should be environmentally acceptable. To optimize the Project's acceptability, we recommend changes in the reclamation plan and the environmental monitoring program. Additionally, there are a few errors and omissions or needs for additional information in the DES which are itemized in the enclosed detailed comments.

According to the procedures EPA has adopted to rate environmental statements, the DES for the Bear Creek Project will be listed in the Federal Register as Category ER-2. This means we have environmental reservations on the implementation of this proposal and do request certain project changes and additional information as outlined in our enclosed comments.

We will be glad to discuss these comments with you, at your convenience, if you need further clarification or desire additional guidance on how these can be effectively addressed in the final environmental statement.

Sincerely,

John A. Green
Regional Administrator

Enclosure

ENVIRONMENTAL PROTECTION AGENCY

COMMENTS ON

BEAR CREEK PROJECT DRAFT NUREG-0129

Page i, section c: The table presents concentrations and lung doses to individuals at the nearest ranch. However, the Carson ranch, which is in the prevailing wind direction, is estimated to have higher dose rates.

Page 1-5, 1st paragraph: An exemption was granted by NRC to allow site preparation and construction activities before issuance of the FES. What are the specifics of this exemption and with what conditions (if any) was it granted?

Page 1-5, section 1.6.1: This paragraph specifies that the Highland mill is 35 miles away. Page 2-3 and 2-38 estimates the distance to be 13 miles and 17 miles respectively. Since the major cost is due to transportation, this can be an important point in determining the economics of having two mills quite close together.

Page 1-6, Table 1.1: What was the basis for the "conditional" approval of the right-of-way (access) by the U.S. Forest Service in May 1976?

Page 2-14, sections 1.2, 1.3: Some wells in the Wasatch and Fort Union Formations are free-flowing. At what rates are these wells presently flowing?

Page 2-37, first paragraph: The statement, "Whole body dose from industrial operations is 25 mrem/yr in Bear Creek area, compared to U.S. average of 30 mrem/yr", seems unbelievably high, if it means dose to every member of the population. We don't find such figures in subject reference.

Page 2-38, Table 2.14: What is the meaning of sample type "SA", defined as "Surface Area"? Is this a typo--should it be "Surface Air"? Also, surface and tap water tritium sample results have no value for this application. This eliminates six of the 21 listed stations (thereby agreeing with the statement in the second paragraph, page 2-37, "Fifteen...stations...".)

Page 3-13, section 3.1.2.6: The DES states that radioactivity removed from the mine water will be transferred periodically to the tailings retention pond. How will this transfer be accomplished?

Page 3-16, section 3.1.3.1: We are not in agreement with that part of the reclamation plan for Pit B-1 which leaves the side highwalls in place; a residual "pit" some 200 feet in depth would remain--proposed as an impoundment to serve livestock, wildlife and irrigation needs. 30CFR211 and proposed National Coal Surface Mine and Reclamation Acts will not permit leaving such highwalls in the case of coal mining operations. In order to provide proper protection of the environment and to insure uniformity of environmental controls within the mining industry, we recommend that such side walls be cut to a lesser slope or that the pit be filled. An added justification for complete filling is, that at this point in time, no one knows the expected post-mining water quality of this and other proposed impoundments and if these impoundments will be suitable for the expected post-mining land use.

A reason given for not pushing backslope material into the pit to reduce the final remaining highwall is that the material would cover and seal the stagnant water. Is not the material backfilled into the north half of Pit B-1 creating this condition to some extent anyway and would not such backslope material become saturated on the edges of the pit and yield essentially the same amount of water to the impoundment compared to the situation where the highwalls remained?

Page 3-18, section 3.1.3.2: What is "topsoil"? Is it the original A horizon or some other material deemed suitable? If the latter, appropriate soils analysis data should be provided. The referenced Dames and Moore soils data should be included in the FES, together with the Applicant's plan for which soils are going to be used for the "suitable subsoils". The DES does not actually state that any of the original topsoil will be used at all.

Page 3-18, section 3.1.4: Chemical analyses of overburden samples in the B-1 area have shown minor problems relating to use of this material as a subsoil. What specific problems have been encountered? What has been the extent of the overburden sampling program (i.e., overburden cores per acre) and what specific mitigating measures (e.g., selective placement) will be utilized to handle deleterious strata?

Page 3-27, section 3.2.2: It is indicated that some organic solvent will be lost to the tailings pond. Has the applicant addressed the possibility of interference with the acid leach process as the result of the presence of solvent in the water recirculated from the tailings pond? (We may be raising an inconsequential

Page 3-27, section 3.2.2. (cont'd): issue; however, the basis for no effluent from the tailings pond is that there will be significant recirculation. If, for any reason, the quality of tailings pond water becomes unsuitable for use in the uranium extraction circuit, the tailings pond will have a continuous liquid effluent.)

Page 3-27, section 3.2.31: Particulate emissions will result from the combustion of fuel oil, as well as SO_2 and NO_2.

Page 3-29, section 3.3.1: The DES states that "prior to ground stripping and ore extraction, the mineralized zone is dewatered by pumping of wells near its perimeter". The mining description portion of the DES which discusses sumps in the pit should also mention such dewatering wells.

Page 3-29, section 3.3.1: The DES states that water extracted from the mineralized zone may contain more radium than 3.3 pCi/l and that the concentration of radium in several mining areas has been reported to exceed 100 pCi/l. What is the expected radium concentration in the ground waters of the mineralized zone in the Bear Creek Project area? This value may give some idea of the concentration of radium in pit B-1 if it is left as a pond.

Page 3-33, section 3.3.4: Apparently no attempt is planned to reduce resuspension of dust from the ore storage pad. It seems that windbreaks and/or sprinkling might significantly reduce this source of radioactive particulates. Furthermore, keeping the ore moist might also reduce the radon emanation slightly. Finally, reduced dust concentrations in this area should reduce occupational exposures to workers. A suitable sprinkler system should add relatively little initial or operational cost, and since the ore is to be wet ground (section 10.3) sprinkling should pose no process problems.

Page 3-33, section 3.3.6: It is not readily apparent how the source terms for the yellow cake drying and packaging operations were calculated. Using the parameters given in Table 3.5, we calculate annual releases of 26.5 mCi U-238, 1.3 mCi Th-230, and 26 μCi Ra-226. These are about 15 - 20 percent lower than the source terms given. The carryover percentage for radium as given in section 3.3.6 is 0.1 percent, but Table 3.5 implies 0.2 percent. Which is the best estimate?

Page 3-35, paragraph 6: Average annual emission from tailings is estimated to be 8000 Ci. We can reproduce this number using the total tailings area of 6.1×10^5 m^2 (Table 3.5), an assumed exhalation rate of 1 pCi $Rn/m^2/sec$ per pCi Ra/gm (from Appendix K.2) and the 420 pCi Ra/gm of ore. This is then reduced by 80 percent (to 1600 Ci) on the assumption that 80 percent of the tailings pile will be covered by water. This is contradictory to the statement in section 4.8.1 (page 4-13) that "the maximum rate of release of radon from the tailings surface is 6400 Ci per year". Is this latter statement in error? Is it a coincidence that 8000 - 1600 = 6400, or is there a mixup of numbers between these two pages?

Table 3.6 indicates that, in essence, all the radon generated by a year's supply of ore will be released to the atmosphere since the total annual source term, or radon is given as 9110 Ci (compared to 9200 Ci generated; see comment on Table 3.6, page 3.36). We cannot tell whether this is a coincidence or was deliberate. While this is a conservative approach, it appears (intuitively) to over-estimate the radon source term. Some fraction of the radon will be trapped and will decay (in pieces of ore during mining, transport, and milling, and in the tailings pile after milling) and therefore will not be available for release to the atmosphere. The source term from mining and milling should be relatively constant over the life of the project, assuming that ore grade and volume processed is reasonably constant. The source term from the tailings pile will increase as more material is added to the pile, perhaps reaching an equilibrium value before the end of the project.

Page 3-36, Table 3.6: Ore grinding is postulated to be the largest source term for radioactive particulates (except for uranium), although the method of calculation is not shown. Apparently no control measures for this source are planned. While wet grinding will reduce dust releases (as stated in section 10.3), it seems that it might be worthwhile to investigate control measures for this portion of the process, if this has not been done. Also, why is Po-210 not considered here or in Appendix K as a nuclide of interest?

Page 3-36, Table 3.6, and Appendix K-2: We have considerable difficulty correlating radon source term numbers between this table and various passages in the text and appendix, and in determining the origin/rationale for some of the numbers. The radon source term from mining operations is given in Table 3.6 as 7.4×10^3 curies/year. In section 3.3.2, this is supposedly estimated from reference

Page 3-36, Table 3.6, and Appendix K-2 (cont'd): 40 (Barretto, IAEA-PL-565/1) and from Appendix K. In Appendix K, this number is quoted as being estimated from GESMO, Vol. 3. We are unable to find or readily derive this number from either reference. The total radon generated annually in 3.3 x 10^5 tonnes of ore containing 420 pCi/gm is 9200 Ci; the 7400 Ci figure apparently is derived as (336/420) x 9200 = 7400 Ci. We do not understand this use of the figure of 336 pCi or Rn/gm of soil (ore?). It seems that the radon concentration retained in ore should be 420 x (1-0.20) (equilibrium concentration minus faction emanated) = 336 pCi of Rn/gram of ore. Therefore, the 7400 curies should be retained in the ore; for 20 percent emanating fraction, the radon released should be only 1800 curies (9200 - 7400). The 20 percent emanating power is the maximum given by Barretto for a variety of rocks and minerals. The following article in the same proceedings, by S. R. Austin, gives estimates of emanation factors for a variety of uranium ores, which should be more relevant to the present question. Samples from Turnercrest, Wyoming (which may be similar to the Bear Creek ore) have emanation factors from 14-50 percent, with a mean of 38 percent. Assuming 40 percent emanation, this would result in 252 pCi Rn retained per gram of ore, and would result in an estimated 3680 curies of radon released per year (9200 x 40 percent). Although many gross assumptions are involved in a calculation of this type, this seems to be a more defensible estimate than does the 7400 Ci estimate.

In section 3.3.4, the radon release from ore storage, mill feed, and grinding is stated to be 117 Ci/year. In Table 3.6, the radon source term for these operations is listed as 110 Ci/year; the difference is negligible but confusing. The 117 Ci/yr is apparently calculated as 85 percent (for 10 days' storage) of the secular equilibrium value multiplied by the equilibrium value of 139 Ci in 3.3 x 10^5 tonnes of ore at 420 pCi Ra/gram. Conceptually, we have some difficulty with this calculation. It seems that this radon has already been counted as being released at the mine. It seems that different types of calculations have been used for what appear to be similar situations at the mine and mill. For the mine, the total radon activity generated (per year) by the volume of ore processed per year, modified by an emanation fraction, is assumed to be released. For the mill situation, the equilibrium activity in the ore is modified by a percentage factor for an assumed storage time, and this is called the release quantity (with no mention of emanation fraction). This mixes a static, equilibrium concept with a dynamic, constant generation concept. The equilibrium radon activity (139 Ci) at any given time in the annual valume of ore processed is negligible compared to the total radon generated in a year (9200 Ci) by the radium in this amount of ore.

Page 3-37, section 3.4.3: No mention is made of the compacted clay cap as specified later in the report to be part of the six-foot cover.

Page 3-40, reference 43: This draft document is now in published form.

Page 4-1, Air Quality General Comments: The description of the air quality analysis is inadequate. The operational data and emission factors should have been presented as well as a description of the model and meteorological inputs to the model used to predict the air quality levels.

The air quality impact of the mining operations should have been modeled, not just the mill.

Since the air quality levels are predicted to increase from highest-measured 24-hour concentrations of 25 ug/m^3 to a predicted annual average at the north boundary of 70 ug/m^3, the statement that "the resulting impact upon the air quality will be minor" is absurd.

Depending on the legal definition of a federally-licensed facility, a permit to construct may have to be obtained from the Wyoming Department of Environmental Quality, as required by the Wyoming State Implementation Plan (SIP). In any case, all substantive requirements of the Wyoming SIP will have to be complied with.

Page 4-1, section 4.1.2: Annual average concentrations were predicted and given; however, no 24-hour averages were predicted. The discussion indicates that the maximum annual average concentration is expected to be 70 ug/m^3 at a distance of .15 km from the tailings piles and 9 ug/m^3 at a distance of .9 km away. The 24-hour concentrations of course would be expected to be much higher. We should then compare, if applicable, these concentrations to the Prevention Significant Deterioration (PSD) increments of 30 ug/m^3 (24-hour average) and 10 ug/m^3 (annual average). These apparent excessive concentrations place importance on how the Bear Creek complex fits into the State of Wyoming's SIP.

Page 4-5, section 4.3.1.1: The DES states that the amount of change has not been estimated for effects on the flow regimen with resultant

Page 4-5, section 4.3.1.1 (cont'd): changes in erosion and sedimentation down gradient of the mining operation. It seems that such analyses should be undertaken so that a proper assessment of off-site impacts may be made. The same comment can be made with respect to the effects of dewatering the mine on off-site ground water users. Expected drawdowns of ground water levels around the site at various distances should be given. Such information should be derived from aquifer test data collected from a pumping well in conjunction with nearby observation wells.

Page 4-5, section 4.3.1.1, third paragraph: It is implied that water will be taken directly from the mine for livestock use. Page 3-13 specifies that the mine water will be treated with barium chloride.

Page 4-5, section 4.3.1.2: The DES states that replaced overburden will be less permeable, after settling and compaction, than before disturbance due to increased heterogenicity of the aquifer. Is data available from other open-pit mine sites to substantiate this? The DES goes on to state that replaced overburden will be less stable, more reactive, and thus subject to leaching. Have any column or static leaching tests been run to estimate post-mining ground water quality? How will such changes in water quality affect local ground water users?

Page 4-6, section on Water Quality: The water quality is affected by the mining operation and will have to be treated with barium chloride as on page 3-13.

Page 4-10, last sentence: According to figure 4.7, the concentrations of radon approach the limits of 10 CFR 20. It is not clear whether this is from the tailings pile alone or includes the mine effluents. The FES should indicate whether the Figure 4.7 concentration includes the mine effluents or not.

Page 4-13, first full paragraph, fourth sentence: Was this maximum rate of release used in determining concentrations of radon off-site or the figures in Table 3.6 or both?

Page 4-13, fourth paragraph, next to last sentence: The concentrations of radon will not cease after termination of mill operations. There is also the likelihood of dissolved radionuclides reaching ground and surface waters and any impoundments.

Page 4-26, section 4.8.4: No mention is made of chemical contaminants such as nitrates, sulfates, selenium, and chlorides. This is a potential leaching problem as shown by an EPA study on Grants, New Mexico, ground water.

Page 5-1, section 5.1.1: The exposure of underground uranium miners should not be classified as an accident.

Page 5-1, section 5.1.1: The discussion of effects on uranium miners from the inhalation of radon daughter products appears vague and inconclusive. The references used are not up to date in terms of the most recent epidemiological findings on lung cancer among uranium miners and EPA Guidance on the matter. We suggest that the following references be used and reviewed by Rocky Mountain Energy Company to get a better understanding of the problem.

1. "Radon Daughters Exposure and Respiratory Cancer Quantitative and Temporal Effects", National Institute of Occupational Safety and Health, National Institute of Environmental Health Sciences, Joint Monograph No. 1, 1971.

2. "Radiation Protection Guidance for Federal Agencies", Federal Register, May 25, 1971 (36 FR 9480).

Page 5-1, section 5.1.1, second paragraph, third sentence: The exposure to the general public from radon was not found to be "negligible".

Page 5-5, sixth paragraph: The recent dike failure incident at the United Nuclear Homestake mill near Grants, New Mexico, could be included in this summary of dam failure or flooding.

Page 5-6, second full paragraph: The transport of tailings by wind and water erosion normally is not considered an accident. The long-term effects of nature may be prevented by proper interim treatment and final stabilization of the tailings pile. The figure of $33,000 should be $550,000 as presented in the Vitro Phase II Report as referenced.

Page 5-7, first sentence: Radium-226 is another is another isotope of concern. If the concentration of Th-230 is one third of the MPC, the concentration of radium-226 would be 30 pCi/l. The FES should include a consideration of the fate of Radium-226 in the environment following release from the tailings reservoir.

Page 6-1, section 6.1, Air Quality: Apparently, the only air monitoring being conducted during the pre-operational phase is for total airborne particulates at one location --

> "A high-volume air sampler has been installed near the proposed mill at a site selected under the auspices of the State of Wyoming Department of Environmental Quality (DEQ). The sampler is maintained and operated in conformity with the sampling schedule of the U.S. Environmental Protection Agency (EPA)."

Page 6-1, section 6.1, Air Quality (cont'd):

Recommended Changes:

1) The number of sampling stations should be expanded to provide adequate and meaningful coverage of the entire project area.

2) The radioactivity--gross and specific radionuclides (uranium, thorium-230, radium-226, and lead-210)--of airborne particulates should be determined monthly over the period of one calendar year, at least quarterly.

3) The ambient radon-222 concentration with regard to wind direction at time of sampling should be determined for the project area--prior to mining and milling activities--possibly monthly determinations at key locations to establish seasonal patterns. The stations scheduled for operation during the operational period should be collecting data--for comparative purposes--during the pre-operational phase. Particular attention should be given to EPA Air Quality Comments on Part 4 of the DES which are also relevant to air monitoring.

Page 6-4, section 6.3.3.1:

Surface Water: The dissolved gross alpha results for samples representative of the period, 1965-1969, are unusually high. These data are not comparable to the results for 1971 and 1972 (Table 6.3). An explanation should be provided--a change in analytical procedure or a change in the laboratory performing the analyses, etc. Unless the results for the period of 1965-1969 are supported by elevated concentrations of dissolved uranium, the gross alpha results for this early time period are probably in error on the high side.

During the pre-operational period, surface water samples (dissolved fraction) should be analyzed for specific radionuclides--uranium, thorium, radium-226, and lead-210--as well as gross alpha and beta radioactivity. Additional gross radioactivity analyses should be conducted on the suspended solids portion of each sample. Optimally, analyses should be conducted monthly for a period of one calendar year; quarterly thereafter. Minimally, the frequency should be quarterly.

Page 6-4, section 6.3.3.1 (cont'd):

Groundwater: Lead-210 should be added to the analytical protocol for groundwater samples (semi-annual analysis is adequate).

Considering the summary data for Well Site No. 2--Table 2.7--the uranium concentration of 7µg/l and the radium-226 concentration of 2.2 pCi/l do not account for the relatively high gross alpha concentration--30 pCi/l. Analytical error in the gross alpha determination is suspected. Data verification and additional sampling at this well site are necessary.

Bottom Sediment/Soil (Dry Drainage): Bottom sediment samples should be collected annually at each established surface water sampling station and from drainages which will receive treated mine dewatering effluents during the operational stage. Radiological analyses should include gross radioactivity and specific radionuclides--uranium, thorium, radium-226, and lead-210. Analyses should also be conducted for those inorganic constituents which may be of significance in the dewatering effluents--arsenic, molybdenum, selenium, etc.

(Suggested Addition)
Fish-Betty Reservoir: Since there is some potential for radiological quality impacts on this reservoir, a monitoring effort should be undertaken to determine the baseline radioactivity concentrations in the bone and edible tissue of the resident fish in this reservoir. A single sampling should be adequate for this purpose. Although gross radioactivity concentrations might be useful, the concentrations of specific radionuclides are of greatest interest and importance.

Page 6-2, section 6.3.1: With regard to ground water monitoring, it would be helpful if a list of parameters to be sampled were given. It would appear, based on the hydrological sampling site map on page 6-11, that a deep (i.e., ∿ 250-450 feet) ground water sampling well site is needed down gradient (i.e., NE) of the entire project area. The only well in the Northern ore body vicinity is 80 feet deep (#5).

11

Page 6-9, Table 6.4:

Item--Air, 6 "hi-vol" sampling stations

Comments:

1) There should be at least one station "upwind" of the site. Consideration should be given to an intermittent station (one weekly collection per month) at Betty Reservoir.

2) From the weekly filter samples, quarterly composite samples should be prepared for uranium, thorium-230, radium-226, and lead-210 analyses. Specific analyses should be conducted on each weekly filter sample showing unusually high gross radioactivity.

Item--Groundwater, several offsite wells (10) located generally downgradient from proposed mine

Comments:

1) The gamma scan is of no real value (except for a K-40 correction to gross β radioactivity).

2) Although not stated as such, we assume the analytical scheme for quarterly analyses is that specific radionuclide analyses will be undertaken if gross alpha exceeds 3 pCi/l or gross beta exceeds 10 pCi/l. Specific radionuclides to consider are uranium, radium-226, polonium-210, thorium-230, lead-210 and potassium-40 (natural beta emitter). The quarterly analysis is more than adequate; semi-annual would be satisfactory for offsite wells.

3) Chemical analyses should be conducted semi-annually.

4) Complete spectrum of specific radionuclide analysis should be performed annually.

Item--Groundwater, three wells around tailings area

Comments:

1) For comparative purposes, there should be a well site up-gradient of the tailings area.

12

Page 6-9, Table 6.4 (cont'd):

2) Monthly analysis should include gross < , gross β, uranium, and radium-226, as a minimum. It would also be desirable to conduct analyses for the critical chemical constituents (non-radioactive) on a monthly basis; also, total organics on a monthly basis. BOD analysis is unnecessary.

3) Quarterly analysis--lead-210 and thorium.

Item--Groundwater, well sites 6, 7, 8, and 11

Comments:

1) The location of those wells and other wells should be shown clearly on a schematic.

2) Quarterly analysis--gross <, gross β, uranium, radium-226, and chemical.

3) Semi-annually--lead-210 and thorium.

Item--Mine water (assumed to be treated effluent discharged to natural drainage)

Comments:

1) Monthly--Uranium, radium-226, and all significant chemical constituents (molybdenum, barium, arsenic, solenium, etc.). Analysis to be on a composite sample; daily grabs or continuous collection.
--pH to be measured daily
--suspended solids to be measured once per week

2) Quarterly--composite of monthly samples. Analysis to be for lead-210 and thorium.

3) The monitoring should be adequate to demonstrate the efficiency of the treatment process.

Item--Soils

Comments:

1) We seriously doubt that a network of five sites on the periphery of the project area is an adequate network. Eight sites based on an octagonal gradient system weighted to the downwind areas might be adequate.

Page 6-9, Table 6.4 (cont'd):

2) We see no need for gamma spectrometry analysis of such samples. Specific radionuclide analyses are sufficient.

Item--Biota

Comments:

1) The specific radionuclides of interest are those with the potential for environmental impacts as the result of mining and milling activities--uranium, thorium-230, radium-226, polonium-210, and lead-210. With the relatively low concentrations that are anticipated, the gamma scan lacks the sensitivity to identify radionuclides, thereby warranting quantitative identification.

Item--Surface waters

Comments:

1) The surface water sampling program established during the pre-operational period should be continued during operational period. For comparative purposes with the groundwater data, the radiological and chemical quality of impounded tailings water should be analyzed monthly during the first year of pond use; quarterly thereafter.

2) Through a combination of evaporation and influent and effluent flow measurements, estimates of seepage loss from the tailings pond should be made on an annual basis.

Item--Bottom Sediment

Comments:

1) The bottom sediment sampling program initiated during the pre-operational period should be continued during the operational period. Of particular importance is the early identification of sedimentation "hot-spots" in the natural drainages receiving treated dewatering effluents.

Page 6-10, footnote "a": EPA would like to have copies of this radon sampling program when it is finalized.

Page 7-1, Part 7 (in general): EPA comments previously presented under Parts 4 and 6 are also applicable when considering unavoidable adverse environmental impacts.

Page 7-1, section 7.3: The DES states that "after mining ceases and pumping stops, water levels will return to pre-mining levels, so this (lowering of water levels) is a temporary effect". This must be considered rather speculative given changes in aquifer characteristics (e.g., permeability), in infiltration rates, and in the surface water hydrologic regimen (e.g., formation of permanent impoundments).

Page 7-2, first paragraph: The water quality of post-mining lakes and impoundments should be projected (i.e., will it be adequate for its intended use?).

Page 7-2, second paragraph: Leakage of chemical contaminants can also be expected.

Page 10-6: Alternative E for Reclamation of Open-Pit Mining is the same as Alternative A with respect to Mining Areas II and III. The primary difference between A and E is in the highwall reduction and reclamation of the B-1 pit area. As the DES states, the areas left as highwall (under Alternative A) represent a net loss in terms of long-term productivity, and Alternative E would return the greatest surface area to the widest range of productive use at a median cost compared to the other alternatives. For these reasons and due to compatibility with proposed post-mining land uses and the very limited access to the lake as proposed, Alternative E seems to be a reasonable option.

Page 10-14, third full paragraph: A reference or sample calculation should be shown for the 10-fold decrease in radon emanation.

Page 10-15, Alternative III, second paragraph: A reference or list of assumptions should be shown for a 100-fold reduction in radon emanation.

Page 10-18, section 10.4.3: In the section on Alternative Methods for Tailings Management, the DES states that "it is the staff's opinion that Alternative III represents the most environmentally sound, reliable, and reasonable methods of tailings management using existing, commercially-available technology". Alternative

Page 10-18, section 10.4.3 (cont'd): III includes utilization of a clay liner and clay cap (thicknesses not specified). This recommended alternative appears to conflict with the proposal of the Applicant (i.e., Alternative I, a tailings pond with scarified and recompacted natural foundation and preliminary burial of remaining tailings to a total depth of six feet, the top one-half foot being topsoil). Based on the natural foundation of the proposed tailings disposal area (i.e., alluvium and claystone), expected seepage rates with no liner and expected emissions of radionuclides by wind action with stabilization as proposed, it seems logical that the NRC would recommend that the Applicant proceed with Alternative III.

Page 10-20, second sentence: Page 2-3 says Highland mill is 3 miles away.

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February 28, 1977

Subject: Comments on Rocky Mountain Energy Company Bear Creek Project.

Director
Division of Fuel Cycle & Material Safety
Office of Nuclear Material Safety & Safeguards
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

This letter is written regarding the Rocky Mountain Energy Company joint venture with Mono Power Company to operate a mining and milling complex known as the Bear Creek Project in the Powder River Basin, northeast of Casper, Wyoming.

Rocky Mountain Energy is a firm dedicated to proper utilization of extraction and milling techniques to minimize the effect of the operation on the environment. The environmental impacts created by this project are temporary as corrective measures have been incorporated into the company plans to mitigate them and return the area to useful purposes.

Therefore, we believe that a proper balance of energy development and environmental protection can be attained in the Powder River Basin area and that this project should be allowed to proceed.

Sincerely,

CHEN AND ASSOCIATES, INC.

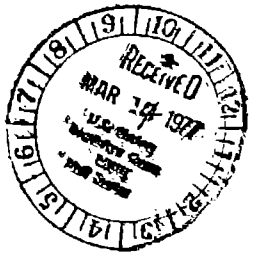
By _____
Fu Hua Chen, P. E.

RBS/med

DEPARTMENT OF TRANSPORTATION
REGIONAL REPRESENTATIVE OF THE SECRETARY
SUITE 1822, PRUDENTIAL PLAZA BUILDING
1050 SEVENTEENTH STREET
DENVER, COLORADO 80202

REGION VIII

March 8, 1977



United States Nuclear Regulatory Commission
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
Washington, D. C. 20555

Gentlemen:

Thank you for the opportunity to review your draft environmental impact statement concerning the Rocky Mountain Energy Company's Bear Creek Project.

We have no substantive comments to make on this EIS.

Sincerely,

William C. Evans

WILLIAM C. EVANS
Senior Staff Officer

THE STATE OF WYOMING

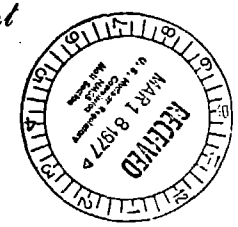
ED HERSCHLER
GOVERNOR

Game and Fish Department

CHEYENNE, WYOMING 82002

EARL M. THOMAS
DIRECTOR

March 10, 1977



Mr. John Kendig
Division of Fuel Cycle and Material Safety
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Kendig:

The Wyoming Game and Fish Department has reviewed the Draft Environmental Statement related to Operation of Bear Creek Project by Rocky Mountain Energy Company in Converse County, Wyoming (NUREG-0129, Docket No. 40-8452). Our comments on the DES and the project are as follows:

1. The Water Resources Section (Pages 4-5, item 4.3) mentions that water quality is expected to be suitable for consumption by livestock and wildlife. The mine site is located in a region offering limited fishing opportunities. We strongly urge that adequate evaluations be conducted to determine whether or not ponds conducive to fisheries can be constructed. Water quality and quantity would be possible limiting factors. We would welcome the opportunity to work with the mining interests on possible fisheries developments.

   Water-filled pits are not acceptable reclamation if we cannot be sure that the ponds created will be suitable for wildlife. These pits are called "aquatic habitat" in the environmental statement, however, aquatic habitat is much more than a water filled pit. Many years may be required to convert these pits to aquatic habitat, if it truly can be accomplished. These pits and the proposed settling basins have the potential to be harmful to waterfowl. There is inadequate explanation of measures which will be taken to prevent water birds from being subjected to caustic materials that may be present in these ponds.

2. How will water be treated to make it "suitable for agricultural and wildlife use?"

3. There is no explanation of the affect of disruption of aquifers on the water table and subsequently on stock ponds, streams and springs in the area. The assumption that water levels in nearby wells will return after mining is unsubstantiated by data.

4. It does not appear that "satisfactory" vegetative cover, that is, cover satisfactory to wildlife, can be reestablished with the reclamation plan proposed in this document. Currently 60 percent of the mine site is sagebrush type, yet the reclamation plan calls for reseeding with various grasses. "Native species" as used in the assessment, are not necessarily good for wildlife. If the native species removed are browse plants, and the stated objective of reclamation is to return the area to its current use, then browse species must be replaced in greater numbers than proposed in the reclamation plan. Planting grasses and waiting 50-100 years for succession to return the range to its former state (if it does) is not appropriate reclamation.

   There is not adequate documentation to support the conclusion that reclamation will be successful. What research or current reclamation projects indicate that vegetation can be reestablished? The tailings area that will not be available for use for 50-100 years (if then) cannot be said to be reclaimed.

5. If browse species are not reintroduced, or are established in lesser numbers or different species composition, then the browsing mammals and shrub-dwelling birds currently on this area constitute some of the irreversible and irretrievable commitments of resources which could not be identified in section 9.7.

6. Reducing seepage of tailing ponds "to the extent practicable" does not guarantee that groundwater and surface water supplies will remain uncontaminated.

7. Secondary or indirect impacts to wildlife as a result of increased population have not been quantified, though experience with other developments in Wyoming indicates that these effects may be very large.

8. The statement is made that temporary riparian habitat will benefit wildlife. A riparian habitat probably cannot be created in ten years. If it is created, those species attracted to the habitat will be destroyed or displaced when the water source dries up.

9. There is no explanation of the means of determining that 10 percent of the big game populations would be lost annually because of the proposed project. This may be an underestimation in view of current conditions at the Decker Mine site. At that site, 15 of a population of 17 mule deer have been poached or killed in vehicle-deer collisions in less than a year. This leads us to believe that actual game animal losses may be much higher than indicated in this assessment.

10. If rough-significant relief areas were undesirable for grazing, as this report maintains, there would be no grazing in much of Wyoming. Flat, level topography suitable for a monoculture is undesirable for wildlife. Restoring the original topography or restoration as close to the original as possible will best mitigate wildlife habitat losses.

11. If there is little dry-land farming in the area, there is no reason to increase the acreage available for such farming.

12. What will be the impact of storage of over-burden on wildlife?

13. It is difficult to see how availability of water can be a problem for grouse if there are stockwater ponds and small reservoirs in the area which are full enough to be used by resting waterfowl.

14. Waterfowl do nest on or near stockponds in shortgrass prairie.

15. It should be the responsibility of the company to restore or replace wetlands and dryland habitats which will be lost as a result of mining.

16. Among the unavoidable impacts would be the destruction of small mammals killed as a result of earthmoving activities.

17. Cumulative impact of this project with other mines in the area should be quantified. It is not enough merely to mention that cumulative impacts will occur.

18. Do the quoted densities of antelope, mule deer, and sage grouse occur all year? Are there seasonal variations in density? Obviously, this is true for antelope, but no figures are given for total numbers of antelope present. The reader is only told that "bands of 60-100" antelope have been seen.

19. It is difficult to believe, with all the unavoidable impacts listed in section 7, that the benefits of this project outweigh the costs.

Thank you for the opportunity to review this Draft Environmental Statement and proposed project in the interest of the wildlife resource.

To assist you in considering this and future permits, I am enclosing a copy of a recent Wyoming Game and Fish Department publication entitled "Considerations For Wildlife In Industrial Development And Reclamation." I hope you will find it useful.

Sincerely,

W. DONALD DEXTER, ASSISTANT DIRECTOR
WYOMING GAME AND FISH DEPARTMENT

WDD/HBM/jlm
cc: Donald Rollens, Forest Supervisor
Medicine Bow National Forest
State Planning Coordinator
Game Division
Fish Division

Enclosure

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

USAEC
MAR 30 1977
REGULATORY
FILE SECTION

In Reply Refer To:
EGS-ER-77/38
Mail Stop 760

MAR 28 1977

RECEIVED
MAR 30 1977

Director
Division of Fuel Cycle and Material Safety
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

This responds to Mr. Rouse's notice of December 29 relating to comments on the draft environmental statement for the Bear Creek Project in Wyoming.

We find that the draft statement's treatment of matters of concern to this Department is generally adequate. Specific items that deserve attention, statements that require clarification or elaboration, and inaccuracies that should be corrected are discussed in the enclosure.

We hope our comments will be helpful.

Sincerely yours,

Stanley K. Boremus

Deputy Assistant Secretary of the Interior

Enclosure

Enclosure to the Department of the Interior's comments on the environmental statement on the Bear Creek Project in Wyoming.

General Comments

The draft statement contains much information presented in easily understandable form on the types of impact that could be expected from uranium mining and processing. However, the significance of the impacts often is not clearly defined and quantified other than in terms of acreages disturbed. Examples of those deficiencies can be found on pages 4-8 and 4-9 in the description of impacts on vegetation and wildlife.

We had some difficulty in our review because of the many sections that treat the same subject but use different explanations as to intent and purpose. Discrepancies also can be found in the same chapter, such as the discussion of the B-1 and B-4 ore deposits, pages 3-4 and 3-8, where the B-1 ore body is said to be both 7,600 and 4,300 feet long and to have a maximum depth of both 200 and 400 feet.

The maps used as illustrations and figures should be referenced to a map showing the relationships among, and exact locations of, the different mining activities within the area of operations.

Specific Comments

Page 1-1: Section 1.2 should mention the role of BLM in managing the mineral estate on Bankhead-Jones LU Lands. BLM leases minerals on these lands, with consent of the surface managing agency, while USDI-GS supervises the development of minerals. The Forest Service function is that of a surface managing agency.

Page 2-11: In section 2.4.1.1 and figure 2.5, the impression is left that the project area is located in the Powder River Basin. It should be clearly stated that the project is situated in the Cheyenne River drainage.

Page 2-34 et seq.: The treatment of potential impacts on fish and wildlife resources and the related environment appears generally adequate. However, certain mitigation potentials should be further considered and implementation prospects presented in the final impact statement, as follows:

1. Fenced areas should specifically provide for antelope and deer movement, especially escape passage from newly fenced areas.

2. Reclamation efforts should be designed to reestablish native flora that will survive in the semi-arid climate having a mean annual precipitation of 12.0 inches.

3. Land reclamation directed towards creating a flat, level topography best suited to a monocultural purpose like domestic livestock grazing will result in a permanent loss of wildlife habitat. Restoring the topography to its original form might best mitigate damages to existing wildlife habitat.

4. Power lines and their supports should be designed to prevent the electrocution of raptors.

5. At the completion of mining and reclamation, any lands owned by the mining company and having fish and wildlife habitat suitable for management and public use could be made available to the Wyoming Game and Fish Department for management.

Page 3-13 et seq.: Section 3.1.3 is described in very general terms and the reclamation procedures to be used are missing. For example, the quantity of topsoil to be spread on disturbed areas by tracts for each of the soil capability classes should be listed.

Page 3-13: Section 3.1.2.6 Paragraph 2 (lines 7-9) refers to a settling pond at the north end of the proposed B-1 pit. There is some inconsistency in statements assuring that the mine water will be pumped to settling ponds where it will be treated before discharge to streams or used for industrial purposes and other statements reporting that the mine water will be discharged directly into streams because it is sufficiently high quality for livestock and wildlife use. In addition, figure 3.17 (page 3-32) does not explain whether the water will be treated, or, if untreated, whether it should be used for dust suppression as noted in the figure and reported on page 3-22 (par. 3).

Page 3-29: Section 3.3.1 Paragraph 1 states that "Prior to ground stripping and ore extraction, the mineralized zone is dewatered by pumping of wells developed near its perimeter." However, in Rocky Mountain Energy Company's

April 1976 response to question No. 45, it is said that "We no longer intend to dewater the B-1 ore body via wells, but will ditch the interior perimeter of the floor of the pit and dewater from collection sumps on the pit floor."

Page 3-32: Figure 3.17 shows an average mine-water volume of 1,000 gallons per minute or 1,600 acre-feet per year entering the dewatering impoundment from where 446-457 acre-feet per year goes to the mill and to dust suppression, or is evaporated. This leaves 1,143-1,154 acre-feet per year unaccounted for. With recirculation, water to the mill totals 517 acre-feet per year or about 462,000 gallons per day. A more realistic amount of water for milling would be 700,000 gallons per day, as stated on page 3-27 (line 2). On page 3-29, section 3.3.1, it is stated that "The overwhelming bulk of the liquid used throughout the plant (5×10^5 m^3/yr) will be routed to the tailings pond." However, 5×10^5 m^3/yr is about 362,000 gallons per day, which is not in agreement with the 700,000 gallons per day previously mentioned.

Page 3-35: In paragraph 3, it is stated that "The area chosen for tailings disposal and embankment is underlain by some alluvium and the Fort Union Formation, chiefly claystone of relatively limited permeability." In figure 3.18, the profile through the tailings pond, however, shows the pond underlain by the Wasatch Formation with the ground water near the surface. Map No. 1-877 of the U. S. Geological Survey Miscellaneous Investigation series shows that the uranium-bearing Wasatch Formation crops out in the project area and that the Fort Union Formation crops out about two miles east. The discussion on geology on page 2-16 could better describe the Wasatch Formation in the Bear Creek area.

Page 4-3: Table 4.1 lists four classes of soils under dry cropland, but only class IVe is reported to be suitable for mechanized production of common field crops.

Page 4-7: Section 4.5, which includes a description of what is expected to happen to the natural soil body, should also discuss effects of the changes on the reclamation potential and future land use.

Page 4-7: Increased erosion resulting from the project is mentioned in passing here and on page 7-2. The potential quantity of erosion and the possible downstream sedimentation are not discussed. The increased rate and quantity of sedimentation at the Bureau of Reclamation's Angostura Reservoir, downstream from the project, are of public concern and should be discussed.

Page 6-12: We note from page C-1 that the State Historic Preservation Officer has commented upon this project and endorsed it, subject of course to the procedures for the protection of cultural resource sites stated on page 6-12 of this document. In this connection, we note further that the project development area has been archeologically surveyed by Dr. George Frisson, State Archeologist for the State of Wyoming. We do find references on pages A-36 and 7-4 to possible damage or destruction of cultural resource sites a matter of concern.

Since there is such a present possibility, it would appear to be all the more incumbent upon the Rocky Mountain Energy Company to take every precaution possible to avoid any irretrievable commitment of such resources.

In addition, we suggest that the final statement confirm consultation of the most current listing of the National Register of Historic Places as published in the Federal Register, and all monthly supplements. On the basis of findings reflected by this document, there are no known cultural resource sites that will be affected; however, there is a need to establish that the National Register was consulted. There is also a need to establish that should any cultural resource sites that meet the criteria of the National Register be discovered, they will be protected in compliance with the Advisory Council on Historic Preservation's "Procedures for the Protection of Historic and Cultural Properties" (36 CFR, Part 800).

Page 7-2: In section 7.5, unavoidable adverse environmental impacts on soils are listed, but only one, soil productivity, is semiquantified. Also, the statement does not fully agree with the indicated increase of production from the 622 acres of new IVe land. Some soils will be degraded, but some soils will be improved, and the disturbance may have little effect on some soils.

Page 8-1: In sections 8.5.1 and 8.5.2, the questions of why will long-term productivity of soils improve on about 1,600 (mine) acres and possibly 150 (mill) acres and what procedures will be used to effect the improvement need to be addressed.

Page 9-1: Will "The change in productivity potential of about 1,600 acres...." (sec. 9.5.1) improve or reduce the productive potential?

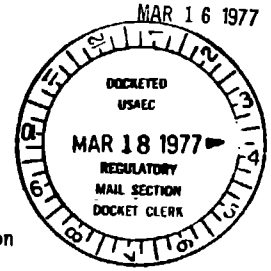
Page 9-1: Section 9.5.2 is inconsistent with the statement in section 8.5.2: "The estimated forage production potential of reclaimed soils overlying the tailings deposits will increase compared to the present production levels, but may not be available because of excessive radiation levels."

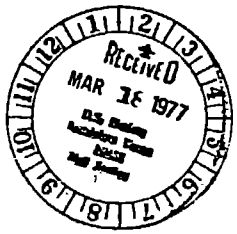
Section 9 should include a summary of the fuel and energy used in recovering and processing the uranium.

If the benefit-cost analysis (Section 11) is to be a part of the EIS, energy and environmental tradeoffs should be compared. The appropriate base for comparison on an individual deposit would probably be with national averages. This will become more significant with increasing development of lower grade deposits requiring higher energy and fuel expenditures per pound of recovered uranium.

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

MAR 16 1977





Mr. L. C. Rouse, Chief
Fuel Processing and
Fabrication Branch
Division of Fuel Cycle and
Material Safety
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rouse:

This is in response to your letter dated January 10, 1977, transmitting a copy of the Commission's draft environmental impact statement related to the operation of the Bear Creek project, NUREG-0129, for review and comment.

We have reviewed the draft statement and have determined that the proposed action will not conflict with current or known future Energy Research and Development Administration programs. We are, however, enclosing staff comments for your consideration in the preparation of the final statement.

Thank you for providing us the opportunity to review this draft statement.

Sincerely,

W. H. Pennington, Director
Office of NEPA Coordination

Enclosure:
ERDA Staff Comments

cc w/enclosure:
Council on Environmental Quality (5)

ERDA STAFF COMMENTS
ON THE
NUCLEAR REGULATORY COMMISSION DRAFT ENVIRONMENTAL IMPACT STATEMENT
RELATED TO THE OPERATION OF THE BEAR CREEK PROJECT
NUREG-0129

1. On page 2-18, the draft states that the uranium ore will contain significant quantities of vanadium, selenium, arsenic, and iron sulfides. While the natural ground water of the area contains relatively high concentrations of these elements compared to EPA Drinking Water Criteria (EPA-44D/9-76-023), the effect which the mining and milling operation effluents have on natural concentrations of these elements should be elaborated. In particular the effect of seepage from the mill tailings on the ground water should be discussed in greater detail. Also, it would be helpful if a copy of the NPDES permit (see page 1-6) were included as an appendix. We believe that these items deserve additional emphasis in view of the present concern over the effects of uranium mining and milling in the Grants Mineral Belt of New Mexico (see the article by Kaufmann, et al, in Ground Water, Volume 14, number 5, September-October 1976).

2. Table 4.4 - Dose rate to the whole body is not meaningful when the main source of radiation is via inhaled particles which may be quite localized in the lung and associated tissues.

3. The radiological impact has been calculated in great detail (see Tables 4.3 to 4.13). However, some qualitative assessments should be included especially for high dose values such as those given in Table 4.6 which indicates that the total lung dose at the east boundary will be greater than 6 rem/yr. (Incidentally, a "Total Dose" column is missing from Table 4.6.) While we realize that there are no residents at that particular location, it appears to deserve further explanation. Also, it is difficult to accept the conclusion beginning at the bottom of page 4-10 which states that, "The quantities of radionuclides...released are expected to produce concentrations in air and water at the boundary of the controlled area less than the limits specified in 10 CFR Part 20..." and continuing on page 4-13 that, "It is the NRC staff's opinion,...that the proposed Bear Creek Project satisfies the 'as low as reasonably attainable' guides..."

   In view of the above paragraph, an estimate of the occupational doses that mine/mill personnel are likely to receive should be included.

4. Page 4-32, second paragraph: The Ra-226 concentrations in ground water are compared to MPC values when, in fact, they should be compared to EPA Quality Criteria for drinking water.

5. Section 4.8.2: The 1.2 X 10^4 Mrem/year is considerably less than background radiation, but is not negligible. Further discussion should be given to limit external and/or inhalation of particles by workers.

6. Section 5.1.1 and 5.1.2: Should also address the routine exposure of workers during mining and milling.

DOCKETED USNRC APR 1977 REGULATORY PUBLICATION CLERK

40-8452

Cornell University
LABORATORY OF ATOMIC AND SOLID STATE PHYSICS
CLARK HALL · ITHACA, NEW YORK 14853

April 6, 1977

RECEIVED APR 15 1977 U.S. Nuclear Regulatory Comm. NMSS Mail Section

Director
Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

Re: Comments on NUREG-0129

The following information should be continued in the final report:

(a) All maps should have clearly readable scales.

(b) The total land-use of the project should be determined and listed. Land-use is measured in acre-years. This quantity has been introduced in GESMO (NUREG-0002), and measures the area unavailable for non-project activities times the time for which it will be unavailable.

(c) The total amount of energy potentially derived in LWR's from the ore to be mined at Bear Creek should be given. According to GESMO (p. IV-J(E)-17), 1.77 x 10^6 short tons U_3O_8 will ultimately result in a net energy of 4036 GW(e)y of electricity generated, i.e. 439 short tons U_3O_8/GW(e)y (for the no-recycle option). According to NUREG-0129, p. 3-1, total U_3O_8 to be mined is estimated to be 3000 short tons. According to GESMO, this would yield 6.8 GW(e)y. Without such information, an Environmental Statement is inadequate since it does not allow to compare the benefit with the environmental cost.

(d) Maps and a table should be provided to indicate the area in which the average atmospheric Radon-222 concentration will be 100%, 33%, 10%, 3%, and 1% larger than the present average concentration, prior to startup of the project. Both the time during the mining/milling and the time after the activity has ceased and the tailings have been protected as recommended (p. 10-18), should be considered. Fig. 4.7, which lists concentration vs. distance, is not adequate to assess the total area affected. Furthermore, Fig. 4.7 does not show the natural, preproject, average radon-222 concentration.

Sincerely,

Robert Pohl

lh

Robert O. Pohl

A-41

COMMENTS RECEIVED AT PUBLIC MEETINGS

During the course of public meetings held at Douglas and at Casper, attendees were offered the opportunity to express their concerns and opinions to each other and to the agencies by means of a so-called ABC exercise. The ABC Exercise form shows how the meeting was conducted. From these exercises, the matters of most concern were recorded on "Task Cards," on which the participants wrote brief notes on the:

Concern

Possible Causes

Recommendation

Advantages to Land

Disadvantages to Land

Advantages to People

Disadvantages to People

Such notes were made after discussion among themselves.

The following are the comments on the concerns, possible causes and recommendations as they were given on the task cards. Table A.1 shows a tabulation of the items of concern, grouped by subject. This table will reflect the numbers of expressions, first on the exercise forms, then on the task cards.

Each of these matters of concern have been considered seriously by the agencies. While some relate to actions or conditions beyond the authority of the agencies, most pertain to subjects that are discussed in the environmental statements. It is hoped that this final statement covers all such topics in a manner that is generally considered fair and equitable, and as conducive as possible to the long-term betterment of our environment.

ABC Exercise A

1. Write down two situations about which you may be concerned pertaining to the Project or the EIS process. _____

_____

_____

_____

The whole idea of communication is the way we:
Share ideas (send messages)
Listen (receive messages)
Provide feedback (tell how well you sent or received the message)

2. Working in groups of three identify yourself as A, B, or C.

3. Now, share your situations of concern with the other two in your group in the following manner:
   a) A will be the first to state his/her situations of concern.
   b) B will act as the receiver/listener (provider of feedback).
   c) C will act as observer to give feedback to A & B. (Take notes on: how well A has stated his/her situations of concern, how well B is helping/listening/receiving, etc.)

   This should take 3 minutes, with two minutes for feedback from C.

4. Switch Roles:
   a) B states situations of concern.
   b) C acts as receiver/listener/provider of feedback.
   c) A acts as observer.

   This should take 3 minutes, with two minutes for feedback from A.

5. Switch Roles:
   a) C states situations of concern.
   b) A acts as receiver/listener/provider of feedback.
   c) B acts as observer.

   This should take 3 minutes, with two minutes for feedback from B.

6. Your group of three should share your six situations of concern with the other group of three at your table. Come up with just six situations of concern from your table's original 12. Write each situation clearly on the Task Card.

7. Take a 10-15 minute coffee break.

8. Working in groups of 6 (one table) select a group spokesperson and discuss your six situations of concern. Determine causes, recommendations, advantages, and disadvantages as shown on Task Card.

9. Group spokespersons present a brief report to the total workshop group, from Task Card.

TASK CARD

CONCERN: _____

_____

POSSIBLE CAUSES: _____

_____

RECOMMENDATION: _____

_____

ADVANTAGES TO LAND: _____

_____

DISADVANTAGES TO LAND: _____

_____

ADVANTAGES TO PEOPLE: _____

_____

DISADVANTAGES TO PEOPLE: _____

_____

CONCERN: _____

_____

POSSIBLE CAUSES: _____

_____

RECOMMENDATION: _____

_____

ADVANTAGES TO LAND: _____

_____

DISADVANTAGES TO LAND: _____

_____

ADVANTAGES TO PEOPLE: _____

_____

DISADVANTAGES TO PEOPLE: _____

_____

TASK CARDS -- DOUGLAS MEETING

CONCERN: Delay in progress caused by groups or organizations from outside areas. Increased costs to consumers.

POSSIBLE CAUSES: People without the requirement to make a living devote energies to this area.

RECOMMENDATION: Foster logical thinking. Let people in localities control more of their own problems.

CONCERN: Too much publicity by news media

POSSIBLE CAUSES: Editors devote too much newsprint to select groups -- because of monetary compensation possibly.

RECOMMENDATION:

CONCERN: Ground water loss through mine dewatering

POSSIBLE CAUSES: Drill holes and dewatering

RECOMMENDATION: Policing by agencies. Replacing lost water from other sources. Update holes in regard to abandonment of drill holes.

CONCERN: Reclamation of the area (Backslope requirement. Forage vs Weeds.

POSSIBLE CAUSES: Excess concern over esthetic values to resulting burdensome costs.

RECOMMENDATION: Close monitoring of weeds especially noxious ones

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CONCERN: Encourage cooperation of industry and ranchers to promote orderly developments.

POSSIBLE CAUSES: Lack of communication

RECOMMENDATION: Improve communication

CONCERN: That the environmental impact process maintain a reasonable balance of concerns

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: More communication of what the public concerns are.

POSSIBLE CAUSES: Public apathy plus failure of normal communications by media.

RECOMMENDATION: More coverage by media.

CONCERN: The process of involvement of the general public in the EIS procedure - we are a representative government.

POSSIBLE CAUSES: Involvement by local elected officials

RECOMMENDATION: Make an election issue of lack of involvement

---

CONCERN: Effects of dewatering on local wells

POSSIBLE CAUSES: Intefception of aquifers - Drainage of perched water tables.

RECOMMENDATION: Use mine water in irrigation system.

CONCERN: Achievement of Successful Reclamation

POSSIBLE CAUSES: Drought - Lack of water

RECOMMENDATION: Implementation of properly planned programs.

CONCERN: Socio-impact on Converse County and the state of Wyoming.

POSSIBLE CAUSES: Additional employment created by the mine and mill together with future mines and mills/industries

RECOMMENDATION: Group planning as opposed to individual project planning

---

CONCERN: Disposition of mill tailings.

POSSIBLE CAUSES:

RECOMMENDATION: Additional studies for permanent disposal

CONCERN: Ultimate use of land at end of operations.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: The concern of people in the area of project

POSSIBLE CAUSES: The project will be employing people in the area.

RECOMMENDATION: That Rocky Mountain will work with the Land Owner in patroling the area.

CONCERN: Water

POSSIBLE CAUSES: Mining excavations will run into water tables at the depths of local wells in the area, and that a lowering of the water tables in the area will result.

RECOMMENDATION:

CONCERN: The country needs uranium as a valuable energy resource.

POSSIBLE CAUSES:

RECOMMENDATION: Continue Bear Creek Project. Use resources efficiently.

CONCERN: Misinterpretation of the EIS concerning radiation by readers of the document.

POSSIBLE CAUSES: Technical language may be misunderstood by people causing unfounded fears about radiation.

RECOMMENDATION: Simpler explanation of radiation cause and effect.

CONCERN: Quantity of well water in vicinity of operation.

POSSIBLE CAUSES: Dewatering of pits. Process water wells.

RECOMMENDATION: Hydrology studies.

CONCERN: Air quality (road dust). Effect on grazing and palatability of forage. General housekeeping programs.

POSSIBLE CAUSES: Lack of control on personnel and disposal of trash; equip. operation on dry nonsurfaced roads.

RECOMMENDATION: Provision of trash recepticles of approp. sites; maintained (covered) sanitary landfill; surfaced roads or use of water on road or oil or other dust palliatives.

CONCERN: Restoration of surface to equal productivity post-mining

POSSIBLE CAUSES: Lack of proper seeding - Lack of complete topsoil cover, Poor contouring.

RECOMMENDATION: Well balanced reclamation plan frequently checked by government authorities.

CONCERN: Highway 59 and Ross Road - increase in traffic and deterioration of roadways.

POSSIBLE CAUSES: Increased heavy truck traffic.

RECOMMENDATION: Allocation of money to rebuild Highway 59.

CONCERN: EIS process does not adequately address cumulative impacts. Changes are so hard to accommodate in process.

POSSIBLE CAUSES: Too short time period - availability of needed information a problem. No group with overall responsibility - Lack of regional comprehensive planning.

RECOMMENDATION: Regional planning. More state activity such as siting control.

CONCERN: EIS takes to long therefore frequently doesn't come out until project has much momentum.

POSSIBLE CAUSES: Understaff federal agencies - companies in too much of a hurry - project planning requires considerable lead time

RECOMMENDATION: Simplify EIS do only relevant points - time limits on EIS and no company can start until EIS complete.

CONCERN: More people in area change the "way of life" we have always known.

POSSIBLE CAUSES: Need people for project

RECOMMENDATION: Responsible action by company. Local land we control. Long-range planning for orderly growth.

CONCERN: After energy sources are depleted, what happens to mills and communities built during peak activity?

POSSIBLE CAUSES: Obvious when the uranium ore project is over.

RECOMMENDATION: None forthcoming. Difficult problem - minimized by better long-range planning.

CONCERN: Lowering of water table.

POSSIBLE CAUSES: Surface mining or exploration.

RECOMMENDATION: Project all existing water uses and users. Industrial impacts before action begins. Use water that is encountered on project.

CONCERN: Job - employment

POSSIBLE CAUSES: Employment problem

RECOMMENDATION:

CONCERN: Groundwater

POSSIBLE CAUSES: Dewatering wells water pumped from pits

RECOMMENDATION: Study of recovery rate and extent of recharge of water tables

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CONCERN: Potential Hazard of increased traffic to livestock

POSSIBLE CAUSES: Vehicles traveling to mine

RECOMMENDATION: Increased security by company on county or both.

CONCERN: 1.) Fluctuation or effect on water table (Carson). 2.) Easment/crossing (Baker). 3.) Economic impacts (i.e. Douglas).

POSSIBLE CAUSES: Housing costs. Fixed income. Tax Base.

RECOMMENDATION: 1 & 2 Consultation with RMEC. 3 State legislation on tax direction.

CONCERN: Cultural community impact

POSSIBLE CAUSES: People, taxes, lack of services

RECOMMENDATION: More advance warning from companies

CONCERN: That the EIS is not a proposal as such but almost as a finality

POSSIBLE CAUSES: Poor planning, government red tape

RECOMMENDATION: That EIS be issued prior to construction.

TASK CARDS -- CASPER MEETING

CONCERN: Reclamation of surface.

POSSIBLE CAUSES: Traffic--its very presence causes disturbance.

RECOMMENDATION: Reclaim and restore.

CONCERN: Red tape.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: Source of energy for the county.

POSSIBLE CAUSES: We need the energy.

RECOMMENDATION: Faster progress.

CONCERN: I work for Bear Creek and need the job. Also construction and service employees.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: I hope that environmental concerns will still exist 10 to 12 years when the project is winding down.

POSSIBLE CAUSES: Change in National and State policy. Possible deemphasis.

RECOMMENDATION: Bonding. Continued public concern. Enforcement.

CONCERN: Slow bureaucratic process. Red tape.

POSSIBLE CAUSES: Public apathy to create a change in process. Lack of coordination. Inger-agency rivalry. Complex legal system (ownership and regulatory control).

RECOMMENDATION: Piecework pay rather than salary to bureaucrats. Federal reorganization. Streamlining. Definite lead agency designation. Possible agreement state.

CONCERN: Social impacts on communities and rural life.

POSSIBLE CAUSES: Employees-families-population inflow for support services (construction and operation) and shutdown.

RECOMMENDATION: Community planning.

CONCERN: Change of contour of land and how does it affect water drainage.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: Impact of traffic and increase of population in the immediate area.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: What happens to our national energy consuming economy if we do not develop this and similar resources.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: Employment and energy. Reclamation of land.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: Social concerns.

POSSIBLE CAUSES: Uncontrolled growth. Controlled future employment.

RECOMMENDATION: Coordination of development of projects, consolidation of Federal agencies, and local governments to better implement licensing for projects.

CONCERN: Economic concerns.

POSSIBLE CAUSES: Time lag caused by current legal requirements. Towns providing services.

RECOMMENDATION: Longer lead time. Greater responsiveness of governments to economic needs of local communities, people and jobs and to RME.

CONCERN: Need for additional information relative to the needed fuel for purpose of savings in terms of oil imports and achieving energy independence.

POSSIBLE CAUSES: Lack of positive energy policy.

RECOMMENDATION: Expand the EIS to reflect these needs and goals.

CONCERN: Need for additional information relative to the needed fuel for purpose of savings in terms of oil imports and achieving energy independence. When will permit be issued?

POSSIBLE CAUSES:

RECOMMENDATION: Expand the EIS to reflect these needs and goals.

CONCERN: Length of time involved in processing EIS.

POSSIBLE CAUSES: Red tape.

RECOMMENDATION: One agency lead process.

CONCERN: Needed jobs for Wyoming people.

POSSIBLE CAUSES:

RECOMMENDATION: Speed up EIS process and limit coverage to relevant issues.

CONCERN: Source of energy for the country.

POSSIBLE CAUSES: Concern of the energy shortage throughout most of the country.

RECOMMENDATION: Less red tape and faster functioning committee.

CONCERN: By holding up the project the taxpayer will bear the burden.

POSSIBLE CAUSES: A longer energy shortage.

RECOMMENDATION: Reach an agreement either to go ahead or to stop the project without so much red tape.

CONCERN: The longer the delay, the more costly this is to the country.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: Land use.

POSSIBLE CAUSES:

RECOMMENDATION:

CONCERN: Loss of time in development of energy so desperately needed by all.

POSSIBLE CAUSES: Paperwork--too many concerns that are far remote of subject.

RECOMMENDATION: Act prudently and in a straightforward command cause.

CONCERN: None if development is not done.

POSSIBLE CAUSES: None.

RECOMMENDATION: None.

CONCERN: Multiple agencies include: Federal, State, and local are too hung up in their role--unwilling to talk with each other and compromise.

POSSIBLE CAUSES: Jurisdiction jealousy--unfamiliarity with other agency's role.

RECOMMENDATION: State involvement in NEPA process. Federal/State agreements like those Interior/Wyoming have now for Federal coal.

CONCERN: Water impoundment. Approve the creation of the water reservoir (RMEC Plant).

POSSIBLE CAUSES: USFS not responsive to RMEC and the land owners.

RECOMMENDATION:

CONCERN: Will the high cost of tailings containment prohibit the possible mining of low grade deposits?

POSSIBLE CAUSES: Is it undue goverment regulation? Difficult area of containment?

RECOMMENDATION: Determine if uranium tailings are truly harmful and, if so, to what degree.

CONCERN: Has there been sufficient consideration given to the relative value to the State and Nation of go or no go on this project as far as energy and taxes and general economics.

POSSIBLE CAUSES: Too much concern for environmental factors; lack of concern for economic factors.

RECOMMENDATION:

Table A.1. Summary of Community Discussion Sessions

	Concerns												EIS Process		
	Jobs Needed	Disp'n of Tailings	Reclam. of Land	Ground-water Effects	Need for Energy	Comm. Impacts	Effects on Ranchers	Pop. Impacts	More Infor. Needed	Economic Effects	Agency Coord.	Road Constr. Effects	Too Long	FES not a Proposal	Need More Public Involv.
ABC	x o x o o o o o o o o o o	x o x o o	x o x o x o x o x o x x x	x o x x x x x x x x x	x o x o x o o o o o o o	x o x o o	x x	x o x	x o o o	x o x o x o	x o x o x x	x o x o x x	x o x o o o	x o o	x x
Task Card	x o o	x o x o x	x o x x	x o x o x x x x x x	x o o	x	x	x	x o o	x o x o	x o x x	x o x	x o x o o o	x o	x

Casper = o
Douglas = x

APPENDIX B. STATEMENT OF UNDERSTANDING BETWEEN THE NUCLEAR REGULATORY COMMISSION, UNITED STATES GEOLOGICAL SURVEY OF THE DEPARTMENT OF THE INTERIOR, AND THE UNITED STATES FOREST SERVICE OF THE DEPARTMENT OF AGRICULTURE

The purpose of the Statement is to establish the basis for the preparation of a joint environmental impact statement as prescribed by the National Environmental Policy Act of 1969 (Public Law 91 - 190, 42 USC 4321 - 4347 and Executive Order No. 11514 (35 FR 4247) and applicable agency regulations for the Bear Creek Project of Rocky Mountain Energy Company (RMEC) in Converse County, Wyoming. This uranium mining and milling project will have significant impact upon the quality of the human environment and involves major federal actions.

WHEREAS, the Nuclear Regulatory Commission (NRC) has the authority to issue the source material license necessary to operate the uranium mill; and

WHEREAS, the Director for the Geological Survey (USGS) has the authority to administer leases for federal minerals under the Mineral Leasing Acts; and

WHEREAS, the Regional Forester of the Rocky Mountain Region of the Forest Service (FS) has the authority to administer the surface resources of lands reserved from the public domain and acquired public lands of the National Forest System under the jurisdiction of the Forest Service.

It is mutually agreed that:

1. The NRC, USGS, and FS will work jointly to prepare an environmental impact statement (EIS) for the Bear Creek Project of the Rocky Mountain Energy Company.

   a. The EIS will describe the impacts, effects and necessary mitigating measures for the RMEC proposed project, both on-site and off-site.

   b. Each agency will be responsible for data collection and analysis and the preparation of text and illustrations in their respective areas of assigned responsibility. The agencies will contribute the the development of all sections of the EIS, with the objective of minimizing the environmental impacts and effects of each part of this RMEC development upon the site and adjacent area. Each agency will provide leadership in specific areas as follows:

      (1) Surface physical resources: Forest Service

      (2) Mining and subsurface resources: Geological Survey

      (3) Radiological health and safety, and milling: Nuclear Regulatory Commission

      (4) Socio-economics: Nuclear Regulatory Commission with assistance from Forest Service and Geological Survey when within Forest Service and Geological Survey purview.

   c. The EIS will be approved for publication by:

      (1) the Regional Forester, Rocky Mountain Region United States Forest Service

      (2) The Director of the United States Geological Survey and the Assistant Secretary of the Interior for Program Development and Budget, Department of the Interior

      (3) the Chief, Fuel Processing and Fabrication Branch, Division of Fuel Cycle and Material Safety, NRC

   d. Each participating agency's separate view as to unresolved environmental issues will be accurately stated in the final EIS.

2. Each agency will designate an EIS team member. The EIS team will prepare operating documents for the following matters:

a. Detailing of each participating agency's area of responsibility and interface.

b. Coordination of effort, involvement of resource specialists, and review and approval procedures for both draft and final EIS.

3. NRC will act as the coordinator of the EIS effort and will be responsible for incorporating the product of each agency into the draft and final EIS and their publication, including necessary Federal Register notices.

4. NRC, FS and USGS will cooperate, to the extent allowed by regulation, in public meetings to assure the dissemination of factual information.

   a. FS will be responsible for organizing any local public meeting of an informational nature. NRC and GS personnel will be available upon request.

   b. If an "on-the-record" hearing under 10 CFR Part 2 is found necessary NRC, FS and USGS will make available persons capable of providing expert testimony within their areas of assigned responsibility.

5. It is understood that NRC under its regulations in 10 CFR 40.14 may waive the requirements of 10 CFR 40.31(f) and 10 CFR 40.32(e) and may authorize the commencement of construction of the uranium mill under certain conditions prior to thirty (30) days after publication of the final EIS.

   Any such authorization by NRC, however, does not commit FS, USGS, or any other agency in the Department of the Interior to issue any other permit or authorization for the use of public land or resources. Nor will NRC make any efforts on behalf of RMEC to secure any permit or authorization.

6. a. It is anticipated that RMEC will be required to post bonds or other forms of security to guarantee its performance in reclaiming and stabilizing tailings disposal areas, and areas disturbed by mining. It is intended that bonds or other sureties be executed in favor of the agency with the primary interest in the reclamation and stabilization of the area involved, as appropriate and within the scope of its authority.

   b. Long-term maintenance and radiological monitoring of tailings areas and other areas with a radiological health hazard and the feasibility of appropriate bonding are unresolved issues. It is expected that these two issues will be examined in the GEIS on uranium milling to be prepared by NRC.

7. It is understood that work on the EIS will receive appropriate attention, except as limited by availability of funds and resources. Each participating agency will fund its own activities and agrees to use its best efforts to complete the EIS by December 1976.

8. NRC, as EIS team coordinator, with the assistance of FS, will contact the appropriate agency of the State or County of Wyoming to participate in a meeting to discuss the activities of the EIS team and to determine the necessary State and local permits and approvals required by RMEC.

APPENDIX C. ACQUIRED LANDS MINERAL LEASE W-4416

Form 3220-1
(October 1966)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

RECEIVED
APR 17 1970
BR. OF MINING
DENVER, COLO.

FORM APPROVED
BUDGET BUREAU NO. 42-R934

Land Office Serial Number
W-4416

State
Wyoming

ACQUIRED LANDS MINERAL LEASE
Preference Right Uranium, Vanadium and Associated Minerals

This lease entered into on April 1, 1970 between the United States of America, as lessor, through the Bureau of Land Management, and Union Pacific Railroad Company (noted Goodrich)
5480 Ferguson Drive, Los Angeles, California 90022
, as lessee,

pursuant to the authority set out in, and subject to, the regulations 43 CFR 3220-3227, and to all regulations of the Secretary of the Interior now or hereafter in force when not inconsistent with any provisions herein.

WITNESSETH:

Sec. 1. (a) *Rights of lessee.* In consideration of the rents and royalties to be paid and conditions and covenants to be observed as herein set forth the lessor grants to the lessee, subject to all privileges and uses heretofore duly authorized and prior valid claims, the exclusive right to mine, remove, and dispose of all the Uranium, Vanadium and associated minerals and any other minerals except oil, gas, oil shale, coal, phosphate, potassium, sodium, or sulphur in, upon, or under the following-described acquired lands in the United States, in the State of Wyoming

T. 38 N., R. 73 W., 6th P.M.
Sec. 4: $SW\frac{1}{4}NE\frac{1}{4}$, $SE\frac{1}{4}NW\frac{1}{4}$, $N\frac{1}{2}S\frac{1}{2}$, $SW\frac{1}{4}SW\frac{1}{4}$
Sec. 5: $N\frac{1}{2}SW\frac{1}{4}$, $SW\frac{1}{4}SW\frac{1}{4}$
Sec. 6: $SE\frac{1}{4}SE\frac{1}{4}$
Sec. 7: $E\frac{1}{2}NE\frac{1}{4}$, $SW\frac{1}{4}NE\frac{1}{4}$, $NW\frac{1}{4}SE\frac{1}{4}$
Sec. 9: $NW\frac{1}{4}NW\frac{1}{4}$
Sec. 10: $SW\frac{1}{4}$
Sec. 11: $N\frac{1}{2}$
Sec. 15: $NW\frac{1}{4}$

T. 39 N., R. 73 W., 6th P.M.
Sec. 22: $S\frac{1}{2}NW\frac{1}{4}$, $SW\frac{1}{4}$
Sec. 27: $N\frac{1}{2}NW\frac{1}{4}$
Sec. 28: $SW\frac{1}{4}$
Sec. 29: $SE\frac{1}{4}$
Sec. 32: $S\frac{1}{2}$
Sec. 33: $W\frac{1}{2}$

NOTED
MAY 25 1970
V. B. GAZDIK

NOTED
MAY 25 1970
A. V. BAILEY

RECEIVED
MAY 5 - 1970

Bond in sum of $10,000.00
with Continental Casualty Co.
as surety filed.

containing 2,560.00 acres, more or less, together with the right to construct and maintain thereon such structures and other facilities as may be necessary for the mining, preparation, and removal of said minerals for a period of twenty years with a right in the lessee to renew the same for successive periods ~~xxxxxxxxxx~~ in accordance with regulation 43 CFR 3221.4(f).

(b) *Authorized Agency Representative.* The United States agency having administrative control over the surface use of the land is Department of Agriculture and its authorized agency representative to whom inquiries should be addressed is Forest Supervisor of Medicine Bow National Forest, 1948 Grand Avenue, Laramie, Wyoming 82070

Sec. 2. In consideration of the foregoing, the lessee agrees:

(a) *Operation and production.* To carry on operations under this lease with reasonable diligence and to begin operations within -- months and to continue production thereafter unless operations are interrupted by strikes, the elements, or casualties not attributable to the lessee. The lessor may grant reasonable extensions of time for the commencement of production and may authorize suspensions of operations and production in accordance with regulation 43 CFR 3222.6-2 for reasonable periods of time in the interest of conservation or when the lease cannot be successfully operated at a profit, or for other reasons when such action does not adversely affect the interest of the United States.

(b) *Royalty.* To pay the lessor within 30 days after the end of each period prescribed in subsection (f) of this section a royalty of percent of the gross value of the minerals mined hereunder at the point of shipment to market, such point of shipment to be the mine or preparation plant, as the case may be. The lessee agrees that the Secretary of the Interior, for the purpose of determining the royalties due hereunder, may establish reasonable minimum values for the minerals mined, due consideration being given to the highest price paid for a part or a majority of the production of minerals of like quality produced from the same general area, the price received by the lessee, posted prices, and other relevant matters. A royalty rate will be established for each mineral or group of minerals following discovery and prior to mining.

(c) *Rentals.* To pay to the lessor annually in advance, beginning with the date of this lease, rental of $1.00 for each acre, or fraction thereof, for each lease year until production commences, the rental payment for the year in which production commences to be credited on royalties that accrue during that lease year.

(d) *Minimum royalty.* If there is no production or if royalties under subsection (b) of this section total less than $1.00 per acre in any lease year, to pay the lessor a sum equal to the difference between such royalties and $ 1.00 per acre such minimum royalty obligation to become effective the first lease year commencing after production begins, and to be payable within 30 days following the end of the lease year for which due. Lessor may, in its discretion, suspend the minimum royalty requirement when production is interrupted or suspended as provided in subsection (a) in accordance with regulation 43 CFR 3222.6-2.

(e) *Bond.* To furnish and maintain a bond in the sum of $10,000.00 conditioned upon compliance with the terms and conditions of this lease, and to increase the amount thereof or furnish such other bond as may be required.

(f) *Statement.* To furnish for each month or such other period as may be designated by the Regional Mining Supervisor of the United States Geological Survey statements in detail, in such form as may be prescribed by him, of the amount and value of output from the leasehold during such period for use in determining royalties, such statements to be furnished within 30 days from the close of the month or period so designated. Falsification of such statements shall be grounds for cancellation of the lease.

(g) *Inspection.* To permit at all reasonable times: (1) inspection by any authorized officer of the leased premises and all surface and underground improvements,

works, machinery, equipment, and all books and records pertaining to operations and surveys or investigations under this lease; and (2) the lessor to make copies of and extracts from any or all books and records pertaining to operations under this lease.

(h) *Maps--Reports.* To furnish, in *duplicate*, to the Regional Mining Supervisor, at such times as he may require, a plat in the manner and form prescribed by him showing prospecting and development work and improvements on the lease land and other related information, with a report as to all buildings, structures and other works or equipment, situated elsewhere and owned or operated in conjunction with, or as a part of the operations conducted hereunder.

(i) To comply with all regulations of the Secretary of the Interior or the Secretary of Agriculture as to the lands herein described which are under his jurisdiction; and to conduct operations in an orderly manner and in accordance with regulations 30 CFR, Part 231 and the applicable Federal and State laws; and to exercise reasonable diligence, skill, and care in the operation of the property; and to carry on all operations in accordance with approved methods and practices, having due regard for the prevention of damage to mineral deposits, water horizons and property, injury to life and health, and economic waste.

(j) *Taxes* To pay when due all taxes lawfully assessed and levied under the laws of the State or the United States upon improvements, output of mines, and other rights, property, and assets of the lessee.

(k) *Deliver premises.* To deliver up to the lessor in good order and condition and subject to the provisions in Section 9 hereof on the termination of this lease as a result of forfeiture thereof the lands covered thereby, including all underground timbering and such other supports and structures as are necessary for the preservation of the mine.

(l) *Assignment.* Not to assign this lease, or any interest therein, whether by direct assignment, operating agreement, working or royalty interest, or otherwise, nor sublet any portion of the leased premises, except with the approval, in writing, of the lessor. All such assignments or subleases must be submitted in *triplicate* within 90 days from the date of execution and must contain all of the terms and conditions agreed upon by the parties thereto. Not to create overriding royalties in excess of those authorized by regulation 43 CFR 3226.1. 5%

An assignment of all or part of the record title to a portion of the acreage in the lease shall separate the lease into separate leaseholds and the terms hereof shall apply separately to the segregated portions. Advance annual rental payments, if previously terminated, shall be resumed as to an undeveloped segregated portion on the next anniversary date of the lease; the minimum royalty payment herein specified shall apply separately to the segregated portions and the time allowed within which to commence operations on an undeveloped segregated portion shall be such reasonable period as shall be prescribed by the lessor at the time the assignment is approved.

(m) *Equal Opportunity clause.* During the performance of this contract the lessee agrees as follows:

(1) The lessee will not discriminate against any employee or applicant for employment because of race, creed, color, or national origin. The lessee will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, creed, color, or national origin. Such action shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The lessee agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the contracting officer setting forth the provisions of this nondiscrimination clause.

(2) The lessee will, in all solicitations or advertisements for employees placed by or on behalf of the lessee, state that all qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

(3) The lessee will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the agency contracting officer, advising the labor union or workers' representative of the lessee's commitments under Section 202 of Executive Order No. 11246 of September 24, 1965, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(4) The lessee will comply with all provisions of Executive Order No. 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(5) The lessee will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(6) In the event of the lessee's noncompliance with the nondiscrimination clauses of this contract or with any of such rules, regulations, or orders, this contract may be cancelled, terminated or suspended in whole or in part and the lessee may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order No. 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(7) The lessee will include the provisions of Paragraphs (1) through (7) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The lessee will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions including sanctions for noncompliance: *Provided, however,* That in the event the lessee becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the lessee may request the United States to enter into such litigation to protect the interests of the United States.

(n) *Payments.* Rentals under this lease shall be paid to the Manager of the proper Land Office, *except* that when this lease becomes productive the rentals and royalties shall be paid to the Regional Mining Supervisor of the United States Geological Survey, with whom all reports concerning operations under the lease shall be filed. All remittances to the Bureau of Land Management shall be made payable to the Bureau of Land Management, those to the Geological Survey shall be made payable to the United States Geological Survey. The failure to pay rental on or before the anniversary date shall automatically terminate the lease. However, if the time for payment falls on a day in which the proper office to receive payment is closed, payment shall be deemed timely if made on the next official working day.

Sec. 3. Lessee further agrees:

(a) *Protection of property.* To conduct all operations hereunder with due regard for good land manage-

ment, not to cut or destroy timber without previous permission from the authorized officer and to pay for such timber at rates prescribed by him, to avoid damage to improvements, timber, crops, or other cover; unless otherwise authorized by the authorized officer, not drill any well, carry on operations, make excavations, construct tunnels, drill, or otherwise disturb the surface of the lands within 200 feet of any building thereon and whenever required, in writing, by the authorized officer, and upon any partial or total relinquishment, cancellation, or termination of this lease as to that portion of the land to which his rights have terminated, to fence or fill all sump holes, ditches, and other excavations, remove or cover all debris, and so far as reasonably possible, reseed or otherwise restore the surface of the lands to their former condition, or to a productive or other condition satisfactory to the authorized officer, including the removal of structures as and if required, and when required by such officer to bury all pipelines below plow depth.

(b) *Fire precautions.* To do all in his power to prevent and suppress fires on the land and vicinity, and to require his employees, contractors, and subcontractors to do likewise. Unless prevented by circumstances over which he has no control, to place his employees, contractors, and subcontractors at the disposal of the authorized officer for the purpose of fighting fires on or originating on the land or on adjacent areas or caused by the negligence of the lessee or his employees, contractors, and subcontractors, with the understanding that payment for such services shall be made at rates to be determined by such authorized officer but not less than the current rates of pay prevailing in the vicinity for services of a similar character: *Provided, that* if the lessee, his employees, contractors, or subcontractors, or employees of any of them, caused or could have prevented the origin or spread of said fire or fires, no payment shall be made for services so rendered. During periods of serious fire danger, as may be specified by the authorized officer, the lessee shall prohibit smoking and the building of camp and lunch fires by his employees, contractors, and subcontractors, within the leased area *except* at established camps, and shall enforce this prohibition by all means within his power: *Provided, that* the authorized officer may designate safe places where, after all inflammable material has been cleared away, campfires may be built for the purpose of heating lunches and where, at the option of the lessee, smoking may be permitted; *Provided further, that* when in the judgment of the authorized officer the fire danger is of such serious nature that fires may result from the operation, the lessee will close down operations upon request of such officer for the period of such emergency. The lessee will not burn rubbish, trash, or other inflammable materials *except* with the consent of the authorized officer and shall not use explosives during the fire season *except* as authorized to do so or on areas approved by such officer. The lessee shall build or construct such fire lines or do such clearing on the land as the authorized officer decides is essential for forest, brush, and grass fire prevention which is or may be necessitated by the exercise of the privileges authorized by this lease, and shall maintain such fire tools at his headquarters or at the appropriate location on the land as are deemed necessary by such officer.

(c) *Approval of construction.* Not to clear or use the land for development or for construction purposes of any kind until a plan of construction and development therefor has been approved by the authorized officer and that in the location, design, construction, and maintenance of all authorized works, camps, buildings, plants, waterways, roads, telegraph or telephone lines, pipelines, reservoirs, tanks, pumping stations, or other structures or clearances, lessee shall do all things reasonably necessary to prevent or reduce scarring and erosion of the land, pollution of the water resources and any damage to the watershed.

(d) *Damage to property.* To pay the lessor or its tenant, as the case may be, for any and all damage to or destruction of property caused by the lessee's operations hereunder; to save and hold the lessor or the surface owner or their tenants harmless from all damage or claims for damage to persons or property resulting from the lessee's operations under this lease; and where the surface of the leased land is owned by other than the lessor, to pay such owner, or his tenants, as the case may be, for damage or injury to livestock, crops, trees, pipelines, buildings, and other improvements on the leased lands. That where construction, operation, or maintenance of any of the facilities on or connected with this lease causes damage to the watershed or pollution of the water resources, to repair such damage and take such corrective measures as are required by the authorized officer, including the reseeding or other restoration of the vegetative cover.

(e) *Protection of livestock; access to leased lands.* To install and maintain cattle guards to prevent the passage of livestock in any openings made in fences by the lessee, his contractors, or subcontractors to provide access to the lands covered by this lease for automotive and other equipment.

(f) *Authorized Officer.* All inquiries relating to this section should be addressed to the authorized officer named in Section 1(b) of this lease.

Sec. 4. *Lessee—agent.* Prior to the beginning of operations, the lessee shall appoint and maintain at all times during the term of this lease a local agent upon whom may be served written orders or notices respecting matters contained in this lease, and shall inform the authorized officer and the Regional Mining Supervisor of the United States Geological Survey, in writing, of the name and address of such agent. If a substitute agent is appointed, the lessee shall immediately so inform the said officers.

Sec. 5. The lessor expressly reserves:

(a) *Rights reserved.* The right to permit for joint or several use easements or rights-of-way, including easements in tunnels upon, through, or in the land leased, occupied, or used as may be necessary or appropriate to the working of the same or other lands, and the preparation and shipment of the products thereof by or under authority of the Government, its lessees or permittees, and for other public purposes.

(b) *Monopoly and fair prices.* Full power and authority to promulgate and enforce all orders necessary to insure the sale of the production of the leased lands to the United States and to the public at reasonable prices, to protect the interest of the United States, to prevent monopoly, and to safeguard the public welfare.

(c) *Renewal terms.* The right to reasonably readjust and fix royalties payable hereunder at the end of the primary term of this lease and thereafter at the end of each successive renewal thereof unless otherwise provided by law at the time of the expiration of any such period, and to readjust other terms and conditions of the lease, including the revision of or imposition of stipulations for the protection of the surface of the land as may be required by the agency having jurisdiction thereover.

(d) *Waiver of conditions.* The right to waive any breach of the covenants and conditions contained herein, but any such waiver shall extend only to the particular breach so waived and shall not limit the rights of the lessor with respect to any future breach; nor shall the waiver of a particular cause of forfeiture prevent cancellation of this lease for any other cause, or for the same cause occurring at another time.

Sec. 6. It is mutually agreed:

(a) *Mining methods.* That this lease does not authorize the mining or removal of the mineral deposits by stripping, rim cutting, or open pit methods without

the prior written approval of the authorized officer and on such conditions as he may prescribe.

(b) *Reduction or smelting of ores.* That the reduction or smelting of ores on the leased land is expressly prohibited in the absence of an agreement between the lessee and the authorized officer authorizing such use of the surface of the land and providing for the necessary protection of life and property. Such agreement shall contain all of the terms and conditions under which the reduction or smelting of ores may be carried on and any violation of that agreement shall be considered a violation of the terms of this lease for the purpose of Section 9.

(c) *Uses and disposition of surface.* That the leased land shall be subject at all times to any other lawful uses or sale by the United States, its lessees, permittees, licensees, and assigns; *provided that* such uses or sale shall not prevent, obstruct, or unduly interfere with any privilege granted under this lease: *Provided, that* the lessee shall recognize existing uses and commitments in the form of grazing, timber cutting, and special use permits, water developments, ditch, road, trail, pipeline, telephone and telegraph lines, fences, rights-of-way, and other similar improvements, and to conduct his operations so as to interfere as little as possible with the rights and privileges granted by these permits or with other existing uses.

(d) *Granting leases for other minerals.* That the granting of this lease will not preclude the issuance of other leases of the same land for the purpose of mining and extracting oil, gas, oil shale, coal, phosphate, potassium, sodium, and sulphur.

Sec. 7. *Relinquishment of lease.* The lessee may surrender this lease or any legal subdivision thereof. If the lands are not described by legal subdivision, a partial relinquishment must describe definitely the lands surrendered and give the exact area thereof. A relinquishment must be filed in *triplicate* in the proper Land Office. Upon its acceptance, it will be effective as of the date it filed, subject to the continued obligation of the lessee and his surety to make payment of all accrued rentals and royalties, and to provide for the preservation of any mines or productive works or permanent improvements on the lands in accordance with the regulations and terms of the lease, and for the faithful compliance of all the terms of the lease.

Sec. 8. *Removal of equipment, etc., on termination of lease.* On termination of this lease, by surrender, forfeiture, or otherwise, the lessee shall have the privilege at any time within a period of 90 days thereafter of removing from the premises all machinery, equipment, tools, and materials, other than underground timbering placed by the lessee in or on the leased lands, which are not necessary for the preservation of the mine. Any materials, tools, appliances, machinery, structures, and equipment, subject to removal as above provided, which are allowed to remain on the leased land shall become the property of the lessor on expiration of the 90-day period or such extension thereof as may be granted by the lessor, but the lessee shall remove any or all of such property when so directed by the lessor.

Sec. 9. *Proceedings in case of default.* If the lessee does not comply with the applicable regulations made a part hereof or the terms of this lease and such default continues for a period of 30 days after service of written notice thereof by the lessor, the lease may be cancelled by the Bureau of Land Management. Furthermore, if the lessee fails to take prompt and necessary steps to prevent loss or damage to the mine, property, or premises, or danger to the employees, the lessor may enter on the premises and take such measures as may be deemed necessary to prevent such loss or damage, or to correct the dangerous or unsafe condition of the mine or works thereof, which shall be at the expense of the lessee, but the lessee shall not be held responsible for delays or casualties occasioned by causes beyond the lessee's control.

Sec. 10. *Heirs and successors-in-interest.* Each obligation hereunder shall extend to and be binding upon, and every benefit hereof shall inure to, the heirs, executors, administrators, successors, or assigns of the respective parties hereto.

Sec. 11. *Unlawful interest.* It is also further agreed that no Member of, or Delegate to, Congress, or Resident Commissioner, after his election or appointment, or either before or after he has qualified and during his continuance in office, and that no officer, agent, or employee of the Department of the Interior, *except* as provided in 43 CFR 7.4(a)(1), shall be admitted to any share or part in this lease or derive any benefit that may arise therefrom; and the provisions of Section 3741 of the Revised Statutes of the United States, (41 U.S.C., Sec. 11) as amended, and Sections 431, 432, and 433, Title 18 U.S.C., relating to contracts, enter into and form a part of this lease so far as the same may be applicable.

Sec. 12. *Special stipulations.*

I, D. O. Churchill, do hereby state and affirm that there is no agreement or understanding either oral or written, between Union Pacific Railroad Company and me, or with any other person, by which I have received or am to receive or by which any other person has received or is to receive any interest of any kind in the within Lease.

D O Churchill
Individually and as Attorney-in-Fact

UNION PACIFIC RAILROAD COMPANY

BY: D O Churchill
Attorney-in-Fact

*RESOLUTION AUTHORIZING THE ATTORNEY IN FACT TO EXECUTE THIS INSTRUMENT IS ON FILE UNDER SERIAL NUMBER WYOMING 018503, AND IS STILL IN EFFECT

R. D. Sigerstrom
ASSISTANT SECRETARY
UNION PACIFIC RAILROAD COMPANY

(Sgd) Daniel Y. Meschter

By _____
(Signing Officer)
Daniel Y. Meschter
Assistant Manager, Mining
(Title)

APR 14 1970
(Date)

If this lease is executed by a corporation, it must bear the corporate seal

GPO 810-027

U.S. GEOLOGICAL SURVEY
RECEIVED
APR 1 ° 1970
BR. OF MINING OPER.
DENVER, COLORADO

922
W-4416

ROYALTY

A royalty rate for the first 5 years of the 20-year lease term shall be a sum equal to six and one-quarter percent (6¼%) of the value of such uranium ore, which value shall be determined as follows:

(a) The value of unprocessed or unbeneficiated uranium ore sold by the applicant shall be the actual net proceeds received by the applicant after deducting the cost, if any, of transporting such uranium ore from the mine to the point of sale.

(b) The value of uranium ore processed or beneficiated by or for the applicant shall be computed by:

(b-1) Ascertaining the value per pound of U_3O_8 contained in ore from the grade of ore according to the following schedules:

Grades of Ore Uranium (U_3O_8) Content	Value Per Pound of U_3O_8 Contained in Ore
0.10 percent or less	$ 1.50
0.11	1.70
0.12	1.90
0.13	2.10
0.14	2.30
0.15	2.50
0.16	2.70
0.17	2.90
0.18	3.10
0.19	3.30
0.20 percent and more	3.50

(Fractional parts of a pound will be valued on a pro rata basis to the nearest cent. All weights will be dry weight.)
And

(b-2) Multiplying the applicable value determined from the foregoing schedule by the fraction X divided by $8, where X is the weighted average net price per pound for U_3O_8 in uranium concentrate (commonly referred to in the uranium industry as "yellow cake") received by applicant for sales of uranium concentrate made by the applicant for sales of uranium concentrate made by the applicant during the calendar month in which such uranium ore is processed or beneficiated, or the fair market value, whichever is greater. If no uranium concentrate is sold by applicant during such calendar month, then X shall be weighted average net price received by the applicant for sales of uranium concentrate during the last previous calendar month in which applicant had such sales of uranium concentrate, excepting that in the event applicant had no sales of uranium concentrate for a period of one year prior to the calendar month in which such ore is processed or beneficiated, then such value shall be the published or fair market price of U_3O_8 in the area of the leased premises.

(c) The royalty for ore, other than uranium ore, shall be a sum equal to six and one-quarter percent (6¼%) of its fair mine value. The fair mine value of such other ore is defined as any and all proceeds paid to applicant by a mill or other purchaser of such other ore less the expense, if any, of transporting such other ore to the mill or place of sale. If such other ore is not sold by applicant prior to beneficiation or processing, but is retained by applicant and is beneficiated or processed in a mill or processing plant owned or controlled by applicant, the fair mine value nevertheless shall be its value in crude, raw form at the mine, prior to such beneficiation, processing, and transportation from the mine, and shall not be less than the current weighted average net price received by other producers in the vicinity of the leased premises for the sale of comparable ore.

A royalty rate beginning with the 6th year of the lease and continuing throughout the remainder of the 20-year lease period shall be paid in accordance with the following royalty schedule:

Mine Value Per Dry Ton	Royalty Percentage of Mine Value Per Dry Ton
$ 0.01 to $ 7.50	2½ %
7.50 to 14.00	5 %
14.00 to 20.01	11 %
20.01 to 30.01	12 %
30.01 to 40.01	13 %
40.01 to 50.01	14 %
50.01 to 60.01	15 %
60.01 to 70.01	16 %
70.01 to 80.01	17 %
80.01 to 90.01	18 %
90.01 to 100.01	19 %
100.01 or more	20 %

"Mine Value Per Dry Ton", wherever used herein is hereby defined as the dollar value per dry ton of crude ores at the mine as paid for by the Atomic Energy Commission or other government authorized agency before allowance for transportation and development; however; if the government at any time hereafter does not establish and pay for said ores on a fixed or scheduled dollar value per dry ton of crude ores at the mine, or said ores contain saleable minerals, some or all, of which are disposed of to a custom treatment plant or smelter for treatment, and sale, then mine value per dry ton shall be the gross value per dry ton of said crude ore as paid for by the Atomic Energy Commission or other government authorized agency mill or other buyer, less any allowances or reimbursements for the following specific items: (1) transportation of ores (2) allowances for exploration for, or development of ores and (3) treatment or beneficiation of ores; which specific items shall in such event be deducted from the gross sales price received from the metal content of said ores by the seller before said percentage royalty is calculated and paid.

UNION PACIFIC RAILROAD COMPANY

By: D D Churchill
SIGNATURE
Attorney-in-Fact

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
State Office
2120 Capitol Avenue
P. O. Box 1828
Cheyenne, Wyoming 82001

In reply refer to

W-4416 (943)

CONSENT OF AMENDMENT OF LEASE

We, the undersigned hereby consent to amendment of lease W-4416 to substitute for the Royalty Provision in the original lease, the following language:

ROYALTY

Royalty shall be a sum equal to a percentage royalty rate applied to the value per dry ton of all ore produced, which percentage and value are defined below.

The royalty rate is 3 percent plus an increase of 0.05 percent for each $1 in value per dry ton, but not less than 6-1/4 percent of the value per dry ton. The royalty rate shall be determined to the nearest one-hundredth (0.00) percent, as expressed by the following formula:

$$\text{Percentage Royalty Rate} = 3.00\% + 0.05\% \left(\frac{\text{Value per dry ton}}{\$1.00}\right)$$

"Value per dry ton," whenever used herein, is hereby defined as the dollar value per dry ton of crude uranium ore, as determined by multiplying the actual weighted average price per pound of U_3O_8 in all concentrates sold by the lessee, or a company processing a lessee's ore, during the period for which royalty is being computed, by the weighted average U_3O_8 content per dry ton of the crude ore produced from the leased permises during that period. If there are no sales of concentrates during the period for which royalty is being computed, then the price per pound of U_3O_8 applied will be the average price received by the lessee or company processing the lessee's ore for the preceding six-month period.

Whenever vanadium and other minerals associated with uranium are recovered and sold by the lessee, the lessee shall pay to the lessor a royalty of ten (10) percent of the gross proceeds derived from such sale; and where the lessee retains possession of the associated mineral products, a separate royalty value will be negotiated.

The lessee agrees to pay to the lessor a royalty of ten (10) percent of the value of uranium recovered from mine waters (whether natural or introduced); from leaching ores in place on the leased lands or from leaching such materials after they have been mined (unless the crude has been weighed and assayed prior to leaching) or extracted from the leased lands; or from leaching the waste material resulting from the treatment of ores from the leased lands. The value or uranium, as used herein, shall be the weighted average price per pound of U_3O_8 in all uranium concentrate, at the processing plant producing such concentrate, during the month for which royalty is being computed, except that if no sales have been made during the month for which royalty is being computed, then the value of uranium shall be the weighted average price per pound of U_3O_8 received by the lessee or the seller of lessee's concentrate during the preceding six (6) months.

In the event there are no sales of concentrates in the preceding six (6) months for which royalty is being computed, or for other undefined circumstance, the Secretary of the Interior may establish reasonable minimum values for the purpose of computing royalty on any of the leased deposites, due consideration being given to the highest price paid for a part or a majority of the production of like quality products from the same general area, the price received by the lessees, posted prices, and other relevant matters.

ROCKY MOUNTAIN ENERGY COMPANY

By James C. Wilson (Signed)

President
(Title)

MONO POWER COMPANY

By M. Swinney (Signed)

Vice-President
(Title)

Form 3103-2
(October 1964)
(formerly 4-216)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

U.S. GEOLOGICAL SURVEY
RECEIVED
APR 1 1970
MINING OPER.
DENVER

W-4416

STIPULATION FOR LANDS UNDER JURISDICTION OF DEPARTMENT OF AGRICULTURE *

The lands embraced in this lease or permit being under the jurisdiction of the Secretary of Agriculture, the lessee or permittee hereby agrees:

(1) To conduct all operations authorized by this lease or permit with due regard for good land management, not to cut or destroy timber without first obtaining permission from the authorized representative of the Secretary of Agriculture, and to pay for all such timber cut or destroyed at the rates prescribed by such representative, to avoid unnecessary damage to improvements, timber, crops, or other cover; unless otherwise authorized by the Secretary of Agriculture, not to drill any , carry on operations, make excavations, construct tunnels, drill, or otherwise disturb the surface of the lands within 200 feet of any building standing on the lands and whenever required, in writing, by the authorized representative of the Secretary of Agriculture to fence or fill all sump holes, ditches, and other excavations, remove or cover all debris, and so far as reasonably possible, restore the surface of the lands to their former condition, including the removal of structures as and if required, and when required by such representative to bury all pipelines below plow depth.

(2) To do all in his power to prevent and suppress forest, brush, or grass fires on the lands and in their vicinity, and to require his employees, contractors, subcontractors, and employees of contractors or subcontractors to do likewise. Unless prevented by circumstances over which he has no control, the lessee or permittee shall place his employees, contractors, subcontractors, and employees of contractors and subcontractors employed on the lands at the disposal of any authorized officer of the Department of Agriculture for the purpose of fighting forest, brush, or grass fires on or originating on the lands or on adjacent areas or caused by the negligence of the lessee or permittee or his employees, contractors, subcontractors and employees of contractors and subcontractors, with the understanding that payment for such services shall be made at rates to be determined by the authorized representative of the Secretary of Agriculture, which rates shall not be less than the current rates of pay prevailing in the vicinity for services of a similar character: *Provided*, that if the lessee or permittee, his employees, contractors, subcontractors, or employees of contractors or subcontractors, caused or could have prevented the origin or spread of said fire or fires, no payment shall be made for services so rendered.

During periods of serious fire danger to forest, brush, or grass, as may be specified by the authorized representative of the Secretary of Agriculture, the lessee or permittee shall prohibit smoking and the building of camp and lunch fires by his employees, contractors, subcontractors, and employees of contractors or subcontractors within the area involved except at established camps, and shall enforce this prohibition by all means within his power. *Provided*, that the authorized representative of the Secretary of Agriculture may designate safe places where, after all inflammable material has been cleared away, campfires may be built for the purpose of heating lunches and where, at the option of the lessee or permittee, smoking may be permitted.

The lessee or permittee shall not burn rubbish, trash, or other inflammable materials *except* with the consent of the authorized representative of the Secretary of Agriculture and shall not use explosives in such a manner as to scatter inflammable materials on the surface of the lands during the forest, brush, or grass fire season, *except* as authorized to do so or on areas approved by such representative.

The lessee or permittee shall build or construct such fire lines or do such clearing on the lands as the authorized representative of the Secretary of Agriculture decides is essential for forest, brush, and grass fire prevention which is or may be necessitated by the

* This form of stipulation may be used in connection with leases and permits issued under the Acts of February 25, 1920, as amended (30 U.S.C. 181 *et seq.*), August 7, 1947 (30 U.S.C. 351 *et seq.*); February 7, 1927, as amended (30 U.S.C. 281 *et seq.*), April 17, 1926, as amended (30 U.S.C. 271 *et seq.*), October 20, 1914, as amended (48 U.S.C. 432 *et seq.*); June 28, 1941 (58 Stat. 483 *et seq.*), September 1, 1949 (30 U.S.C. 192c), June 30, 1950 (16 U.S.C. 508b), or under the authority of any of the Acts cited in Section 402 of the President's Reorganization Plan No. 3 of 1946 (5 U.S.C. 133y-16, Note).

exercise of the privileges authorized by this lease or permit, and shall maintain such fire tools at his headquarters or at the appropriate location on the lands as are deemed necessary by such representative.

(3) In the location, design, construction and maintenance of all authorized works, buildings, plants, waterways, roads, telegraph or telephone lines, pipelines, reservoirs, tanks, pumping stations, or other structures or clearance, the lessee or permittee shall do all things reasonably necessary to prevent or reduce to the fullest extent scarring and erosion of the lands, pollution of the water resources and any damage to the watershed. Where construction, operation, or maintenance of any of the facilities on or connected with this lease or permit causes damage to the watershed or pollution of the water resources, the lessee or permittee agrees to repair such damage and to take such corrective measures to prevent further pollution or damage to the watershed as are deemed necessary by the authorized representative of the Secretary of Agriculture.

(4) To pay the lessor or permitter or his tenant or the surface owner or his tenant, as the case may be, for any and all damage to or destruction of property caused by the lessee's or permittee's operations hereunder; to save and hold the lessor or permitter or the surface owner or their tenants harmless from all damage or claims for damage to persons or property resulting from the lessee's or permittee's operations under this lease or permit.

(5) To recognize existing uses and commitments, in the form of Department of Agriculture grazing, timber cutting, and special use permits, water developments, oil, road, trail, pipeline, telephone line, and fence rights-of-way and other similar improvements, and to conduct his operations so as to interfere as little as possible with the rights and privileges granted by these permits or with other existing uses.

(6) To install and maintain cattle guards to prevent the passage of livestock in any openings made in fences by the lessee or permittee or his contractors to provide access to the lands covered by this lease or permit for automotive and other equipment.

(7) If lessee or permittee shall construct any camp on the lands, such camp shall be located at a place approved by the authorized representative of the Secretary of Agriculture, and such representative shall have authority to require that such camp be kept in a neat and sanitary condition.

(8) To comply with all the rules and regulations of the Secretary of Agriculture governing the national forests or other lands under his jurisdiction which are embraced in this lease or permit.

(9) Unless otherwise authorized, prior to the beginning of operations to appoint and maintain at all times during the term of this lease or permit a local agent upon whom may be served written orders or notices respecting matters contained in this stipulation, and to inform the authorized representative of the Secretary of Agriculture, in writing, of the name and address of such agent. If a substitute agent is appointed, the lessee or permittee shall immediately so inform the said representative.

(10) To address all matters relating to this stipulation
to Forest Supervisor
Medicine Bow National Forest

1948 Grand Avenue
at Laramie, Wyoming 82070

who is the authorized representative of the Secretary of Agriculture, or to such other representative as may from time to time, be designated, provided that such designation shall be in writing and be delivered to the lessee or permittee or his agent.

(11) If all or any part of the lands lie within a municipal watershed, or are, in the opinion of the authorized representative of the Secretary of Agriculture, primarily valuable for watershed protection, the lessee or permittee shall reseed or otherwise restore the vegetative cover, as required by the authorized representative of the Secretary of Agriculture, for watershed protection and erosion prevention on any areas damaged because of the operation.

UNION PACIFIC RAILROAD COMPANY

By: D O Churchill
(Signature of Lessee)
Attorney-in-Fact

GPO 844-022

W-4416

SUPPLEMENTAL STIPULATION TO
STIPULATION FOR LANDS UNDER JURISDICTION OF DEPARTMENT OF AGRICULTURE

To be attached to and made a part of Form 3103-2.

A. Applicable to Exploration Activities

1. At least two weeks before beginning any exploration work, including access and work road location and construction, the permittee shall prepare a "Permittee Exploration Plan" with the District Ranger, Douglas, Wyoming. The plan shall be prepared in triplicate, including maps, for approval by the Forest Supervisor. Such approval will be conditioned on reasonable requirements needed to prevent soil erosion, water pollution, and unnecessary damages to the surface vegetation and other resources of the United States and to provide for the restoration of the land surface and vegetation. The plan shall contain all such provisions as the Forest Service may deem necessary to maintain proper management of the lands and resources within the exploration area.

   Where appropriate, depending upon the location and type of operation, the Forest Supervisor may require the plan to contain, at a minimum, the following items:

   a. The location, construction specifications, maintenance program and estimated use by the permittee, his employees, and agents, of all access and work roads.

   b. The exact location and extent of any and all areas to be occupied during the operations.

   c. The methods to be used in the operations, including disposal of waste material.

   d. The size and type of equipment to be used in the operation.

   e. The capacity, size, character, standards of construction and location of all structures and facilities to be constructed.

   f. Typical profiles of cuts and fills of all areas to be graded for the installation of structures and facilities.

   g. The location and size of areas upon which vegetation will be destroyed and/or soil laid bare and the steps which will be taken to prevent and control soil erosion thereon, including but not limited to the proposed program for rehabilitation and revegetation of these disturbed lands both during and upon cessation of operations.

   h. The steps which will be taken to prevent water pollution.

i. The character, amount, and time of use of explosives or fire, including safety precautions which will be taken during their use.

j. Forest user, permitted livestock, and wildlife protection.

If later explorations require departure from or additions to the approved plan, these revisions or amendments, together with justification statement for proposed revisions, will be submitted to the District Ranger for approval by the Forest Supervisor.

Any and all operations conducted in advance of approval of an original, revised, or amended exploration plan, or which are not in accord with an approved plan constitute a violation of the terms of this permit and the Forest Service reserves the right to close down explorations until such corrective action, as is deemed necessary, is taken by the permittee.

2. To guarantee the successful rehabilitation and revegetation of abandoned exploration sites, roads and other disturbed areas, as provided for in the "Permittee Exploration Plan", paragraph 1 above, the permittee will furnish the Forest Service a surety bond in the amount of $10,000 prior to undertaking any work on the permit area. Provided that, in the event the work is conducted in separate phases, each phase will be covered by a separate bond in the minimum amount of $10,000 before the start of any work on each phase. In lieu of surety bond, the permittee may deposit into a Federal Depository cash, through the Unit Collection Officer, ~~Pike National Forest~~,* or negotiable securities through the Regional Fiscal Agent, U. S. Forest Service, Bldg. 65 of Denver Federal Center, Denver, Colorado 80225 in the amounts stated above or each separately bonded phase area. As soon as the permit area has been successfully rehabilitated and revegetated and approved in writing by the Forest Supervisor, surety will be notified, or cash deposits returned without interest, or securities returned without interest. The permittee agrees that all monies or deposits in lieu thereof, deposited under this authority may be retained by the United States to cover the cost of any said restoration and rehabilitation rendered necessary by failure of the permittee to fulfill all and singular the requirements assumed hereunder without prejudice whatever to any other rights and remedies of the United States.

3. No occupancy of the surface of the following areas is authorized by this permit. The permittee is, however, authorized to employ directional drilling to explore the mineral resources under these areas provided that such drilling or other works will not disturb the surface area or otherwise interfere with their use by the Forest Service. It is understood and agreed that the use of these areas

*Should be Medicine Bow National Forest so informs Mr. Dale Gallagher by telephone. 6/12/67 AL

for National Forest purposes is superior to any other use. The excluded areas are:

a. Within 500 feet on either side of the centerline of any and all roads and/or highways within the permit area.

b. Within 200 feet on either side of the centerline of any and all trails within the permit area.

c. Within 500 feet of the normal highwater line of any and all lakes, ponds, and reservoirs located within the permit area.

d. Within 500 feet of the normal highwater line of any and all live streams in the area.

The distances in subparagraphs a, b, c, and d immediately above may be reduced when specifically agreed to in the operating plan, see paragraph 1.

e. Within 400 feet of any and all springs within the permit area.

f. Within 400 feet of any improvements either owned, permitted, leased or otherwise authorized by the Forest Service.

4. In the event of a Preference Right Lease is granted the Permittee as a result of this permit, the Forest Service reserves the right to make such reasonable stipulations as may be necessary to protect the resources of the United States.

UNION PACIFIC RAILROAD COMPANY

By: /S./ D. O. Churchill
SIGNATURE
Attorney-in-Fact

APPENDIX D. SOILS DATA

APPENDIX D-1 ESTIMATED POTENTIAL YIELDS

Table D-1.1. Estimated Potential Yields - Crops
Table D-1.2. Estimated Potential Forage Yields - Native Range

APPENDIX D-2 SOILS MAPS OF MINING AREAS

Figure D-2.1. Soils Map of Mine Area I
Figure D-2.2. Soils Map of Mine Area II
Figure D-2.3. Soils Map of Mine Area III

APPENDIX D-3 SOILS MAPPING UNITS

Descriptions of Soils Mapping Units of the Project Area

APPENDIX D-4 ESTIMATED YIELDS AND RANGE SITE IDENTIFICATIONS

Table D-4.1(a). Estimated Optimum Yields of Nonirrigated Crops
Table D-4.1(b). Estimated Optimum Yields of Irrigated Crops
Table D-4.2. USDA - Soil Conservation Service Descriptions of Range Sites Identified within the Project Area
Inclusion 1. Range Site: Subirrigated (Sb) 10-14 Inches, Northern Plains
Inclusion 2. Range Site: Saline Subirrigated (SS) 10-14 Inches, Northern Plains
Inclusion 3. Range Site: Lowland (LL) 10-14 Inches, Northern Plains
Inclusion 4. Range Site: Sandy (Sy) 10-14 Inches, Northern Plains
Inclusion 5. Range Site: Loamy (Ly) 10-14 Inches, Northern Plains
Inclusion 6. Range Site: Clayey (Cy) 10-14 Inches, Northern Plains
Inclusion 7. Range Site: Steep Loamy (Sly) 10-14 Inches, Northern Plains
Inclusion 8. Range Site: Shallow Sandy (SwSy) 10-14 Inches, Northern Plains
Inclusion 9. Range Site: Shallow Loamy (SwLy) 10-14 Inches, Northern Plains
Inclusion 10. Climate Description for Range Sites

APPENDIX D-5 IRRIGATION FEASIBILITY STUDY

APPENDIX D-1. ESTIMATED POTENTIAL YIELDS

Table D-1.1. Estimated Potential Yield--Crops[a]

Soil Mapping Unit	Soil Capability Class[b]	Wheat, bu/ac	Oats, bu/ac	Barley, bu/ac	Hay (grass) tons/ac	Pasture (tame) tons/ac	Irrigated Alfalfa Hay tons/ac	Irrigated Pasture, AUMs
Irrigated								
Units 1 and 3 0-6% slopes; Units 4, 6, 9, 10, 35, 158, 163, 179, 331, 336, 337, 341, 351, 354, 380, 384	IIIe	-	70-80	55-65	2-3	-	3.0-4.5	5-7
Units 158c, 177, 322, 330c, 336c, 380c, 384c; 0-6% slopes Unit 1; 6-15% slopes Units 4, 6	IVe	-	50-70	40-55	1.0-2.5	-	1.5-4.0	3-6
Nonirrigated								
One-half of Units 1, 3, 4, 6, and 351; all of Units 9, 10, 35, 158, 163, 177, 179, 331, 336, 337, 341, 354, 380 and 384	IVe	15-25	20-35	15-30	0.5-0.75	0.5-0.75	-	-
One-half of Units 1, 3, 4, 6, 351, 404 and 405d; all of Units 7, 158c, 177c, 321c, 322, 330c, 332c, 336c, 380c, 384c	VIe	Not Applicable						
All of Unit 56	VIs							
One-half of Units 404 and 405d; all of Units 2, 8, 80, 400, 401, 402c and 409	VIIe							
All of Unit 5	VIIIe							

Information sources:
1. Dames & Moore
2. USDA, Soil Conservation Service, Technical Guides, Wyoming, Section VB

[a]All yield estimates are based on complete treatment and no adverse crop conditions. Data format follows USDA-SCS Wyoming Technical Guides, Section VB. For irrigated cases, yields also assume full water supply and proper use of irrigation water.

[b]Classes with ratings V through VIII are not suitable for cultivation.

Table D-1.2. Estimated Potential Forage Yields--Native Range[a]

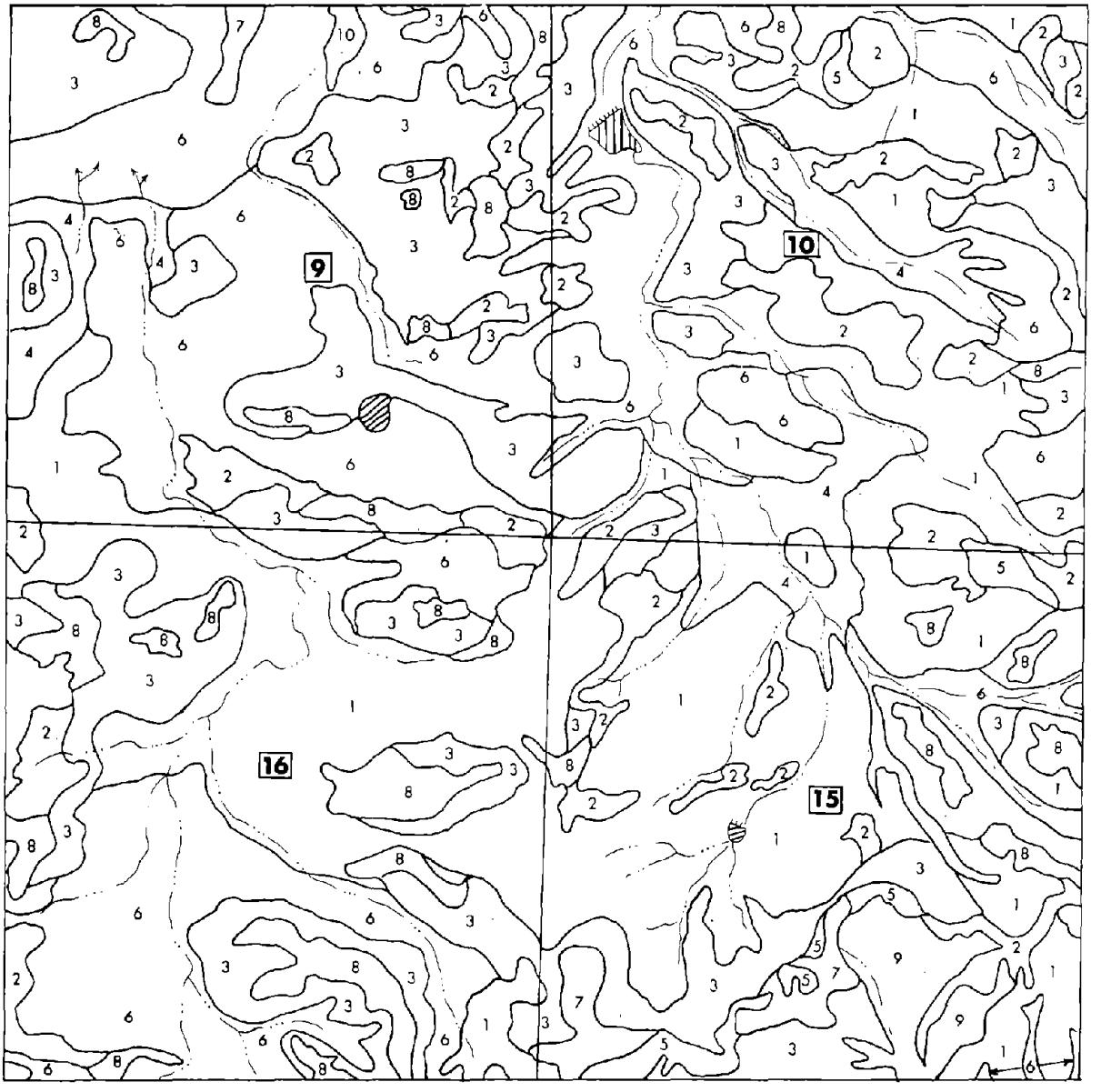
Soil Mapping Unit	Range Site Class, Precipitation 10-14 in.	Range of Annual Yields,[b] lb/ac Air Dry Forage	Average Annual Yield, lb/ac Air Dry Forage
One-half of Units 163, 179, and 321c; all of Units 1 and 35	Clayey	750-1800	1300
All of Unit 80; one-half of Unit 409	Shallow clayey	450-1200	900
All of Unit 56	Saline sub-irrigated	2500-3500	3000
One-half of Units 163, 179, 321c and 332c; all of Units 4,6,9,158,158c, 177,177c,330c,331,336, 336c,337 and 354	Loamy	850-2000	1500
One-half of Units 400, 402c, and 409; all of Units 2,8, and 401	Shallow loamy	450-1200	900
One-half of Units 332c, 351,404 and 405d; all of Units 3,7,322,380, 380c,384 and 384c	Sandy	1000-1200	1600
One-half of Units 402c, 404 and 405d; all of Unit 8	Shallow sandy	600-1400	1000
One-half of Unit 400	Shale	200-500	400
All of Units 10 and 341; one-half of Unit 351	Lowland	2000-3000	2500
All of Unit 5	Not assigned (Rockland)	---	---

Information sources:
1. Dames & Moore
2. USDA, Soil Conservation Service.

[a]Yield estimates are based on range sites in excellent condition. Data format follows USDA-SCS Wyoming Range Site Descriptions.

[b]Based on less favorable to more favorable crop production years.

APPENDIX D-2. SOILS MAPS OF MINING AREAS



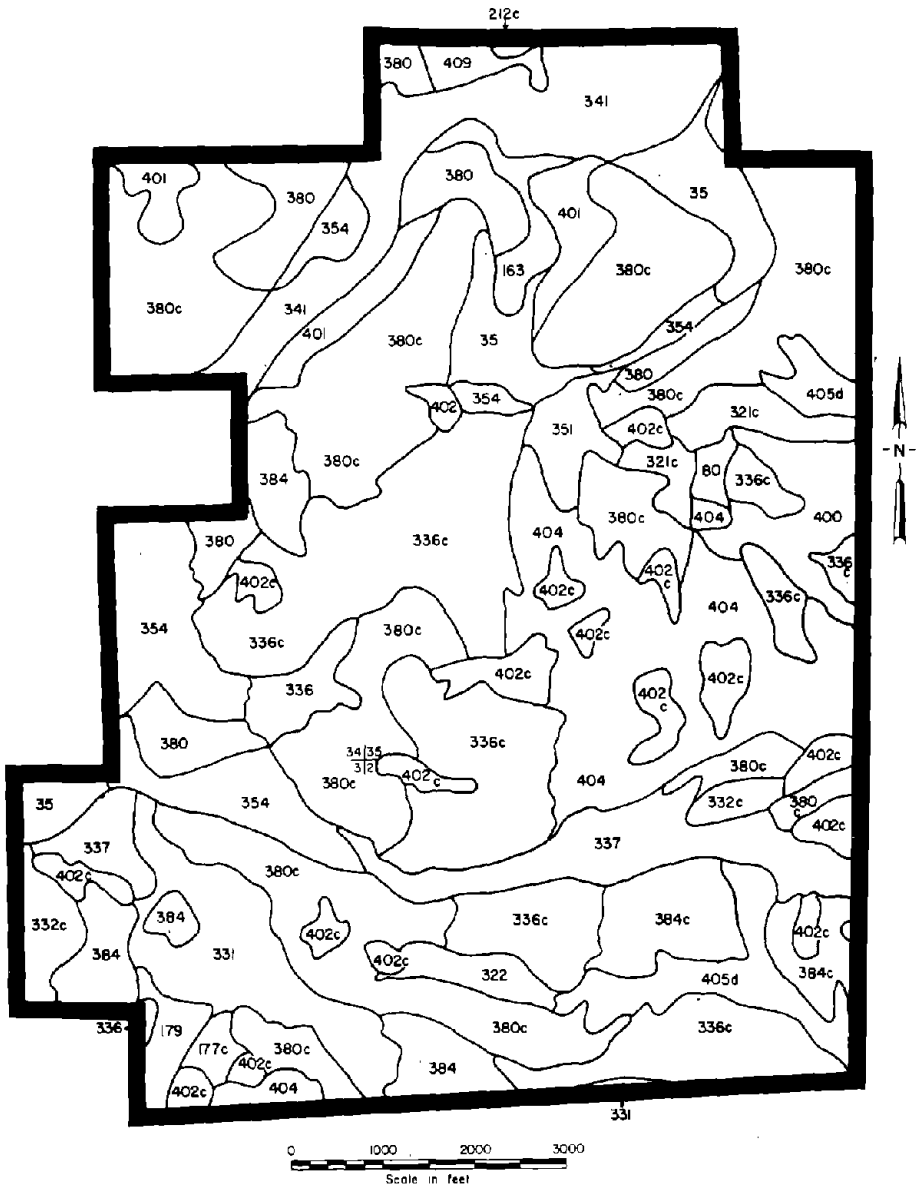
Number	Name
1	Renohill-Ulm-Workfa Association
2	Shingle-Samsil-Outcrops Association
3	Olney-Pugsley-Worf Association
4	Bidman-Briggsdale Association
5	Shale and Sandstone Outcrops and Associated Shallow Soils
6	Fort Collins-Cushman Association
7	Terry-Vona-Otero Association

Number	Name
8	Tassel-Nelson-Rock Outcrops Association
9	Kim-Thedalund-Limon-Shingle Association
10	Haverson-Kim-Thedalund Association
	Soil Boundaries
	Intermittent Pond
	Intermittent Stream

N

Scale: 1 inch = 1000 feet

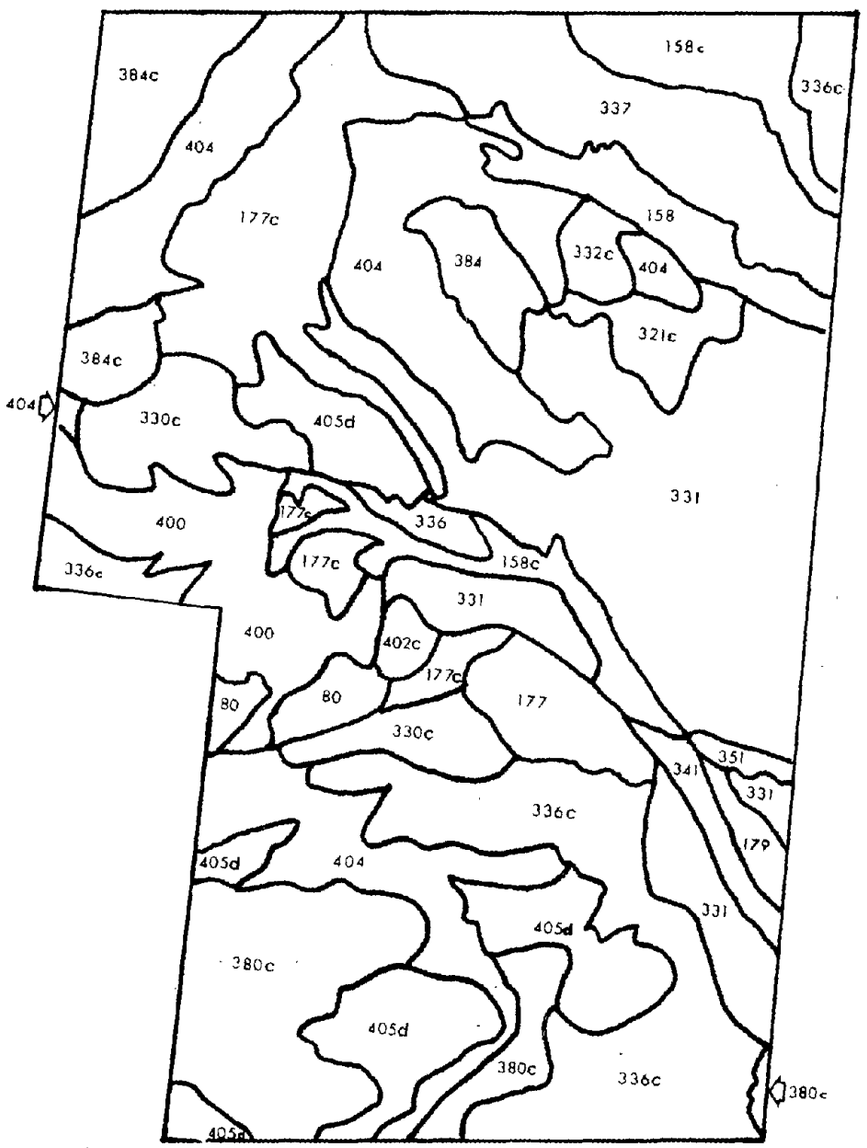
Fig. D-2.1. Soils Map of Mine Area I.



Number	Name
35	Limon clay loam
56	Aeric Haplaquents
80	Samsil clay
163	Kim-Limon Association
177c	Thedalund-Kim Association
179	Ulm-Renohill Association
321c	Cushman-Renohill Association
322	Terry-Tullock Association
321	Fort Collins-Ulm Association
322c	Cushman-Terry Association
336 336c	Fort Collins-Cushman Association

Number	Name
337	Fort Collins-Stoneham Association
351	Ustic Torrifluvents, Sandy-Ustic Torripsamments Association
354	Ulm-Bidman Association
380 380c	Olney-Bowbac Association
384 384c	Olney-Vona Association
400	Shingle-Samsil-Gullied Land Complex
401	Worf-Shingle-Tassel Complex
402c	Shingle-Lesset-Tassel Complex
404	Tassel-Tullock-Vona Association
405d	Tassel-Terry-Rockland Association
409	Samsil-Shingle-Worf Complex

Fig. D-2.2. Soils Map of Mine Area II.



Number	Name
80	Samsil Clay
158, 158c	Kim-Stoneham Association
177, 177c	Thedalund-Kim Association
179	Ulm-Renohill Association
321c	Cushman-Renohill Association
330c	Fort Collins-Thedalund Association
321c	Cushman-Renohill Association
332c	Cushman-Terry Association
336, 336c	Fort Collins-Cushman Association
337	Fort Collins-Stoneham Association

Number	Name
341	Ustic Torrifluvents, fine-loamy
351	Ustic Torrifluvents, Sandy-Ustic Torripsamments Association
380, 380c	Olney Bowbac Association
384, 384c	Olney-Vona Association
400	Shingle-Samsill-Gullied Land Complex
402c	Shingle-Lesset-Tassel Complex
404	Tassel-Tullock-Vona Association
405d	Tassel-Terry-Rockland Association

Scale: 1 inch = 1000 feet

Fig. D-2.3. Soils Map of Mine Area III.

APPENDIX D-3. GENERAL DESCRIPTIONS OF SOIL MAPPING UNITS OF THE BEAR CREEK PROJECT AREA

Unit 1. Renohill-Ulm-Worfka Association

The soils of this association occur on gently sloping to moderately sloping upland hills and fans. These soils are well developed with medium to moderately fine textured subsoils (more than 35% clay). The Renohill and Ulm soils include distinct horizons of secondary calcium carbonate. The Worfka soils are noncalcareous and lack secondary carbonates. The moderately deep Renohill and Worfka soils are underlain by soft, sedimentary bedrock at depths of 20 to 40 inches (51-102 cm). Ulm soils extend more than 40 inches to sedimentary bedrock. This unit consists of 60% Renohill, 35% Ulm and 5% Worfka soils, and occurs on 736 acres (298 ha) (14.4%) of the project area.

Unit 2. Shingle-Samsil-Outcrop Association

The Shingle-Samsil-Outcrop association occurs on moderately steep to steeply sloping hills, ridgetops or valley margins. The soils are well to excessively drained and medium to fine textured. Soft, sedimentary bedrock occurs at depths of less than 20 inches. The Shingle soils are less than 35% clay; the Samsil soils, more than 35% clay. The Shingle and Samsil soils are calcareous at or near the surface. The unit is comprised of 75% Shingle and 20% Samsil soils, and 5% rock outcrops. About 225 acres (91 ha) (4.4%) of the project area are occupied by this association.

Unit 3. Olney-Pugsley-Worf Association

The association occurs on upland sideslopes, alluvial fans and valley filling sideslopes. The soils are well drained, medium to moderately fine textured and well developed. The Olney soils are more than 40 inches deep and include distinct horizons of secondary calcium carbonates. The Pugsley soils are 20 to 40 inches in depth, noncalcareous and underlain by sedimentary bedrock. Worf soils are shallow (less than 20 inches) with distinct horizons of secondary calcium carbonates and rest on soft, sedimentary bedrock. This association occurs on 597 acres (242 ha) (11.7%) of the project area and consists of 65% Olney, 30% Pugsley and 5% Worf soils.

Unit 4. Bidman-Briggsdale Association

The association consists of slowly drained, fine textured soils occurring on upland flats, drainageways and gently sloping fans. Surface horizons are medium textured and abruptly unconformable with fine textured, well developed subsoils. Distinct horizons of secondary calcium carbonate occur in the lower parts of the soil profiles. The moderately deep Briggsdale soils rest on soft, sedimentary bedrock at 20 to 40 inches. The Bidman soils are greater than 40 inches in depth to bedrock. This association consists of 65% Bidman and 35% Briggsdale soils, and occurs on about 108 acres (44 ha) (2.1%) of the project area.

Unit 5. Shale and Sandstone Outcrops and Associated Shallow Soils

This mapping unit is a landtype rather than a soil unit. It is used to delineate areas of bare, or nearly bare outcrops of soft, sedimentary bedrock and occurs along escarpment-like breaks or actively eroding steep upland slopes. This association consists of 95% rock outcrops and 5% shallow soils (less than 20 inches to bedrock), and occupies about 31 acres (13 ha) (0.6%) of the project area.

Unit 6. Fort Collins-Cushman Association

This association occurs on gently to moderately sloping hills, alluvial fans, terraces and valley sideslopes. The soils are well drained, medium to moderately fine textured, and moderately deep to deep. Distinct horizons of secondary calcium carbonate are present in the lower portions of the soil profile. These soils are less sandy than those of the Olney-Pugsley-Worf association.

The moderately deep Cushman soils are underlain by soft sandstone at 20 to 40 inches. The Fort Collins soils are deeper than 40 inches to bedrock. This unit is 75% Fort Collins and 25% Cushman soils and occurs on about 574 acres (232 ha) (11.2%) of the project area.

Unit 7. Terry-Vona-Otero Association

Major soils of this association are moderately deep to deep, well to excessively drained and moderately coarse textured, and occur on sloping uplands hills, ridges, alluvial fans and stream terraces. These are sandy soils with low moisture holding capacities. The moderately deep Terry soils are underlain by soft sandstone at 20 to 40 inches. The Otero and Vona soils are deeper than 40 inches to bedrock. The association is comprised of 65% Terry, 15% Otero, 15% Vona, and 5% Tassel soils. The Tassel soils are shallow and less than 20 inches to bedrock. Occurrence of the association is limited to about 37 acres (15 ha) (0.7%) of the project area.

Unit 8. Tassel-Nelson-Rock Outcrops

The soils in this unit occur on moderately to steeply sloping hills, ridges or valley sideslopes, and are characterized as shallow to moderately deep, moderately coarse textured and calcareous. The shallow Tassel soils are underlain by soft sandstone bedrock at depths of 10 to 20 inches. The bedrock contains lenses and concretionary boulders of resistant sandstone which are 2 to 6 feet (0.6-1.8 m) in diameter. Substrata of Nelson soils are similar but the depth to bedrock ranges from 20 to 40 inches. The association occurs on about 126 acres (51 ha) (2.5%) of the project area and is comprised of 75% Tassel and 10% Nelson soils, the remainder (15%) consisting of rock outcrop.

Unit 9. Kim-Thedalund-Limon-Shingle Association

This unit consists of medium to fine textured, calcareous soils, which commonly occur on alluvial fans below exposures of sedimentary bedrock. The Kim, Thedalund and Shingle soils are less than 35% clay, whereas the Limon soils are more than 35% clay. Bedrock underlying Kim and Limon soils occurs at depths greater than 40 inches. The Thedalund soils overlie bedrock at 20 to 40 inches. The shallow Shingle soils are less than 20 inches to bedrock. About 38 acres (15 ha) (0.7%) of the project area are occupied by this association, which consists of 40% Kim, 40% Thedalund, 15% Limon and 5% Shingle soils.

Unit 10. Haverson-Kim-Thedalund Association

This soil association occurs primarily on broad alluvial flats. The soils are calcareous with medium to moderately fine texture. The Haverson and Kim soils are deeper than 40 inches to bedrock. Thedalund soils are underlain by sedimentary bedrock at 20 to 40 inches. The unit consists of 50% Haverson, 40% Kim, and 10% Thedalund soils, occurring on about 88 acres (36 ha) (1.7%) of the project area.

Unit 35. Limon Clay Loam, 0-6% Slopes

The Limon soils are deep, slowly permeable, and fine textured, and developing on thick, calcareous alluvial fan and valley sediments derived from sedimentary bedrock. The soils are deeper than 40 inches to bedrock and contain more than 35% clay. There are about 44 acres (18 ha) (0.8%) of this unit in the project area.

Unit 56. Aeric Haplaquents

This unit consists of poorly drained, fine to very fine textured and moderately deep to deep soils associated with small playas which occur as small depressions in the landscape. During the spring months, playas are usually filled with water which later disappears due to evaporation and seepage. These soils occur on about four acres (2 ha) (< 0.1%) of the project area.

Unit 80. Samsil Clay, 3-15% Slopes

The Samsil clay is a shallow, well drained and fine textured soil, underlain by calcareous bedrock at depths of 4 to 20 inches. Samsil soils occur on gently sloping to steep hill crests, shoulders and sideslopes. The soil is slowly permeable and contains more than 35% clay. This unit includes small areas of Shingle clay loam, and occurs on about 21 acres (9 ha) (0.4%) of the project area.

Unit 158. Kim-Stoneham Association, 0-6% Slopes

This association occurs on nearly level to undulating soils on toeslopes and footslopes. The soils are moderately permeable and well drained loams to clay loams which are deeper than 40 inches to bedrock. This unit includes about 60% Kim clay loam and 30% Stoneham loam with 10% inclusion of Fort Collins soils. The unit occupies about 28 acres (11 ha) (0.5%) of the project area.

Unit 158C. Kim-Stoneham Association, 6-15% Slopes

This association occurs on footslopes, and soils are somewhat similar to those in Unit 158. The major soils are Kim clay loams (50%) and Stoneham loams (35%). Shallow Shingle soils and moderately deep Thedalund soils comprise about 15% of the unit. The association occurs on about 61 acres (25 ha) (1.2%) of the project area.

Unit 163. Kim-Limon, 0-6% Slopes

This association occurs on nearly level to gently sloping alluvial fans and toeslopes. This association is about 60 percent Kim clay loam, 30 percent Limon clay loam and inclusions of Stoneham and Ulm soils. The Kim and Limon soils are deep, well drained, and formed in calcareous materials derived from shale.

Unit 177. Thedalund-Kim Association, 3-6% Slopes

The association occurs on gently rolling footslopes and toeslopes. Thedalund loam usually occurs on the footslopes and is underlain by bedrock at depths of 20 to 40 inches. The Kim clay loam usually occurs on toeslopes and is deeper than 40 inches to bedrock. The soils have formed in calcareous materials derived from shales. Major soils are Thedalund loams (55%) and Kim clay loams (35%). Cushman and Fort Collins loams are minor soils (10%) of the total unit, which occurs on about 21 acres (9 ha) (0.4%) of the project area.

Unit 177C. Thedalund-Kim Association, 6-15% Slopes

Occurring on upland ridges and sideslopes, these soils are similar to those in Unit 177. This unit is comprised of about 50% Thedalund loam and 35% Kim clay loam. The minor soils (15%) consist of Cushman loams and Shingle clay loams. In total, the unit occurs on about 80 acres (32 ha) (1.6%) of the project area.

Unit 179. Ulm-Renohill Association, 0-6% Slopes

Component soils occur on nearly level to undulating toeslopes and footslopes and are characterized by heavy clay loam to clay subsoils of low permeability. The moderately deep Renohill soils are underlain by bedrock at depths of 20 to 40 inches. The Ulm soils are deeper than 40 inches to bedrock. Ulm and Renohill soils have developed in calcareous materials derived from shales. This unit includes about 50% Ulm loam, about 35% Renohill clay loam and minor inclusions (15%) of Bidman and Briggsdale soils. The unit occurs on about 20 acres (8 ha) (0.3%) of the project area.

Unit 321C. Cushman-Renohill Association, 6-15% Slopes

This association consists of soils on rolling hills and sideslopes that are underlain by bedrock at depths of 20 to 40 inches. Cushman subsoils are medium textured and moderately permeable. Similar strata of Renohill soils are fine textured and of low permeability. Cushman and Renohill soils have developed in calcareous, sedimentary bedrock. This unit includes about 50% Cushman and 40% Renohill soils, and occurs on about 41 acres (17 ha) (0.8%) of the project area.

Unit 322. Terry-Tullock Association, 0-6% Slopes

The Terry-Tullock association occurs on nearly level to undulating footslopes of hilly uplands. Terry and Tullock soils are sandy with rapid permeability and underlain by sandstone bedrock at depths of 20 to 40 inches. This unit is comprised of about 45% Terry and 40% Tullock soils with minor inclusions (15%) of Valent, Vona, Olney and Bowbac soils. About 19 acres (8 ha) (0.3%) of project area soils are of this association.

Unit 330C. Fort Collins-Thedalund Association, 6-15% Slopes

This association occurs on upland ridges and sideslopes. The Fort Collins soils are deeper than 40 inches to bedrock. The moderately deep Thedalund soils are underlain by bedrock at 20 to 40 inches. The soils are loam to clay loam in texture, moderately permeable and consist of about 50% Fort Collins and 35% Thedalund soils with minor inclusions (15%) of Shingle and Cushman soils. The association occurs on about 39 acres (16 ha) (0.8%) of the project area.

Unit 331. Fort Collins-Ulm Association, 0-6% Slopes

The soils in this association occur on nearly level to undulating footslopes. Fort Collins soils are of loam to clay loam texture with moderate permeability. Fine textured subsoils of the Ulm series are of slow permeability. Unit soils are deeper than 40 inches to bedrock and include about 50% Fort Collins and 35% Ulm soils with minor inclusions (15%) of Bidman and Stoneham soils. About 252 acres (102 ha) (5.0%) of project area soils are of this type.

Unit 332. Cushman-Terry Association, 6-15% Slopes

The association occurs on upland ridges and sideslopes. The Cushman soils are loam to clay loam in texture and moderately permeable, while Terry soils are sandy and more permeable. The Cushman and Terry soils are underlain by sedimentary bedrock at depths of 20 to 40 inches. This unit includes about 55% Cushman and 30% Terry soils with minor inclusions (15%) of Shingle, Olney and Fort Collins soils. The unit occurs on about 35 acres (14 ha) (0.7%) of the project area.

Unit 336. Fort Collins-Cushman Association, 0-6% Slopes

Occurring on gentle footslopes, these associated soils are loam to clay loam in texture and moderately permeable. The Fort Collins soils are deeper than 40 inches to bedrock, while bedrock occurs at depths of 20 to 40 inches in Cushman soils. Major components of the association are Fort Collins (55%) and Cushman (25%) soils, and Stoneham and Thedalund soils are minor inclusions (20%). About 34 acres (14 ha) (0.7%) of the project area are so classified.

Unit 336C. Fort Collins-Cushman Association, 6-15% Slopes

Occurring on upland ridges and sideslopes, component soils are similar to those in unit 336 although somewhat altered by steeper slopes. This unit includes about 50% Fort Collins and 35% Cushman soils, the remaining 15% consisting of Shingle and Stoneham soils. About 407 acres (165 ha) (8.0%) of the project area are included in this classification unit.

Unit 337. Fort Collins-Stoneham Association, 0-6% Slopes

This association occurs on nearly level to undulating slopes. The soils are deeper than 40 inches to bedrock, loam to clay loam in texture and moderately permeable. This unit is comprised of 50% Fort Collins and 40% Stoneham soils with minor inclusions (10%) of Kim soils. The association occurs on about 141 acres (57 ha) (2.7%) of the project area.

Unit 341. Ustic Torrifluvents, Fine-Loamy, 0-6% Slopes

These soils occur in stream beds and on stream terraces. The soils are deeper than 60 inches to bedrock, usually stratified, and textures range from clay loams to sand. The unit includes small areas of deep sandy soils. About 8 acres (3 ha) (0.1%) of the project area are included in this taxonomic group.

Unit 351. Ustic Torrifluvents-Ustic Torripsamments Association, 0-10% Slopes

This association occurs on stream terraces, valley bottoms and alluvial fans. The typical soils are sandy, rapidly permeable, well to excessively drained and extend deeper than 60 inches (152 cm) to bedrock. The unit also includes about 20% medium textured soils and gullied lands. About 25 acres (10 ha) (0.4%) of the project area are included in this classification unit.

Unit 354. Ulm-Bidman Association, 0-6% Slopes

This unit occurs on nearly level to undulating footslopes. The soils are more than 40 inches to bedrock, with fine textured subsoils of slow permeability. The soils have developed on calcareous

material weathered from shales. The unit consists of about 50% Ulm and 35% Bidman soils with minor inclusions (15%) of Briggsdale, Renohill, Limon and Absted soils. About 104 acres (42 ha) (2%) of the project area are occupied by such soils.

Unit 380. Olney-Bowbac Association, 0-6% Slopes

The soils in this association occur on nearly level to undulating footslopes. The Olney soils are deeper than 40 inches to bedrock, but only 20 to 40 inches for Bowbac soils. Soil textures range from sandy loam to sandy clay loam with moderate permeability. The unit includes 50% Olney and 30% Bowbac soils, with minor inclusions (20%) of Rauzi, Pugsley, Decolney, Fort Collins and Cushman soils; all variously associated on about 43 acres (17 ha) (0.8%) of the project area.

Unit 380C. Olney-Bowbac Association, 6-15% Slopes

The occurrence and character of this association are similar to that of Unit 380, the differentiation is attributed to steeper slopes and is reflected in distributions of component soils. This unit (380C) is comprised of about 40% Olney and 35% Bowbac soils, with inclusions (25%) of some minor soils. These soils are variously distributed on 346 acres (140 ha) (6.8%) of the project area.

Unit 384. Olney-Vona Association, 0-6% Slopes

The soils in this association occur on nearly level to gently sloping alluvial flats and toeslopes. The Olney soils are sandy loam to sandy clay loam in texture and moderately permeable, whereas Vona soils are sandy and rapidly permeable. Both soils are deeper than 40 inches to bedrock. The unit includes about 50% Olney and 35% Vona, with minor inclusions (15%) of Rauzi and Decolney soils. About 112 acres (45 ha) (2.2%) of the project area are included in this unit designation.

Unit 384C. Olney-Vona Association, 6-15% Slopes

The soils of this unit are similar to those in Unit 384, but occur on steeper slopes. Associated soils include about 40% Olney, 30% Vona and 30% minor soils which include Decolney, Rauzi and Bowbac series. The unit includes about 51 acres (21 ha) (1%) of the project area.

Unit 400. Shingle-Samsil-Gullied Land Complex, 3-15% Slopes

This unit occurs on dissected landscapes. The Shingle soils have a clay loam texture and are moderately permeable, while Samsil soils are finer textured and of slow permeability. Both soils are shallow, underlain by shales at 10 to 20 inches. The gullied land is actively eroding. This association includes about 35% Shingle and 30% Samsil soils as well as 10% Tassel, Thedalund and Kim soils. About 25% is classed as gullied lands. About 84 acres (34 ha) (1.6%) of the project lands are included in this unit designation.

Unit 401. Worf-Shingle-Tassel Complex, 3-30% Slopes

This complex occurs on moderately steep to steep upland ridges and backslopes. This complex consists of about 35 percent Worf, 30 percent Shingle and 20 percent Tassel with 15% inclusions of Thedalund, Cushman and Samsil soils. The principal soils are all shallow and well drained with moderate permeability. Erosion hazard is moderate to severe.

Unit 402C. Shingle-Lesset-Tassel Complex, 6-30% Slopes

This complex is common to sloping areas on ridges and sideslopes and usually occurs at or near the base of steep, interbedded shale and sandstone outcrops. The soils are low in moisture holding capacity and underlain by bedrock at depths of 10 to 20 inches. Shingle soils are of clay loam texture and moderately permeable. Lesset soils are sandy and noncalcareous whereas the Tassel soils are calcareous. The complex consists of 30% Shingle, 25% Lesset and 25% Tassel soils with minor inclusions (20%) of Samsil, Worf and Thedalund soils. Onsite distributions include about 107 acres (43 ha) (2%) of the project area.

Unit 404. Tassel-Tullock-Vona Association, 6-30% Slopes

This unit occurs on slopes generally associated with hilly uplands and stream terraces. The Tassel soils occur on steeper slopes, are of sandy loam texture, is underlain by bedrock at 10 to 20 inches. The Tullock soils are of sandy loam texture and underlain by bedrock at 20 to 40 inches. The Vona soils, also of sandy loam texture, are deeper than 60 inches to bedrock. All such soils are of low moisture holding capacity. This unit includes about 40% Tassel, 20% Tullock and 20% Vona soils with minor inclusions (20%) of Terry, Dwyer, Valent, and Lesset soils, and small rock outcrops. The type occurs on about 324 acres (131 ha) (6.4%) of the project area.

Unit 405D. Tassel-Terry-Rockland Association, 15-30% Slopes

This association occurs on steep upland ridges and sideslopes. The Tassel and Terry soils are of sandy loam textures and low moisture holding capacities. The shallow Tassel soils are underlain by bedrock at depths of 10 to 20 inches while Terry soils are moderately deep, with bedrock occurring at 20 to 40 inches. The Rockland soils include exposures of sandstone bedrock. This unit includes about 40% Tassel and 20% Terry soils, with 20% rock outcrops, as well as minor inclusions (20%) of Lesset, Vona, Tullock and Dwyer soils. About 122 acres (49 ha) (2.4%) of the project area are included in this unit designation.

Unit 409. Samsil-Shingle-Worf Complex, 3-15% Slopes

This complex occurs on rolling hills and uplands and consists of about 30 percent Samsil clay, 20 percent Shingle loam and 20 percent Worf loam with 30 percent inclusions of Worfka, Renohill, Thedalund and Kim soils. All principal soils in this complex are shallow well-drained with slow to moderate permeabilities and moderate to severe erosion hazard.

APPENDIX D-4. ESTIMATED YIELDS AND RANGE SITE IDENTIFICATIONS

Table D-4.1(a). Estimated Optimum Yields of Nonirrigated Crops[a]--Soil Resource Area 58

Soil Capability Groups	Conservation Treatment	Wheat, bu	Oats, bu	Barley, bu	Hay (Alfalfa), tons	Hay (Grass), tons	Pasture AUMs
IIw_{61}, IIc_{46}	No special practices	40	50	40	2	1.5	1.5
	Waterspreading				2.5	2.0	2.0
$IIIe_1$, $IIIe_2$, $IIIe_5$	Terraces	40	60	40	1.5	1.0	
	Wind stripcropping	35	50	35			
	Stubble mulching	35	50	35			
	Hay				1.5	1.0	1.0
$IIIs_1$	Stubble mulching	25	40	30	1.0	0.8	0.8
	No stubble mulch	20	35	25	1.0	0.8	0.8
$IIIc_{46}$	No special practices	35	50	30	1.5	1.0	1.0
	Waterspreading				2	1.5	1.5
IVe_1, IVe_2, IVe_3, IVe_5	Hay					0.75	0.75
	Terraces	25	35	30			
	Stubble mulching	25	35	30			
	Wind stripcropping	20	30	25			
IVe_8, IVs_1	Hay	15	20	15		0.5	0.5
IVe_{15}	Stubble mulching	15	20	15			
	Wind stripcropping	15	20	15			
	Hay					0.5	0.5
IVs_{12}	Wind stripcropping	15	20	20			
	Stubble mulching	15	20	20			
	Hay					0.5	0.5
IVc_{46}	No special practices	25	40	25		0.75	0.75
	Water spreading					1.25	1.25

Source: USDA-Soil Conservation Service, March 1970.

[a]All yield predictions are based on complete conservation treatment and no adverse crop conditions.

Table D-4.1(b). Estimated Optimum Yields of Irrigated Crops[a]--Soil Resource Area 58

Soil Capability Groups	Conservation Treatment	Hay (Alfalfa), tons	Pasture AUMs	Hay (Grass), tons	Oats, bu	Barley, bu
I, IIc_2, IIe_2, II_3, IIs_{16}, IIw_{61}	Land leveling	4.5	7	2.5	90	70
	Sprinkler	5	8	3	90	70
	Contour ditch	3.5	6	2	80	60
	Furrow					
$IIIe_1$, $IIIe_2$, $IIIs_9$, $IIIe_5$, IIs_5, $IIIw_{61}$	Sprinkler	4.5	7	3	80	65
	Contour ditch	3	5	2	70	55
IVe_1, IVe_2, IVe_3, IVe_5, IVs_9, VIe_1, VIe_2, VIe_3, VIe_5	Sprinkler	4	6	2.5	70	55
	Contour ditch	2.5	4	1.5	60	50
$IVws_{10}$, $IVws_{11}$, IVs_{12}, IVe_{10}, IVe_{11}, IVe_{12}, VIe_{10}, VIe_{11}, VIe_{12}	Contour		4	2		40
IIs_2, IIs_{13}	Sprinkler	4	6	2.5	90	70
	Contour ditch	3	5	2.5	80	60
	Furrow					
IIs_7, $IIIs_1$	Sprinkler	4	6	2.5	80	65
	Contour ditch	3	5	2	70	55
	Furrow					
$IIIs_4$, $IIIs_{43}$, IVe_4	Sprinkler	4.5	7	2.5	85	65
	Contour ditch	3	5	1.5	70	55
	Level-border	4	6	2	80	60
	Furrow					
$IIIw_{62}$, IVw_{62}, IVw_{63}	Contour ditch		5	2		
IVs_1, IVs_2, IVs_4, IVs_5, IVs_{13}	Sprinkler	3	6	2.5	80	65
	Contour ditch	2.5	5	2	70	55
	Furrow					
IVs_6, IVs_{14}, IVs_{15}, IVe_6, IVe_{14}, VIe_6, VIe_{14}	Sprinkler	2	4	1.5	60	50
	Contour ditch	1.5	3	1	50	40
IVs_8	Borders - L.L.	4	6	2.5	80	60
	Contour ditch	3	5	2	70	50
	Furrow					
IVw_{63}	Contour ditch		5	2		
$IVws_6$	Contour ditch		4	1.5		
Vs_9, VIs_9	Contour ditch		3			
VIs_{70}, VIw_{64}, Vw_{64}	Contour ditch		3			
VIs_{15}	Sprinkler		3	1.5		
VIs_{71}, VIe_{71}	Contour ditch		3	1		

Source: USDA-SCS Technical Guides, Section VB, Wyoming, March 1970.

[a]All yield productions are based on full water supply, proper use of irrigation water, complete conservation treatment and no adverse crop conditions.

Table D-4.2. USDA-Soil Conservation Service Descriptions of Range Sites Identified within the Project Area.
Land Resource Area:
Northern Rolling High Plains,
Pierre Shale Plains and Badlands

INCLUSION 1.

1. RANGE SITE NAME: Subirrigated (Sb) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site will usually occur adjacent to live streams, lakes, ponds or springs. The elevation ranges from 3,800 feet to 5,100 feet.

4. SOILS:

a. The soils of this site consist of deep (greater than 20" to bedrock), moderately well-drained soils with water tables below the surface for all of the growing season. The soil water is non-saline and non-alkaline. Surface soils may be inundated but only for short periods of time.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by plants that can withstand a high water table throughout most of the growing season.

Decreasers (Relative Importance)		Increasers (Maximum % Found in Climax)	
Prairie cordgrass	3	Western wheatgrass	15
Basin wildrye grass	4	Mat muhly grass	5
Canada wildrye grass	5	Spike sedge	5
Slender wheatgrass	4	Inland sedge	10
Bearded wheatgrass	5	Forbs:	10
Tufted hairgrass	5	American licorice	
Blue-eyed grass	5	Asters spp:	
		Golden pea	
		Meadowrue	
		Starwort	
		Western virginsbower	
		Western yarrow	
		Woody plants:	
		Willows	10

The increasers make up approximately 40% of the vegetation. As the condition deteriorates, annual forbs tend to become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 4,000 lbs. per acre air dry, but varies from 3,500 lbs. in less favorable years to 4,500 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 2.

1. RANGE SITE NAME: Saline Subirrigated (SS) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site occurs on nearly level bottomlands and adjacent to streams, springs or ponds. The elevation ranges from 3,800 feet to 5,100 feet.

4. SOILS:

a. The soils of this site consist of deep (greater than 20" to bedrock), poorly drained soils with saline and/or alkaline soil water below the surface for all of the growing season. Surface soils may be inundated but only for short periods of time.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by plants that can withstand moderately saline and/or alkaline soils. The principal decreaser and increaser species are:

Decreasers (Relative Importance)		Increasers (Maximum % Found in Climax)	
Alkali cordgrass	3	Alkali bluegrass	5
Alkali sacaton	2	Mat muhly grass	5
Nuttalls alkaligrass	4	Inland saltgrass	20
Western wheatgrass	3	Squirreltail	5
		Forbs:	5
		Seepweed	
		Woody plants:	
		Greasewood	5
		Rubber rabbitbrush	10

The increasers make up approximately 40% of the vegetation. As the condition deteriorates, inland saltgrass tends to become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 3,000 lbs. per acre air dry, but varies from 2,500 lbs. in less favorable years to 3,500 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 3.

1. RANGE SITE NAME: Lowland (LL) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site occurs adjacent to streams that run water at least during the major part of the growing season. The elevation ranges from 3,800 feet to 5,100 feet.

4. SOILS:

a. The soils of this site are deep (greater than 20" to bedrock), well drained and moderately to rapidly permeable. The water table fluctuates and is usually deeper than three feet.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by herbaceous plants with shallow roots that do not penetrate to the water table. However, the roots of some trees and shrubs that grow on this site do extend to the water table. The principal decreaser and increaser species are:

Decreasers (Relative Importance)	
Basin wildrye grass	5
Canada wildrye grass	5
Green needlegrass	3
Slender wheatgrass	4
Bearded wheatgrass	5
Big bluestem grass	5
Purple prairie clover	5
Dotted gayfeather	5
Penstemon spp.	5

Increasers (Maximum % Found in Climax)	
Western wheatgrass	10
Needle-and-thread grass	5
Sandberg bluegrass	5
Mat muhly grass	5
Prairie junegrass	5
Forbs:	10
American licorice	
Goldenpea	
Milkvetch	
Fleabane	
Asters	
Green sagewort	
Fringed sagewort	
Woody plants:	
Snowberry	5
Silverberry	5
Silver sagebrush	5
Rubber rabbitbrush	5
Cottonwoods	10
Wild rose	5

The increasers make up approximately 50% of the vegetation. As the condition deteriorates, woody plants tend to become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 2,500 lbs. per acre, but varies from 2,000 lbs. in less favorable years to 3,000 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 4.

1. RANGE SITE NAME: Sandy (Sy) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site usually occurs on lands with gentle to steep slopes and on colluvial fans. Elevation ranges from 3,800 feet to 5,100 feet.

4. SOILS:

a. The soils of this site are deep to moderately deep (greater than 20" to bedrock), well drained and rapidly permeable. The surface soil is at least 3 to 6 inches thick (depending on texture and permeability of the subsoil), and one of the following soil textures: fine sandy loam, sandy loam or loamy very fine sand. Coarser topsoils may be included if underlain by finer textured subsoils.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by tall and mid grasses. Principal decreaser and increaser species are:

Decreasers (Relative Importance)	
Prairie sandreed grass	4
Indian ricegrass	3
Little bluestem grass	4
Penstemon	5
Prairie clover	5
Prairie coneflower	5
American vetch	5
Winterfat	5
Perennial sunflower	5

Increasers (Maximum % Found in Climax)	
Western wheatgrass	15
Needle-and-thread grass	35
Blue grama grass	10
Hairy grama grass	3
Sandberg bluegrass	5
Sand dropseed grass	5
Prairie junegrass	5
Threadleaf sedge	10
Needleleaf sedge	5
Forbs:	10
Cudweed sagewort	
Many flowered scurfpea	
Western yarrow	
Pussytoes	
Hood phlox	
Tailcup lupine	
Death camas	
Miners candle	
Eriogonum	
Fringed sagewort	
Common comandra	
Purple prairie clover	
Sandwort	
Groundsel	
Yucca	
Woody plants:	
Silver sagebrush	5
Low rabbitbrush	5
Big sagebrush	5
Snowberry	5

The increasers make up approximately 50 of the vegetation. As the condition deteriorates, fringed sagewort and cudweed sagewort become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 1,600 lbs. per acre air dry, but varies from 1,000 lbs. in less favorable years to 2,100 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 5.

1. RANGE SITE NAME: Loamy (ly) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site occurs on nearly level land to land with up to 10% slope. Elevation ranges from 3,800 feet to 5,100 feet.

4. SOILS:

a. The soils of this site are deep to moderately deep (greater than 20" to bedrock), well drained, moderately permeable and occur on slopes less than 10%. The surface soil will vary from 3 to 6 inches in thickness depending on the texture and permeability of the subsoil. The texture of the surface soil must be one of the following: very fine sandy loam, loam, silt loam and the friable portions of sandy clay loam, silty clay loam or clay loam. This site designation is not applicable for loess material with little or no development.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by mid grasses. Principal decreaser and increaser species are:

Decreasers (Relative Importance)	
Western wheatgrass	3
Thickspike wheatgrass	4
Green needlegrass	4
Canby bluegrass	5
Bluebunch wheatgrass	5
Indian ricegrass	5
Little bluestem grass	5
Cusick bluegrass	4
American vetch	5
Prairie clover	5
Prairie coneflower	5
True clovers	5
Winterfat	4
Penstemon	5
Bluebell	5

Increasers (Maximum % Found in Climax)	
Needle-and-thread grass	25
Buffalo grass	5
Blue grama grass	15
Hairy grama grass	3
Sandberg bluegrass	5
Plains reedgrass	5
Prairie junegrass	5
Threadleaf sedge	5
Needleleaf sedge	5
Forbs:	10
Biscuitroot	
Indian breadroot	
Many flowered scurfpea	
Tailcup lupine	
Skeleton plant	
Hoods phlox	
Pussytoes	
Locoweed	
Crazy weed	
Milkvetch	
Eriogonum	
Daisy	
Asters	
Fleabane	
Fringed sagewort	5
Woody plants:	
Big sagebrush	10

The increasers make up approximately 50% of the vegetation. As the condition deteriorates, big sagebrush and the short grasses (mainly blue grama) become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 1,500 lbs. per acre air dry, but varies from 850 lbs. in less favorable years to 2,000 lbs. in more favorable years..

Table D-4.2., Continued

INCLUSION 6.

1. RANGE SITE NAME: Clayey (Cy) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site occurs on nearly level land to land with up to 10% slope. Elevation ranges from 3,800 feet to 5,100 feet.

4. SOILS:

a. The soils of this site are deep to moderately deep (greater than 20" to bedrock), well drained, moderately to slowly permeable and occur on slopes less than 10%. The topsoil is at least 2 to 5 inches deep and one of the following textures: silty clay, the finer portions of sandy clay loam, silty clay loam and clays which do not develop severe cracks or become extremely hard when dry and very sticky when wet.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by mid grases. Principal decreaser and increaser species are:

Decreasers (Relative Importance)	
Green needlegrass	2
Thickspike wheatgrass	3
Western wheatgrass	2
Montana wheatgrass	4
Canby bluegrass	5
Winterfat	4

Increasers (Maximum % Found in Climax)	
Sandberg bluegrass	5
Buffalo grass	5
Squirreltail grass	5
Plains reedgrass	5
Needleleaf sedge	5
Forbs:	5
Onion	
Biscuitroot	
Fleabane	
Woody aster	
Two grooved milkvetch	
Woody plants:	
Birdsfoot sagebrush	5
Big sagebrush	5

The increasers make up approximately 35% of the vegetation. As the condition deteriorates, big sagebrush and birdsfoot sagebrush become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 900 lbs. per acre air dry, but varies from 450 lbs. in less favorable years to 1,200 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 7.

1. RANGE SITE NAME: Steep Loamy (Sly) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

   This site occurs on lands with 10% slopes or greater. Elevation ranges from 3,800 feet to 3,100 feet.

4. SOILS:

   a. The soils of this site are deep to moderately deep (greater than 20" to bedrock), well drained, moderately permeable and occur on slopes of 10% or more. The topsoil is 3 to 6 inches thick (depending on texture and permeability of the subsoil), and one of the following textures: very fine sandy loam, loam, silt loam, light sandy clay loam, light silty clay loam, or light clay loam.

   b. The soils in this site may include one or more of the following taxonomic units:

   c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

   The climax plant community is dominated by mid grasses. Principal decreaser and increaser species are:

Decreasers (Relative Importance)	
Green needlegrass	3
Western wheatgrass	3
Thickspike wheatgrass	4
Canby bluegrass	5
Bluebunch wheatgrass	4
Indian ricegrass	5
Little bluestem grass	5
Cusick bluegrass	4
Winterfat	4
American vetch	5
Prairie clover	5
Prairie coneflower	5
True clovers	5
Pentstemon	5
Bluebell	5

Increasers (Maximum % Found in Climax)	
Needle-and-thread grass	25
Blue grama grass	15
Hairy grama grass	3
Sandberg bluegrass	5
Plains reedgrass	5
Buffalo grass	5
Prairie junegrass	5
Threadleaf sedge	5
Forbs:	10
Biscuitroot	
Indian breadroot	
Many flowered scurfpea	
Tailcup lupine	
Skeleton plant	
Hoods phlox	
Pussytoes	
Locoweed	
Daisys	
Asters	
Fleabanes	
Eriogonum	
Scarlet gaura	
Groundsel	
Woody plants:	
Big sagebrush	10

   The increasers make up approximately 45% of the vegetation. As the condition deteriorates, big sagebrush and short grasses (mainly Blue grama) become more dominant.

   Approximate total annual yield of this site in excellent condition in an average year is 1,100 lbs. per acre air dry, but varies from 600 lbs. in less favorable years to 1,500 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 8.

1. RANGE SITE NAME: Shallow Sandy (SwSy) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site usually occurs on steep slopes and ridge tops, but may occur on all slopes. Elevation ranges between 3,800 feet and 5,100 feet.

4. SOILS:

a. The soils of this site are shallow (less than 20" to bedrock), well drained, and rapidly permeable. The bedrock may be of any kind except that of igneous or volcanic origin which is virtually impenetrable by plant roots. The soil textures are a fine sandy loam or coarser. Thin ineffectual layers of other soil textures are disregarded.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by tall and mid grasses. Principal decreaser and increaser species are:

Decreasers (Relative Importance)	
Prairie sandreed grass	3
Sideoats grama grass	4
Bluebunch wheatgrass	4
Indian ricegrass	3
Sand bluestem grass	4
Little bluestem grass	3
Needle-and-thread grass	2
Penstemon	5
Prairie clover	5
American vetch	5
Groundsel	5
Bluebell	5
Dotted gayfeather	5
Bitterbrush	5
Winterfat	5
Fourwing saltbrush	4

Increasers (Maximum % Found in Climax)	
Blue grama grass	15
Sandberg bluegrass	5
Sand dropseed grass	10
Stoneyhills muhly grass	5
Prairie junegrass	5
Threadleaf sedge	10
Forbs:	10
Cudweed sagewort	
Many flowered scurfpea	
Western yarrow	
Pussytoes	
Hoods phlox	
Tailcup lupine	
Stonecrop	
Mountain thermopsis	
Nailworts	
Eriogonum	
Common comandra	
Green sagewort	
Skeleton plant	5
Groundsel	
Clematis	
Sandwort	
Yucca	
Fringed sagewort	
Woody plants:	
Silver sagebrush	5
Low rabbitbrush	5
Big sagebrush	5
Skunkbush sumac	3

Increasers make up approximately 35% of the vegetation. As the conditions deteriorate, threadleaf sedge and fringed sagewort become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 1,000 lbs. but varies from 600 lbs. in less than average year to 1,400 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 9.

1. RANGE SITE NAME: Shallow Loamy (SwLy) 10-14" Northern Plains

2. CLIMATE: (See attached climate description)

3. TOPOGRAPHY AND ELEVATION:

This site will usually occur on steep slopes and ridge tops, but may occur on all slopes. Elevation ranges between 3,800 feet and 5,100 feet.

4. SOILS:

a. The soils of this site are shallow (less than 20" to bedrock), well drained, and moderately permeable and may occur on all slopes. The bedrock may be of any kind except that of igneous origin which is virtually impenetrable to plant roots. The soil textures range from a very fine sandy loam to the light sandy clay loams, light silty clay loams, and clay loams. Thin ineffectual layers of other textures are disregarded.

b. The soils in this site may include one or more of the following taxonomic units:

c. Complete soil series descriptions are available in the Soil Survey Descriptive Legend.

5. CLIMAX VEGETATION:

The climax plant community is dominated by mid grasses. Principal decreaser and increaser species are:

Decreasers (Relative Importance)	
Bluebunch wheatgrass	2
Western wheatgrass	3
Thickspike wheatgrass	4
Needle-and-thread grass	3
Sideoats grama grass	5
Canby bluegrass	5
Indian ricegrass	4
Little bluestem grass	4
Cusick bluegrass	4
American vetch	5
Prairie clover	5
Prairie coneflower	5
Penstemon	5
Bluebell	5
Winterfat	4

Increasers (Maximum % Found in Climax)	
Blue grama grass	15
Hairy grama grass	3
Sandberg bluegrass	5
Plains reedgrass	5
Stoneyhills muhly grass	5
Prairie junegrass	5
Threadleaf sedge	10
Needleleaf sedge	5
Forbs:	10
Biscuitroot	
Indian breadroot	
Many flowered scurfpea	
Tailcup lupine	
Hoods phlox	
Pussytoes	
Locoweed	
Mountain thermopsis	
Stonecrop	
Gromwell	
Western wallflower	
Common comandra	
Western yarrow	
Fleabane	
Fringed sagewort	
Woody plants:	
Skunkbush sumac	3
Big sagebrush	5

The increasers make up approximately 35% of the vegetation. As the condition deteriorates, blue grama and threadleaf sedge tend to become more dominant.

Approximate total annual yield of this site in excellent condition in an average year is 900 lbs., but varies from 450 lbs. in less favorable years to 1,200 lbs. in more favorable years.

Table D-4.2. Continued

INCLUSION 10.

Climate Description for
Range Sites in Northern Plains
10-14 inches

Land Resource Areas (58 (60). Northern Rolling High Plains, Pierre Shale Plains and badlands.

a. Annual precipitation varies from 10 to 14 inches. The normal precipitation pattern shows the lightest fall during December, January and February, increasing rapidly to a peak the last half of May and the first half of June to a low in August, increase again to a secondary peak in September, then decrease to the wintertime minimum. Normally about 35 to 41% (4.1 to 5.6 in.) of the annual precipitation falls between the average 32° freeze free dates, and about 47 to 51% (5.9 to 6.5 in.) falls between the average 28° freeze free dates.

   Sunshine is abundant in the area. It is estimated to average about 65% of possible sunshine on an annual basis, ranging from about 55% in the winter to about 75% in late summer.

b. Hourly winds are estimated to average about 8 mph annually, ranging from hourly speeds averaging about 10 mph during the spring to 7 mph during late summer. Daytime winds are typically stronger than nighttime and occasionally storms can bring brief periods of quite high winds with gusts bettering 75 mph.

c. Temperatures show a wide range between summer and winter and between daily maximums and minimums. This is predominantly due to the high elevation and dry air which permits rapid incoming and outgoing radiation, and passage of both warm and cold air masses. Cold air outbreaks from Canada generally do not last long as their path is generally southeasterly, then easterly in these latitudes. Because of cold air outbreaks from Canada and rapid nighttime radiation cooling, late spring and early fall freezes are not too uncommon. Average spring freezes are about May 15 and fall freezes about September 15.

   Growth of native cool season plants begins about April 1 and continues to about July 1 and native warm season plants beginning about May 15 and continuing to about August 15. September may produce fall green-up of plants lasting through October.

APPENDIX D-5. IRRIGATION FEASIBILITY STUDY

CONSUMPTIVE WATER USE BY CROPS

The project site lies in Climatic Area II as defined by the Soil Conservation Service.[1] This area has a moderate consumptive use for the peak period, which is assumed to be June and July for the crops of interest (see Table D-5.1).

Table D-5.1. Estimated Consumptive Water Use of Crops

Crop	Apr	May	Jun	Jul	Aug	Sep	Oct	Annual Total
Alfalfa Hay								
Total consumptive use		2.48	5.65	7.30	6.03	3.34	0.05	24.85
Effective precipitation		1.14	1.46	1.20	0.88	0.81	0.02	5.51
Net irrig. required		1.34	4.19	6.10	5.15	2.53	0.03	19.34
Pasture Grass								
Total consumptive use	0.44	2.90	4.61	6.05	5.16	2.94	0.79	22.89
Effective precipitation	0.03	1.47	1.30	1.05	0.79	0.75	0.39	6.05
Net irrig. required	0.14	1.43	3.31	5.00	4.37	2.19	0.40	16.84
Oats and Barley								
Total consumptive use	0.36	2.72	6.30	5.44	0.46	-	-	15.28
Effective precipitation	0.34	1.46	1.46	1.43	1.02	-	-	4.54
Net irrig. required	0.02	1.26	4.87	4.42	0.17	-	-	10.74

Ref: "Irrigation Guide Wyoming 1974," U. S. Department of Agriculture, Soil Conservation Service, Casper, Wyoming, (Table 2-2, Douglas, Wyoming, area)

The soil on the reclaimed area is assumed to be similar to the Thedalund soil, a loam or light clay loam.[2] The reclaimed soils will have a depth of about 20 inches or more. Water-holding capacity of this medium is estimated to be 0.16-0.8 inches per inch (or 1.9 to 2.2 in/ft).[3] Total available water-holding capacity is considered to be approximately 3.3 inches. From Table D-5.1 the net irrigation application[4] is as follows:

Crop	Net Peak Irrigation Application	Peak Month
Alfalfa hay	6.10 inches	July
Pasture grass	5.00	July
Oats and barley	4.42	June

Effective precipitation has been estimated at 20% of the average monthly rainfall.

Table D-5.2. Water Quantities

Alternative	Approximate Irrigation Pool, A-ft	Approximate Conservation Pool, A-ft
A	1120	3000-5500
B	1120	3500-6500
C	1120	2800-5000
D	1120	2000-3500
E	0	0

Total water available for various reclamation alternatives is essentially identical for Alternatives A, B, and C. No water from B-1 is available for Alternative D and no water is available from any surface impoundments with Alternative E.

The total quantity of irrigation water that would be available from the combined impoundments (B-1, B-8, B-13W) is estimated to be on the order of one million gallons per day (1120 A-ft/year) on a sustained yield basis, throughout the year, year after year.[6] This value is based upon the predicted annual recharge to the impoundments, the interaction of the drawdown influence among the impoundments, the expected precipitation infiltration to groundwater, and the evaporative losses from the impoundment surfaces. Irrigation water would be drawn only during the months April through October, and peak withdrawals would be available at a rate of about 4 to 5 million gallons per day (12 to 15 A-feet/day) based upon the above factors.[6]

POTENTIAL IRRIGATED ACREAGE

Based upon the soil capability classes of IV or better,[7] and the availability of irrigation water as described above, the potentially irrigable acreages for various crops has been determined. This information is presented in Table D-5.3 along with a designation of the controlling constraint; that is, soil capability or water availability. Areas outside of the immediate reclaimed area were not evaluated.

Table D-5.3. Actual Irrigable Land[a]

Alternative	Crop	Irrigable Acreage as Constrained by: Soil Capability[b]	Available Irrigation Water	Limiting Factor
Present		1569	0	Water
A	Alfalfa	1289	350	Water
	Grass	1289	400	Water
	Grains	1289	622	Water
B	Alfalfa	1222	350	Water
	Grass	1222	400	Water
	Grains	1222	622	Water
C	Alfalfa	1305	350	Water
	Grass	1305	400	Water
	Grains	1305	622	Water
D	Alfalfa	1283	350	Water
	Grass	1283	400	Water
	Grains	1283	622	Water
E	Alfalfa	1608	0	Water
	Grass	1608	0	Water
	Grains	1608	0	Water

[a]Analysis limited to areas disturbed by the project [also see (b)].

[b]All alternatives and present case are compared on a common total area to facilitate comparison.

Daily peak period use,[1,4,5] assuming the monthly net irrigation application presented above, is as follows:

Crop	Peak Consumption Use,
Alfalfa hay	0.24 inches/day
Pasture grass	0.20
Oats and barley	0.22

Assuming a sprinkler application system that has an application efficiency of 50%, the required gross application of irrigation is:

Crop	Gross Peak Irrigation Application
Alfalfa hay	9.4 inches
Pasture grass	7.7
Oats and barley	6.8

With the assumed Thedalund-like soil which has a water intake rate of 0.011 cfs/100 sq ft,[2] utilizing the "Irrigation Guide, Wyoming 1974"[4,5] application intensity during peak utilization periods would be approximately 4.0 inches in 3.5 hours at a frequency of:

Crop	Irrigation Frequency
Alfalfa hay	12-13 days
Pasture grass	15-16
Oats and barley	17-18

This application assumes a sprinkler system and could be utilized on areas having slopes less than 10% with most slopes less than 6%.

Total annual water requirements per acre of irrigated cropland is presented below based upon the above-described system:

Crop	Total Annual Irrigation Water Required
Alfalfa hay	3.2 A-ft/acre
Pasture grass	2.8
Oats and barley	1.8

WATER AVAILABILITY

Total water available for irrigation will be assumed to be derived from the water of the unbackfilled pits B-1, B-8 and B-13W at the Bear Creek project. Water quantities are presented in Table D-5.2, based upon the hydrology studies performed at the site and the size of the remaining impoundments.

IRRIGATION OPTIONS

Systems

Numerous irrigation systems are developed including sprinkler, surface, and subirrigation methods.[6] Only the sprinkler techniques were examined since these are the methods most commonly utilized in eastern Wyoming.

Center pivot irrigation systems are suitable for slopes 0-6% with no ground obstructions.[1] Side-roll sprinklers can operate on slopes up to 12%.[9] Other methods such as gun sprinklers, rotating booms, or set sprinklers may also have some utility.

Costs

A center pivot self-propelled system is estimated to cost from $312 to $375 per acre to install, not including the cost of a water supply and delivery system.[1] A side-roll irrigation system, which would be more adaptable to varying slopes, is estimated to cost about $280/acre, including pipeline, pumps and pivots. This would result in an approximate total capital investment of $45,000 to $50,000 for an irrigated plot of 160 acres.[9]

Operation and Maintenance

Operation of an irrigation system would require attention to ensure correct application of water. Application frequencies of every 12 to 18 days for periods of 3 to 5 hours per application would be required during peak consumptive months. Maintenance tasks on the equipment would be required approximately monthly for pivot mechanisms and rollers. Since electricity would probably be available, the problems associated with generators would be avoided. Pump maintenance would be required periodically, with less frequent complete overhauls.

References for Appendix D-5

1. R. L. Tikka, memo dated June 29, 1976, addressed to Forest Supervisor, Medical Bow National Forest, on the subject of "Sprinkler Irrigation Systems."

2. Personal communication with Hayden Rounsaville, Medical Bow National Forest, March 23, 1977.

3. SCS Soil Survey Interpretations (Form 5) for the Thedalund Series.

4. "Irrigation Guide Wyoming 1974," U. S. Department of Agriculture, SCS, Casper, Wyoming.

5. Personal communication with Dick Loper, District Conservationist, SCS, Douglas, Wyoming, March 31, 1977.

6. Personal communication with Richard W. Davis, Consulting Hydrologist, Laramie, Wyoming, March 31, 1977.

7. Soils Memorandum WY-6, U. S. Department of Agriculture, Soil Conservation Service, Casper, Wyoming, December 12, 1967.

8. Section 15, Chapter 3, "Irrigation - Planning Farm Irrigation Systems," U. S. Department of Agriculture, SCS National Engineering Handbook, July 1967.

9. Personal communication with Orville Bennett, Engineer Technician.

APPENDIX E. ANIMAL SPECIES REPRESENTATIVE OF THE STUDY AREA LISTED ACCORDING TO SIMILARITIES IN HABITAT REQUIREMENTS, HABITS, OR LIFE FORM

Group I		
In the study area, these animals are heavily dependent upon sagebrush for food or cover or nesting sites or combination thereof and/or other upland shrubs such as greasewood saltbush and rabbitbrush, especially for winter feed.	Pronghorn antelope Mule deer White-tailed deer Sagebrush vole Deer mouse Least chipmunk White-tailed prairie dog White-tailed jack rabbit Black-tailed jack rabbit Mountain cottontail Desert cottontail	Sage grouse Sharptail grouse Sage sparrow Dickcissel Lark sparrow Brewer's sparrow Sage thrasher Lazuli bunting Green-tailed towhee Wright's flycatcher Sagebrush lizard
Group II		
In the study area, these animals feed heavily on seeds and/or foliage or roots of weedy species of forb or annual grasses and/or nest on ground in open grasslands.	Thirteen-lined ground squirrel Richardson's ground squirrel Northern pocket gopher Wyoming pocket mouse Hispid pocket mouse Ord's kangaroo rat Western harvest mouse Plains harvest mouse	Hungarian partridge Mourning dove Lark bunting Savannah sparrow Grasshopper sparrow Vesper sparrow Horned lark
Group III		
In the study area, these animals nest on the ground in open grasslands and/or feed primarily on perennial grass seeds or foliage.	Black-tailed prairie dog Prairie vole Chestnut collared longspur McCown's longspur	
Group IV		
In the study area, these animals depend primarily on the riparian (streamside) plant associations and/or marshy or moist meadow areas around lakes or ponds to directly or indirectly provide food or cover or nesting or breeding sites or combinations thereof.	Raccoon Mink Striped skunk Beaver Muskrat Long-tailed vole Black-billed magpie Red-shafted flicker Wilson's snipe Eastern kingbird Traill's flycatcher Goldfinch Catbird	Long-billed marsh wren Brown thrasher Robin Yellow warbler Yellowthroat Long-tailed chat Brown-headed cowbird Western hognose snake Eastern yellow-bellied racer Common garter snake Plains garter snake Western terrestrial garter snake
Group V		
In the study area, these animals require the open pine timber, juniper breaks or rough, rocky topography for cover or food or nesting sites or a combination thereof.	Elk Bushytail wood rat Porcupine Pygmy nuthatch Cassins kingbird White-winged junco Pinon jay	

Group VI

The composition of insect and spider populations and the relative abundance of different taxonomic groups vary with season, vegetative type and stage of succession. There is generally a greater variety of species and a greater abundance of individuals in the intermediate stages of grassland succession than in either the early or climax stages. Invertebrates are one of the three major groups of grazing animals.	Invertebrates, . . . including a wide variety of insect families and spiders such as: Springtails Long-horned grasshoppers Short-horned grasshoppers Barklice Thrips Plant bugs Lace bugs Seed bugs Leafhoppers Aphids	Ground beetles Carrion beetles Dermestid beetles Darkling beetles Snout beetles Moths Midges Mosquitoes Wasps Ants Harvestmen Wolf spiders Orb weaver spiders etc.

Group VII

These animals are all highly insectivorous, if not totally so; their presence, density, and distribution is significantly influenced by the status of local insect populations.	Hoary bat Big brown bat Little brown bat Vagrant shrew Masked shrew Grasshopper mouse Common nighthawk Western kingbird Say's phoebe	Bank swallow Rough-winged swallow Eastern bluebird Mountain bluebird Loggerhead shrike Bobolink Meadowlark Eastern short-horned lizard

Group VIII

Members of these animal groups found within the study area exhibit from high to total dependence upon stream, lake, or pond-marsh biotic communities for continued existence.	Waterfowl, shorebirds, amphibians, and fish - Grebes Herons Geese Dabbling ducks Diving ducks Sandpipers Snipe Avosets	Phalaropes Salamanders Frogs Toads Turtles Trouts Minnows Suckers Catfishes Sunfishes Perches

Group IX

These animals are somewhat wide-ranging and/or highly flexible predators. They prey, to varying extents, on members of most other groups; their presence, abundance, and distribution are influenced primarily by availability of prey species, in some it is strongly influenced by the availability of nesting trees, den sites, or burrows.	Coyote Red fox Gray fox Bobcat Long-tailed weasel Black-footed ferret Badger Great horned owl Burrowing owl Long-eared owl Short-eared owl Cooper's hawk	Red-tailed hawk Swainson's hawk Rough-legged hawk Ferruginous hawk Bald eagle Golden eagle Marsh hawk Prairie falcon Sparrow hawk Milksnake Bullsnake Prairie rattlesnake

APPENDIX F. METHODOLOGY AND ASSUMPTIONS FOR FORECASTING PUBLIC SERVICES NEEDS AND PUBLIC FINANCE

This appendix describes in detail the methodology and assumption used in identifying needs for public facilities and services and in forecasting public costs and revenues. The tables in the appendix will be reviewed with local officials to verify the accuracy of the many assumptions which are required.

Projections are made using a relatively simple computer-based model which projects public revenues and needs for public expenditures in rapidly growing communities. The model was developed during the course of a study, conducted for the Federal Energy Administration, of the financial problems confronting communities hosting large-scale coal and/or shale developments. During the study, it became apparent that considerable computational detail was required in order to make meaningful projections of local financial needs. The model makes it possible to compare projections made under different sets of assumptions.

Figure F.1 provides an overview of the data collection and analysis process involved. The model is designed to be adapted to the fiscal structure of a specific community. It relies heavily on data collected in the community to be studied. Information concerning the local economic base and likely energy development is used to describe a development profile. The profile includes schedules for annual increases in employment, taxable improvements, and production as well as assumptions regarding where the employees will live and what the relationship between the growth in basic and nonbasic employment will be. Assumptions concerning the financial structure of the area and likely future requirements are based on local information sources (budgets, bond prospects, etc.) and are incorporated into the model.

The model projects public revenues and expenditures for three local entities--the county, the principal municipality, and the principal school district--over a ten-year period. Each of the steps described below is carried out for each entity in each year.

1. Calculate population. Estimates of basic employment (construction and permanent) and of employment multipliers in each year are used to calculate total employment. Employment serves as the basis for household and population (or school enrollment) estimates.

2. Calculate assessed valuation. Separate estimates are made of the increases in assessed valuation resulting from new industrial improvements, increased leasehold values (or production values) of producing properties, new single family units, new mobile homes, new multifamily units, and new private commercial and services improvements.

3. Calculate public revenues. Separate estimates are made by each revenue source. Revenues are grouped into operating revenues and capital revenues. Existing tax rates and fee structures are assumed to continue unless otherwise specified. Most nonproperty tax revenues are calculated on the basis of per capita rates. Exceptions to this include school foundation funds and revenue sharing, which are calculated on the basis of slightly more complex formulae attempting to approximate statutory allocation equations.

4. Calculate operating expenditures. Most operating expenditures are also calculated on a per capita basis. The marginal rates of increase in expenditures per capita are estimated based on present rates in the community, state and national average rates, interviews with local officials providing the services, and reasoning by analogy with other boom communities (for instance, previous experience has been that municipal expenditures for police protection have consistently jumped to $20 or more per capita when the construction force arrives). Rates used in this working paper are detailed in Table F.1.

5. Determine needs, costs, and debt service on new capital facilities. The determination as to when new capital facilities are needed is typically made on the basis of population thresholds. Both the population-serving capacity of existing facilities and the costs of new ones are estimated based on the best available sources of local information and are specified in the model. Population thresholds are set, and

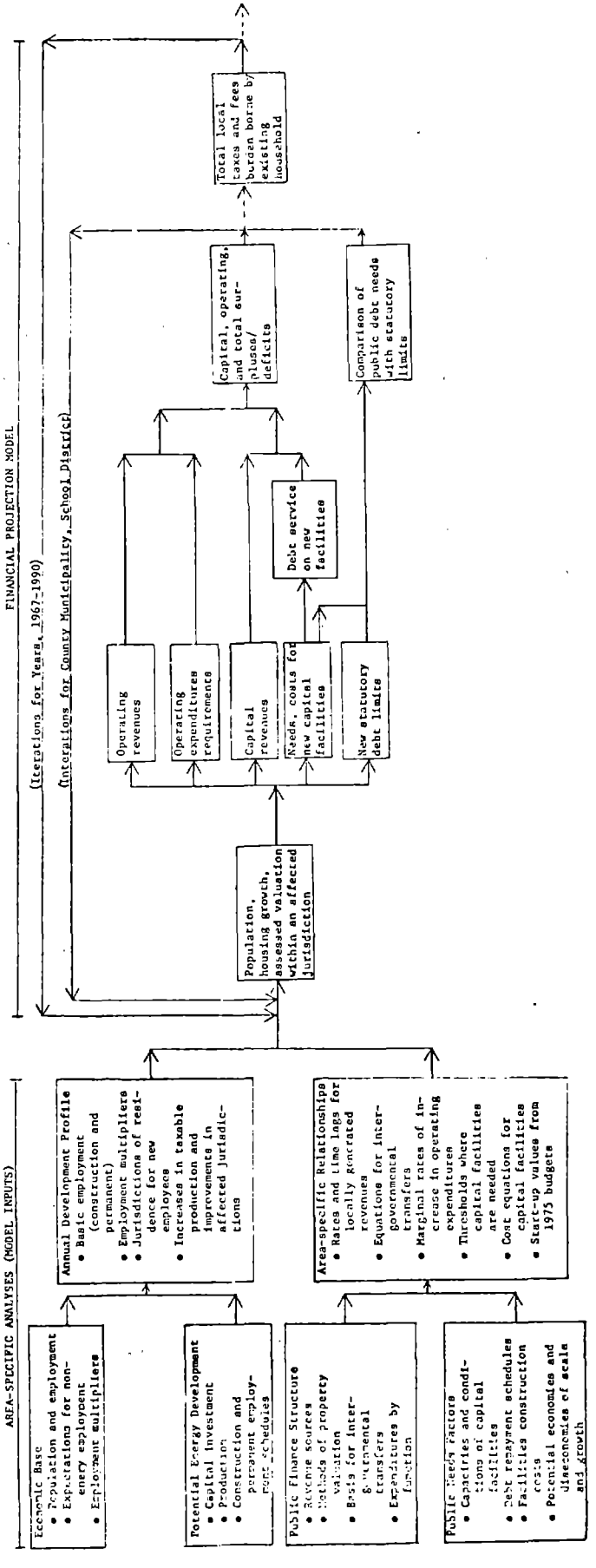


Fig. F.1. Methodology for Financial Projections.

Table F.1. Assumptions Used in Estimating Public Operating Expenditures Needs[a]

Category	Expenditure Assumption	Comments/Explanations
Town of Douglas		
General administration	$22 per capita	Present rate or level
Police and fire protection	$33 per capita	Present rate or level
Streets	$12 per capita	Present rate is $9 per capita. Maintenance appears to be behind schedule (physical inspection, 1975).
Health, recreation, and welfare	$10 per capita	Present rate or level. Most expenditures are for recreation.
Utilities	Water and sewer costs increased concurrently with the construction of new facilities. Sanitation costs at $23 per capita.	Water and sewer operating costs for each level of facilities taken from Nelson Engineering Study, 1975. Sanitation costs are present per capita level.
Miscellaneous	$5 per capita	Present rate or level
Converse County		
General administration	Calculated by the formula: $E_{year} = Pop_{year} \times \$59$ per capita $\times (Pop_{1976}/Pop_{year})^{0.3}$ where E_{year} is the expenditure in a given year and Pop_{year} is the population in a given year.	Present expenditures are $59 per capita. The other terms in the formula are intended to reflect the economies of scale which exist in county administration.
Sheriff	$15 per capita	Present rate or level
Rural fire protection	$36 per rural resident	Present rate or level
Health and hospitals	$62 per capita	Present rate or level. The major item is the county subsidy of operating expenditures at the county hospital.
Aid to schools and municipalities	$24,000 each year	Assumed continuation of juvenile recreation programs in Glenrock and Douglas at their present funding level.
Roads and bridges	$43 per capita	Present rate or level. Dedications of county roads to the state should be more than offset by dedication of roads by energy companies and housing developers to the county.
Welfare	$13 per capita	Present rate or level
Miscellaneous	$8 per capita	Present rate or level
Converse County School District #1		
Instruction	$1,290 per enrollee	Present rate or level
Transportation	$82 per enrollee	Present rate or level
Administration and miscellaneous	Existing amount plus $400 per new enrollee	$400 per enrollee is substantially less than the present level. These should be significant economies of scale.

[a]All assumptions are to be verified with local officials.

new facilities are assumed to be constructed as the forecasted population crosses these thresholds. The thresholds and cost assumptions used in this working paper are detailed in Table F.2.

All new facilities are assumed to be financed through bonded indebtedness. Unless otherwise specified the terms of 7 percent over 20 years (the terms for the new Douglas utility improvements) are assumed.

6. Calculate totals, surpluses and deficits. Revenues and expenditures needs are totaled and annual operating, capital, and total surpluses (or deficits) are calculated.

7. Compare public debt needs and debt limits. Both the needs for public debt and the statutory debt limits are calculated so that the need for an entity to exceed its debt limits can be identified if it exists.

The purpose of this methodological approach is to compare the public financial impacts of different development scenarios and to provide "order of magnitude" estimates of the amount of assistance needed to mitigate adverse impacts. The model generates results which are normative, not predictive. The expenditure projections attempt to depict those expenditure levels which would be necessary to maintain the present levels of public services. In Sweetwater County, Wyoming, where the boom has already occurred and no assistance was immediately received from outside sources, public officials chose to accept some reduction in public services rather than tax local residents the amount required to maintain previous levels of services.

Attempts to develop simpler methods for generating the necessary data for policy analysis proved unsatisfactory. Time lags, facilities thresholds, and the differential impacts on counties, municipalities, and school districts all have significant effects in the results of the analyses.

Table F.2. Thresholds and Outlay Requirements for Capital Facilities[a]

	Threshold	Outlay Requirements	Comments/Explanations
Town of Douglas			
Administrative space	7,000 population	$ 90,000	Expand, renovate town hall; renovation $75,000; expansion 500 new sq. ft. @ $35 per sq. ft.
	16,000 population	$ 60,000	Expand town hall; 190 sq. ft. per 1000 new population @ $35 per sq. ft.
	30,000 population	$ 90,000	Expand town hall
Police and fire	5,000 population	$ 70,000	New fire engine truck with pumper; new police car
	6,000 population	$ 10,000	New police car (1.5 new officers per 1000 new population and 1 new car per 3 new officers
	8,000 population	$ 10,000	New police car
	10,000 population	$ 70,000	New police car, new fire engine truck with pumper
			(Additional note: additional police car added for each 2000 additional population beyond 10,000; additional engine truck for each 4000 new population)
Streets	6,000 population	$ 20,000	Street arterial improvements at .2 miles per 2000 new population and $100,000 per mile (Note: subsequent improvements for each 2000 new population beyond 6000 total population)
Parks, recreation, library	5,000 population	$ 70,000	Neighborhood park
	8,000 population	$ 40,000	Tennis courts
	10,000 population	$ 60,000	Swimming pool
	15,000 population	$ 140,000	Neighborhood parks
	20,000 population	$ 80,000	Miscellaneous recreation facilities
	30,000 population	$ 800,000	Community park and community center (Note: Library expenditures are treated at the county level)
Utilities	Needed now (1976)	$1,900,000	Water and sewer improvements to accommodate 6000 additional population (for details, see the Town of Douglas application for assistance to the Wyoming Community Development Authority
	10,000 population	$1,300,000	Water and sewer improvements (see Water and Sewer Study, Nelson Engineering, 1975)
	13,000 population	$2,000,000	"
	17,000 population	$3,400,000	"
	21,000 population	$5,000,000	New subsidiary systems
Miscellaneous	7,000 population	$ 10,000	New sanitary collection equipment
	10,000 population	$ 400,000	New sanitary land fill
	15,000 population	$ 40,000	New sanitary collection equipment
	25,000 population	$ 70,000	New collection system, ancillary public

[a]All figures are rounded to the nearest $10,000.

Table F.2. Continued

	Threshold	Outlay Requirements	Comments/Explanations
Converse County			
Administrative/ judicial space	35,000 population	$ 330,000	Courthouse expansion; new courthouse, now under construction should be adequate for 35,000 population; expansion is calculated @ 300 sq. ft. per 1000 population and $55 per sq. ft.
	55,000 population	$ 170,000	Courthouse expansion calculated @ 200 sq. ft. per 1000 new residents and $55 per sq. ft. (economies of scale are assumed, both for employees and administrative space, as the county grows in population)
Sheriff's office and fire	35,000 population	$ 80,000	Sheriff's expansion; new sheriff's facilities included in courthouse under construction; expansion is for 2000 sq. ft. @ $40 per sq. ft.
	55,000 population	$ 80,000	Sheriff's expansion
Hospitals and mental health	13,000 population	$1,440,000	Hospital expansion; there are presently 32 beds (3.7 beds per 1000 residents); standards generally call for 4 beds per 1000 residents; however, Casper serves as the medical center for the region; the present hospital can accommodate still more population growth; a standard of 3 beds per 1000 population is used to estimate needs for Converse County; expansion is for 36 new beds @ $40,000 per bed
	18,000 population	$ 50,000	Mental health clinic; 1500 sq. ft. @ $35 per sq. ft.
	25,000 population	$1,440,000	Hospital expansion; 36 more beds
	37,000 population	$1,440,000	Hospital expansion; 36 more beds
	50,000 population	$1,490,000	Hospital expansion; 30 more beds; also a second mental health clinic
Roads and bridges	Presently none	$ 215,000	Needed road improvements include Wyoming Highway 59, Wyoming Highway 93 (presently a county road), and a bypass around Douglas connecting Wyoming 59 and Interstate 25. Presently, it is not clear what the county's share of these costs will be (most will be federal and state costs). The county's share of Highway 93 improvement costs will be $215,000. More information will be incorporated into later analyses
Other	10,000 population (outside of Douglas)	$ 70,000	Fire equipment for rural districts
	20,000 population (outside of Douglas)	$ 200,000	Fire equipment for rural districts, also sheriff's equipment supplement
Converse County School District #1			
Schools	Present capacity, after completion of new construction, will be 2600 students; beyond that, every 400 new enrollees is a threshold	$1,600,000	100 sq. ft. per new student @ $40 per sq. ft.
Administrative space	2,000 total enrollment	$26.25 per new enrollee	Administrative facilities: 1 new employee per 200 new enrollees, 150 sq. ft. per new employee @ $35 per sq. ft.

APPENDIX G. LETTER CONCERNING ARCHEOLOGY AND PRESERVATION

THE UNIVERSITY OF WYOMING
DEPARTMENT OF ANTHROPOLOGY
ARTS AND SCIENCES BUILDING
UNIVERSITY STATION, BOX 3431
LARAMIE, WYOMING 82071

May 16, 1975

Mr. James Shaw
Environmental Coordinator
Rocky Mountain Energy Co.
Lakeside National Bank Bldg.
4704 Harlan St.
Denver, Colorado 80212

Dear Mr. Shaw:

Members of our archeological team under the direct supervision of George Frison recently completed an archeological reconnaissance of the proposed Bear Creek uranium project area. The method employed by the team was to check all erosional cuts, road cuts, rock out-crops, and other topographic features where archeological materials are commonly found. Several other areas were spot-checked.

The area of concern included all of section 16, the southern one-half of sections 9 and 10, and the northern one-half of section 15, T.38N., R.73W. Also included was an access road running in a southwesterly direction from the mining area to the Ross Road. The road transects sections 21, 20, and 30 in T.38N., R.73W., and section 25 in T.38N., R.74W.

An occasional flake was found on the surface indicating light use of the area sometime in the prehistoric past. No archeological sites or other significant historic or prehistoric cultural materials were found. Archeological clearance is now provided for the entire project area with the stipulation that if any archeological materials become apparent during mining or construction activities, the State Archeologist should be notified at once. It is his policy to act on such reports immediately and to keep interference with such projects at a minimum.

Our fee for this project is $590.00. A check for that amount should be made payable to - Wyoming Recreation Commission - Archeological Budget, and sent to the Anthropology Dept., University of Wyoming.

Sincerely,

George M. Zeimens
Asst. State Archeologist

Paul K Westedt
Paul Westedt
State Historic Preservation Officer

GMZ:PW:lm

APPENDIX H. BASIS FOR NRC EVALUATION OF THE BEAR CREEK MILL PROPOSAL

THE NUCLEAR FUEL CYCLE

The nuclear "fuel cycle" comprises all the processes involved in the utilization of uranium as a source of energy for the generation of electrical power.

The nuclear fuel cycle consists of several steps:

1. Extraction - removing the ore (uranium) from the ground, separating uranium from the waste, and converting the uranium to a chemically stable oxide (nominally U_3O_8).

2. Conversion - changing the U_3O_8 to a fluoride (UF_6), which is a solid at room temperature but becomes a gas at slightly elevated temperatures, prior to enrichment.

3. Enrichment - concentrating the fissionable isotope (U-235) of uranium from the naturally occurring 0.7% to 2-4% for use in reactors for power generation.

4. Fabrication - coverting the enriched uranium fluoride to uranium dioxide (UO_2), forming it into pellets, and encasing the pellets in tubes (rods) that are assembled into fuel bundles for use in power generating reactors.

5. Nuclear Power Generation - using the heat resulting from the fissioning of uranium and plutonium for generating steam for the turbines.

6. Spent Fuel Reprocessing - involves chemical separation of fissionable and fertile values (U-235, U-238, Pu) from fission products (waste) with concurrent separation of uranium from plutonium.

7. Waste Management - the storage of fission products and low level wastes resulting from reprocessing in a manner that is safe and no threat to human health or the environment.

This cycle is portrayed in Figure H.1.

Nuclear reactor operation converts about 75% of the fissionable isotope (U-235) into fission products, thereby liberating thermal energy and creating plutonium, another fissionable element, in the process. The remaining quantities of fissionable uranium (U-235) (about the same concentration as exists in natural uranium) and the plutonium are recoverable for reuse in the cycle.

The spent fuel removed from the reactor is stored at the reactor site and later at the reprocessing plant to "cool" the spent fuel. The radioactivity of the fuel is reduced by a factor of about 10 after 150 days storage.

The reprocessing of spent fuel would produce fissionable material that could be used in combination with new (virgin) material obtained by mining and milling. In the absence of reprocessing, all replacement fuel must come from the mining and milling of ore from projects such as Bear Creek.

USE OF NUCLEAR FUEL IN REACTORS

Two types of reactors are currently used to generate essentially all of the nuclear energy sold in the U.S.; the boiling-water reactor (BWR) and the pressurized-water reactor (PWR). Each reactor type is operated with a fuel management scheme designed to meet the requirements of the utility operator. Different fuel management schemes result in different fuel burnup rates, along with other design parameters, affect the quantity of residual fissionable materials and the type and amount of radioactive wastes in the spent fuel. These differences, in turn, require specific treatment processes at the reprocessing plant; thus, for maximum overall efficiency, the spent fuel is stored at reactor or reprocessing sites (or both) until a "campaign," using a process related to the individual spent fuels, can be undertaken.

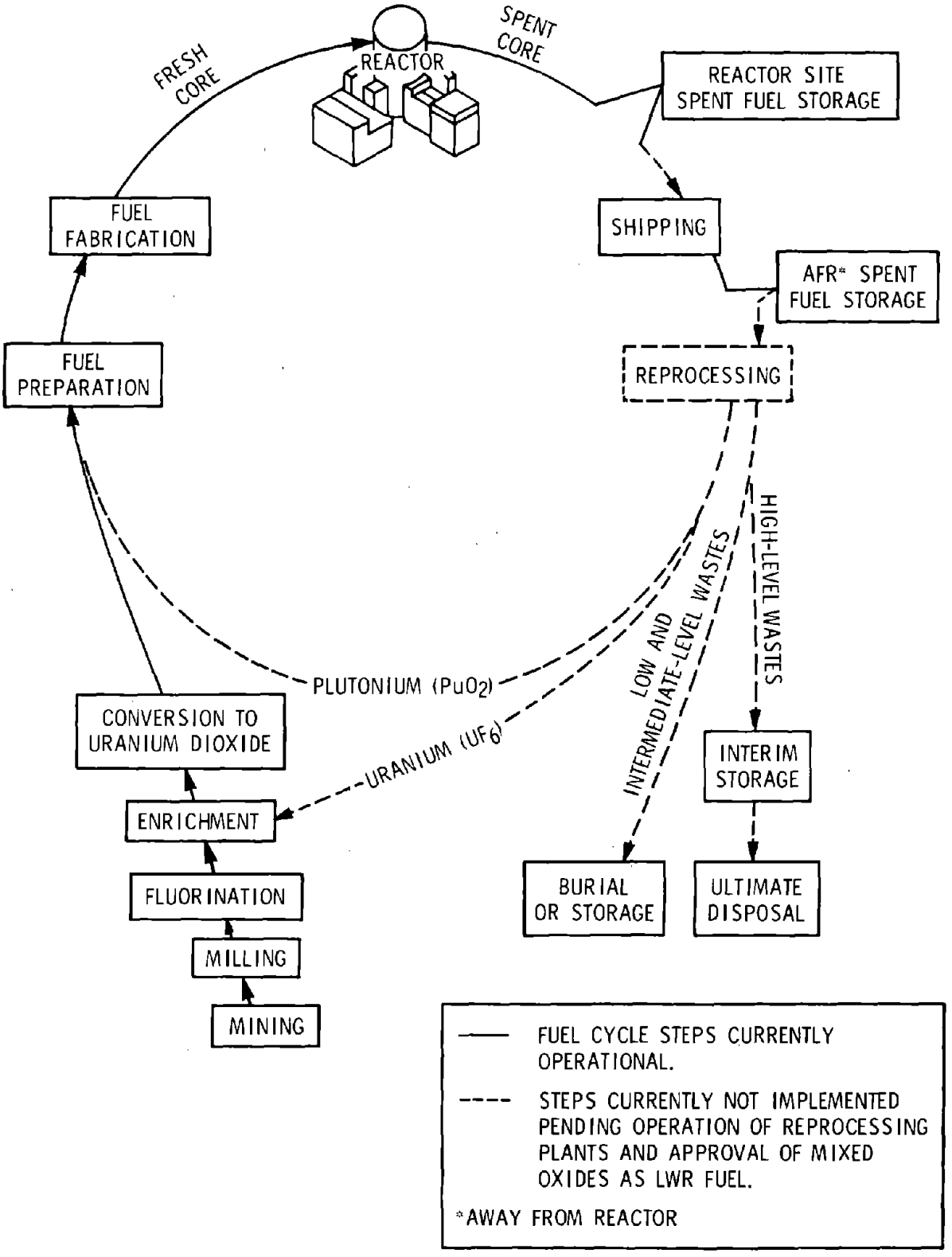


Fig. H.1. The LWR Fuel Cycle

No commercial reprocessing of spent fuel from power reactors has been carried out since late 1971, and only 244 metric tons of spent fuel (about two reactor core loadings, or six annual reloads) were processed between 1966 and 1971. Since the number of operating reactors has increased ten fold in the last decade and is expected to double by 1980, the need for mining and milling capacity will continue to increase. If reprocessing facilities were available to handle the spent fuel as it is generated, the rate of increase would be more moderate.

The general need for uranium as a fuel for generating electrical power in the U.S. over the next decade has been addressed in Section 10.1.1 of this statement. The specific need for the Bear Creek Project is outlined below.

Current mill capacity in the U.S. is 26,700 tons of ore per day. These mills operated at 85% of capacity in 1975. Uranium oxide output was approximately 11,500 tons, equivalent to slightly less than 3 lb U_3O_8 per ton of ore. The Bear Creek ore will have an average U_3O_8 content very close to the national average.

Forecasting U_3O_8 requirements over the next decade depends entirely on estimates of the rate at which new nuclear generating capacity is installed. Estimating U_3O_8 requirements for the next five years is somewhat easier because those reactors which will need fuel in that time period are either operating now (1976) or are well along in construction and will operate prior to 1981. Table H.1 shows the cumulative nuclear capacity as forecast for Project Independence by FEA.[1] (The staff considers this forecast, on the basis of licensing time required, to be reasonable, though somewhat optimistic.[2]) If a vigorously conservative position is taken that no installation of nuclear capacity will occur after 1985, the minimum need for fuel, and hence for U_3O_8, can be computed from the data in Table H.1, on the basis of various assumptions.

Fuel usage in nuclear reactors depends on the power generated, which is conventionally expressed as a decimal or per cent, and called "plant factor" (PF) or "capacity factor" (CF). The staff has chosen 0.6 as a minimum plant factor and 0.8 as a maximum to give a range of requirements for U_3O_8 over the next decade.*

Figure H.2 shows projected fuel requirements, assuming a minimum user rate; Figure H.3 shows maximum requirements. At minimum usage, current milling capacity could be exceeded in 1980, maximum usage would advance the negative imbalance to 1979. The Bear Creek mill is scheduled to produce U_3O_8 in 1978 and at that time would increase national production by about 2.6%.

Table H.1. "National Energy Outlook" Forecast of Nuclear Capacity

Year	Gigawatts
1976	29.2
1977	35.7
1978	42.2
1979	53.2
1980	60.0
1981	68.6
1982	88.5
1983	112.5
1984	126.8
1985	142.0

References

1. "National Energy Outlook, 1976," Federal Energy Administration, 1976.

2. NRC Yellow Book, NUREG 0030-6, U. S. Nuclear Regulatory Commission, July 1976.

*A 1000-MWe reactor will require ∿ 22 MT of uranium fuel per year at a PF of 0.6 and ∿ 30 MT uranium fuel for PF 0.8. For a 3% enriched fuel, and 0.25 tails assay, MT of fuel converts to tons of U_3O_8 as follows: (MT of fuel) (7.9) = tons U_3O_8.

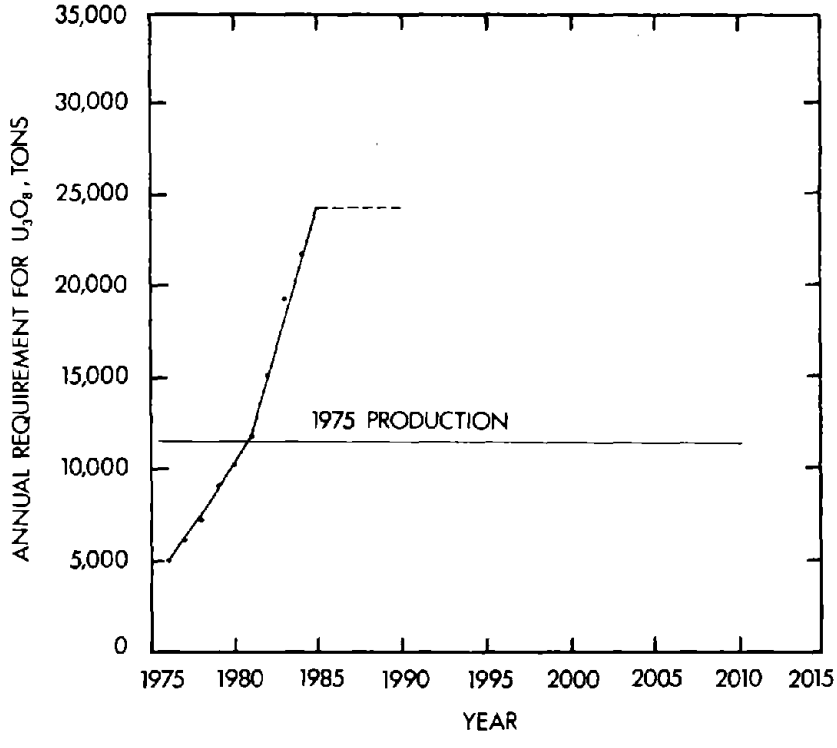


Fig. H.2. Minimum Annual U_3O_8 Requirements.

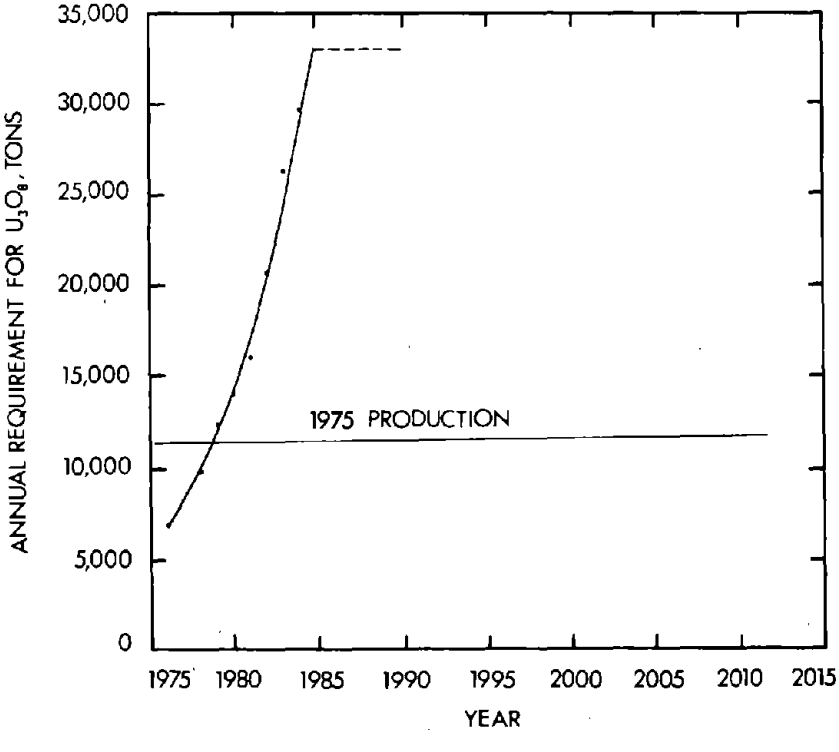


Fig. H.3. Maximum Annual U_3O_8 Requirements.

APPENDIX I. FOREST SERVICE POSITION REGARDING APPROVALS AND PERMITS
April 1977*

The Forest Service believes that its position should be made visible as an integral part of this environmental statement. This appendix is an expression of that position, including the decision-making rationale leading to it.

MAJOR FOREST SERVICE SURFACE MANAGEMENT RESPONSIBILITIES WITH RESPECT TO THE BEAR CREEK PROJECT

Minerals-area management activities will be implemented in accordance with the general objectives of multiple use (and sustained yield). All minerals-area management activities will be administered with the safeguards needed to attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences (FSM 2802).

"Multiple use" means the management of all the various renewable surface resources of natural forest (system lands) so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.

"Sustained yield of the several products and services" means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the National Forest without impairment of the productivity of the land (Multiple Use--Sustained Yield Act 6-12-60).

The Secretary of Agriculture (Forest Service) is authorized and directed to develop a program of land conservation and land utilization in order to correct maladjustments in land use, control soil erosion, preserve natural resources, protect wildlife, the public lands, health, safety and welfare; improve, develop, and administer any property so acquired and to construct such structures as may be necessary to adapt it to its most beneficial use (Bankhead-Jones Farm Tenant Act 7-22-37).

Congress declares that the National Forest System consists of units of federally owned forest, range, and related lands throughout the United States and its territories, united into a nationally significant system dedicated to the long-term benefit for present and future generations, and that it is the purpose of this section to include all such areas into one integral system (Forest and Rangeland Renewable Resources Planning Act 8-17-74).

The Forest Service, by virtue of its statutory authority for management of the National Forest System, research and cooperative programs, and its role as an agency in the Department of Agriculture, has both a responsibility and an opportunity to be a leader in assuring that the Nation maintains a natural resource conservation posture that will meet the requirements of our people in perpetuity (National Forest Management Act 10-22-76).

BRIEF DESCRIPTION OF THE RECLAMATION ALTERNATIVES

A. Alternative A would result in approximately 46.5 percent backfill of the B-1 pit and form a 31-acre lake with about 48 acres of steep highwalls. The B-8 and part of the B-13 pits will form lakes with highwalls reduced to 3:1 or less slopes. All other pits will be completely backfilled and, along with the spoil dumps, graded, topsoiled and revegetated. This alternative is proposed by the company in their Mining and Reclamation Plan.

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*This reflects the Forest Service position as of this date.

B. Alternative B is similar to alternative A except that the B-1 pit area would be reclaimed differently on federal surface. Highwalls would be reduced to 3:1 or less on the National Grasslands and a 57-acre lake would form of which approximately 34 acres would be on federal surface.

Highwall reduction would require an additional 48-acre disturbance adjacent to the pit and enlarge the spoil dump by about 66 acres. The highwall would not be reduced on private surface.

C. Alternative C is similar to A but differs by the reclamation procedures of the B-1 pit. The highwalls could be reduced to 3:1 slopes or less on the federal surface and the resulting lake of about 19 acres would be confined to private land.

Highwall reduction will disturb an additional 20 acres adjacent to the B-1 pit and reduce the depth of the northern end of the mine pit. The highwall would not be reduced on private surface.

D. Alternative D is similar to alternative A, but would completely reduce the highwall surrounding the B-1 pit to 3:1 slopes. Approximately 68 additional acres would be disturbed during highwall reduction. Since all slideslope material would be spoiled into the pit, the option of a lake would be eliminated and the resulting depression would be similar to a playa condition.

E. Alternative E would result in a complete backfill of all mined pits. A more complete description of the various alternatives is given in Section 10.1.3.

ALTERNATIVE ANALYSIS

The analysis of alternatives included an expression of estimated production outputs based upon a predicted land capability classification method and predicted range sites. The model concept is essentially a quantification of the suitable and available soil resources that are salvageable onsite and the operational possibilities of landform reconstruction with attention given to slope shaping and soil building according to design. The natural land capability and range sites of the disturbed area served as the quality standard for comparison. The output tables are shown in Section 10.1.3 and Appendix D.

The relative costs of each alternative are displayed in Section 10.1.3. Cost relationships between alternatives, based on conventional earth-moving equipment, were furnished by the applicant.

It was necessary to identify the following assumptions for the purpose of this analysis:

1. Mining will occur using open pit methods.

2. Water quality of the planned lakes will be and remain adequate for livestock, wildlife, fisheries, irrigation and recreation uses.

The analysis process included the quantification of the attributes of each alternative expressed as output objectives. These outputs were than rated against the listed land management goals of the Forest Service within the interalternative analysis matrix.

The conclusions reached by the analysis are as follows:

1. Alternatives D and E are not considered viable at this time because they would close the water resource options desired by the adjacent local landowners.

2. Alternative A is not considered fully suitable because of the highwall impairment on the National Grassland surface while giving primary benefit to adjacent private landowners.

3. Alternatives B and C would satisfy the management requirements of the National Grassland surface and maintain the water resource options of the adjacent private landowners.

Forest Service Land Management Goals derived from the basic Laws providing Surface Management authority are:	Rating	Alternative A Output Objectives	Rating	Alternative B Output Objectives	Rating	Alternative C Output Objectives	Rating	Al Outp
1. To adapt the reclaimed land to the widest range of beneficial uses.	+	a) Accessible water for man and other animals; unlimited access on 86 acres; limited access on 31 acres.	+	a) Accessible water for man and other animals; unlimited access on 120 acres; limited access on 23 acres.	+	a) Accessible water for man and other animals; unlimited access on 86 acres; limited access on 19 acres.	+	a) Accessible w animals; unlimit
	+	b) 117 surface acres of water available for possible fisheries, wildlife and livestock watering, recreation and irrigation use. 85 acres are available on Federal surface, 32 acres on private surface.	+++	b) 143 surface acres of water available for possible fisheries, wildlife and livestock watering, irrigation and recreation use. 109 acres on Federal surface; 34 acres on private land.	+	b) 105 acres of surface water available for possible fisheries, wildlife and livestock watering, irrigation and recreation use. 75 acres on Federal surface; 30 acres on private surface.	-	b) 86 acres of for possible fis livestock wateri recreation use. surface; 11 acre
	+	c) 1753 acres available for wildlife and livestock range.	+	c) 1735 acres available for wildlife and livestock range.	+	c) 1856 acres available for wildlife and livestock range.	+	c) 1833 acres a and livestock ra
	+	d) 1380 acres capable and suitable for nonirrigated crops and 1289 acres capable and suitable for irrigated crops.	+	d) 1364 acres capable and suitable for nonirrigated crops and 1222 acres capable and suitable for irrigated crops.	+	d) 1433 acres capable and suitable for nonirrigated crops and 1305 acres capable and suitable for irrigated crops.	+	d) 1433 acres c nonirrigated cro capable and suit
2. To avoid undesirable or unintended consequences and maladjustments in land use.	---	a) 48 acres of steep highwall; about 15 acres on Federal surface having no agricultural potential.	-	a) 47 acres of steep highwall; none on Federal surface having no agricultural potential.	-	a) 41 acres of steep highwall; none on Federal surface having no agricultural potential.	+++	a) No highwall.
	-	b) Antelope habitat will be less desirable due to a loss of forbs and shrubs on 1786 acres of reclaimed land.	-	b) Antelope habitat will be less desirable due to a loss of forbs and shrubs on 1900 acres of reclaimed land.	-	b) Antelope habitat will be less desirable due to a loss of forbs and shrubs on 1870 acres of reclaimed land.	-	b) Antelope hab desirable due to shrubs on 1919 a
3. To avoid unnecessary and unreasonable risks to public health and safety.	---	a) 48 acres of highwall having near vertical slopes presenting a hazard to man and beasts (about 15 acres are on Federal surface).	-	a) 47 acres of steep highwall having near vertical slopes presenting a hazard to man and beasts (none on Federal surface).	-	a) 41 acres of steep highwall having near vertical slopes presenting a hazard to man and beasts (none on Federal surface).	+++	a) No highwall.
4. To attain fair and reasonable reclamation without impairment to the productivity of the land compared to the present potential.	-	a) Based on present potential, 38% of the reclaimed area would have a higher response to treatment and reduced output costs, 54% would be unchanged and 8% would be lost from production.		a) Based on present potential, 37% of the reclaimed area would have a higher response to treatment and reduced output costs, 54% would be unchanged and 9% would be lost from production.		a) Based on present potential, 41% of the reclaimed area would have a higher response to treatment and reduced output costs, 52% would be unchanged and 7% would be lost from production.	+	a) Based on pre the reclaimed ar response to trea costs, 55% would would be lost fr
	-	b) ----		b) Reclamation costs compared to Alternative A is an additional $7 million.		b) Reclamation costs compared to Alternative A is an additional $1.2 million.	-	b) Reclamation Alternative A is $4.4 million.
	-	c) 380,200 pounds of potential forage production loss.		c) 418,300 pounds of potential forage production loss.		c) 345,900 pounds of potential forage production loss.	+	c) 285,100 pour production loss.

INTERALTERNATIVE ANALYSIS

ve A ctives	Rating	Alternative B Output Objectives	Rating	Alternative C Output Objectives	Rating	Alternative D Output Objectives	Rating	Alternative E Output Objectives
or man and other ss on 86 acres; res.	+	a) Accessible water for man and other animals; unlimited access on 120 acres; limited access on 23 acres.	+	a) Accessible water for man and other animals; unlimited access on 86 acres; limited access on 19 acres.	+	a) Accessible water for man and other animals; unlimited on 86 acres.		a) No surface water.
of water available , wildlife and reation and es are available acres on private	+++	b) 143 surface acres of water available for possible fisheries, wildlife and livestock watering, irrigation and recreation use. 109 acres on Federal surface; 34 acres on private land.	+	b) 105 acres of surface water available for possible fisheries, wildlife and livestock watering, irrigation and recreation use. 75 acres on Federal surface; 30 acres on private surface.	-	b) 86 acres of surface water available for possible fisheries, wildlife and livestock watering, irrigation and recreation use. 75 acres on Federal surface; 11 acres on private surface.	---	b) No surface water.
le for wildlife	+	c) 1735 acres available for wildlife and livestock range.	+	c) 1856 acres available for wildlife and livestock range.	+	c) 1833 acres available for wildlife and livestock range.	+++	c) 1919 acres available for wildlife and livestock range.
and suitable for 1289 acres or irrigated	+	d) 1364 acres capable and suitable for nonirrigated crops and 1222 acres capable and suitable for irrigated crops.	+	d) 1433 acres capable and suitable for nonirrigated crops and 1305 acres capable and suitable for irrigated crops.	+	d) 1433 acres capable and suitable for nonirrigated crops and 1283 acres capable and suitable for irrigated crops.	+++	d) 1699 acres capable and suitable for nonirrigated crops and 1608 acres capable and suitable for irrigated crops.
highwall; about face having no	-	a) 47 acres of steep highwall; none on Federal surface having no agricultural potential.	-	a) 41 acres of steep highwall; none on Federal surface having no agricultural potential.	+++	a) No highwall.	+++	a) No highwall.
ill be less of forbs and reclaimed land.	-	b) Antelope habitat will be less desirable due to a loss of forbs and shrubs on 1900 acres of reclaimed land.	-	b) Antelope habitat will be less desirable due to a loss of forbs and shrubs on 1870 acres of reclaimed land.	-	b) Antelope habitat will be less desirable due to a loss of forbs and shrubs on 1919 acres of reclaimed land.	-	b) Antelope habitat will be less desirable due to a loss of forbs and shrubs on 1786 acres of reclaimed land.
ll having near ing a hazard to 5 acres are on	-	a) 47 acres of steep highwall having near vertical slopes presenting a hazard to man and beasts (none on Federal surface).	-	a) 41 acres of steep highwall having near vertical slopes presenting a hazard to man and beasts (none on Federal surface).	+++	a) No highwall.	+++	a) No highwall.
otential, 38% ould have a tment and reduced be unchanged om production.		a) Based on present potential, 37% of the reclaimed area would have a higher response to treatment and reduced output costs, 54% would be unchanged and 9% would be lost from production.		a) Based on present potential, 41% of the reclaimed area would have a higher response to treatment and reduced output costs, 52% would be unchanged and 7% would be lost from production.	+	a) Based on present potential, 41% of the reclaimed area would have a higher response to treatment and reduced output costs, 55% would be unchanged and 4% would be lost from production.	+++	a) Based on present potential, 55% of the reclaimed area would have a higher response to treatment and reduced output costs; the remaining 45% would be unchanged.
otential forage		b) Reclamation costs compared to Alternative A is an additional $7 million.		b) Reclamation costs compared to Alternative A is an additional $1.2 million.	-	b) Reclamation costs compared to Alternative A is an additional $4.4 million.	---	b) Reclamation costs compared to Alternative A is an additional $28.8 million.
		c) 418,300 pounds of potential forage production loss.		c) 345,900 pounds of potential forage production loss.	+	c) 285,100 pounds of potential forage production loss.	+++	c) 675,000 pounds of increased forage production potential.

APPENDIX J

ROCKY MOUNTAIN ENERGY COMPANY
LAKESIDE NATIONAL BANK BLDG.
4704 HARLAN ST.
DENVER, COLORADO 80212

ENVIRONMENTAL SERVICES
JAMES W. SHAW, MANAGER

October 19, 1976

Mr. Leland C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

ATTENTION: Mr. Ross Scarano

Dear Mr. Rouse:

Re: Bonding - Bear Creek Mill

This letter is to advise you of Rocky Mountain Energy Company's bonding intentions relative to the Bear Creek mill. Arrangements have been, or will be made to obtain a surety bond to insure adequate reclamation of all lands disturbed by mining or milling, including stabilization of tailings, and to insure RMEC conducts a monitoring program associated with the stabilized tailings for a period of at least fifty years.

The vehicle for the bonding to insure reclamation of disturbed lands is the State of Wyoming. RMEC currently has posted a bond in the amount of one million one hundred thousand dollars ($1,100,000.00), with the Wyoming Department of Environmental Quality. Amendments have been submitted which, when approved, will raise the bond with the State to one million nine hundred twenty thousand dollars ($1,920,000.00). Pursuant to our revised tailings stabilization plan transmitted to NRC on October 7, 1976, we intend to revise our reclamation plan with the State and increase our total mine permit associated bond to two million five hundred thousand dollars, ($2,500,000.00). This will result in a surety bond covering reclamation of all disturbed lands, including stabilization of tailings.

In addition, RMEC will post a surety bond in the amount of five hundred thousand dollars ($500,000.00), payable to the U. S. Nuclear Regulatory Commission or its designee, to insure RMEC will perform, at least annually, environmental and radiometric surveys of the tailings area, and conduct, at least annually, maintenance of the tailings dam and diversion systems and keep records of such annual work. Further, RMEC will arrange an institution, such as a bank, to maintain custody of this bond until NRC requests custody or designates an agency to maintain custody. The exact monitoring program will be agreed upon at the conclusion of our tailings stabilization program and the termination of our license.

It is my understanding that these arrangements meet the criteria of the NRC for insuring responsible reclamation. Please advise me if other arrangements are necessary.

Sincerely,

/s/ James W. Shaw

J. W. Shaw

JWS:sh

"RETYPED FROM TELECOPY"

ROCKY MOUNTAIN ENERGY COMPANY
LAKESIDE NATIONAL BANK BLDG.
4704 HARLAN ST.
DENVER, COLORADO 80212

ENVIRONMENTAL SERVICES
JAMES W. SHAW, MANAGER

November 5, 1976

Mr. Leland C. Rouse, Chief
Nuclear Regulatory Commission
Facility Environmental Assessment Branch
Division of Fuel Cycle and Material Safety
Washington, D. C. 20555

ATTENTION: Mr. Ross Scarano

Dear Mr. Rouse:

Re: Bear Creek - Bonding

In my October 19, 1975 letter I incorrectly calculated our total bond requirement with the state. The amount of $2,500,000.00 stated in the letter, overstated the costs slightly. Enclosed for your information is the summary table of reclamation costs for the Bear Creek project. It is taken from our state mine permit application, as we have recently revised it.

Please notice the tailings reclamation amount corresponds to our cost estimates associated with our tailings stabilization plan as presented to NRC. Further, you will notice the correct total is two million, one hundred ninety-five thousand, eight hundred dollars ($2,195,800.00). Arrangements are underway to provide a bond in the amount of $2,200,000.00 with the state. As my earlier letter stated, we currently have a bond for one million, one hundred thousand dollars ($1,100,000.00) in effect with the state.

Please excuse my earlier error.

Sincerely,

/s/ James W. Shaw

J. W. Shaw

JWS:sh
Enclosure

"RETYPED FROM TELECOPY"

TABLE I
COST ESTIMATE SUMMARY FOR RECLAMATION PROGRAM

Reclaimed Area	Task	Estimated $ Per Acre	Acres	Cost
B-1 Mine Pit,* west overburden pile, haul roads	Spreading Soil, Seeding, etc.	$ 524 125 $ 649	294	$ 190,800
B-1 Overburden Dump, East	Reshaping, Spreading Soil, Seeding, etc.	$ 113 524 125 $ 762	284	$ 216,400
Mill Area, includes ore stockpiles	Burial Spreading Soil Seeding, etc.	$1,060 524 125 $1,709	100	$ 170,900
Tailings	Burial (incl. topsoil) Spreading Soil Seeding, etc.	$6,295 524 125 $6,944	100 50 150	$ 629,500 $ 26,200 $ 18,750 $ 674,450
Settling Ponds	Burial Spreading Soil Seeding, etc.	$1,060 524 125 $1,709	26	$ 44,400
Topsoil Stockpiles	Seeding, etc.	$ 125 $ 125	138	$ 17,250
B-4 (backfilled) pit, B-4 and B-3 overburden dumps, haul roads	Reshaping Spreading Soil Seeding, etc.	$ 113 524 125 $ 762	300	$ 228,600
B-3 pit (backfilled)	Spreading Soil Seeding, etc.	$ 524 125 $ 649	88	$ 57,100
			-26- (Revised)	
B-6 pit (backfilled)	Spreading Soil Seeding, etc.	$ 524 125 $ 649	49	$ 31,800
B-8 pit* highwall slope reduction & reclamation	(a) Reshaping	$ 113 $ 113	82	$ 9,300
	(b) Spreading Soil Seeding, etc.	$ 524 125 $ 649	31	$ 20,100
Mine Shop & Change House	Burial Spreading Soil Seeding, etc.	$1,060 524 125 $1,709	40	$ 68,400
B-13 east pit overburden dumps haul roads	Reshaping	$ 113 524 125 $ 762	194	$ 147,800
B-13 west pit highwall slope reduction & reclamation	(a) Reshaping	$ 113 $ 113	79	$ 8,900
	(b) Spreading Soil Seeding, etc.	$ 524 125 $ 649	44	$ 28,600
Mill and Mine Shop Building Decommissioning	Labor Equipment		2,049	$ 75,000 $ 75,000
	TOTAL ESTIMATED COSTS			$2,064,800
	PER ACRE COST			$1,008/acre
			-27- (Revised)	
Dilts Overburden	Reshaping	$ 113 $ 113	103	$ 11,600
Topsoil	Spreading	$ 524 $ 524	184	$ 96,400
Revegetation	Fertilizer, Seed Bed Preparation, Seed, Seeding	$ 125 $ 125	471	$ 23,000
	SUBTOTAL: DILTS PROJECT			$ 131,000
	TOTAL BEAR CREEK & DILTS AREA			$2,195,800

*Excluding lake areas

"RETYPED FROM TELECOPY"

APPENDIX K. DETAILED RADIOLOGICAL ASSESSMENT

The data presented in Appendix K, together with information given in Sections 3.3 and 4.8, permit detailed analysis of the radiological implications of the Bear Creek project. This information is presented to allow complete review and verification of the radiological assessment by qualified radiological scientists.

		Page
K-1	Water Balance for the Bear Creek Project	K-5
K-2	Radioactive Release from the Mining Operation	K-7
K-3	Argonne Steady-State (Plume Depletion) Uranium Dispersion and Dosimetry Code (UDAD)	K-8
	K-3.1 Meteorological Input Data	
	K-3.2 Source Characterization in Air	
	K-3.3 Effective Dispersion Factor for the Dryer	
	K-3.4 Effective Dispersion Factor for the Mine	
	K-3.5 Concentrations of Radionuclides in Air	
	K-3.6 Concentrations, Ratios, and Work Levels of Radon Daughters at Various Distances from the Site	
	K-3.7 Radionuclide Concentration Isopleths	
K-4	Dose Rate as a Function of Direction and Distance to 80 Km	K-16
	K-4.1 Dose Rate to Whole Body (U-238)	
	K-4.2 Dose Rate to Whole Body (U-234)	
	K-4.3 Dose Rate to Whole Body (Th-230)	
	K-4.4 Dose Rate to Whole Body (Ra-226)	
	K-4.5 Dose Rate to Whole Body (Pb-210)	
	K-4.6 Dose Rate to Bone (U-238)	
	K-4.7 Dose Rate to Bone (U-234)	
	K-4.8 Dose Rate to Bone (Th-230)	
	K-4.9 Dose Rate to Bone (Ra-226)	
	K-4.10 Dose Rate to Bone (Pb-210)	
	K-4.11 Dose Rate to Lung (U-238)	
	K-4.12 Dose Rate to Lung (U-234)	
	K-4.13 Dose Rate to Lung (Th-230)	
	K-4.14 Dose Rate to Lung (Ra-226)	
	K-4.15 Dose Rate to Lung (Pb-210)	
	K-4.16 Dose Rate to Lung (Rn-222)	
	K-4.17 Dose Rate to GI (sol) (U-238)	
	K-4.18 Dose Rate to GI (sol) (U-234)	
	K-4.19 Dose Rate to GI (sol) (Th-230)	
	K-4.20 Dose Rate to GI (sol) (Ra-226)	
	K-4.21 Dose Rate to GI (sol) (Pb-210)	
	K-4.22 Dose Rate to GI (insol) (U-238)	
	K-4.23 Dose Rate to GI (insol) (U-234)	
	K-4.24 Dose Rate to GI (insol) (Th-230)	
	K-4.25 Dose Rate to GI (insol) (Ra-226)	
	K-4.26 Dose Rate to GI (insol) (Pb-210)	
K-5	Time-Integrated Dose from Inhalation of Airborne Particulates and Radon in the Vicinity of Bear Creek to 80 Km	K-30
	K-5.1 Dose to Whole Body (angle = 0, north)	
	K-5.2 Dose to Whole Body (angle = 45)	
	K-5.3 Dose to Whole Body (angle = 90, east)	
	K-5.4 Dose to Whole Body (angle = 180, south)	
	K-5.5 Dose to Whole Body (angle = 270, west)	

Page

K-5.6 Dose to Bone (angle = 0, north)
K-5.7 Dose to Bone (angle = 45)
K-5.8 Dose to Bone (angle = 90, east)
K-5.9 Dose to Bone (angle = 180, south)
K-5.10 Dose to Bone (angle = 270, west)

K-5.11 Dose to Lung (angle = 0, north)
K-5.12 Dose to Lung (angle = 45)
K-5.13 Dose to Lung (angle = 90, east)
K-5.14 Dose to Lung (angle = 180, south)
K-5.15 Dose to Lung (angle = 270, west)

K-5.16 Dose to Kidney (angle = 0, north)
K-5.17 Dose to Kidney (angle = 45)
K-5.18 Dose to Kidney (angle = 90, east)
K-5.19 Dose to Kidney (angle = 180, south)
K-5.20 Dose to Kidney (angle = 270, west)

K-5.21 Dose to GI System (soluble radionuclides) (angle = 0, north)
K-5.22 Dose to GI System (soluble radionuclides) (angle = 45)
K-5.23 Dose to GI System (soluble radionuclides) (angle = 90, east)
K-5.24 Dose to GI System (soluble radionuclides) (angle = 180, south)
K-5.25 Dose to GI System (soluble radionuclides) (angle = 270, west)

K-5.26 Dose to GI System (insoluble radionuclides) (angle = 0, north)
K-5.27 Dose to GI System (insoluble radionuclides) (angle = 45)
K-5.28 Dose to GI System (insoluble radionuclides) (angle = 90, east)
K-5.29 Dose to GI System (insoluble radionuclides) (angle = 180, south)
K-5.30 Dose to GI System (insoluble radionuclides) (angle = 270, west)

K-5.31 Dose to Liver (angle = 0, north)
K-5.32 Dose to Liver (angle = 45)
K-5.33 Dose to Liver (angle = 90, east)
K-5.34 Dose to Liver (angle = 180, south)
K-5.35 Dose to Liver (angle = 270, west)

K-6 Total Dose Rate from Airborne and Ground-Deposited Radionuclides K-49
K-6.1 Maximum Total Dose Rate from Ground and Cloud
K-6.2 Total Dose Rate from Ground and Cloud--angle = 0
K-6.3 Total Dose Rate from Ground and Cloud--angle = 90
K-6.4 Total Dose Rate from Ground and Cloud--angle = 180
K-6.5 Total Dose Rate from Ground and Cloud--angle = 270

K-7 Time-Integrated Dose from External Exposure to Airborne Radionuclides K-53
K-7.1 Dose to the Whole Body (angle = 0, north)
K-7.2 Dose to the Whole Body (angle = 45)
K-7.3 Dose to the Whole Body (angle = 90, east)
K-7.4 Dose to the Whole Body (angle = 180, south)
K-7.5 Dose to the Whole Body (angle = 270, west)

K-7.6 Dose to Skin (angle = 0, north)
K-7.7 Dose to Skin (angle = 45)
K-7.8 Dose to Skin (angle = 90, east)
K-7.9 Dose to Skin (angle = 180, south)
K-7.10 Dose to Skin (angle = 270, west)

K-7.11 Dose to Ovaries (angle = 0, north)
K-7.12 Dose to Ovaries (angle = 45)
K-7.13 Dose to Ovaries (angle = 90, east)
K-7.14 Dose to Ovaries (angle = 180, south)
K-7.15 Dose to Ovaries (angle = 270, west)

K-7.16 Dose to Testes (angle = 0, north)
K-7.17 Dose to Testes (angle = 45)
K-7.18 Dose to Testes (angle = 90, east)
K-7.19 Dose to Testes (angle = 180, south)
K-7.20 Dose to Testes (angle = 270, west)

K-7.21 Dose to Small Intestine (angle = 0, north)
K-7.22 Dose to Small Intestine (angle = 45)
K-7.23 Dose to Small Intestine (angle = 90, east)
K-7.24 Dose to Small Intestine (angle = 180, south)
K-7.25 Dose to Small Intestine (angle = 270, west)

Page

K-7.26 Dose to Lung (angle = 0, north)
K-7.27 Dose to Lung (angle = 45)
K-7.28 Dose to Lung (angle = 90, east)
K-7.29 Dose to Lung (angle = 180, south)
K-7.30 Dose to Lung (angle = 270, west)

K-7.31 Dose to Red Marrow (angle = 0, north)
K-7.32 Dose to Red Marrow (angle = 45)
K-7.33 Dose to Red Marrow (angle = 90, east)
K-7.34 Dose to Red Marrow (angle = 180, south)
K-7.35 Dose to Red Marrow (angle = 270, west)

K-7.36 Dose to Skeleton (angle = 0, north)
K-7.37 Dose to Skeleton (angle = 45)
K-7.38 Dose to Skeleton (angle = 90, east)
K-7.39 Dose to Skeleton (angle = 180, south)
K-7.40 Dose to Skeleton (angle = 270, west)

K-7.41 Dose to Spleen (angle = 0, north)
K-7.42 Dose to Spleen (angle = 45)
K-7.43 Dose to Spleen (angle = 90, east)
K-7.44 Dose to Spleen (angle = 180, south)
K-7.45 Dose to Spleen (angle = 270, west)

K-8 Time-Integrated Dose from External Exposure to Surface Activity during the Period of Bear Creek Uranium Milling Operation K-77
K-8.1 Dose to Whole Body (angle = 0, north)
K-8.2 Dose to Whole Body (angle = 45)
K-8.3 Dose to Whole Body (angle = 90, east)
K-8.4 Dose to Whole Body (angle = 180, south)
K-8.5 Dose to Whole Body (angle = 270, west)

K-8.6 Dose to Skin (angle = 0, north)
K-8.7 Dose to Skin (angle = 45)
K-8.8 Dose to Skin (angle = 90, east)
K-8.9 Dose to Skin (angle = 180, south)
K-8.10 Dose to Skin (angle = 270, west)

K-8.11 Dose to Ovaries (angle = 0, north)
K-8.12 Dose to Ovaries (angle = 45)
K-8.13 Dose to Ovaries (angle = 90, east)
K-8.14 Dose to Ovaries (angle = 180, south)
K-8.15 Dose to Ovaries (angle = 270, west)

K-8.16 Dose to Testes (angle = 0, north)
K-8.17 Dose to Testes (angle = 45)
K-8.18 Dose to Testes (angle = 90, east)
K-8.19 Dose to Testes (angle = 180, south)
K-8.20 Dose to Testes (angle = 270, west)

K-8.21 Dose to Small Intestine (angle = 0, north)
K-8.22 Dose to Small Intestine (angle = 45)
K-8.23 Dose to Small Intestine (angle = 90, east)
K-8.24 Dose to Small Intestine (angle = 180, south)
K-8.25 Dose to Small Intestine (angle = 270, west)

K-8.26 Dose to Lung (angle = 0, north)
K-8.27 Dose to Lung (angle = 45)
K-8.28 Dose to Lung (angle = 90, east)
K-8.29 Dose to Lung (angle = 180, south)
K-8.30 Dose to Lung (angle = 270, west)

K-8.31 Dose to Red Marrow (angle = 0, north)
K-8.32 Dose to Red Marrow (angle = 45)
K-8.33 Dose to Red Marrow (angle = 90, east)
K-8.34 Dose to Red Marrow (angle = 180, south)
K-8.35 Dose to Red Marrow (angle = 270, west)

K-8.36 Dose to Skeleton (angle = 0, north)
K-8.37 Dose to Skeleton (angle = 45)
K-8.38 Dose to Skeleton (angle = 90, east)
K-8.39 Dose to Skeleton (angle = 180, south)
K-8.40 Dose to Skeleton (angle = 270, west)

Page

K-8.41 Dose to Spleen (angle = 0, north)
K-8.42 Dose to Spleen (angle = 45)
K-8.43 Dose to Spleen (angle = 90, east)
K-8.44 Dose to Spleen (angle = 180, south)
K-8.45 Dose to Spleen (angle = 270, west)

K-9 Food Pathway - Fish K-101

APPENDIX K-1. WATER BALANCE FOR BEAR CREEK PROJECT

1) Annual evaporation from tailings pond

Annual evaporation rate = 40 inches (ER, p. 2-116)

Range of areas of evaporative surface = 50 to 120 acres

or 167 to 400 acre-ft/yr

Annual Evaporation = $\frac{40 \text{ in.}}{\text{year}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times (50 \text{ to } 120) \text{ acres} \times \frac{1233 \text{ m}^3}{\text{acre-ft}}$ = 205,500 to 493,200 m^3/yr,

or 167 to 400 acre-ft/yr.

2) Annual precipitation on undiverted tailings watershed

Annual precipitation = 12 inches (ER, p. 2-113)

Watershed area (below diversions) = 202 acres

Pond surface area = 50 to 120 acres

Annual precipitation input to pond = $\frac{12 \text{ in.}}{\text{year}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times (50 \text{ to } 120) \text{ acres} \times \frac{1233 \text{ m}^3}{\text{acre-ft}}$

= 61,650 to 147,960 m^3/yr or 50 to 120 acre-ft/yr to pond

Annual runoff from watershed

= $\frac{12 \text{ in.}}{\text{year}} \times \frac{1 \text{ ft}}{12 \text{ in.}} \times [(202-120) \text{ to } (202-50)] \text{ acres} \times \frac{1233 \text{ m}^3}{\text{acre-ft}} \times 0.67$ = 125,760 to 67,740 m^3/yr

or 102 to 55 acre-ft/yr

Total precipitation input

= 187,410 to 215,700 m^3/yr, or 152 to 175 acre-ft/yr

This calculation is expected to be an overstatement; evapotranspiration (estimated at 20 to 25 inches per year) is ignored and a conservative runoff coefficient (0.67) is used.

3) Seepage from tailing basin

Seepage is projected to be 10 gpm*

$\frac{10 \text{ gal}}{\text{min}} \times \frac{\text{acre-ft}}{43{,}560 \text{ ft}^3} \times \frac{\text{ft}^3}{7.481 \text{ gal}} \times \frac{60 \text{ min}}{\text{hour}} \times \frac{24 \text{ hr}}{\text{day}} \times \frac{365 \text{ d}}{\text{year}} \times \frac{1233 \text{ m}^3}{\text{acre-ft}} = 16 \frac{\text{acre-ft}}{\text{year}}$, or 19,887 m^3/yr

4) Transpiration [see item (2) above]

5) Mill circuit discharge to tailings pond

Transported tailings are 35% solids with water rate being about 500 acre-ft/year (see Fig. 3.17) or 616,500 m^3/year.

*"Additional Investigations for Proposed Tailing Dam and Pond Area," Chen and Associates, p. 6, January 20, 1977.

6) Recycle from pond to mill

Pump back of solution from tailings pond is about 270 acre-ft/year, or 332,910 m^3/year (see Fig. 3.17).

7) Mine water = 1,000 gpm (ER, p. 3-30) = 1,600 ac-ft/yr, or 1,990,000 m^3/yr

8) Water for dust suppression on haulage roads = 40,000 to 50,000 gpd (Sec. 3.1.8.2) = 45 ac-ft to 56 ac-ft/yr (55,200 to 69,000 m^3/yr).

9) Process water = 228 gpm (ER, p. 3-12, plate 36) = 368 ac-ft/yr, or 453,500 m^3yr [sum of streams #3 (68 gpm), #6 (64.6 gpm), #9 (12.8 gpm), #26 (72.6 gpm) and #28 (10 gpm) of plate 36].

10) Domestic water (from deep well and other sources) = 22 ac-ft/yr (27,600 m^3/yr. Based on an average figure of 50 gal/person/day for domestic use and a total employment figure of 400 (ER, p. 8-4).

11) Sewage from mill = domestic water consumption.

12) Losses from mill = difference of quantities entering and leaving the mill; primarily steam and evaporation losses and leakages = 103 ac-ft/yr (127,000 m^3/yr).

13) Evaporation from dewatering impoundment system = 40 in./yr = 33 ac-ft/yr or 41,000 m^3/yr.

APPENDIX K-2. RADIOACTIVE RELEASE FROM THE MINING OPERATION

Both ore and overburden contain Rn-222 in pore spaces in direct proportion to the Ra-226 concentration in the ore. At secular equilibrium, a 0.15% grade ore has 420 pCi Rn-222 per gram of ore. The fraction of this radon activity available for release, called the "emanating power," is about 20%, or 84 pCi Rn-222/g of ore. When the ore is disturbed by mining this radon is released into the atmosphere. The total radon released from ore gas at Bear Creek is 27.7 Ci/year. By a similar mechanism about 1.4 Ci/yr of Rn-222 will be released as a result of removal and relocation of 6.84×10^5 tonnes of overburden.

The surface of the mined ore and the pit walls containing residual ore will also release radon in proportion to the surface area and the exhalation rate from the surfaces. The infinite radon flux (ϕ_∞) estimated for tailings has been reported to be 1.6 pCi Rn-222/m^2-sec per pCi Ra-226/g of tailings.[1] This flux will be appreciably less during rainy and cold weather. Measurements of the radon flux during winter with the ground frozen but not capped with ice showed a 40% reduction relative to summer measurements under similar atmospheric conditions.[2] The annual average for Bear Creek may be closer to ϕ_∞ = 1 pCi/m^2-sec/(pCi Ra-226/g). [The radon flux in soil containing an average concentration of 1.1 pCi Ra-226/g was reported[3] as 9×10^{-17} Ci/cm^2-sec (0.82 pCi Rn-222/m^2-sec/(pCi Ra-226/g) of soil. The estimated global radon flux has been reported[4] as 4×10^{-17} Ci/cm^2-sec (0.36 pCi Rn-222/m^2-sec/pCi Ra-226/g).]

Assuming that the mine surface area excavated (base and walls of the open pit) is 3.5×10^5 m^2 and that ϕ_∞ = 1.6 pCi Rn-222/m^2-sec per pCi Ra-226/g, the mine source term will be

$$\phi = \frac{420 \text{ pCi Ra-226}}{\text{g ore}} \quad \frac{1.6 \text{ pCi Rn-222}}{\text{m}^2\text{-sec}}$$

$$\times 3.5 \times 10^5 \text{ m}^2 \times 3.15 \times 10^7 \text{ sec/yr} = 7409 \text{ Ci Rn-222/yr.}$$

If ϕ_∞ = 1 pCi Rn-222/m^2-sec per pCi Ra-226/g of ore, then

$$\phi = \frac{420 \text{ pCi Ra-226}}{\text{g ore}} \quad \frac{1 \text{ pCi Rn-222}}{\text{m}^2\text{-sec}}$$

$$\times 3.5 \times 10^5 \text{ m}^2 \times 3.15 \times 10^7 \text{ sec/yr} = 4631 \text{ Ci Rn-222/yr.}$$

Thus the total mining release will be within a range of:

	Upper Limit	Lower Limit
Ore gas	27.7 Ci/yr	27.7 Ci/yr
Overburden	1.4 Ci/yr	1.4 Ci/yr
Mine surface	7409.0 Ci/yr	4631.0 Ci/yr
Total	7438.1 Ci/yr	4660.1 Ci/yr

It has been estimated that underground mining releases 1.5×10^{-2} Ci Rn-222/m^3 of ore excavated.[5] Since the ore process rate is 3.3×10^5 tonnes/yr, or 1.83×10^5 m^3/yr (assuming a density of 1.8 g/cm^3) the release rate is expected to be 2740 Ci Rn-222/yr. Because of the greater atmospheric mixing, the effect of barometric pressure, and the drying of ore during open pit mining, a higher rate of radon release into atmosphere is expected at Bear Creek (see Table 3.6).

References for Appendix K-2

1. K. J. Schiager, "Analysis of Radiation Exposure on or Near Uranium Mill Tailings Piles," Rad. Data and Reports 14:411, 1974.

2. "Generic Environmental Statement on the Use of Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors," NUREG-0002, Volume 3, FV21.

3. H. W. Kaner, G. L. Schroeder, and R. D. Evans, in "The Natural Radiation Environment," J. A. Adams and W. M. Lowder, eds., University of Chicago Press, p. 191, 1964.

4. M. H. Wilkening and J. E. Hand, J. of Geophysical Res., V. 65 No. 10, Oct. 1960, p. 3367.

5. "Final Generic Environmental Statement on the Use of Recycle Plutonium Mixed Oxide Fuel in Light Water Cooled Reactors; Health, Safety and Environment," Report NUREG-0002, Vol. 4, U. S. Nuclear Regulatory Commission, August 1976.

APPENDIX K-3. ARGONNE STEADY-STATE (PLUME DEPLETION) URANIUM DISPERSION AND DOSIMETRY CODE*--UDAD

The atmospheric dispersion of released particulates and radon-222 is calculated on the basis of steady-state Gaussian (plume depletion) diffusion corrected for ground deposition of the particulates and for radioactive decay, as well as the production of radon daughters. The diffusion function for a stack of height located at (0,0,h) emitting one unit of radioactivity at a constant and continuous rate is:

$$T(x,y,z;h) = \frac{f_\theta}{2\pi\sigma_y\sigma_z\bar{u}} \left[\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\right] \left\{\exp\left[-\frac{(h-z)^2}{2\sigma_z^2}\right] + \alpha \exp\left[-\frac{(h+z)^2}{2\alpha_z^2}\right]\right\},$$

where $T(x,y,z)$ is the undepleted normalized concentration in air at location (x,y,z), σ_y and σ_z are, respectively, the horizontal and vertical dispersion coefficients, $\bar{u}$ is the mean wind velocity blowing in direction x, with annual probability of f_θ in the direction of θ (see Fig. 4.9), and α is a function of particulate size, ground roughness, and wind speed. For $z = 0$, i.e., at ground height, the parameter α, which is a measure of ground reflection, will be a slowly varying function of the variables and thus assumed to be a constant ($\alpha = 0.5$). The decrease in the concentration of particulates of diameter d by ground deposition results in an air concentration at ground level of

$$\chi(x,y,0) = f_d\left[\frac{f_\theta}{\sqrt{2\pi}\sigma_z\bar{u}}\left\{\exp\left[-\frac{(h-z)^2}{2\sigma_z^2}\right] + \alpha \exp\left[-\frac{(h+z)^2}{2\sigma_z^2}\right]\right\} - \int_{-\infty}^{+\infty} d_\psi \int_{-\infty}^{+\infty} d_\eta \int_0^x V_d T(\psi,\eta,0) T(x-\psi,y-\eta,0) d_y\right],$$

where f_d is the fraction of the source emission in the particulate size range d, and V_d is the deposition velocity (see Tables K-3.1 and K-3.2).

The effective dispersion factors in directions ($\theta = 0°$, 90°, 180°) for the yellowcake dryer (a point source) and the mine (a large area source) are given in Tables K-3.3 and K-3.4. The effective dispersion factor (EDF) is the ratio of combined concentrations (pCi/m^3) from each source to the combined rate of emission Q^C (pCi/sec) for each radionuclide. The effective dispersion factor is equivalent to the dispersion factor for a single point source.

The average ground deposited activity was calculated for each of the radionuclides, assuming $V = 0$ for Rn-222 and all of its short-lived radioactive daughters (Po-218, Pb-214, Bi-214). The surface activities deposited over a 20-year period were calculated assuming the surface activity to have an effective mean residence time of 50 years (Table K-3.5). The airborne concentration ($\mu g/m^3$) relative to ground contamination ($\mu g/m^2$) is 1×10^{-4} m^{-1} (Sec. 3, Ref. 42, 43) or less.[1,2] The airborne concentration from resuspension and rain washout was not considered.

References for Appendix K-3

1. J. Misima, "A Review of Research on Plutonium Release during Overheating and Fires," Hanford Laboratories, General Electric Co., report HW-83668, 1964.

2. K. Stewart, in "Surface Contamination," B. R. Fish, ed., Pergamon Press, Oxford, p. 63, 1967.

*M. H. Momeni, Argonne National Laboratory, report in preparation.

TABLE K-3.1. METEOROLOGICAL INPUT DATA

SEASONS CONSIDERED:	WINTER	SPRING	SUMMER	FALL
MIXING HEIGHT FACTOR (FT):	600.00	850.00	1100.00	850.00
DEGREE DAY FACTOR:	2.16	1.00	0.04	0.80
AMBIENT TEMPERATURES (°K):	271.89	283.00	296.89	283.00

WIND DIRECTION PROBABILITY

SECTOR	WIND DIRECTION	THETA	PROBABILITY
1	N	0.0	0.04500
2	NNE	22.5	0.07300
3	NE	45.0	0.03900
4	ENE	67.5	0.02900
5	E	90.0	0.04900
6	ESE	112.5	0.02100
7	SE	135.0	0.01500
8	SSE	157.5	0.01400
9	S	180.0	0.01700
10	SSW	202.5	0.14100
11	SW	225.0	0.16800
12	WSW	247.5	0.15000
13	W	270.0	0.12600
14	WNW	292.5	0.03900
15	NW	315.0	0.03000
16	NNW	337.5	0.04500
			1.00100

WIND SPEED

RANGE	SPEED (MPH)	PROBABILITY
1	0 - 3	0.05
2	4 - 6	0.20
3	7 - 10	0.27
4	11 - 16	0.27
5	17 - 21	0.14
6	OVER 21	0.07
		1.00

STABILITY

CLASS	DEFINITION	PROBABILITY
1	VERY UNSTABLE	0.04
2	MODERATELY UNSTABLE	0.07
3	SLIGHTLY UNSTABLE	0.65
4	NEUTRAL (NIGHT)	0.14
5	STABLE	0.07
		1.00

Table K-3.2. Source Characterization in Air

Particulate Size, μm	Fraction in the Source	Deposition Velocity, m/sec
1-4	0.01	5×10^{-5}
5-9	0.05	5×10^{-2}
10-19	0.1	1×10^{-1}
20-49	0.2	1.5×10^{-1}
>50	0.64	3×10^{-1}

Table K-3.3. Effective Dispersion Factor for the Dryer

THETA = 0.0 DEGREE RADIONUCLIDES DISPERSED

DISTANCE (KM)	U-238	TH-230	RA-226	PB-210
0.100	0.1708E-05	0.1708E-05	0.1708E-05	0.1708E-05
0.500	0.5222E-06	0.5222E-06	0.5222E-06	0.5222E-06
1.000	0.1588E-06	0.1588E-06	0.1588E-06	0.1588E-06
2.000	0.4605E-07	0.4605E-07	0.4605E-07	0.4605E-07
3.000	0.2249E-07	0.2249E-07	0.2249E-07	0.2249E-07
4.000	0.1361E-07	0.1361E-07	0.1361E-07	0.1361E-07
5.000	0.9251E-08	0.9251E-08	0.9251E-08	0.9251E-08
10.000	0.2954E-08	0.2954E-08	0.2954E-08	0.2954E-08
20.000	0.1091E-08	0.1091E-08	0.1091E-08	0.1091E-08
30.000	0.6593E-09	0.6593E-09	0.6593E-09	0.6593E-09
40.000	0.4645E-09	0.4645E-09	0.4645E-09	0.4645E-09
50.000	0.3554E-09	0.3554E-09	0.3554E-09	0.3554E-09
60.000	0.2862E-09	0.2862E-09	0.2862E-09	0.2862E-09
70.000	0.2387E-09	0.2387E-09	0.2387E-09	0.2387E-09
80.000	0.2042E-09	0.2042E-09	0.2042E-09	0.2042E-09

THETA = 90.00 DEGREE RADIONUCLIDES DISPERSED

DISTANCE (KM)	U-238	TH-230	RA-226	PB-210
0.100	0.1266E-04	0.1266E-04	0.1266E-04	0.1266E-04
0.500	0.3870E-05	0.3870E-05	0.3870E-05	0.3870E-05
1.000	0.1177E-05	0.1177E-05	0.1177E-05	0.1177E-05
2.000	0.3413E-06	0.3413E-06	0.3413E-06	0.3413E-06
3.000	0.1667E-06	0.1667E-06	0.1667E-06	0.1667E-06
4.000	0.1009E-06	0.1009E-06	0.1009E-06	0.1009E-06
5.000	0.6857E-07	0.6857E-07	0.6857E-07	0.6857E-07
10.000	0.2190E-07	0.2190E-07	0.2190E-07	0.2190E-07
20.000	0.8084E-08	0.8084E-08	0.8084E-08	0.8084E-08
30.000	0.4886E-08	0.4886E-08	0.4886E-08	0.4886E-08
40.000	0.3443E-08	0.3443E-08	0.3443E-08	0.3443E-08
50.000	0.2634E-08	0.2634E-08	0.2634E-08	0.2634E-08
60.000	0.2121E-08	0.2121E-08	0.2121E-08	0.2121E-08
70.000	0.1769E-08	0.1769E-08	0.1769E-08	0.1769E-08
80.000	0.1514E-08	0.1514E-08	0.1514E-08	0.1514E-08

THETA = 180.00 DEGREE RADIONUCLIDES DISPERSED

DISTANCE (KM)	U-238	TH-230	RA-226	PB-210
0.100	0.4522E-05	0.4522E-05	0.4522E-05	0.4522E-05
0.500	0.1382E-05	0.1382E-05	0.1382E-05	0.1382E-05
1.000	0.4204E-06	0.4204E-06	0.4204E-06	0.4204E-06
2.000	0.1219E-06	0.1219E-06	0.1219E-06	0.1219E-06
3.000	0.5952E-07	0.5952E-07	0.5952E-07	0.5952E-07
4.000	0.3602E-07	0.3602E-07	0.3602E-07	0.3602E-07
5.000	0.2449E-07	0.2449E-07	0.2449E-07	0.2449E-07
10.000	0.7820E-08	0.7820E-08	0.7820E-08	0.7820E-08
20.000	0.2887E-08	0.2887E-08	0.2887E-08	0.2887E-08
30.000	0.1745E-08	0.1745E-08	0.1745E-08	0.1745E-08
40.000	0.1230E-08	0.1230E-08	0.1230E-08	0.1230E-08
50.000	0.9408E-09	0.9408E-09	0.9408E-09	0.9408E-09
60.000	0.7577E-09	0.7577E-09	0.7577E-09	0.7577E-09
70.000	0.6319E-09	0.6319E-09	0.6319E-09	0.6319E-09
80.000	0.5406E-09	0.5406E-09	0.5406E-09	0.5406E-09

TABLE K-3.4. EFFECTIVE DISPERSION FACTOR FOR THE MINE

THETA =	0.0 DEGREE	90.00 DEGREE	180.00 DEGREE
DISTANCE (KM)	RN-222	RN-222	RN-222
0.100	0.1982E-06	0.2510E-06	0.2284E-06
0.500	0.1400E-06	0.5377E-06	0.2845E-06
1.000	0.9440E-07	0.4401E-05	0.3622E-06
2.000	0.3167E-07	0.7704E-06	0.2319E-06
3.000	0.1642E-07	0.2746E-06	0.1201E-06
4.000	0.1073E-07	0.1459E-06	0.6242E-07
5.000	0.7639E-08	0.9207E-07	0.3839E-07
10.000	0.2618E-08	0.2473E-07	0.9617E-08
20.000	0.9924E-09	0.8126E-08	0.3012E-08
30.000	0.5970E-09	0.4734E-08	0.1708E-08
40.000	0.4170E-09	0.3261E-08	0.1157E-08
50.000	0.3161E-09	0.2452E-08	0.8600E-09
60.000	0.2527E-09	0.1947E-08	0.6810E-09
70.000	0.2096E-09	0.1604E-08	0.5628E-09
80.000	0.1783E-09	0.1357E-08	0.4779E-09

TABLE K-3.5. CONCENTRATIONS (pCi/m^3) OF RADIONUCLIDES IN AIR

THETA = 45.00 DEGREE (DIRECTION OF PREVAILING WIND)

DISTANCE (KM)	U-238	TH-230	RA-226	PB-210	RN-222
0.10	0.67E-01	0.46E-01	0.45E-01	0.45E-01	0.17E 04
0.50	0.13E-01	0.67E-02	0.63E-02	0.63E-02	0.75E 03
1.00	0.40E-02	0.21E-02	0.20E-02	0.20E-02	0.41E 03
2.00	0.12E-02	0.62E-03	0.59E-03	0.59E-03	0.29E 03
3.00	0.58E-03	0.31E-03	0.29E-03	0.29E-03	0.13E 03
4.00	0.35E-03	0.19E-03	0.18E-03	0.18E-03	0.79E 02
5.00	0.24E-03	0.13E-03	0.12E-03	0.12E-03	0.55E 02
10.00	0.77E-04	0.41E-04	0.39E-04	0.39E-04	0.18E 02
20.00	0.29E-04	0.15E-04	0.15E-04	0.15E-04	0.67E 01
30.00	0.17E-04	0.92E-05	0.88E-05	0.88E-05	0.41E 01
40.00	0.12E-04	0.65E-05	0.62E-05	0.62E-05	0.29E 01
50.00	0.94E-05	0.50E-05	0.48E-05	0.48E-05	0.22E 01
60.00	0.75E-05	0.40E-05	0.38E-05	0.38E-05	0.17E 01
70.00	0.63E-05	0.34E-05	0.32E-05	0.32E-05	0.14E 01
80.00	0.54E-05	0.29E-05	0.27E-05	0.27E-05	0.12E 01

K-3.6. CONCENTRATIONS, RATIOS, AND WORK LEVELS OF RADON DAUGHTERS AT VARIOUS DISTANCES FROM THE SITE

Table K-3.6. Concentration of Radon Daughters at Various Distances from the Site (θ = 45°)

	Rádon Daughters (pCi/m^3)				
Distance	Rn-222	Po-218	Pb-214	Bi-214	Pb-210
0.10	0.17E 04	0.49E 00	0.55E 00	0.76E-01	0.18E-01
0.50	0.75D 03	0.28E 00	0.40E 00	0.93E-01	0.28E-01
1.00	0.41D 03	0.17E 00	0.37E 00	0.95E-01	0.44E-01
2.00	0.29D 03	0.12E 00	0.32E 00	0.10E 00	0.76E-01
3.00	0.13D 03	0.66E-01	0.24E 00	0.92E-01	0.10E 00
4.00	0.70D 02	0.42E-01	0.18E 00	0.76E-01	0.11E 00
5.00	0.55D 02	0.30E-01	0.14E 00	0.63E-01	0.12E 00
10.00	0.18D 02	0.99E-02	0.62E-01	0.33E-01	0.12E 00
20.00	0.67D 01	0.37E-02	0.29E-01	0.18E-01	0.12E 00
30.00	0.41D 01	0.23E-02	0.19E-01	0.13E-01	0.12E 00
40.00	0.29D 01	0.16E-02	0.14E-01	0.95E-02	0.12E 00
50.00	0.22D 01	0.12E-02	0.10E-01	0.75E-02	0.12E 00
60.00	0.17D 01	0.97E-03	0.84E-02	0.61E-02	0.12E 00
70.00	0.14D 01	0.80E-03	0.70E-02	0.51E-02	0.11E 00
80.00	0.12D 01	0.68E-03	0.60E-02	0.44E-02	0.11E 00

	Concentration Ratios[a] and Work Level				
Distance	Rn-222	Po-218	Pb-214	Bi-214	WL[b]
0.10	0.10E 01	0.29E-03	0.33E-03	0.46E-04	0.36E-05
0.50	0.10E 01	0.38E-03	0.54E-03	0.12E-03	0.31E-05
1.00	0.10E 01	0.42E-03	0.90E-03	0.23E-03	0.24E-05
2.00	0.10E 01	0.43E-03	0.11E-02	0.35E-03	0.21E-05
3.00	0.10E 01	0.51E-03	0.18E-02	0.71E-03	0.16E-05
4.00	0.10E 01	0.53E-03	0.22E-02	0.96E-03	0.12E-05
5.00	0.10E 01	0.54E-03	0.25E-02	0.12E-02	0.97E-06
10.00	0.10E 01	0.55E-03	0.35E-02	0.19E-02	0.45E-06
20.00	0.10E 01	0.55E-03	0.43E-02	0.27E-02	0.22E-06
30.00	0.10E 01	0.55E-03	0.46E-02	0.31E-02	0.14E-06
40.00	0.10E 01	0.55E-03	0.47E-02	0.33E-02	0.11E-06
50.00	0.10E 01	0.55E-03	0.48E-02	0.34E-02	0.92E-07
60.00	0.10E 01	0.55E-03	0.48E-02	0.35E-02	0.66E-07
70.00	0.10E 01	0.55E-03	0.49E-02	0.35E-02	0.55E-07
80.00	0.10E 01	0.55E-03	0.49E-02	0.36E-02	0.47E-07

[a]"Concentration ratio" is defined as the concentration of a radon daughter relative to the concentration of radon.

[b]WL indicates "working level." Numerically it is equal to 7 rads to the bronchial epithelium for an inhalation period of one working-month (172 hours).

APPENDIX K-3.7. RADIONUCLIDE CONCENTRATION ISOPLETHS

For an inhalable radionuclide, the safety factor with respect to its effect on an organ of the body, is defined as

$$\text{Safety Factor} = \log \left[\frac{(\text{Concentration of the Radionuclide in the Environment})}{(\text{Suggested Maximum Permissible Concentration})} \right]$$

The safety factor, when plotted on an isopleth, may be depicted as lines of constant concentration at various distances from the mill site of a radionuclide relative to its maximum permissible concentration. For example, for U-238 toxicity in bone, the line marked with a safety factor of (-4) indicates that the U-238 concentration is only 0.0001 of the maximum permissible concentration of U-238 for bone. A safety factor of +1 indicates regions with a U-238 concentration 10 times larger than the maximum permissible concentration for bone. In the figures the lines are drawn for 0.125 safety-factor increments.

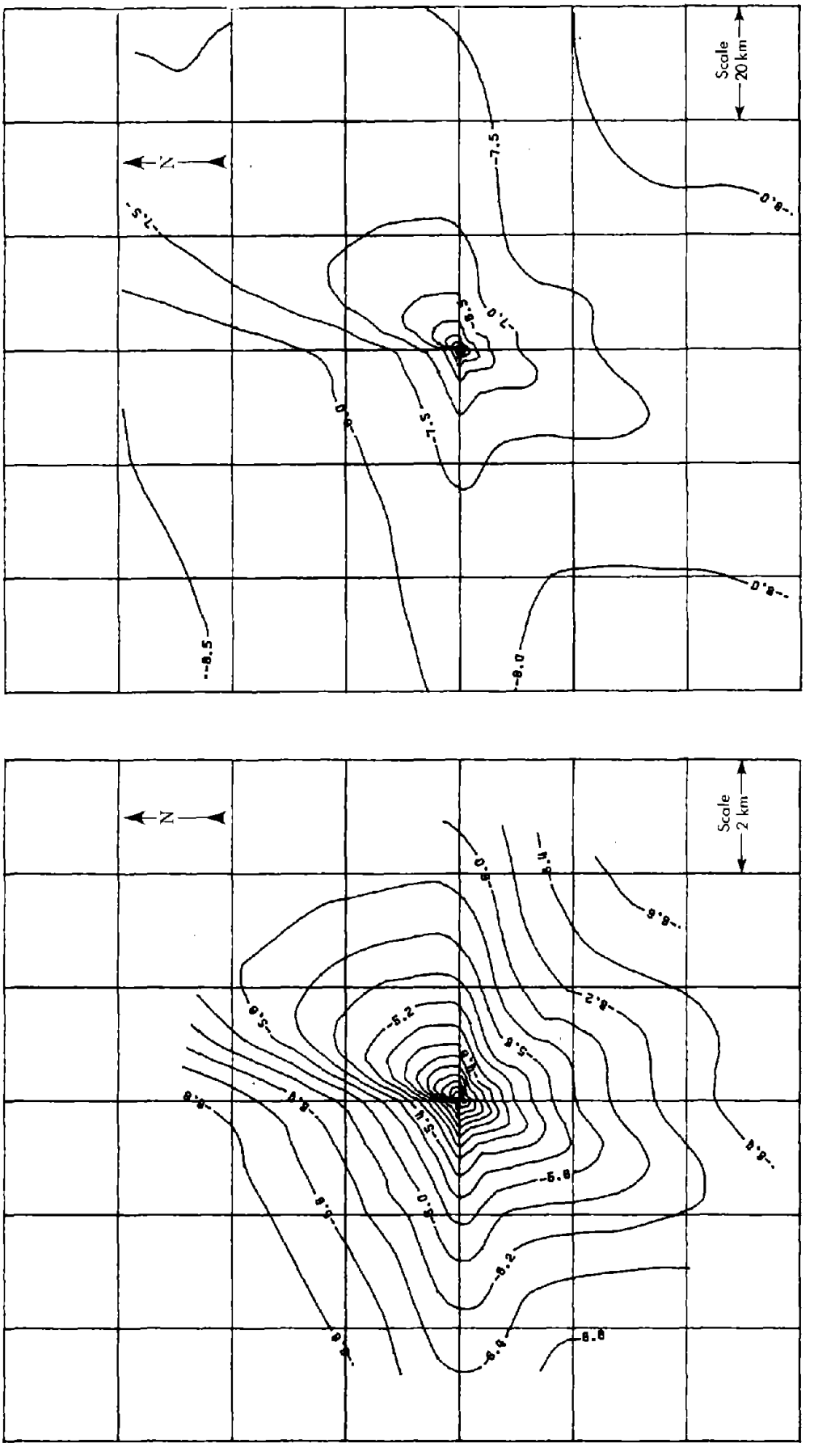


Fig. K-3.7.1. Safety Factor for U-238 for Bone.

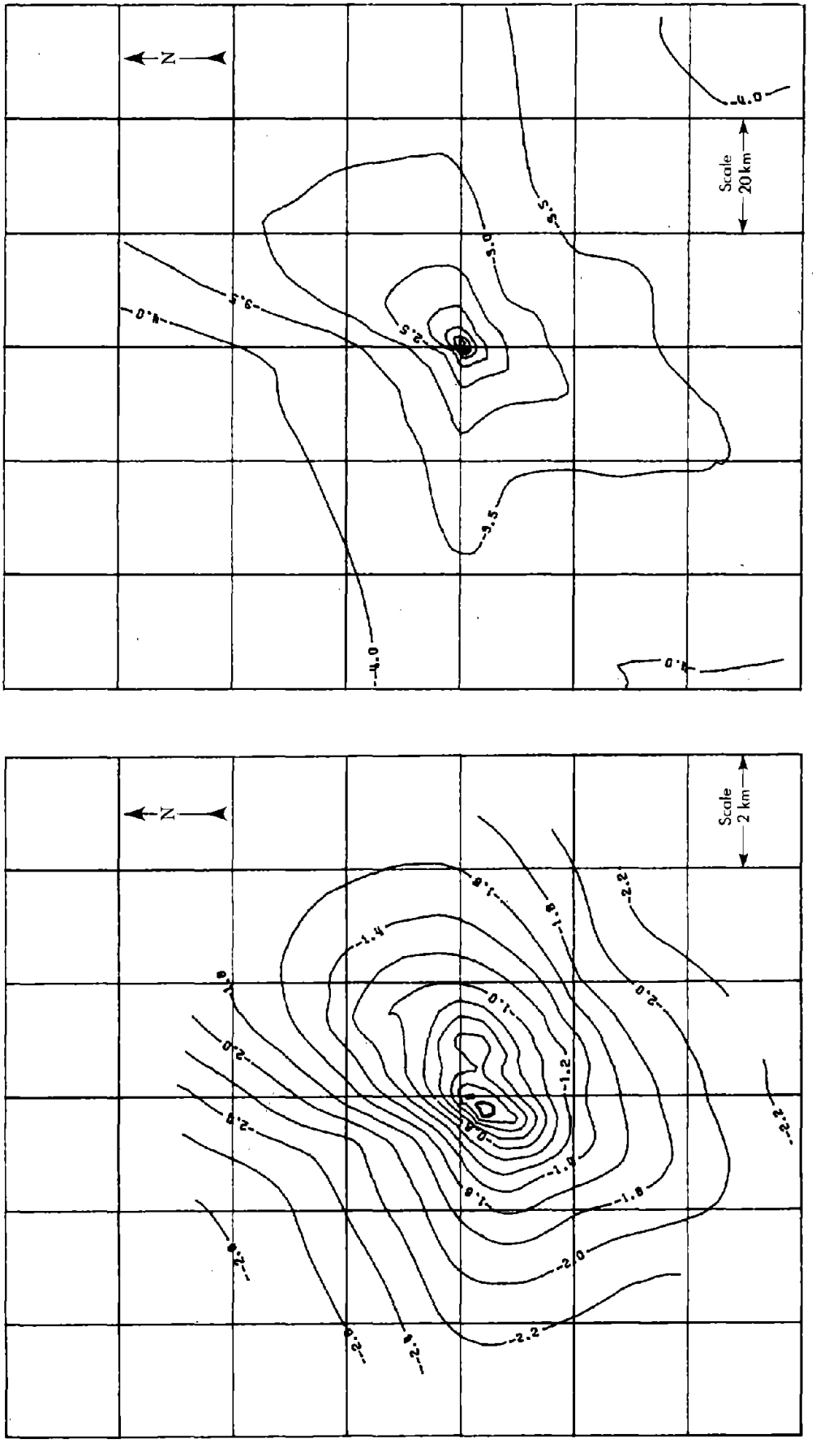


Fig. K-3.7.2. Safety Factor for Rn-222 for Lungs.

APPENDIX K-4. DOSE RATE (50th Year) AS A FUNCTION OF DIRECTION AND DISTANCE TO 80 KM

The dose rate (D, in mrem/year) from continuous inhalation for a 50-year period was calculated on the basis of the 1959 recommendations of the International Commission on Radiological Protection (ICRP)[1] and the 1965 report of the task group on the Lung Dynamics for Committee II of ICRP.[2] For each radionuclide, the dose rate commitment to the organs specified by ICRP II (whole body, bone, lung, gastrointestinal (soluble and insoluble), kidney) were estimated.

Tables K-4.1--K-4.5	Dose Rate to Whole Body
Tables K-4.6--K.4.10	Dose Rate to Bone
Tables K-4.11--K.4.16	Dose Rate to Lung
Tables K-4.17--K.4.21	Dose Rate to Gastrointestine (soluble radionuclides)
Tables K-4.22--K.4.26	Dose Rate to Gastrointestine (insoluble radionuclides)

References for Appendix K-4

1. "Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation," Health Physics, Volume 3, pp. 1-380, 1960.

2. Recommendations of the International Commission on Radiological Protection, The Task Group Report on the Lung Dynamics for Committee II of ICRP," Health Physics, Volume 12, No. 2, pp. 173-208, 1966.

Table K-4.1. Dose Rate (mrem/yr) to Whole Body from U-238

DISTANCE(KM)	DEGREES 0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.24E 00	0.51E 00	0.56E 00	0.53E 00	0.47E 00	0.30E 00	0.14E 00	0.15E 00
0.5	0.22E-01	0.94E-01	0.11E 00	0.97E-01	0.84E-01	0.32E-01	0.22E-01	0.32E-01
1.0	0.48E-02	0.29E-01	0.33E-01	0.30E-01	0.25E-01	0.87E-02	0.64E-02	0.94E-02
2.0	0.12E-02	0.83E-02	0.99E-02	0.88E-02	0.74E-02	0.24E-02	0.18E-02	0.27E-02
3.0	0.57E-03	0.41E-02	0.48E-02	0.43E-02	0.36E-02	0.12E-02	0.89E-03	0.13E-02
4.0	0.33E-03	0.25E-02	0.29E-02	0.26E-02	0.22E-02	0.70E-03	0.54E-03	0.81E-03
5.0	0.22E-03	0.17E-02	0.20E-02	0.18E-02	0.15E-02	0.47E-03	0.37E-03	0.55E-03
10.0	0.68E-04	0.54E-03	0.64E-03	0.57E-03	0.48E-03	0.15E-03	0.12E-03	0.18E-03
20.0	0.24E-04	0.20E-03	0.24E-03	0.21E-03	0.18E-03	0.56E-04	0.44E-04	0.65E-04
30.0	0.15E-04	0.12E-03	0.14E-03	0.13E-03	0.11E-03	0.34E-04	0.26E-04	0.40E-04
40.0	0.10E-04	0.85E-04	0.10E-03	0.91E-04	0.76E-04	0.24E-04	0.19E-04	0.28E-04
50.0	0.80E-05	0.65E-04	0.78E-04	0.69E-04	0.58E-04	0.18E-04	0.14E-04	0.21E-04
60.0	0.64E-05	0.53E-04	0.63E-04	0.56E-04	0.47E-04	0.15E-04	0.11E-04	0.17E-04
70.0	0.54E-05	0.44E-04	0.52E-04	0.47E-04	0.39E-04	0.12E-04	0.96E-05	0.14E-04
80.0	0.46E-05	0.38E-04	0.45E-04	0.40E-04	0.34E-04	0.11E-04	0.82E-05	0.12E-04

DISTANCE(KM)	DEGREES 180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.14E 00	0.27E 00	0.19E 00	0.18E 00	0.17E 00	0.12E 00	0.99E-01	0.94E-01
0.5	0.34E-01	0.55E-01	0.34E-01	0.26E-01	0.30E-01	0.17E-01	0.12E-01	0.13E-01
1.0	0.97E-02	0.16E-01	0.91E-02	0.67E-02	0.11E-01	0.47E-02	0.32E-02	0.30E-02
2.0	0.28E-02	0.45E-02	0.25E-02	0.18E-02	0.31E-02	0.13E-02	0.92E-03	0.86E-03
3.0	0.13E-02	0.22E-02	0.12E-02	0.89E-03	0.15E-02	0.63E-03	0.45E-03	0.42E-03
4.0	0.81E-03	0.13E-02	0.72E-03	0.53E-03	0.89E-03	0.38E-03	0.27E-03	0.25E-03
5.0	0.55E-03	0.90E-03	0.49E-03	0.36E-03	0.61E-03	0.26E-03	0.18E-03	0.17E-03
10.0	0.18E-03	0.29E-03	0.15E-03	0.11E-03	0.19E-03	0.83E-04	0.59E-04	0.55E-04
20.0	0.65E-04	0.11E-03	0.57E-04	0.42E-04	0.71E-04	0.31E-04	0.22E-04	0.20E-04
30.0	0.39E-04	0.64E-04	0.34E-04	0.25E-04	0.43E-04	0.18E-04	0.13E-04	0.12E-04
40.0	0.28E-04	0.45E-04	0.24E-04	0.18E-04	0.30E-04	0.13E-04	0.93E-05	0.87E-05
50.0	0.21E-04	0.34E-04	0.18E-04	0.14E-04	0.23E-04	0.10E-04	0.71E-05	0.67E-05
60.0	0.17E-04	0.28E-04	0.15E-04	0.11E-04	0.19E-04	0.80E-05	0.57E-05	0.54E-05
70.0	0.14E-04	0.23E-04	0.12E-04	0.92E-05	0.16E-04	0.67E-05	0.48E-05	0.45E-05
80.0	0.12E-04	0.20E-04	0.11E-04	0.79E-05	0.13E-04	0.57E-05	0.41E-05	0.38E-05

Table K-4.2. Dose Rate (mrem/yr) to Whole Body from U-234

DISTANCE(KM)	DEGREES 0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.24E 00	0.51E 00	0.56E 00	0.53E 00	0.47E 00	0.30E 00	0.14E 00	0.15E 00
0.5	0.22E-01	0.94E-01	0.11E 00	0.97E-01	0.84E-01	0.32E-01	0.22E-01	0.32E-01
1.0	0.48E-02	0.29E-01	0.33E-01	0.30E-01	0.25E-01	0.87E-02	0.64E-02	0.94E-02
2.0	0.12E-02	0.83E-02	0.99E-02	0.88E-02	0.74E-02	0.24E-02	0.18E-02	0.27E-02
3.0	0.57E-03	0.41E-02	0.48E-02	0.43E-02	0.36E-02	0.12E-02	0.89E-03	0.13E-02
4.0	0.33E-03	0.25E-02	0.29E-02	0.26E-02	0.22E-02	0.70E-03	0.54E-03	0.81E-03
5.0	0.22E-03	0.17E-02	0.20E-02	0.18E-02	0.15E-02	0.47E-03	0.37E-03	0.55E-03
10.0	0.68E-04	0.54E-03	0.64E-03	0.57E-03	0.48E-03	0.15E-03	0.12E-03	0.18E-03
20.0	0.24E-04	0.20E-03	0.24E-03	0.21E-03	0.18E-03	0.56E-04	0.44E-04	0.65E-04
30.0	0.15E-04	0.12E-03	0.14E-03	0.13E-03	0.11E-03	0.34E-04	0.26E-04	0.40E-04
40.0	0.10E-04	0.85E-04	0.10E-03	0.91E-04	0.76E-04	0.24E-04	0.19E-04	0.28E-04
50.0	0.80E-05	0.65E-04	0.78E-04	0.69E-04	0.58E-04	0.18E-04	0.14E-04	0.21E-04
60.0	0.64E-05	0.53E-04	0.63E-04	0.56E-04	0.47E-04	0.15E-04	0.11E-04	0.17E-04
70.0	0.54E-05	0.44E-04	0.52E-04	0.47E-04	0.39E-04	0.12E-04	0.96E-05	0.14E-04
80.0	0.46E-05	0.38E-04	0.45E-04	0.40E-04	0.34E-04	0.11E-04	0.82E-05	0.12E-04

DISTANCE(KM)	DEGREES 180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.14E 00	0.27E 00	0.19E 00	0.18E 00	0.17E 00	0.12E 00	0.99E-01	0.94E-01
0.5	0.34E-01	0.55E-01	0.34E-01	0.26E-01	0.38E-01	0.17E-01	0.12E-01	0.13E-01
1.0	0.97E-02	0.16E-01	0.91E-02	0.67E-02	0.11E-01	0.47E-02	0.32E-02	0.30E-02
2.0	0.28E-02	0.45E-02	0.25E-02	0.18E-02	0.31E-02	0.13E-02	0.92E-03	0.86E-03
3.0	0.13E-02	0.22E-02	0.12E-02	0.89E-03	0.15E-02	0.63E-03	0.45E-03	0.42E-03
4.0	0.81E-03	0.13E-02	0.72E-03	0.53E-03	0.89E-03	0.38E-03	0.27E-03	0.25E-03
5.0	0.55E-03	0.90E-03	0.49E-03	0.36E-03	0.61E-03	0.26E-03	0.18E-03	0.17E-03
10.0	0.18E-03	0.29E-03	0.15E-03	0.11E-03	0.19E-03	0.83E-04	0.59E-04	0.55E-04
20.0	0.65E-04	0.11E-03	0.57E-04	0.42E-04	0.71E-04	0.31E-04	0.22E-04	0.20E-04
30.0	0.39E-04	0.64E-04	0.34E-04	0.25E-04	0.43E-04	0.18E-04	0.13E-04	0.12E-04
40.0	0.28E-04	0.45E-04	0.24E-04	0.18E-04	0.30E-04	0.13E-04	0.93E-05	0.87E-05
50.0	0.21E-04	0.34E-04	0.18E-04	0.14E-04	0.23E-04	0.10E-04	0.71E-05	0.67E-05
60.0	0.17E-04	0.28E-04	0.15E-04	0.11E-04	0.19E-04	0.80E-05	0.57E-05	0.54E-05
70.0	0.14E-04	0.23E-04	0.12E-04	0.92E-05	0.16E-04	0.67E-05	0.48E-05	0.45E-05
80.0	0.12E-04	0.20E-04	0.11E-04	0.79E-05	0.13E-04	0.57E-05	0.41E-05	0.38E-05

Table K-4.3. Dose Rate (mrem/yr) to Whole Body from Th-230

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.26E 02	0.43E 02	0.46E 02	0.44E 02	0.41E 02	0.31E 02	0.13E 02	0.13E 02
0.5	0.20E 01	0.59E 01	0.67E 01	0.59E 01	0.53E 01	0.23E 01	0.15E 01	0.21E 01
1.0	0.38E 00	0.18E 01	0.21E 01	0.18E 01	0.16E 01	0.59E 00	0.41E 00	0.60E 00
2.0	0.97E-01	0.53E 00	0.62E 00	0.55E 00	0.46E 00	0.15E 00	0.12E 00	0.17E 00
3.0	0.40E-01	0.26E 00	0.31E 00	0.27E 00	0.23E 00	0.74E-01	0.57E-01	0.85E-01
4.0	0.23E-01	0.16E 00	0.19E 00	0.17E 00	0.14E 00	0.45E-01	0.35E-01	0.52E-01
5.0	0.15E-01	0.11E 00	0.13E 00	0.11E 00	0.95E-01	0.30E-01	0.24E-01	0.35E-01
10.0	0.44E-02	0.35E-01	0.41E-01	0.37E-01	0.31E-01	0.96E-02	0.76E-02	0.11E-01
20.0	0.16E-02	0.13E-01	0.15E-01	0.14E-01	0.11E-01	0.36E-02	0.28E-02	0.42E-02
30.0	0.95E-03	0.78E-02	0.92E-02	0.83E-02	0.70E-02	0.22E-02	0.17E-02	0.26E-02
40.0	0.67E-03	0.55E-02	0.65E-02	0.58E-02	0.49E-02	0.15E-02	0.12E-02	0.18E-02
50.0	0.51E-03	0.42E-02	0.50E-02	0.45E-02	0.38E-02	0.12E-02	0.92E-03	0.14E-02
60.0	0.41E-03	0.34E-02	0.40E-02	0.36E-02	0.30E-02	0.95E-03	0.74E-03	0.11E-02
70.0	0.35E-03	0.28E-02	0.34E-02	0.30E-02	0.25E-02	0.79E-03	0.62E-03	0.93E-03
80.0	0.30E-03	0.24E-02	0.29E-02	0.26E-02	0.22E-02	0.68E-03	0.53E-03	0.80E-03

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.18E 02	0.23E 02	0.18E 02	0.18E 02	0.14E 02	0.12E 02	0.10E 02	0.95E 01
0.5	0.23E 01	0.37E 01	0.26E 01	0.21E 01	0.27E 01	0.12E 01	0.82E 00	0.11E 01
1.0	0.63E 00	0.10E 01	0.64E 00	0.46E 00	0.73E 00	0.31E 00	0.21E 00	0.20E 00
2.0	0.18E 00	0.29E 00	0.17E 00	0.12E 00	0.20E 00	0.85E-01	0.59E-01	0.55E-01
3.0	0.87E-01	0.14E 00	0.80E-01	0.58E-01	0.97E-01	0.41E-01	0.29E-01	0.27E-01
4.0	0.53E-01	0.85E-01	0.48E-01	0.35E-01	0.58E-01	0.25E-01	0.18E-01	0.16E-01
5.0	0.36E-01	0.58E-01	0.32E-01	0.23E-01	0.39E-01	0.17E-01	0.12E-01	0.11E-01
10.0	0.11E-01	0.18E-01	0.10E-01	0.74E-02	0.13E-01	0.53E-02	0.38E-02	0.36E-02
20.0	0.42E-02	0.69E-02	0.37E-02	0.27E-02	0.46E-02	0.20E-02	0.14E-02	0.13E-02
30.0	0.25E-02	0.41E-02	0.22E-02	0.16E-02	0.28E-02	0.12E-02	0.86E-03	0.80E-03
40.0	0.18E-02	0.29E-02	0.16E-02	0.12E-02	0.20E-02	0.84E-03	0.60E-03	0.56E-03
50.0	0.14E-02	0.22E-02	0.12E-02	0.89E-03	0.15E-02	0.65E-03	0.46E-03	0.43E-03
60.0	0.11E-02	0.18E-02	0.96E-03	0.72E-03	0.12E-02	0.52E-03	0.37E-03	0.35E-03
70.0	0.93E-03	0.15E-02	0.80E-03	0.60E-03	0.10E-02	0.43E-03	0.31E-03	0.29E-03
80.0	0.79E-03	0.13E-02	0.69E-03	0.51E-03	0.87E-03	0.37E-03	0.27E-03	0.25E-03

Table K-4.4. Dose Rate (mrem/yr) to Whole Body from Ra-226

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.65E 01	0.11E 02	0.11E 02	0.11E 02	0.10E 02	0.77E 01	0.33E 01	0.31E 01
0.5	0.49E 00	0.14E 01	0.16E 01	0.14E 01	0.13E 01	0.56E 00	0.35E 00	0.49E 00
1.0	0.92E-01	0.42E 00	0.50E 00	0.43E 00	0.37E 00	0.14E 00	0.98E-01	0.14E 00
2.0	0.21E-01	0.13E 00	0.15E 00	0.13E 00	0.11E 00	0.36E-01	0.28E-01	0.41E-01
3.0	0.96E-02	0.62E-01	0.73E-01	0.65E-01	0.54E-01	0.18E-01	0.14E-01	0.20E-01
4.0	0.55E-02	0.38E-01	0.45E-01	0.39E-01	0.33E-01	0.11E-01	0.83E-02	0.12E-01
5.0	0.36E-02	0.26E-01	0.30E-01	0.27E-01	0.23E-01	0.72E-02	0.56E-02	0.84E-02
10.0	0.11E-02	0.82E-02	0.98E-02	0.87E-02	0.73E-02	0.23E-02	0.18E-02	0.27E-02
20.0	0.37E-03	0.30E-02	0.36E-02	0.32E-02	0.27E-02	0.85E-03	0.67E-03	0.10E-02
30.0	0.23E-03	0.18E-02	0.22E-02	0.20E-02	0.17E-02	0.52E-03	0.41E-03	0.61E-03
40.0	0.16E-03	0.13E-02	0.16E-02	0.14E-02	0.12E-02	0.37E-03	0.29E-03	0.43E-03
50.0	0.12E-03	0.10E-02	0.12E-02	0.11E-02	0.90E-03	0.28E-03	0.22E-03	0.33E-03
60.0	0.99E-04	0.81E-03	0.96E-03	0.86E-03	0.72E-03	0.23E-03	0.18E-03	0.27E-03
70.0	0.82E-04	0.67E-03	0.80E-03	0.71E-03	0.60E-03	0.19E-03	0.15E-03	0.22E-03
80.0	0.71E-04	0.57E-03	0.68E-03	0.61E-03	0.52E-03	0.16E-03	0.13E-03	0.19E-03

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.43E 01	0.57E 01	0.45E 01	0.44E 01	0.34E 01	0.29E 01	0.25E 01	0.24E 01
0.5	0.56E 00	0.90E 00	0.62E 00	0.50E 00	0.65E 00	0.29E 00	0.20E 00	0.26E 00
1.0	0.15E 00	0.24E 00	0.15E 00	0.11E 00	0.18E 00	0.75E-01	0.51E-01	0.47E-01
2.0	0.43E-01	0.69E-01	0.41E-01	0.29E-01	0.48E-01	0.20E-01	0.14E-01	0.13E-01
3.0	0.21E-01	0.34E-01	0.19E-01	0.14E-01	0.23E-01	0.97E-02	0.69E-02	0.65E-02
4.0	0.13E-01	0.20E-01	0.11E-01	0.83E-02	0.14E-01	0.59E-02	0.42E-02	0.39E-02
5.0	0.85E-02	0.14E-01	0.77E-02	0.56E-02	0.94E-02	0.40E-02	0.28E-02	0.27E-02
10.0	0.27E-02	0.44E-02	0.24E-02	0.18E-02	0.30E-02	0.13E-02	0.91E-03	0.85E-03
20.0	0.10E-02	0.16E-02	0.87E-03	0.65E-03	0.11E-02	0.47E-03	0.34E-03	0.31E-03
30.0	0.61E-03	0.98E-03	0.53E-03	0.39E-03	0.67E-03	0.29E-03	0.20E-03	0.19E-03
40.0	0.43E-03	0.69E-03	0.37E-03	0.28E-03	0.47E-03	0.20E-03	0.14E-03	0.13E-03
50.0	0.33E-03	0.53E-03	0.28E-03	0.21E-03	0.36E-03	0.15E-03	0.11E-03	0.10E-03
60.0	0.26E-03	0.43E-03	0.23E-03	0.17E-03	0.29E-03	0.12E-03	0.89E-04	0.83E-04
70.0	0.22E-03	0.36E-03	0.19E-03	0.14E-03	0.24E-03	0.10E-03	0.74E-04	0.69E-04
80.0	0.19E-03	0.30E-03	0.16E-03	0.12E-03	0.21E-03	0.89E-04	0.63E-04	0.59E-04

Table K-4.5. Dose Rate (mrem/yr) to Whole Body from Pb-210

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.33E 00	0.53E 00	0.56E 00	0.54E 00	0.50E 00	0.38E 00	0.16E 00	0.15E 00
0.5	0.24E-01	0.70E-01	0.79E-01	0.70E-01	0.63E-01	0.28E-01	0.18E-01	0.25E-01
1.0	0.46E-02	0.21E-01	0.25E-01	0.22E-01	0.19E-01	0.70E-02	0.49E-02	0.71E-02
2.0	0.11E-02	0.63E-02	0.74E-02	0.65E-02	0.55E-02	0.18E-02	0.14E-02	0.21E-02
3.0	0.48E-03	0.31E-02	0.37E-02	0.32E-02	0.27E-02	0.88E-03	0.68E-03	0.10E-02
4.0	0.28E-03	0.19E-02	0.22E-02	0.20E-02	0.17E-02	0.53E-03	0.41E-03	0.62E-03
5.0	0.18E-03	0.13E-02	0.15E-02	0.13E-02	0.11E-02	0.36E-03	0.28E-03	0.42E-03
10.0	0.53E-04	0.41E-03	0.49E-03	0.44E-03	0.37E-03	0.11E-03	0.90E-04	0.14E-03
20.0	0.19E-04	0.15E-03	0.18E-03	0.16E-03	0.14E-03	0.43E-04	0.33E-04	0.50E-04
30.0	0.11E-04	0.92E-04	0.11E-03	0.98E-04	0.83E-04	0.26E-04	0.20E-04	0.31E-04
40.0	0.80E-05	0.65E-04	0.78E-04	0.69E-04	0.58E-04	0.18E-04	0.14E-04	0.22E-04
50.0	0.61E-05	0.50E-04	0.59E-04	0.53E-04	0.45E-04	0.14E-04	0.11E-04	0.16E-04
60.0	0.49E-05	0.40E-04	0.48E-04	0.43E-04	0.36E-04	0.11E-04	0.88E-05	0.13E-04
70.0	0.41E-05	0.34E-04	0.40E-04	0.36E-04	0.30E-04	0.94E-05	0.74E-05	0.11E-04
80.0	0.35E-05	0.29E-04	0.34E-04	0.31E-04	0.26E-04	0.80E-05	0.63E-05	0.95E-05

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.22E 00	0.29E 00	0.22E 00	0.22E 00	0.17E 00	0.14E 00	0.12E 00	0.12E 00
0.5	0.28E-01	0.45E-01	0.31E-01	0.25E-01	0.33E-01	0.15E-01	0.98E-02	0.13E-01
1.0	0.76E-02	0.12E-01	0.76E-02	0.55E-02	0.88E-02	0.38E-02	0.26E-02	0.24E-02
2.0	0.21E-02	0.35E-02	0.20E-02	0.15E-02	0.24E-02	0.10E-02	0.71E-03	0.66E-03
3.0	0.10E-02	0.17E-02	0.96E-03	0.69E-03	0.12E-02	0.49E-03	0.35E-03	0.32E-03
4.0	0.63E-03	0.10E-02	0.57E-03	0.42E-03	0.69E-03	0.29E-03	0.21E-03	0.20E-03
5.0	0.43E-03	0.69E-03	0.38E-03	0.28E-03	0.47E-03	0.20E-03	0.14E-03	0.13E-03
10.0	0.14E-03	0.22E-03	0.12E-03	0.88E-04	0.15E-03	0.64E-04	0.46E-04	0.42E-04
20.0	0.50E-04	0.81E-04	0.44E-04	0.32E-04	0.55E-04	0.24E-04	0.17E-04	0.16E-04
30.0	0.30E-04	0.49E-04	0.26E-04	0.20E-04	0.33E-04	0.14E-04	0.10E-04	0.95E-05
40.0	0.21E-04	0.35E-04	0.19E-04	0.14E-04	0.24E-04	0.10E-04	0.72E-05	0.67E-05
50.0	0.16E-04	0.27E-04	0.14E-04	0.11E-04	0.18E-04	0.77E-05	0.55E-05	0.51E-05
60.0	0.13E-04	0.21E-04	0.11E-04	0.85E-05	0.14E-04	0.62E-05	0.44E-05	0.41E-05
70.0	0.11E-04	0.18E-04	0.96E-05	0.71E-05	0.12E-04	0.52E-05	0.37E-05	0.35E-05
80.0	0.94E-05	0.15E-04	0.82E-05	0.61E-05	0.10E-04	0.44E-05	0.32E-05	0.30E-05

Table K-4.6. Dose Rate (mrem/yr) to Bone from U-238

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.43E 01	0.92E 01	0.10E 02	0.95E 01	0.86E 01	0.54E 01	0.26E 01	0.28E 01
0.5	0.40E 00	0.17E 01	0.20E 01	0.18E 01	0.15E 01	0.58E 00	0.40E 00	0.57E 00
1.0	0.87E-01	0.51E 00	0.61E 00	0.53E 00	0.46E 00	0.16E 00	0.11E 00	0.17E 00
2.0	0.22E-01	0.15E 00	0.18E 00	0.16E 00	0.13E 00	0.43E-01	0.33E-01	0.49E-01
3.0	0.10E-01	0.74E-01	0.88E-01	0.78E-01	0.66E-01	0.21E-01	0.16E-01	0.24E-01
4.0	0.60E-02	0.45E-01	0.53E-01	0.47E-01	0.40E-01	0.13E-01	0.97E-02	0.15E-01
5.0	0.40E-02	0.31E-01	0.36E-01	0.32E-01	0.27E-01	0.86E-02	0.66E-02	0.99E-02
10.0	0.12E-02	0.98E-02	0.12E-01	0.10E-01	0.87E-02	0.27E-02	0.21E-02	0.32E-02
20.0	0.44E-03	0.36E-02	0.43E-02	0.38E-02	0.32E-02	0.10E-02	0.79E-03	0.12E-02
30.0	0.27E-03	0.22E-02	0.26E-02	0.23E-02	0.20E-02	0.61E-03	0.48E-03	0.71E-03
40.0	0.19E-03	0.15E-02	0.18E-02	0.16E-02	0.14E-02	0.43E-03	0.34E-03	0.50E-03
50.0	0.14E-03	0.12E-02	0.14E-02	0.13E-02	0.11E-02	0.33E-03	0.26E-03	0.39E-03
60.0	0.12E-03	0.95E-03	0.11E-02	0.10E-02	0.85E-03	0.27E-03	0.21E-03	0.31E-03
70.0	0.97E-04	0.79E-03	0.94E-03	0.84E-03	0.71E-03	0.22E-03	0.17E-03	0.26E-03
80.0	0.83E-04	0.68E-03	0.81E-03	0.72E-03	0.61E-03	0.19E-03	0.15E-03	0.22E-03

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.35E 01	0.49E 01	0.35E 01	0.32E 01	0.30E 01	0.22E 01	0.18E 01	0.17E 01
0.5	0.61E 00	0.99E 00	0.61E 00	0.48E 00	0.69E 00	0.30E 00	0.21E 00	0.24E 00
1.0	0.17E 00	0.28E 00	0.16E 00	0.12E 00	0.20E 00	0.84E-01	0.59E-01	0.54E-01
2.0	0.50E-01	0.81E-01	0.45E-01	0.33E-01	0.55E-01	0.24E-01	0.17E-01	0.15E-01
3.0	0.24E-01	0.39E-01	0.22E-01	0.16E-01	0.27E-01	0.11E-01	0.81E-02	0.76E-02
4.0	0.15E-01	0.24E-01	0.13E-01	0.96E-02	0.16E-01	0.69E-02	0.49E-02	0.46E-02
5.0	0.10E-01	0.16E-01	0.88E-02	0.65E-02	0.11E-01	0.47E-02	0.33E-02	0.31E-02
10.0	0.32E-02	0.52E-02	0.28E-02	0.21E-02	0.35E-02	0.15E-02	0.11E-02	0.10E-02
20.0	0.12E-02	0.19E-02	0.10E-02	0.76E-03	0.13E-02	0.55E-03	0.39E-03	0.37E-03
30.0	0.71E-03	0.12E-02	0.62E-03	0.46E-03	0.78E-03	0.33E-03	0.24E-03	0.22E-03
40.0	0.50E-03	0.81E-03	0.44E-03	0.32E-03	0.55E-03	0.24E-03	0.17E-03	0.16E-03
50.0	0.38E-03	0.62E-03	0.33E-03	0.25E-03	0.42E-03	0.18E-03	0.13E-03	0.12E-03
60.0	0.31E-03	0.50E-03	0.27E-03	0.20E-03	0.34E-03	0.15E-03	0.10E-03	0.97E-04
70.0	0.26E-03	0.42E-03	0.22E-03	0.17E-03	0.28E-03	0.12E-03	0.87E-04	0.81E-04
80.0	0.22E-03	0.36E-03	0.19E-03	0.14E-03	0.24E-03	0.10E-03	0.74E-04	0.69E-04

Table K-4.7. Dose Rate (mrem/yr) to Bone from U-234

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.43E 01	0.92E 01	0.10E 02	0.85E 01	0.86E 01	0.54E 01	0.26E 01	0.28E 01
0.5	0.40E 00	0.17E 01	0.20E 01	0.18E 01	0.15E 01	0.58E 00	0.40E 00	0.57E 00
1.0	0.97E-01	0.51E 00	0.61E 00	0.53E 00	0.46E 00	0.16E 00	0.11E 00	0.17E 00
2.0	0.22E-01	0.15E 00	0.18E 00	0.16E 00	0.13E 00	0.43E-01	0.33E-01	0.49E-01
3.0	0.10E-01	0.74E-01	0.88E-01	0.78E-01	0.66E-01	0.21E-01	0.16E-01	0.24E-01
4.0	0.60E-02	0.45E-01	0.53E-01	0.47E-01	0.40E-01	0.13E-01	0.97E-02	0.15E-01
5.0	0.40E-02	0.31E-01	0.36E-01	0.32E-01	0.27E-01	0.86E-02	0.66E-02	0.99E-02
10.0	0.12E-02	0.98E-02	0.12E-01	0.10E-01	0.87E-02	0.27E-02	0.21E-02	0.32E-02
20.0	0.44E-03	0.36E-02	0.43E-02	0.38E-02	0.32E-02	0.10E-02	0.79E-03	0.12E-02
30.0	0.27E-03	0.22E-02	0.26E-02	0.23E-02	0.20E-02	0.61E-03	0.48E-03	0.71E-03
40.0	0.19E-03	0.15E-02	0.18E-02	0.16E-02	0.14E-02	0.43E-03	0.34E-03	0.50E-03
50.0	0.14E-03	0.12E-02	0.14E-02	0.13E-02	0.11E-02	0.33E-03	0.26E-03	0.39E-03
60.0	0.12E-03	0.95E-03	0.11E-02	0.10E-02	0.85E-03	0.27E-03	0.21E-03	0.31E-03
70.0	0.97E-04	0.79E-03	0.94E-03	0.84E-03	0.71E-03	0.22E-03	0.17E-03	0.26E-03
80.0	0.83E-04	0.68E-03	0.81E-03	0.72E-03	0.61E-03	0.19E-03	0.15E-03	0.22E-03

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.95E 01	0.49E 01	0.35E 01	0.32E 01	0.30E 01	0.22E 01	0.18E 01	0.17E 01
0.5	0.61E 00	0.99E 00	0.61E 00	0.48E 00	0.69E 00	0.30E 00	0.21E 00	0.24E 00
1.0	0.17E 00	0.28E 00	0.16E 00	0.12E 00	0.20E 00	0.84E-01	0.59E-01	0.54E-01
2.0	0.50E-01	0.81E-01	0.45E-01	0.33E-01	0.55E-01	0.24E-01	0.17E-01	0.15E-01
3.0	0.24E-01	0.39E-01	0.22E-01	0.16E-01	0.27E-01	0.11E-01	0.81E-02	0.76E-02
4.0	0.15E-01	0.24E-01	0.13E-01	0.96E-02	0.16E-01	0.69E-02	0.49E-02	0.46E-02
5.0	0.10E-01	0.16E-01	0.88E-02	0.65E-02	0.11E-01	0.47E-02	0.33E-02	0.31E-02
10.0	0.32E-02	0.52E-02	0.28E-02	0.21E-02	0.35E-02	0.15E-02	0.11E-02	0.10E-02
20.0	0.12E-02	0.19E-02	0.10E-02	0.76E-03	0.13E-02	0.55E-03	0.39E-03	0.37E-03
30.0	0.71E-03	0.12E-02	0.62E-03	0.46E-03	0.78E-03	0.33E-03	0.24E-03	0.22E-03
40.0	0.50E-03	0.81E-03	0.44E-03	0.32E-03	0.55E-03	0.24E-03	0.17E-03	0.16E-03
50.0	0.38E-03	0.62E-03	0.33E-03	0.25E-03	0.42E-03	0.18E-03	0.13E-03	0.12E-03
60.0	0.31E-03	0.50E-03	0.27E-03	0.20E-03	0.34E-03	0.15E-03	0.10E-03	0.97E-04
70.0	0.26E-03	0.42E-03	0.22E-03	0.17E-03	0.28E-03	0.12E-03	0.87E-04	0.81E-04
80.0	0.22E-03	0.36E-03	0.19E-03	0.14E-03	0.24E-03	0.10E-03	0.74E-04	0.69E-04

Table K-4.8. Dose Rate (mrem/yr) to Bone from Th-230

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.98E 03	0.16E 04	0.17E 04	0.17E 04	0.15E 04	0.12E 04	0.50E 03	0.47E 03
0.5	0.74E 02	0.22E 03	0.25E 03	0.22E 03	0.20E 03	0.87E 02	0.55E 02	0.78E 02
1.0	0.14E 02	0.66E 02	0.78E 02	0.68E 02	0.59E 02	0.22E 02	0.15E 02	0.22E 02
2.0	0.33E 01	0.20E 02	0.23E 02	0.21E 02	0.17E 02	0.57E 01	0.43E 01	0.65E 01
3.0	0.15E 01	0.98E 01	0.12E 02	0.10E 02	0.86E 01	0.28E 01	0.21E 01	0.32E 01
4.0	0.86E 00	0.59E 01	0.70E 01	0.62E 01	0.52E 01	0.17E 01	0.13E 01	0.19E 01
5.0	0.57E 00	0.40E 01	0.48E 01	0.42E 01	0.36E 01	0.11E 01	0.89E 00	0.13E 01
10.0	0.17E 00	0.13E 01	0.15E 01	0.14E 01	0.12E 01	0.36E 00	0.28E 00	0.43E 00
20.0	0.59E-01	0.48E 00	0.57E 00	0.51E 00	0.43E 00	0.13E 00	0.11E 00	0.16E 00
30.0	0.36E-01	0.29E 00	0.35E 00	0.31E 00	0.26E 00	0.81E-01	0.64E-01	0.96E-01
40.0	0.25E-01	0.21E 00	0.24E 00	0.22E 00	0.18E 00	0.57E-01	0.45E-01	0.68E-01
50.0	0.19E-01	0.16E 00	0.19E 00	0.17E 00	0.14E 00	0.44E-01	0.35E-01	0.52E-01
60.0	0.16E-01	0.13E 00	0.15E 00	0.13E 00	0.11E 00	0.35E-01	0.28E-01	0.42E-01
70.0	0.13E-01	0.11E 00	0.13E 00	0.11E 00	0.95E-01	0.30E-01	0.23E-01	0.35E-01
80.0	0.11E-01	0.96E-01	0.11E 00	0.96E-01	0.81E-01	0.25E-01	0.20E-01	0.30E-01

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.66E 03	0.88E 03	0.68E 03	0.66E 03	0.52E 03	0.44E 03	0.36E 03	0.36E 03
0.5	0.88E 02	0.14E 03	0.96E 02	0.77E 02	0.10E 03	0.46E 02	0.31E 02	0.39E 02
1.0	0.24E 02	0.38E 02	0.24E 02	0.17E 02	0.27E 02	0.12E 02	0.80E 01	0.74E 01
2.0	0.67E 01	0.11E 02	0.64E 01	0.46E 01	0.75E 01	0.32E 01	0.22E 01	0.21E 01
3.0	0.33E 01	0.53E 01	0.30E 01	0.22E 01	0.36E 01	0.15E 01	0.11E 01	0.10E 01
4.0	0.20E 01	0.32E 01	0.18E 01	0.13E 01	0.22E 01	0.93E 00	0.66E 00	0.62E 00
5.0	0.13E 01	0.22E 01	0.12E 01	0.88E 00	0.15E 01	0.63E 00	0.45E 00	0.42E 00
10.0	0.43E 00	0.69E 00	0.38E 00	0.28E 00	0.47E 00	0.20E 00	0.14E 00	0.13E 00
20.0	0.16E 00	0.26E 00	0.14E 00	0.10E 00	0.17E 00	0.74E-01	0.53E-01	0.49E-01
30.0	0.96E-01	0.15E 00	0.83E-01	0.62E-01	0.10E 00	0.45E-01	0.32E-01	0.30E-01
40.0	0.67E-01	0.11E 00	0.59E-01	0.44E-01	0.74E-01	0.32E-01	0.23E-01	0.21E-01
50.0	0.52E-01	0.83E-01	0.45E-01	0.33E-01	0.57E-01	0.24E-01	0.17E-01	0.16E-01
60.0	0.42E-01	0.67E-01	0.36E-01	0.27E-01	0.46E-01	0.20E-01	0.14E-01	0.13E-01
70.0	0.35E-01	0.56E-01	0.30E-01	0.22E-01	0.38E-01	0.16E-01	0.12E-01	0.11E-01
80.0	0.30E-01	0.48E-01	0.26E-01	0.19E-01	0.33E-01	0.14E-01	0.10E-01	0.93E-02

Table K-4.9. Dose Rate (mrem/yr) to Bone from Ra-226

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.78E 02	0.13E 03	0.13E 03	0.13E 03	0.12E 03	0.92E 02	0.39E 02	0.37E 02
0.5	0.58E 01	0.17E 02	0.19E 02	0.17E 02	0.15E 02	0.67E 01	0.42E 01	0.59E 01
1.0	0.11E 01	0.50E 01	0.59E 01	0.52E 01	0.45E 01	0.17E 01	0.12E 01	0.17E 01
2.0	0.25E 00	0.15E 01	0.18E 01	0.16E 01	0.13E 01	0.43E 00	0.33E 00	0.49E 00
3.0	0.11E 00	0.74E 00	0.88E 00	0.78E 00	0.65E 00	0.21E 00	0.16E 00	0.24E 00
4.0	0.66E-01	0.45E 00	0.54E 00	0.47E 00	0.40E 00	0.13E 00	0.99E-01	0.15E 00
5.0	0.43E-01	0.31E 00	0.36E 00	0.32E 00	0.27E 00	0.87E-01	0.68E-01	0.10E 00
10.0	0.13E-01	0.99E-01	0.12E 00	0.10E 00	0.88E-01	0.28E-01	0.22E-01	0.33E-01
20.0	0.45E-02	0.37E-01	0.44E-01	0.39E-01	0.33E-01	0.10E-01	0.80E-02	0.12E-01
30.0	0.27E-02	0.22E-01	0.26E-01	0.24E-01	0.20E-01	0.62E-02	0.49E-02	0.73E-02
40.0	0.19E-02	0.16E-01	0.19E-01	0.17E-01	0.14E-01	0.44E-02	0.34E-02	0.52E-02
50.0	0.15E-02	0.12E-01	0.14E-01	0.13E-01	0.11E-01	0.34E-02	0.26E-02	0.40E-02
60.0	0.12E-02	0.97E-02	0.11E-01	0.10E-01	0.87E-02	0.27E-02	0.21E-02	0.32E-02
70.0	0.99E-03	0.81E-02	0.96E-02	0.86E-02	0.72E-02	0.23E-02	0.18E-02	0.27E-02
80.0	0.85E-03	0.69E-02	0.82E-02	0.73E-02	0.62E-02	0.19E-02	0.15E-02	0.23E-02

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.52E 02	0.69E 02	0.54E 02	0.52E 02	0.40E 02	0.35E 02	0.30E 02	0.28E 02
0.5	0.67E 01	0.11E 02	0.74E 01	0.60E 01	0.78E 01	0.35E 01	0.24E 01	0.31E 01
1.0	0.19E 01	0.29E 01	0.18E 01	0.13E 01	0.21E 01	0.90E 00	0.61E 00	0.57E 00
2.0	0.51E 00	0.83E 00	0.49E 00	0.35E 00	0.58E 00	0.24E 00	0.17E 00	0.16E 00
3.0	0.25E 00	0.40E 00	0.23E 00	0.17E 00	0.28E 00	0.12E 00	0.83E-01	0.78E-01
4.0	0.15E 00	0.24E 00	0.14E 00	0.10E 00	0.17E 00	0.71E-01	0.50E-01	0.47E-01
5.0	0.10E 00	0.17E 00	0.92E-01	0.67E-01	0.11E 00	0.48E-01	0.34E-01	0.32E-01
10.0	0.33E-01	0.53E-01	0.29E-01	0.21E-01	0.36E-01	0.15E-01	0.11E-01	0.10E-01
20.0	0.12E-01	0.19E-01	0.10E-01	0.78E-02	0.13E-01	0.57E-02	0.40E-02	0.38E-02
30.0	0.73E-02	0.12E-01	0.63E-02	0.47E-02	0.80E-02	0.34E-02	0.24E-02	0.23E-02
40.0	0.51E-02	0.83E-02	0.45E-02	0.33E-02	0.56E-02	0.24E-02	0.17E-02	0.16E-02
50.0	0.39E-02	0.64E-02	0.34E-02	0.25E-02	0.43E-02	0.19E-02	0.13E-02	0.12E-02
60.0	0.32E-02	0.51E-02	0.28E-02	0.20E-02	0.35E-02	0.15E-02	0.11E-02	0.99E-03
70.0	0.26E-02	0.43E-02	0.23E-02	0.17E-02	0.29E-02	0.12E-02	0.89E-03	0.83E-03
80.0	0.23E-02	0.37E-02	0.20E-02	0.15E-02	0.25E-02	0.11E-02	0.76E-03	0.71E-03

Table K-4.10. Dose Rate (mrem/yr) to Bone from Pb-210

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.11E 02	0.18E 02	0.19E 02	0.19E 02	0.17E 02	0.13E 02	0.57E 01	0.53E 01
0.5	0.84E 00	0.24E 01	0.27E 01	0.24E 01	0.22E 01	0.96E 00	0.61E 00	0.85E 00
1.0	0.16E 00	0.72E 00	0.85E 00	0.74E 00	0.64E 00	0.24E 00	0.17E 00	0.24E 00
2.0	0.36E-01	0.22E 00	0.25E 00	0.22E 00	0.19E 00	0.62E-01	0.47E-01	0.71E-01
3.0	0.16E-01	0.11E 00	0.13E 00	0.11E 00	0.94E-01	0.30E-01	0.23E-01	0.35E-01
4.0	0.95E-02	0.65E-01	0.77E-01	0.68E-01	0.57E-01	0.18E-01	0.14E-01	0.21E-01
5.0	0.62E-02	0.44E-01	0.52E-01	0.46E-01	0.39E-01	0.12E-01	0.97E-02	0.15E-01
10.0	0.18E-02	0.14E-01	0.17E-01	0.15E-01	0.13E-01	0.39E-02	0.31E-02	0.47E-02
20.0	0.64E-03	0.52E-02	0.62E-02	0.56E-02	0.47E-02	0.15E-02	0.12E-02	0.17E-02
30.0	0.39E-03	0.32E-02	0.38E-02	0.34E-02	0.29E-02	0.89E-03	0.70E-03	0.10E-02
40.0	0.28E-03	0.22E-02	0.27E-02	0.24E-02	0.20E-02	0.63E-03	0.49E-03	0.74E-03
50.0	0.21E-03	0.17E-02	0.20E-02	0.18E-02	0.15E-02	0.48E-03	0.38E-03	0.57E-03
60.0	0.17E-03	0.14E-02	0.16E-02	0.15E-02	0.12E-02	0.39E-03	0.30E-03	0.46E-03
70.0	0.14E-03	0.12E-02	0.14E-02	0.12E-02	0.10E-02	0.32E-03	0.25E-03	0.38E-03
80.0	0.12E-03	0.99E-03	0.12E-02	0.11E-02	0.89E-03	0.28E-03	0.22E-03	0.33E-03

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.74E 01	0.98E 01	0.77E 01	0.75E 01	0.58E 01	0.50E 01	0.43E 01	0.40E 01
0.5	0.96E 00	0.15E 01	0.11E 01	0.86E 00	0.11E 01	0.50E 00	0.34E 00	0.44E 00
1.0	0.26E 00	0.42E 00	0.26E 00	0.19E 00	0.30E 00	0.13E 00	0.88E-01	0.81E-01
2.0	0.73E-01	0.12E 00	0.70E-01	0.50E-01	0.82E-01	0.35E-01	0.24E-01	0.23E-01
3.0	0.36E-01	0.58E-01	0.33E-01	0.24E-01	0.40E-01	0.17E-01	0.12E-01	0.11E-01
4.0	0.22E-01	0.35E-01	0.20E-01	0.14E-01	0.24E-01	0.10E-01	0.72E-02	0.67E-02
5.0	0.15E-01	0.24E-01	0.13E-01	0.96E-02	0.16E-01	0.69E-02	0.49E-02	0.46E-02
10.0	0.47E-02	0.76E-02	0.41E-02	0.30E-02	0.51E-02	0.22E-02	0.16E-02	0.15E-02
20.0	0.17E-02	0.28E-02	0.15E-02	0.11E-02	0.19E-02	0.81E-03	0.58E-03	0.54E-03
30.0	0.10E-02	0.17E-02	0.91E-03	0.68E-03	0.11E-02	0.49E-03	0.35E-03	0.33E-03
40.0	0.74E-03	0.12E-02	0.64E-03	0.48E-03	0.81E-03	0.35E-03	0.25E-03	0.23E-03
50.0	0.56E-03	0.91E-03	0.49E-03	0.36E-03	0.62E-03	0.27E-03	0.19E-03	0.18E-03
60.0	0.45E-03	0.73E-03	0.39E-03	0.29E-03	0.50E-03	0.21E-03	0.15E-03	0.14E-03
70.0	0.38E-03	0.61E-03	0.33E-03	0.24E-03	0.42E-03	0.18E-03	0.13E-03	0.12E-03
80.0	0.32E-03	0.52E-03	0.28E-03	0.21E-03	0.36E-03	0.15E-03	0.11E-03	0.10E-03

Table K-4.11. Dose Rate (mrem/yr) to Lung from U-238

	DEGREES							
DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.26E 03	0.61E 03	0.67E 03	0.63E 03	0.57E 03	0.36E 03	0.17E 03	0.18E 03
0.5	0.27E 02	0.11E 03	0.13E 03	0.12E 03	0.10E 03	0.38E 02	0.26E 02	0.38E 02
1.0	0.58E 01	0.34E 02	0.40E 02	0.36E 02	0.30E 02	0.10E 02	0.77E 01	0.11E 02
2.0	0.15E 01	0.10E 02	0.12E 02	0.11E 02	0.89E 01	0.29E 01	0.22E 01	0.33E 01
3.0	0.68E 00	0.49E 01	0.58E 01	0.52E 01	0.44E 01	0.14E 01	0.11E 01	0.16E 01
4.0	0.40E 00	0.30E 01	0.35E 01	0.32E 01	0.27E 01	0.84E 00	0.65E 00	0.97E 00
5.0	0.27E 00	0.20E 01	0.24E 01	0.21E 01	0.18E 01	0.57E 00	0.44E 00	0.66E 00
10.0	0.82E-01	0.65E 00	0.77E 00	0.69E 00	0.58E 00	0.18E 00	0.14E 00	0.21E 00
20.0	0.29E-01	0.24E 00	0.29E 00	0.26E 00	0.22E 00	0.67E-01	0.52E-01	0.79E-01
30.0	0.18E-01	0.15E 00	0.17E 00	0.15E 00	0.13E 00	0.41E-01	0.32E-01	0.48E-01
40.0	0.13E-01	0.10E 00	0.12E 00	0.11E 00	0.92E-01	0.29E-01	0.22E-01	0.34E-01
50.0	0.96E-02	0.79E-01	0.94E-01	0.84E-01	0.70E-01	0.22E-01	0.17E-01	0.26E-01
60.0	0.78E-02	0.63E-01	0.75E-01	0.67E-01	0.57E-01	0.18E-01	0.14E-01	0.21E-01
70.0	0.65E-02	0.53E-01	0.63E-01	0.56E-01	0.47E-01	0.15E-01	0.12E-01	0.17E-01
80.0	0.55E-02	0.45E-01	0.54E-01	0.48E-01	0.41E-01	0.13E-01	0.99E-02	0.15E-01

	DEGREES							
DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.23E 03	0.33E 03	0.23E 03	0.21E 03	0.20E 03	0.14E 03	0.12E 03	0.11E 03
0.5	0.41E 02	0.66E 02	0.41E 02	0.32E 02	0.46E 02	0.20E 02	0.14E 02	0.16E 02
1.0	0.12E 02	0.19E 02	0.11E 02	0.80E 01	0.13E 02	0.56E 01	0.39E 01	0.36E 01
2.0	0.33E 01	0.54E 01	0.30E 01	0.22E 01	0.37E 01	0.16E 01	0.11E 01	0.10E 01
3.0	0.16E 01	0.26E 01	0.15E 01	0.11E 01	0.18E 01	0.76E 00	0.54E 00	0.51E 00
4.0	0.98E 00	0.16E 01	0.87E 00	0.64E 00	0.11E 01	0.46E 00	0.33E 00	0.31E 00
5.0	0.67E 00	0.11E 01	0.59E 00	0.43E 00	0.73E 00	0.31E 00	0.22E 00	0.21E 00
10.0	0.21E 00	0.34E 00	0.19E 00	0.14E 00	0.23E 00	0.10E 00	0.71E-01	0.66E-01
20.0	0.78E-01	0.13E 00	0.68E-01	0.51E-01	0.86E-01	0.37E-01	0.26E-01	0.25E-01
30.0	0.48E-01	0.77E-01	0.41E-01	0.31E-01	0.52E-01	0.22E-01	0.16E-01	0.15E-01
40.0	0.33E-01	0.54E-01	0.29E-01	0.22E-01	0.37E-01	0.16E-01	0.11E-01	0.10E-01
50.0	0.26E-01	0.41E-01	0.22E-01	0.17E-01	0.28E-01	0.12E-01	0.86E-02	0.80E-02
60.0	0.21E-01	0.33E-01	0.18E-01	0.13E-01	0.23E-01	0.97E-02	0.69E-02	0.65E-02
70.0	0.17E-01	0.28E-01	0.15E-01	0.11E-01	0.19E-01	0.81E-02	0.58E-02	0.54E-02
80.0	0.15E-01	0.24E-01	0.13E-01	0.95E-02	0.16E-01	0.69E-02	0.49E-02	0.46E-02

Table K-4.12. Dose Rate (mrem/yr) to Lung from U-234

	DEGREES							
DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.29E 03	0.61E 03	0.67E 03	0.63E 03	0.57E 03	0.36E 03	0.17E 03	0.18E 03
0.5	0.27E 02	0.11E 03	0.13E 03	0.12E 03	0.10E 03	0.38E 02	0.26E 02	0.38E 02
1.0	0.58E 01	0.34E 02	0.40E 02	0.36E 02	0.30E 02	0.10E 02	0.77E 01	0.11E 02
2.0	0.15E 01	0.10E 02	0.12E 02	0.11E 02	0.89E 01	0.29E 01	0.22E 01	0.33E 01
3.0	0.68E 00	0.49E 01	0.58E 01	0.52E 01	0.44E 01	0.14E 01	0.11E 01	0.16E 01
4.0	0.40E 00	0.30E 01	0.35E 01	0.32E 01	0.27E 01	0.84E 00	0.65E 00	0.97E 00
5.0	0.27E 00	0.20E 01	0.24E 01	0.21E 01	0.18E 01	0.57E 00	0.44E 00	0.66E 00
10.0	0.82E-01	0.65E 00	0.77E 00	0.69E 00	0.58E 00	0.18E 00	0.14E 00	0.21E 00
20.0	0.29E-01	0.24E 00	0.29E 00	0.26E 00	0.22E 00	0.67E-01	0.52E-01	0.79E-01
30.0	0.18E-01	0.15E 00	0.17E 00	0.15E 00	0.13E 00	0.41E-01	0.32E-01	0.48E-01
40.0	0.13E-01	0.10E 00	0.12E 00	0.11E 00	0.92E-01	0.29E-01	0.22E-01	0.34E-01
50.0	0.96E-02	0.79E-01	0.94E-01	0.84E-01	0.70E-01	0.22E-01	0.17E-01	0.26E-01
60.0	0.78E-02	0.63E-01	0.75E-01	0.67E-01	0.57E-01	0.18E-01	0.14E-01	0.21E-01
70.0	0.65E-02	0.53E-01	0.63E-01	0.56E-01	0.47E-01	0.15E-01	0.12E-01	0.17E-01
80.0	0.55E-02	0.45E-01	0.54E-01	0.48E-01	0.41E-01	0.13E-01	0.99E-02	0.15E-01

	DEGREES							
DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.23E 03	0.33E 03	0.23E 03	0.21E 03	0.20E 03	0.14E 03	0.12E 03	0.11E 03
0.5	0.41E 02	0.66E 02	0.41E 02	0.32E 02	0.46E 02	0.20E 02	0.14E 02	0.16E 02
1.0	0.12E 02	0.19E 02	0.11E 02	0.80E 01	0.13E 02	0.56E 01	0.39E 01	0.36E 01
2.0	0.33E 01	0.54E 01	0.30E 01	0.22E 01	0.37E 01	0.16E 01	0.11E 01	0.10E 01
3.0	0.16E 01	0.26E 01	0.15E 01	0.11E 01	0.18E 01	0.76E 00	0.54E 00	0.51E 00
4.0	0.98E 00	0.16E 01	0.87E 00	0.64E 00	0.11E 01	0.46E 00	0.33E 00	0.31E 00
5.0	0.67E 00	0.11E 01	0.59E 00	0.43E 00	0.73E 00	0.31E 00	0.22E 00	0.21E 00
10.0	0.21E 00	0.34E 00	0.19E 00	0.14E 00	0.23E 00	0.10E 00	0.71E-01	0.66E-01
20.0	0.78E-01	0.13E 00	0.68E-01	0.51E-01	0.86E-01	0.37E-01	0.26E-01	0.25E-01
30.0	0.48E-01	0.77E-01	0.41E-01	0.31E-01	0.52E-01	0.22E-01	0.16E-01	0.15E-01
40.0	0.33E-01	0.54E-01	0.29E-01	0.22E-01	0.37E-01	0.16E-01	0.11E-01	0.10E-01
50.0	0.26E-01	0.41E-01	0.22E-01	0.17E-01	0.28E-01	0.12E-01	0.86E-02	0.80E-02
60.0	0.21E-01	0.33E-01	0.18E-01	0.13E-01	0.23E-01	0.97E-02	0.69E-02	0.65E-02
70.0	0.17E-01	0.28E-01	0.15E-01	0.11E-01	0.19E-01	0.81E-02	0.58E-02	0.54E-02
80.0	0.15E-01	0.24E-01	0.13E-01	0.95E-02	0.16E-01	0.69E-02	0.49E-02	0.46E-02

Table K-4.13. Dose Rate (mrem/yr) to Lung from Th-230

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.29E 03	0.48E 03	0.51E 03	0.49E 03	0.45E 03	0.34E 03	0.15E 03	0.14E 03
0.5	0.22E 02	0.65E 02	0.74E 02	0.65E 02	0.58E 02	0.26E 02	0.16E 02	0.23E 02
1.0	0.41E 01	0.19E 02	0.23E 02	0.20E 02	0.17E 02	0.64E 01	0.45E 01	0.66E 01
2.0	0.96E 00	0.58E 01	0.69E 01	0.60E 01	0.51E 01	0.17E 01	0.13E 01	0.19E 01
3.0	0.44E 00	0.29E 01	0.34E 01	0.30E 01	0.25E 01	0.82E 00	0.63E 00	0.94E 00
4.0	0.25E 00	0.17E 01	0.21E 01	0.18E 01	0.15E 01	0.49E 00	0.38E 00	0.57E 00
5.0	0.17E 00	0.12E 01	0.14E 01	0.12E 01	0.10E 01	0.33E 00	0.26E 00	0.39E 00
10.0	0.49E-01	0.38E 00	0.45E 00	0.40E 00	0.34E 00	0.11E 00	0.83E-01	0.13E 00
20.0	0.17E-01	0.14E 00	0.17E 00	0.15E 00	0.13E 00	0.39E-01	0.31E-01	0.46E-01
30.0	0.10E-01	0.85E-01	0.10E 00	0.91E-01	0.77E-01	0.24E-01	0.19E-01	0.28E-01
40.0	0.74E-02	0.60E-01	0.72E-01	0.64E-01	0.54E-01	0.17E-01	0.13E-01	0.20E-01
50.0	0.57E-02	0.46E-01	0.55E-01	0.49E-01	0.41E-01	0.13E-01	0.10E-01	0.15E-01
60.0	0.46E-02	0.37E-01	0.44E-01	0.40E-01	0.33E-01	0.10E-01	0.82E-02	0.12E-01
70.0	0.38E-02	0.31E-01	0.37E-01	0.33E-01	0.28E-01	0.87E-02	0.69E-02	0.10E-01
80.0	0.33E-02	0.27E-01	0.32E-01	0.28E-01	0.24E-01	0.74E-02	0.58E-02	0.88E-02

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.19E 03	0.26E 03	0.20E 03	0.19E 03	0.15E 03	0.13E 03	0.11E 03	0.10E 03
0.5	0.26E 02	0.41E 02	0.28E 02	0.23E 02	0.30E 02	0.13E 02	0.90E 01	0.12E 02
1.0	0.70E 01	0.11E 02	0.70E 01	0.51E 01	0.80E 01	0.35E 01	0.23E 01	0.22E 01
2.0	0.20E 01	0.32E 01	0.19E 01	0.13E 01	0.22E 01	0.93E 00	0.65E 00	0.61E 00
3.0	0.96E 00	0.16E 01	0.88E 00	0.64E 00	0.11E 01	0.45E 00	0.32E 00	0.30E 00
4.0	0.58E 00	0.94E 00	0.52E 00	0.38E 00	0.64E 00	0.27E 00	0.19E 00	0.18E 00
5.0	0.39E 00	0.64E 00	0.35E 00	0.26E 00	0.43E 00	0.18E 00	0.13E 00	0.12E 00
10.0	0.13E 00	0.20E 00	0.11E 00	0.81E-01	0.14E 00	0.59E-01	0.42E-01	0.39E-01
20.0	0.46E-01	0.75E-01	0.40E-01	0.30E-01	0.51E-01	0.22E-01	0.16E-01	0.14E-01
30.0	0.28E-01	0.45E-01	0.24E-01	0.18E-01	0.31E-01	0.13E-01	0.94E-02	0.88E-02
40.0	0.20E-01	0.32E-01	0.17E-01	0.13E-01	0.22E-01	0.93E-02	0.66E-02	0.62E-02
50.0	0.15E-01	0.24E-01	0.13E-01	0.98E-02	0.17E-01	0.71E-02	0.51E-02	0.47E-02
60.0	0.12E-01	0.20E-01	0.11E-01	0.79E-02	0.13E-01	0.57E-02	0.41E-02	0.38E-02
70.0	0.10E-01	0.16E-01	0.88E-02	0.66E-02	0.11E-01	0.48E-02	0.34E-02	0.32E-02
80.0	0.87E-02	0.14E-01	0.76E-02	0.56E-02	0.95E-02	0.41E-02	0.29E-02	0.27E-02

Table K-4.14. Dose Rate (mrem/yr) to Lung from Ra-226

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.29E 03	0.47E 03	0.49E 03	0.47E 03	0.44E 03	0.34E 03	0.14E 03	0.14E 03
0.5	0.21E 02	0.62E 02	0.70E 02	0.62E 02	0.55E 02	0.25E 02	0.15E 02	0.22E 02
1.0	0.40E 01	0.18E 02	0.22E 02	0.19E 02	0.16E 02	0.62E 01	0.43E 01	0.63E 01
2.0	0.93E 00	0.55E 01	0.65E 01	0.57E 01	0.48E 01	0.16E 01	0.12E 01	0.18E 01
3.0	0.42E 00	0.27E 01	0.32E 01	0.28E 01	0.24E 01	0.78E 00	0.60E 00	0.89E 00
4.0	0.24E 00	0.17E 01	0.20E 01	0.17E 01	0.15E 01	0.47E 00	0.36E 00	0.54E 00
5.0	0.16E 00	0.11E 01	0.13E 01	0.12E 01	0.10E 01	0.32E 00	0.25E 00	0.37E 00
10.0	0.47E-01	0.36E 00	0.43E 00	0.38E 00	0.32E 00	0.10E 00	0.79E-01	0.12E 00
20.0	0.16E-01	0.13E 00	0.16E 00	0.14E 00	0.12E 00	0.38E-01	0.29E-01	0.44E-01
30.0	0.10E-01	0.81E-01	0.97E-01	0.87E-01	0.73E-01	0.23E-01	0.18E-01	0.27E-01
40.0	0.70E-02	0.57E-01	0.68E-01	0.61E-01	0.51E-01	0.16E-01	0.13E-01	0.19E-01
50.0	0.54E-02	0.44E-01	0.52E-01	0.47E-01	0.39E-01	0.12E-01	0.97E-02	0.15E-01
60.0	0.43E-02	0.35E-01	0.42E-01	0.38E-01	0.32E-01	0.99E-02	0.78E-02	0.12E-01
70.0	0.36E-02	0.30E-01	0.35E-01	0.31E-01	0.26E-01	0.83E-02	0.65E-02	0.98E-02
80.0	0.31E-02	0.25E-01	0.30E-01	0.27E-01	0.23E-01	0.71E-02	0.56E-02	0.84E-02

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.19E 03	0.25E 03	0.20E 03	0.19E 03	0.15E 03	0.13E 03	0.11E 03	0.10E 03
0.5	0.25E 02	0.40E 02	0.27E 02	0.22E 02	0.29E 02	0.13E 02	0.86E 01	0.11E 02
1.0	0.67E 01	0.11E 02	0.67E 01	0.49E 01	0.77E 01	0.33E 01	0.22E 01	0.21E 01
2.0	0.19E 01	0.31E 01	0.18E 01	0.13E 01	0.21E 01	0.89E 00	0.62E 00	0.58E 00
3.0	0.91E 00	0.15E 01	0.84E 00	0.61E 00	0.10E 01	0.43E 00	0.30E 00	0.28E 00
4.0	0.55E 00	0.90E 00	0.50E 00	0.37E 00	0.61E 00	0.26E 00	0.18E 00	0.17E 00
5.0	0.38E 00	0.61E 00	0.34E 00	0.25E 00	0.41E 00	0.18E 00	0.13E 00	0.12E 00
10.0	0.12E 00	0.19E 00	0.11E 00	0.78E-01	0.13E 00	0.56E-01	0.40E-01	0.37E-01
20.0	0.44E-01	0.71E-01	0.38E-01	0.29E-01	0.49E-01	0.21E-01	0.15E-01	0.14E-01
30.0	0.27E-01	0.43E-01	0.23E-01	0.17E-01	0.29E-01	0.13E-01	0.90E-02	0.84E-02
40.0	0.19E-01	0.30E-01	0.16E-01	0.12E-01	0.21E-01	0.89E-02	0.63E-02	0.59E-02
50.0	0.14E-01	0.23E-01	0.13E-01	0.93E-02	0.16E-01	0.68E-02	0.48E-02	0.45E-02
60.0	0.12E-01	0.19E-01	0.10E-01	0.75E-02	0.13E-01	0.55E-02	0.39E-02	0.36E-02
70.0	0.97E-02	0.16E-01	0.84E-02	0.63E-02	0.11E-01	0.46E-02	0.33E-02	0.30E-02
80.0	0.83E-02	0.13E-01	0.72E-02	0.54E-02	0.91E-02	0.39E-02	0.28E-02	0.26E-02

Table K-4.15. Dose Rate (mrem/yr) to Lung from Pb-210

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.39E 02	0.64E 02	0.68E 02	0.65E 02	0.60E 02	0.46E 02	0.20E 02	0.19E 02
0.5	0.29E 01	0.85E 01	0.95E 01	0.85E 01	0.75E 01	0.34E 01	0.21E 01	0.30E 01
1.0	0.55E 00	0.25E 01	0.30E 01	0.26E 01	0.22E 01	0.84E 00	0.59E 00	0.86E 00
2.0	0.13E 00	0.76E 00	0.89E 00	0.78E 00	0.66E 00	0.22E 00	0.17E 00	0.25E 00
3.0	0.58E-01	0.37E 00	0.44E 00	0.39E 00	0.33E 00	0.11E 00	0.82E-01	0.12E 00
4.0	0.33E-01	0.23E 00	0.27E 00	0.24E 00	0.20E 00	0.64E-01	0.50E-01	0.74E-01
5.0	0.22E-01	0.15E 00	0.18E 00	0.16E 00	0.14E 00	0.44E-01	0.34E-01	0.51E-01
10.0	0.64E-02	0.50E-01	0.59E-01	0.52E-01	0.44E-01	0.14E-01	0.11E-01	0.16E-01
20.0	0.22E-02	0.18E-01	0.22E-01	0.20E-01	0.16E-01	0.51E-02	0.40E-02	0.61E-02
30.0	0.14E-02	0.11E-01	0.13E-01	0.12E-01	0.10E-01	0.31E-02	0.24E-02	0.37E-02
40.0	0.96E-03	0.78E-02	0.93E-02	0.83E-02	0.70E-02	0.22E-02	0.17E-02	0.26E-02
50.0	0.74E-03	0.60E-02	0.71E-02	0.64E-02	0.54E-02	0.17E-02	0.13E-02	0.20E-02
60.0	0.59E-03	0.49E-02	0.58E-02	0.51E-02	0.43E-02	0.14E-02	0.11E-02	0.16E-02
70.0	0.50E-03	0.40E-02	0.48E-02	0.43E-02	0.36E-02	0.11E-02	0.89E-03	0.13E-02
80.0	0.42E-03	0.35E-02	0.41E-02	0.37E-02	0.31E-02	0.97E-03	0.76E-03	0.11E-02

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.26E 02	0.34E 02	0.27E 02	0.26E 02	0.20E 02	0.17E 02	0.15E 02	0.14E 02
0.5	0.34E 01	0.54E 01	0.37E 01	0.30E 01	0.39E 01	0.18E 01	0.12E 01	0.15E 01
1.0	0.91E 00	0.15E 01	0.92E 00	0.67E 00	0.11E 01	0.45E 00	0.31E 00	0.28E 00
2.0	0.26E 00	0.42E 00	0.24E 00	0.18E 00	0.29E 00	0.12E 00	0.85E-01	0.79E-01
3.0	0.13E 00	0.20E 00	0.12E 00	0.84E-01	0.14E 00	0.59E-01	0.42E-01	0.39E-01
4.0	0.76E-01	0.12E 00	0.69E-01	0.50E-01	0.84E-01	0.35E-01	0.25E-01	0.24E-01
5.0	0.51E-01	0.83E-01	0.46E-01	0.34E-01	0.57E-01	0.24E-01	0.17E-01	0.16E-01
10.0	0.16E-01	0.26E-01	0.14E-01	0.11E-01	0.18E-01	0.77E-02	0.55E-02	0.51E-02
20.0	0.60E-02	0.98E-02	0.53E-02	0.39E-02	0.66E-02	0.28E-02	0.20E-02	0.19E-02
30.0	0.37E-02	0.59E-02	0.32E-02	0.24E-02	0.40E-02	0.17E-02	0.12E-02	0.11E-02
40.0	0.26E-02	0.42E-02	0.22E-02	0.17E-02	0.28E-02	0.12E-02	0.87E-03	0.81E-03
50.0	0.20E-02	0.32E-02	0.17E-02	0.13E-02	0.22E-02	0.93E-03	0.66E-03	0.62E-03
60.0	0.16E-02	0.26E-02	0.14E-02	0.10E-02	0.17E-02	0.75E-03	0.53E-03	0.50E-03
70.0	0.13E-02	0.21E-02	0.12E-02	0.86E-03	0.15E-02	0.62E-03	0.45E-03	0.42E-03
80.0	0.11E-02	0.18E-02	0.99E-03	0.73E-03	0.12E-02	0.53E-03	0.38E-03	0.36E-03

Table K-4.16. Dose Rate (mrem/yr) to Lung from Rn-222

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.59E 04	0.62E 04	0.66E 04	0.74E 04	0.84E 04	0.92E 04	0.10E 05	0.12E 05
0.5	0.18E 04	0.25E 04	0.30E 04	0.36E 04	0.40E 04	0.47E 04	0.51E 04	0.63E 04
1.0	0.70E 03	0.13E 04	0.16E 04	0.31E 04	0.52E 04	0.55E 04	0.37E 04	0.22E 04
2.0	0.23E 03	0.51E 03	0.12E 04	0.12E 04	0.12E 04	0.94E 03	0.81E 03	0.75E 03
3.0	0.11E 03	0.31E 03	0.52E 03	0.56E 03	0.51E 03	0.34E 03	0.18E 03	0.21E 03
4.0	0.63E 02	0.21E 03	0.32E 03	0.33E 03	0.30E 03	0.17E 03	0.92E 02	0.11E 03
5.0	0.41E 02	0.15E 03	0.22E 03	0.22E 03	0.20E 03	0.11E 03	0.58E 02	0.75E 02
10.0	0.10E 02	0.55E 02	0.72E 02	0.69E 02	0.60E 02	0.25E 02	0.16E 02	0.22E 02
20.0	0.30E 01	0.22E 02	0.27E 02	0.25E 02	0.21E 02	0.74E 01	0.52E 01	0.76E 01
30.0	0.17E 01	0.13E 02	0.16E 02	0.15E 02	0.12E 02	0.41E 01	0.30E 01	0.45E 01
40.0	0.11E 01	0.95E 01	0.11E 02	0.10E 02	0.87E 01	0.28E 01	0.21E 01	0.31E 01
50.0	0.87E 00	0.73E 01	0.87E 01	0.78E 01	0.65E 01	0.21E 01	0.16E 01	0.24E 01
60.0	0.70E 00	0.58E 01	0.70E 01	0.62E 01	0.52E 01	0.16E 01	0.13E 01	0.19E 01
70.0	0.58E 00	0.48E 01	0.58E 01	0.51E 01	0.43E 01	0.13E 01	0.10E 01	0.16E 01
80.0	0.49E 00	0.41E 01	0.49E 01	0.44E 01	0.37E 01	0.11E 01	0.88E 00	0.13E 01

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.12E 05	0.11E 05	0.90E 04	0.79E 04	0.69E 04	0.62E 04	0.58E 04	0.57E 04
0.5	0.92E 04	0.14E 05	0.11E 05	0.29E 04	0.15E 04	0.10E 04	0.97E 03	0.12E 04
1.0	0.31E 04	0.87E 04	0.33E 04	0.12E 04	0.54E 03	0.30E 03	0.23E 03	0.35E 03
2.0	0.60E 03	0.81E 03	0.49E 03	0.38E 03	0.22E 03	0.11E 03	0.84E 02	0.78E 02
3.0	0.27E 03	0.31E 03	0.18E 03	0.16E 03	0.13E 03	0.62E 02	0.44E 02	0.42E 02
4.0	0.14E 03	0.18E 03	0.96E 02	0.89E 02	0.82E 02	0.40E 02	0.28E 02	0.26E 02
5.0	0.99E 02	0.12E 03	0.62E 02	0.56E 02	0.59E 02	0.28E 02	0.20E 02	0.18E 02
10.0	0.24E 02	0.34E 02	0.18E 02	0.15E 02	0.20E 02	0.92E 01	0.65E 01	0.61E 01
20.0	0.79E 01	0.12E 02	0.65E 01	0.50E 01	0.78E 01	0.34E 01	0.24E 01	0.23E 01
30.0	0.46E 01	0.73E 01	0.39E 01	0.29E 01	0.47E 01	0.20E 01	0.15E 01	0.14E 01
40.0	0.32E 01	0.51E 01	0.27E 01	0.20E 01	0.33E 01	0.14E 01	0.10E 01	0.95E 00
50.0	0.24E 01	0.39E 01	0.21E 01	0.15E 01	0.25E 01	0.11E 01	0.77E 00	0.72E 00
60.0	0.19E 01	0.31E 01	0.16E 01	0.12E 01	0.20E 01	0.86E 00	0.62E 00	0.57E 00
70.0	0.16E 01	0.25E 01	0.14E 01	0.10E 01	0.17E 01	0.72E 00	0.51E 00	0.48E 00
80.0	0.13E 01	0.22E 01	0.11E 01	0.85E 00	0.14E 01	0.61E 00	0.43E 00	0.40E 00

Table K-4.17. Dose Rate (mrem/yr) to Gastrointestine (soluble radionuclides) from U-238

	DEGREES							
DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.54E-02	0.12E-01	0.13E-01	0.12E-01	0.11E-01	0.68E-02	0.32E-02	0.34E-02
0.5	0.50E-03	0.21E-02	0.25E-02	0.22E-02	0.19E-02	0.72E-03	0.50E-03	0.72E-03
1.0	0.11E-03	0.64E-03	0.76E-03	0.67E-03	0.57E-03	0.20E-03	0.14E-03	0.21E-03
2.0	0.27E-04	0.19E-03	0.22E-03	0.20E-03	0.17E-03	0.54E-04	0.41E-04	0.61E-04
3.0	0.13E-04	0.93E-04	0.11E-03	0.98E-04	0.82E-04	0.26E-04	0.20E-04	0.30E-04
4.0	0.76E-05	0.56E-04	0.67E-04	0.59E-04	0.50E-04	0.16E-04	0.12E-04	0.18E-04
5.0	0.50E-05	0.38E-04	0.45E-04	0.40E-04	0.34E-04	0.11E-04	0.83E-05	0.12E-04
10.0	0.15E-05	0.12E-04	0.15E-04	0.13E-04	0.11E-04	0.34E-05	0.27E-05	0.40E-05
20.0	0.55E-06	0.45E-05	0.54E-05	0.48E-05	0.41E-05	0.13E-05	0.99E-06	0.15E-05
30.0	0.34E-06	0.27E-05	0.33E-05	0.29E-05	0.25E-05	0.77E-06	0.60E-06	0.90E-06
40.0	0.24E-06	0.19E-05	0.23E-05	0.21E-05	0.17E-05	0.54E-06	0.42E-06	0.63E-06
50.0	0.18E-06	0.15E-05	0.18E-05	0.16E-05	0.13E-05	0.41E-06	0.32E-06	0.48E-06
60.0	0.15E-06	0.12E-05	0.14E-05	0.13E-05	0.11E-05	0.33E-06	0.26E-06	0.39E-06
70.0	0.12E-06	0.99E-06	0.12E-05	0.11E-05	0.89E-06	0.28E-06	0.22E-06	0.32E-06
80.0	0.10E-06	0.85E-06	0.10E-05	0.90E-06	0.76E-06	0.24E-06	0.19E-06	0.28E-06

	DEGREES							
DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.44E-02	0.61E-02	0.44E-02	0.40E-02	0.38E-02	0.27E-02	0.23E-02	0.21E-02
0.5	0.77E-03	0.12E-02	0.77E-03	0.60E-03	0.87E-03	0.38E-03	0.26E-03	0.30E-03
1.0	0.22E-03	0.35E-03	0.21E-03	0.15E-03	0.25E-03	0.11E-03	0.74E-04	0.68E-04
2.0	0.63E-04	0.10E-03	0.57E-04	0.42E-04	0.69E-04	0.29E-04	0.21E-04	0.19E-04
3.0	0.31E-04	0.49E-04	0.27E-04	0.20E-04	0.34E-04	0.14E-04	0.10E-04	0.95E-05
4.0	0.18E-04	0.30E-04	0.16E-04	0.12E-04	0.20E-04	0.86E-05	0.62E-05	0.58E-05
5.0	0.13E-04	0.20E-04	0.11E-04	0.82E-05	0.14E-04	0.59E-05	0.42E-05	0.39E-05
10.0	0.40E-05	0.65E-05	0.35E-05	0.26E-05	0.44E-05	0.19E-05	0.13E-05	0.12E-05
20.0	0.15E-05	0.24E-05	0.13E-05	0.95E-06	0.16E-05	0.69E-06	0.49E-06	0.46E-06
30.0	0.89E-06	0.14E-05	0.78E-06	0.58E-06	0.98E-06	0.42E-06	0.30E-06	0.28E-06
40.0	0.63E-06	0.10E-05	0.55E-06	0.41E-06	0.69E-06	0.30E-06	0.21E-06	0.20E-06
50.0	0.48E-06	0.78E-06	0.42E-06	0.31E-06	0.53E-06	0.23E-06	0.16E-06	0.15E-06
60.0	0.39E-06	0.63E-06	0.34E-06	0.25E-06	0.42E-06	0.18E-06	0.13E-06	0.12E-06
70.0	0.32E-06	0.52E-06	0.28E-06	0.21E-06	0.35E-06	0.15E-06	0.11E-06	0.10E-06
80.0	0.28E-06	0.45E-06	0.24E-06	0.18E-06	0.30E-06	0.13E-06	0.93E-07	0.87E-07

Table K-4.18. Dose Rate (mrem/yr) to Gastrointestine (soluble radionuclides) from U-234

	DEGREES							
DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.61E-02	0.13E-01	0.14E-01	0.14E-01	0.12E-01	0.73E-02	0.37E-02	0.39E-02
0.5	0.57E-03	0.24E-02	0.28E-02	0.25E-02	0.22E-02	0.82E-03	0.56E-03	0.82E-03
1.0	0.12E-03	0.73E-03	0.86E-03	0.76E-03	0.65E-03	0.22E-03	0.16E-03	0.24E-03
2.0	0.31E-04	0.21E-03	0.25E-03	0.23E-03	0.19E-03	0.61E-04	0.47E-04	0.70E-04
3.0	0.15E-04	0.11E-03	0.12E-03	0.11E-03	0.94E-04	0.30E-04	0.23E-04	0.34E-04
4.0	0.86E-05	0.64E-04	0.76E-04	0.67E-04	0.57E-04	0.18E-04	0.14E-04	0.21E-04
5.0	0.57E-05	0.44E-04	0.52E-04	0.46E-04	0.39E-04	0.12E-04	0.95E-05	0.14E-04
10.0	0.18E-05	0.14E-04	0.17E-04	0.15E-04	0.12E-04	0.39E-05	0.30E-05	0.45E-05
20.0	0.63E-06	0.52E-05	0.61E-05	0.55E-05	0.46E-05	0.14E-05	0.11E-05	0.17E-05
30.0	0.38E-06	0.31E-05	0.37E-05	0.33E-05	0.28E-05	0.87E-06	0.68E-06	0.10E-05
40.0	0.27E-06	0.22E-05	0.26E-05	0.23E-05	0.20E-05	0.62E-06	0.48E-06	0.72E-06
50.0	0.21E-06	0.17E-05	0.20E-05	0.18E-05	0.15E-05	0.47E-06	0.37E-06	0.55E-06
60.0	0.17E-06	0.14E-05	0.16E-05	0.14E-05	0.12E-05	0.38E-06	0.30E-06	0.44E-06
70.0	0.14E-06	0.11E-05	0.13E-05	0.12E-05	0.10E-05	0.32E-06	0.25E-06	0.37E-06
80.0	0.12E-06	0.97E-06	0.12E-05	0.10E-05	0.87E-06	0.27E-06	0.21E-06	0.32E-06

	DEGREES							
DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.50E-02	0.70E-02	0.50E-02	0.46E-02	0.43E-02	0.31E-02	0.26E-02	0.24E-02
0.5	0.87E-03	0.14E-02	0.87E-03	0.68E-03	0.99E-03	0.43E-03	0.30E-03	0.34E-03
1.0	0.25E-03	0.40E-03	0.23E-03	0.17E-03	0.28E-03	0.12E-03	0.84E-04	0.78E-04
2.0	0.71E-04	0.12E-03	0.65E-04	0.48E-04	0.79E-04	0.34E-04	0.24E-04	0.22E-04
3.0	0.35E-04	0.56E-04	0.31E-04	0.23E-04	0.38E-04	0.16E-04	0.12E-04	0.11E-04
4.0	0.21E-04	0.34E-04	0.19E-04	0.14E-04	0.23E-04	0.98E-05	0.70E-05	0.65E-05
5.0	0.14E-04	0.23E-04	0.13E-04	0.93E-05	0.16E-04	0.67E-05	0.48E-05	0.45E-05
10.0	0.46E-05	0.74E-05	0.40E-05	0.29E-05	0.50E-05	0.21E-05	0.15E-05	0.14E-05
20.0	0.17E-05	0.27E-05	0.15E-05	0.11E-05	0.18E-05	0.79E-06	0.56E-06	0.53E-06
30.0	0.10E-05	0.16E-05	0.88E-06	0.66E-06	0.11E-05	0.48E-06	0.34E-06	0.32E-06
40.0	0.72E-06	0.12E-05	0.62E-06	0.46E-06	0.78E-06	0.34E-06	0.24E-06	0.22E-06
50.0	0.55E-06	0.89E-06	0.48E-06	0.35E-06	0.60E-06	0.26E-06	0.18E-06	0.17E-06
60.0	0.44E-06	0.71E-06	0.38E-06	0.29E-06	0.48E-06	0.21E-06	0.15E-06	0.14E-06
70.0	0.37E-06	0.60E-06	0.32E-06	0.24E-06	0.40E-06	0.17E-06	0.12E-06	0.12E-06
80.0	0.32E-06	0.51E-06	0.27E-06	0.20E-06	0.34E-06	0.15E-06	0.11E-06	0.99E-07

Table K-4.19. Dose Rate (mrem/yr) to Gastrointestine (soluble radionuclides) from Th-230

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.66E-02	0.93E-02	0.99E-02	0.95E-02	0.88E-02	0.66E-02	0.29E-02	0.27E-02
0.5	0.42E-03	0.13E-02	0.14E-02	0.13E-02	0.11E-02	0.50E-03	0.31E-03	0.44E-03
1.0	0.81E-04	0.38E-03	0.45E-03	0.39E-03	0.34E-03	0.13E-03	0.88E-04	0.13E-03
2.0	0.19E-04	0.11E-03	0.13E-03	0.12E-03	0.99E-04	0.32E-04	0.25E-04	0.37E-04
3.0	0.95E-05	0.56E-04	0.66E-04	0.58E-04	0.49E-04	0.16E-04	0.12E-04	0.18E-04
4.0	0.49E-05	0.34E-04	0.40E-04	0.35E-04	0.30E-04	0.96E-05	0.74E-05	0.11E-04
5.0	0.32E-05	0.23E-04	0.27E-04	0.24E-04	0.20E-04	0.65E-05	0.51E-05	0.76E-05
10.0	0.95E-06	0.74E-05	0.88E-05	0.78E-05	0.66E-05	0.21E-05	0.16E-05	0.24E-05
20.0	0.34E-06	0.27E-05	0.33E-05	0.29E-05	0.25E-05	0.77E-06	0.60E-06	0.90E-06
30.0	0.20E-06	0.17E-05	0.20E-05	0.18E-05	0.15E-05	0.46E-06	0.36E-06	0.55E-06
40.0	0.14E-06	0.12E-05	0.14E-05	0.12E-05	0.11E-05	0.33E-06	0.26E-06	0.39E-06
50.0	0.11E-06	0.90E-06	0.11E-05	0.95E-06	0.80E-06	0.25E-06	0.20E-06	0.30E-06
60.0	0.89E-07	0.72E-06	0.86E-06	0.77E-06	0.65E-06	0.20E-06	0.16E-06	0.24E-06
70.0	0.74E-07	0.60E-06	0.72E-06	0.64E-06	0.54E-06	0.17E-06	0.13E-06	0.20E-06
80.0	0.63E-07	0.52E-06	0.61E-06	0.55E-06	0.46E-06	0.14E-06	0.11E-06	0.17E-06

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.38E-02	0.50E-02	0.39E-02	0.38E-02	0.29E-02	0.25E-02	0.21E-02	0.20E-02
0.5	0.50E-03	0.80E-03	0.55E-03	0.44E-03	0.58E-03	0.26E-03	0.17E-03	0.22E-03
1.0	0.14E-03	0.22E-03	0.14E-03	0.99E-04	0.16E-03	0.67E-04	0.46E-04	0.42E-04
2.0	0.38E-04	0.62E-04	0.36E-04	0.26E-04	0.43E-04	0.18E-04	0.13E-04	0.12E-04
3.0	0.19E-04	0.30E-04	0.17E-04	0.12E-04	0.21E-04	0.87E-05	0.62E-05	0.58E-05
4.0	0.11E-04	0.19E-04	0.10E-04	0.74E-05	0.12E-04	0.53E-05	0.38E-05	0.35E-05
5.0	0.77E-05	0.12E-04	0.69E-05	0.50E-05	0.84E-05	0.36E-05	0.26E-05	0.24E-05
10.0	0.24E-05	0.39E-05	0.21E-05	0.16E-05	0.27E-05	0.11E-05	0.82E-06	0.76E-06
20.0	0.90E-06	0.15E-05	0.78E-06	0.58E-06	0.99E-06	0.42E-06	0.30E-06	0.28E-06
30.0	0.55E-06	0.89E-06	0.47E-06	0.35E-06	0.60E-06	0.26E-06	0.18E-06	0.17E-06
40.0	0.38E-06	0.62E-06	0.33E-06	0.25E-06	0.42E-06	0.18E-06	0.13E-06	0.12E-06
50.0	0.29E-06	0.49E-06	0.26E-06	0.19E-06	0.32E-06	0.14E-06	0.99E-07	0.92E-07
60.0	0.24E-06	0.38E-06	0.21E-06	0.15E-06	0.26E-06	0.11E-06	0.80E-07	0.74E-07
70.0	0.20E-06	0.32E-06	0.17E-06	0.13E-06	0.22E-06	0.93E-07	0.66E-07	0.62E-07
80.0	0.17E-06	0.27E-06	0.15E-06	0.11E-06	0.19E-06	0.80E-07	0.57E-07	0.53E-07

Table K-4.20. Dose Rate (mrem/yr) to Gastrointestine (soluble radionuclides) from Ra-226

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.39E-02	0.64E-02	0.67E-02	0.65E-02	0.60E-02	0.46E-02	0.20E-02	0.18E-02
0.5	0.29E-03	0.84E-03	0.95E-03	0.85E-03	0.75E-03	0.34E-03	0.21E-03	0.30E-03
1.0	0.55E-04	0.25E-03	0.30E-03	0.26E-03	0.22E-03	0.84E-04	0.59E-04	0.85E-04
2.0	0.13E-04	0.75E-04	0.89E-04	0.78E-04	0.66E-04	0.22E-04	0.17E-04	0.25E-04
3.0	0.57E-05	0.37E-04	0.44E-04	0.39E-04	0.33E-04	0.11E-04	0.81E-05	0.12E-04
4.0	0.33E-05	0.23E-04	0.27E-04	0.24E-04	0.20E-04	0.64E-05	0.50E-05	0.74E-05
5.0	0.22E-05	0.15E-04	0.18E-04	0.16E-04	0.14E-04	0.43E-05	0.34E-05	0.51E-05
10.0	0.64E-06	0.49E-05	0.59E-05	0.52E-05	0.44E-05	0.14E-05	0.11E-05	0.16E-05
20.0	0.22E-06	0.18E-05	0.22E-05	0.19E-05	0.16E-05	0.51E-06	0.40E-06	0.60E-06
30.0	0.14E-06	0.11E-05	0.13E-05	0.12E-05	0.99E-06	0.31E-06	0.24E-06	0.37E-06
40.0	0.96E-07	0.78E-06	0.93E-06	0.83E-06	0.70E-06	0.22E-06	0.17E-06	0.26E-06
50.0	0.74E-07	0.60E-06	0.71E-06	0.64E-06	0.54E-06	0.17E-06	0.13E-06	0.20E-06
60.0	0.59E-07	0.48E-06	0.57E-06	0.51E-06	0.43E-06	0.14E-06	0.11E-06	0.16E-06
70.0	0.49E-07	0.40E-06	0.48E-06	0.43E-06	0.36E-06	0.11E-06	0.89E-07	0.13E-06
80.0	0.42E-07	0.34E-06	0.41E-06	0.37E-06	0.31E-06	0.97E-07	0.76E-07	0.11E-06

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.26E-02	0.34E-02	0.27E-02	0.26E-02	0.20E-02	0.17E-02	0.15E-02	0.14E-02
0.5	0.34E-03	0.54E-03	0.37E-03	0.30E-03	0.39E-03	0.18E-03	0.12E-03	0.15E-03
1.0	0.91E-04	0.15E-03	0.92E-04	0.66E-04	0.11E-03	0.45E-04	0.31E-04	0.28E-04
2.0	0.26E-04	0.42E-04	0.24E-04	0.18E-04	0.29E-04	0.12E-04	0.85E-05	0.79E-05
3.0	0.12E-04	0.20E-04	0.12E-04	0.83E-05	0.14E-04	0.58E-05	0.42E-05	0.39E-05
4.0	0.75E-05	0.12E-04	0.68E-05	0.50E-05	0.83E-05	0.35E-05	0.25E-05	0.23E-05
5.0	0.51E-05	0.83E-05	0.46E-05	0.34E-05	0.56E-05	0.24E-05	0.17E-05	0.16E-05
10.0	0.16E-05	0.26E-05	0.14E-05	0.11E-05	0.18E-05	0.77E-06	0.55E-06	0.51E-06
20.0	0.60E-06	0.97E-06	0.52E-06	0.39E-06	0.66E-06	0.28E-06	0.20E-06	0.19E-06
30.0	0.36E-06	0.59E-06	0.32E-06	0.24E-06	0.40E-06	0.17E-06	0.12E-06	0.11E-06
40.0	0.26E-06	0.42E-06	0.22E-06	0.17E-06	0.28E-06	0.12E-06	0.86E-07	0.81E-07
50.0	0.20E-06	0.32E-06	0.17E-06	0.13E-06	0.22E-06	0.93E-07	0.66E-07	0.62E-07
60.0	0.16E-06	0.26E-06	0.14E-06	0.10E-06	0.17E-06	0.75E-07	0.53E-07	0.50E-07
70.0	0.13E-06	0.21E-06	0.11E-06	0.85E-07	0.15E-06	0.62E-07	0.44E-07	0.42E-07
80.0	0.11E-06	0.18E-06	0.98E-07	0.73E-07	0.12E-06	0.53E-07	0.38E-07	0.36E-07

Table K-4.21. Dose Rate (mrem/yr) to Gastrointestine (soluble radionuclides) from Pb-210

	DEGREES							
DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.98E-04	0.16E-03	0.17E-03	0.16E-03	0.15E-03	0.11E-03	0.49E-04	0.46E-04
0.5	0.73E-05	0.21E-04	0.24E-04	0.21E-04	0.19E-04	0.84E-05	0.53E-05	0.74E-05
1.0	0.14E-05	0.63E-05	0.74E-05	0.65E-05	0.56E-05	0.21E-05	0.15E-05	0.21E-05
2.0	0.32E-06	0.19E-05	0.22E-05	0.20E-05	0.16E-05	0.54E-06	0.41E-06	0.62E-06
3.0	0.14E-06	0.93E-06	0.11E-05	0.97E-06	0.82E-06	0.26E-06	0.20E-06	0.30E-06
4.0	0.83E-07	0.57E-06	0.67E-06	0.59E-06	0.50E-06	0.16E-06	0.12E-06	0.19E-06
5.0	0.56E-07	0.39E-06	0.46E-06	0.40E-06	0.34E-06	0.11E-06	0.84E-07	0.13E-06
10.0	0.16E-07	0.12E-06	0.15E-06	0.13E-06	0.11E-06	0.34E-07	0.27E-07	0.41E-07
20.0	0.56E-08	0.46E-07	0.54E-07	0.49E-07	0.41E-07	0.13E-07	0.10E-07	0.15E-07
30.0	0.30E-08	0.28E-07	0.33E-07	0.29E-07	0.25E-07	0.78E-08	0.61E-08	0.92E-08
40.0	0.24E-08	0.20E-07	0.23E-07	0.21E-07	0.18E-07	0.55E-08	0.43E-08	0.65E-08
50.0	0.18E-08	0.15E-07	0.18E-07	0.16E-07	0.13E-07	0.42E-08	0.33E-08	0.49E-08
60.0	0.15E-08	0.12E-07	0.14E-07	0.13E-07	0.11E-07	0.34E-08	0.27E-08	0.40E-08
70.0	0.12E-08	0.10E-07	0.12E-07	0.11E-07	0.90E-08	0.28E-08	0.22E-08	0.33E-08
80.0	0.11E-08	0.86E-08	0.10E-07	0.92E-08	0.77E-08	0.24E-08	0.19E-08	0.28E-08

	DEGREES							
DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.65E-04	0.86E-04	0.67E-04	0.65E-04	0.50E-04	0.43E-04	0.37E-04	0.35E-04
0.5	0.94E-05	0.13E-04	0.93E-05	0.75E-05	0.98E-05	0.44E-05	0.29E-05	0.38E-05
1.0	0.23E-05	0.37E-05	0.23E-05	0.17E-05	0.26E-05	0.11E-05	0.77E-06	0.71E-06
2.0	0.64E-06	0.10E-05	0.61E-06	0.44E-06	0.72E-06	0.30E-06	0.21E-06	0.20E-06
3.0	0.31E-06	0.51E-06	0.29E-06	0.21E-06	0.35E-06	0.15E-06	0.10E-06	0.97E-07
4.0	0.19E-06	0.31E-06	0.17E-06	0.12E-06	0.21E-06	0.88E-07	0.63E-07	0.59E-07
5.0	0.13E-06	0.21E-06	0.11E-06	0.84E-07	0.14E-06	0.60E-07	0.43E-07	0.40E-07
10.0	0.41E-07	0.66E-07	0.36E-07	0.26E-07	0.45E-07	0.19E-07	0.14E-07	0.13E-07
20.0	0.15E-07	0.24E-07	0.13E-07	0.97E-08	0.17E-07	0.71E-08	0.51E-08	0.47E-08
30.0	0.91E-08	0.15E-07	0.79E-08	0.59E-08	0.10E-07	0.43E-08	0.31E-08	0.29E-08
40.0	0.64E-08	0.10E-07	0.56E-08	0.42E-08	0.71E-08	0.30E-08	0.22E-08	0.20E-08
50.0	0.49E-08	0.80E-08	0.43E-08	0.32E-08	0.54E-08	0.23E-08	0.17E-08	0.15E-08
60.0	0.40E-08	0.64E-08	0.34E-08	0.26E-08	0.43E-08	0.19E-08	0.13E-08	0.12E-08
70.0	0.33E-08	0.53E-08	0.29E-08	0.21E-08	0.36E-08	0.16E-08	0.11E-08	0.10E-08
80.0	0.28E-08	0.46E-08	0.25E-08	0.18E-08	0.31E-08	0.13E-08	0.95E-09	0.89E-09

Table K-4.22. Dose Rate (mrem/yr) to Gastrointestine (insoluble radionuclides) from U-238

	DEGREES							
DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.77E-02	0.11E-01	0.13E-01	0.11E-01	0.15E-01	0.98E-02	0.46E-02	0.50E-02
0.5	0.72E-03	0.31E-02	0.35E-02	0.32E-02	0.27E-02	0.10E-02	0.71E-03	0.10E-02
1.0	0.16E-03	0.92E-03	0.11E-02	0.96E-03	0.82E-03	0.28E-03	0.21E-03	0.30E-03
2.0	0.39E-04	0.27E-03	0.32E-03	0.28E-03	0.24E-03	0.77E-04	0.59E-04	0.88E-04
3.0	0.18E-04	0.13E-03	0.16E-03	0.14E-03	0.12E-03	0.38E-04	0.29E-04	0.43E-04
4.0	0.11E-04	0.81E-04	0.96E-04	0.85E-04	0.72E-04	0.23E-04	0.18E-04	0.26E-04
5.0	0.72E-05	0.55E-04	0.65E-04	0.58E-04	0.49E-04	0.15E-04	0.12E-04	0.18E-04
10.0	0.22E-05	0.18E-04	0.21E-04	0.19E-04	0.16E-04	0.49E-05	0.38E-05	0.57E-05
20.0	0.80E-06	0.65E-05	0.77E-05	0.69E-05	0.58E-05	0.18E-05	0.14E-05	0.21E-05
30.0	0.48E-06	0.39E-05	0.47E-05	0.42E-05	0.35E-05	0.11E-05	0.86E-06	0.13E-05
40.0	0.34E-06	0.28E-05	0.33E-05	0.30E-05	0.25E-05	0.78E-06	0.60E-06	0.91E-06
50.0	0.26E-06	0.21E-05	0.25E-05	0.23E-05	0.19E-05	0.59E-06	0.46E-06	0.69E-06
60.0	0.21E-06	0.17E-05	0.20E-05	0.18E-05	0.15E-05	0.48E-06	0.37E-06	0.56E-06
70.0	0.17E-06	0.14E-05	0.17E-05	0.15E-05	0.13E-05	0.40E-06	0.31E-06	0.47E-06
80.0	0.15E-06	0.12E-05	0.15E-05	0.13E-05	0.11E-05	0.34E-06	0.27E-06	0.40E-06

	DEGREES							
DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.63E-02	0.88E-02	0.63E-02	0.58E-02	0.54E-02	0.39E-02	0.32E-02	0.31E-02
0.5	0.11E-02	0.19E-02	0.11E-02	0.86E-03	0.12E-02	0.55E-03	0.38E-03	0.43E-03
1.0	0.31E-03	0.51E-03	0.30E-03	0.22E-03	0.35E-03	0.15E-03	0.11E-03	0.98E-04
2.0	0.90E-04	0.15E-03	0.82E-04	0.60E-04	0.99E-04	0.42E-04	0.30E-04	0.28E-04
3.0	0.44E-04	0.71E-04	0.39E-04	0.29E-04	0.48E-04	0.21E-04	0.15E-04	0.14E-04
4.0	0.27E-04	0.43E-04	0.24E-04	0.17E-04	0.29E-04	0.12E-04	0.88E-05	0.83E-05
5.0	0.18E-04	0.29E-04	0.16E-04	0.12E-04	0.20E-04	0.84E-05	0.60E-05	0.56E-05
10.0	0.57E-05	0.93E-05	0.50E-05	0.37E-05	0.63E-05	0.27E-05	0.19E-05	0.18E-05
20.0	0.21E-05	0.34E-05	0.18E-05	0.14E-05	0.23E-05	0.99E-06	0.71E-06	0.66E-06
30.0	0.13E-05	0.21E-05	0.11E-05	0.83E-06	0.14E-05	0.60E-06	0.43E-06	0.40E-06
40.0	0.90E-06	0.15E-05	0.78E-06	0.58E-06	0.99E-06	0.42E-06	0.30E-06	0.28E-06
50.0	0.69E-06	0.11E-05	0.60E-06	0.45E-06	0.76E-06	0.32E-06	0.23E-06	0.22E-06
60.0	0.56E-06	0.90E-06	0.48E-06	0.36E-06	0.61E-06	0.26E-06	0.19E-06	0.17E-06
70.0	0.47E-06	0.75E-06	0.40E-06	0.30E-06	0.51E-06	0.22E-06	0.16E-06	0.15E-06
80.0	0.40E-06	0.64E-06	0.35E-06	0.26E-06	0.43E-06	0.19E-06	0.13E-06	0.12E-06

Table K-4.23. Dose Rate (mrem/yr) to Gastrointestine (insoluble radionuclides) from U-234

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.72E-02	0.15E-01	0.17E-01	0.16E-01	0.14E-01	0.91E-02	0.43E-02	0.46E-02
0.5	0.66E-03	0.28E-02	0.33E-02	0.29E-02	0.25E-02	0.96E-03	0.66E-03	0.95E-03
1.0	0.14E-03	0.85E-03	0.10E-02	0.89E-03	0.76E-03	0.26E-03	0.19E-03	0.28E-03
2.0	0.36E-04	0.25E-03	0.30E-03	0.26E-03	0.22E-03	0.71E-04	0.55E-04	0.82E-04
3.0	0.17E-04	0.12E-03	0.15E-03	0.13E-03	0.11E-03	0.35E-04	0.27E-04	0.40E-04
4.0	0.10E-04	0.75E-04	0.89E-04	0.79E-04	0.66E-04	0.21E-04	0.16E-04	0.24E-04
5.0	0.67E-05	0.51E-04	0.60E-04	0.54E-04	0.45E-04	0.14E-04	0.11E-04	0.17E-04
10.0	0.20E-05	0.16E-04	0.19E-04	0.17E-04	0.15E-04	0.45E-05	0.35E-05	0.53E-05
20.0	0.74E-06	0.60E-05	0.72E-05	0.64E-05	0.54E-05	0.17E-05	0.13E-05	0.20E-05
30.0	0.45E-06	0.36E-05	0.43E-05	0.39E-05	0.33E-05	0.10E-05	0.79E-06	0.12E-05
40.0	0.31E-06	0.26E-05	0.31E-05	0.27E-05	0.23E-05	0.72E-06	0.56E-06	0.84E-06
50.0	0.24E-06	0.20E-05	0.23E-05	0.21E-05	0.18E-05	0.55E-06	0.43E-06	0.64E-06
60.0	0.19E-06	0.16E-05	0.19E-05	0.17E-05	0.14E-05	0.44E-06	0.35E-06	0.52E-06
70.0	0.16E-06	0.13E-05	0.16E-05	0.14E-05	0.12E-05	0.37E-06	0.29E-06	0.43E-06
80.0	0.14E-06	0.11E-05	0.13E-05	0.12E-05	0.10E-05	0.32E-06	0.25E-06	0.37E-06

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.58E-02	0.82E-02	0.50E-02	0.54E-02	0.50E-02	0.36E-02	0.30E-02	0.24E-02
0.5	0.10E-02	0.16E-02	0.10E-02	0.80E-03	0.12E-02	0.51E-03	0.35E-03	0.40E-03
1.0	0.29E-03	0.47E-03	0.27E-03	0.20E-03	0.33E-03	0.14E-03	0.98E-04	0.91E-04
2.0	0.93E-04	0.13E-03	0.76E-04	0.55E-04	0.92E-04	0.39E-04	0.28E-04	0.26E-04
3.0	0.41E-04	0.66E-04	0.36E-04	0.27E-04	0.45E-04	0.19E-04	0.14E-04	0.13E-04
4.0	0.25E-04	0.40E-04	0.22E-04	0.16E-04	0.27E-04	0.11E-04	0.82E-05	0.77E-05
5.0	0.17E-04	0.27E-04	0.15E-04	0.11E-04	0.18E-04	0.78E-05	0.56E-05	0.52E-05
10.0	0.53E-05	0.86E-05	0.46E-05	0.34E-05	0.58E-05	0.25E-05	0.18E-05	0.17E-05
20.0	0.20E-05	0.32E-05	0.17E-05	0.13E-05	0.21E-05	0.92E-06	0.66E-06	0.61E-06
30.0	0.12E-05	0.19E-05	0.10E-05	0.77E-06	0.13E-05	0.56E-06	0.40E-06	0.37E-06
40.0	0.84E-06	0.14E-05	0.73E-06	0.54E-06	0.92E-06	0.39E-06	0.28E-06	0.26E-06
50.0	0.64E-06	0.10E-05	0.56E-06	0.41E-06	0.70E-06	0.30E-06	0.21E-06	0.20E-06
60.0	0.52E-06	0.83E-06	0.45E-06	0.33E-06	0.56E-06	0.24E-06	0.17E-06	0.16E-06
70.0	0.43E-06	0.70E-06	0.37E-06	0.28E-06	0.47E-06	0.20E-06	0.14E-06	0.13E-06
80.0	0.37E-06	0.60E-06	0.32E-06	0.24E-06	0.40E-06	0.17E-06	0.12E-06	0.12E-06

Table K-4.24. Dose Rate (mrem/yr) to Gastrointestine (insoluble radionuclides) from Th-230

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.66E-02	0.11E-01	0.12E-01	0.11E-01	0.10E-01	0.77E-02	0.33E-02	0.32E-02
0.5	0.50E-03	0.15E-02	0.17E-02	0.15E-02	0.13E-02	0.58E-03	0.37E-03	0.52E-03
1.0	0.94E-04	0.44E-03	0.52E-03	0.46E-03	0.39E-03	0.15E-03	0.10E-03	0.15E-03
2.0	0.22E-04	0.13E-03	0.16E-03	0.14E-03	0.12E-03	0.38E-04	0.29E-04	0.43E-04
3.0	0.10E-04	0.65E-04	0.77E-04	0.68E-04	0.57E-04	0.19E-04	0.14E-04	0.21E-04
4.0	0.57E-05	0.40E-04	0.47E-04	0.41E-04	0.35E-04	0.11E-04	0.87E-05	0.13E-04
5.0	0.38E-05	0.27E-04	0.32E-04	0.28E-04	0.24E-04	0.76E-05	0.59E-05	0.89E-05
10.0	0.11E-05	0.86E-05	0.10E-04	0.91E-05	0.77E-05	0.24E-05	0.19E-05	0.28E-05
20.0	0.39E-06	0.32E-05	0.38E-05	0.34E-05	0.29E-05	0.90E-06	0.70E-06	0.11E-05
30.0	0.24E-06	0.19E-05	0.23E-05	0.21E-05	0.17E-05	0.54E-06	0.43E-06	0.64E-06
40.0	0.17E-06	0.14E-05	0.16E-05	0.15E-05	0.12E-05	0.38E-06	0.30E-06	0.45E-06
50.0	0.13E-06	0.10E-05	0.12E-05	0.11E-05	0.94E-06	0.29E-06	0.23E-06	0.35E-06
60.0	0.10E-06	0.84E-06	0.10E-05	0.90E-06	0.76E-06	0.24E-06	0.19E-06	0.28E-06
70.0	0.86E-07	0.70E-06	0.84E-06	0.75E-06	0.63E-06	0.20E-06	0.15E-06	0.23E-06
80.0	0.74E-07	0.60E-06	0.72E-06	0.64E-06	0.54E-06	0.17E-06	0.13E-06	0.20E-06

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.44E-02	0.58E-02	0.45E-02	0.44E-02	0.34E-02	0.29E-02	0.25E-02	0.24E-02
0.5	0.58E-03	0.94E-03	0.64E-03	0.51E-03	0.68E-03	0.30E-03	0.20E-03	0.26E-03
1.0	0.16E-03	0.26E-03	0.16E-03	0.12E-03	0.18E-03	0.79E-04	0.53E-04	0.49E-04
2.0	0.45E-04	0.73E-04	0.42E-04	0.31E-04	0.50E-04	0.21E-04	0.15E-04	0.14E-04
3.0	0.22E-04	0.35E-04	0.20E-04	0.15E-04	0.24E-04	0.10E-04	0.73E-05	0.68E-05
4.0	0.13E-04	0.21E-04	0.12E-04	0.87E-05	0.15E-04	0.62E-05	0.44E-05	0.41E-05
5.0	0.90E-05	0.14E-04	0.80E-05	0.59E-05	0.99E-05	0.42E-05	0.30E-05	0.28E-05
10.0	0.29E-05	0.46E-05	0.25E-05	0.18E-05	0.31E-05	0.13E-05	0.95E-06	0.89E-06
20.0	0.11E-05	0.17E-05	0.92E-06	0.68E-06	0.12E-05	0.49E-06	0.35E-06	0.33E-06
30.0	0.64E-06	0.10E-05	0.55E-06	0.41E-06	0.70E-06	0.30E-06	0.21E-06	0.20E-06
40.0	0.45E-06	0.73E-06	0.39E-06	0.29E-06	0.49E-06	0.21E-06	0.15E-06	0.14E-06
50.0	0.34E-06	0.56E-06	0.30E-06	0.22E-06	0.38E-06	0.16E-06	0.12E-06	0.11E-06
60.0	0.28E-06	0.45E-06	0.24E-06	0.18E-06	0.30E-06	0.13E-06	0.93E-07	0.87E-07
70.0	0.23E-06	0.37E-06	0.20E-06	0.15E-06	0.25E-06	0.11E-06	0.78E-07	0.73E-07
80.0	0.20E-06	0.32E-06	0.17E-06	0.13E-06	0.22E-06	0.93E-07	0.66E-07	0.62E-07

Table K-4.25. Dose Rate (mrem/yr) to Gastrointestine (insoluble radionuclides) from Ra-226

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.55E-02	0.11E-01	0.11E-01	0.11E-01	0.10E-01	0.77E-02	0.33E-02	0.31E-02
0.5	0.49E-03	0.14E-02	0.16E-02	0.14E-02	0.13E-02	0.56E-03	0.36E-03	0.49E-03
1.0	0.92E-04	0.42E-03	0.50E-03	0.43E-03	0.37E-03	0.14E-03	0.98E-04	0.14E-03
2.0	0.21E-04	0.13E-03	0.15E-03	0.13E-03	0.11E-03	0.36E-04	0.28E-04	0.41E-04
3.0	0.96E-05	0.62E-04	0.73E-04	0.65E-04	0.54E-04	0.18E-04	0.14E-04	0.20E-04
4.0	0.55E-05	0.38E-04	0.45E-04	0.39E-04	0.33E-04	0.11E-04	0.83E-05	0.12E-04
5.0	0.36E-05	0.26E-04	0.30E-04	0.27E-04	0.23E-04	0.72E-05	0.56E-05	0.84E-05
10.0	0.11E-05	0.82E-05	0.98E-05	0.87E-05	0.73E-05	0.23E-05	0.18E-05	0.27E-05
20.0	0.37E-06	0.30E-05	0.36E-05	0.32E-05	0.27E-05	0.85E-06	0.67E-06	0.10E-05
30.0	0.23E-06	0.18E-05	0.22E-05	0.20E-05	0.17E-05	0.52E-06	0.41E-06	0.61E-06
40.0	0.16E-06	0.13E-05	0.16E-05	0.14E-05	0.12E-05	0.37E-06	0.29E-06	0.43E-06
50.0	0.12E-06	0.10E-05	0.12E-05	0.11E-05	0.90E-06	0.28E-06	0.22E-06	0.33E-06
60.0	0.99E-07	0.81E-06	0.96E-06	0.86E-06	0.72E-06	0.23E-06	0.18E-06	0.27E-06
70.0	0.82E-07	0.67E-06	0.80E-06	0.71E-06	0.60E-06	0.19E-06	0.15E-06	0.22E-06
80.0	0.71E-07	0.57E-06	0.68E-06	0.61E-06	0.52E-06	0.16E-06	0.13E-06	0.19E-06

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.43E-02	0.57E-02	0.45E-02	0.44E-02	0.34E-02	0.29E-02	0.25E-02	0.24E-02
0.5	0.56E-03	0.90E-03	0.62E-03	0.50E-03	0.65E-03	0.29E-03	0.20E-03	0.26E-03
1.0	0.15E-03	0.24E-03	0.15E-03	0.11E-03	0.18E-03	0.75E-04	0.51E-04	0.47E-04
2.0	0.43E-04	0.69E-04	0.41E-04	0.29E-04	0.48E-04	0.20E-04	0.14E-04	0.13E-04
3.0	0.21E-04	0.34E-04	0.19E-04	0.14E-04	0.23E-04	0.97E-05	0.69E-05	0.65E-05
4.0	0.13E-04	0.20E-04	0.11E-04	0.83E-05	0.14E-04	0.59E-05	0.42E-05	0.39E-05
5.0	0.85E-05	0.14E-04	0.77E-05	0.56E-05	0.94E-05	0.40E-05	0.28E-05	0.27E-05
10.0	0.27E-05	0.44E-05	0.24E-05	0.18E-05	0.30E-05	0.13E-05	0.91E-06	0.85E-06
20.0	0.10E-05	0.16E-05	0.87E-06	0.65E-06	0.11E-05	0.47E-06	0.34E-06	0.31E-06
30.0	0.61E-06	0.98E-06	0.53E-06	0.39E-06	0.67E-06	0.29E-06	0.20E-06	0.19E-06
40.0	0.43E-06	0.69E-06	0.37E-06	0.28E-06	0.47E-06	0.20E-06	0.14E-06	0.13E-06
50.0	0.33E-06	0.53E-06	0.28E-06	0.21E-06	0.36E-06	0.15E-06	0.11E-06	0.10E-06
60.0	0.26E-06	0.43E-06	0.23E-06	0.17E-06	0.29E-06	0.12E-06	0.89E-07	0.83E-07
70.0	0.22E-06	0.36E-06	0.19E-06	0.14E-06	0.24E-06	0.10E-06	0.74E-07	0.69E-07
80.0	0.19E-06	0.30E-06	0.16E-06	0.12E-06	0.21E-06	0.89E-07	0.63E-07	0.59E-07

Table K-4.26. Dose Rate (mrem/yr) to Gastrointestine (insoluble radionuclides) from Pb-210

DEGREES

DISTANCE(KM)	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5
0.1	0.13E-02	0.21E-02	0.22E-02	0.22E-02	0.20E-02	0.15E-02	0.66E-03	0.62E-03
0.5	0.97E-04	0.29E-03	0.32E-03	0.28E-03	0.25E-03	0.11E-03	0.70E-04	0.99E-04
1.0	0.19E-04	0.84E-04	0.99E-04	0.86E-04	0.74E-04	0.28E-04	0.20E-04	0.28E-04
2.0	0.42E-05	0.25E-04	0.30E-04	0.26E-04	0.22E-04	0.72E-05	0.55E-05	0.82E-05
3.0	0.19E-05	0.12E-04	0.15E-04	0.13E-04	0.11E-04	0.35E-05	0.27E-05	0.41E-05
4.0	0.11E-05	0.75E-05	0.89E-05	0.79E-05	0.66E-05	0.21E-05	0.17E-05	0.25E-05
5.0	0.72E-06	0.51E-05	0.61E-05	0.54E-05	0.45E-05	0.14E-05	0.11E-05	0.17E-05
10.0	0.21E-06	0.16E-05	0.20E-05	0.17E-05	0.15E-05	0.46E-06	0.36E-06	0.54E-06
20.0	0.75E-07	0.61E-06	0.73E-06	0.65E-06	0.55E-06	0.17E-06	0.13E-06	0.20E-06
30.0	0.45E-07	0.37E-06	0.44E-06	0.39E-06	0.33E-06	0.10E-06	0.81E-07	0.12E-06
40.0	0.32E-07	0.26E-06	0.31E-06	0.28E-06	0.23E-06	0.73E-07	0.57E-07	0.86E-07
50.0	0.25E-07	0.20E-06	0.24E-06	0.21E-06	0.18E-06	0.56E-07	0.44E-07	0.66E-07
60.0	0.20E-07	0.16E-06	0.19E-06	0.17E-06	0.14E-06	0.45E-07	0.35E-07	0.53E-07
70.0	0.16E-07	0.13E-06	0.16E-06	0.14E-06	0.12E-06	0.38E-07	0.30E-07	0.44E-07
80.0	0.14E-07	0.11E-06	0.14E-06	0.12E-06	0.10E-06	0.32E-07	0.25E-07	0.38E-07

DEGREES

DISTANCE(KM)	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.1	0.86E-03	0.11E-02	0.89E-03	0.87E-03	0.67E-03	0.58E-03	0.50E-03	0.47E-03
0.5	0.11E-03	0.18E-03	0.12E-03	0.10E-03	0.13E-03	0.58E-04	0.39E-04	0.51E-04
1.0	0.39E-04	0.49E-04	0.31E-04	0.22E-04	0.35E-04	0.15E-04	0.10E-04	0.94E-05
2.0	0.85E-05	0.14E-04	0.81E-05	0.59E-05	0.96E-05	0.40E-05	0.28E-05	0.26E-05
3.0	0.42E-05	0.67E-05	0.38E-05	0.28E-05	0.46E-05	0.19E-05	0.14E-05	0.13E-05
4.0	0.25E-05	0.41E-05	0.23E-05	0.17E-05	0.28E-05	0.12E-05	0.84E-06	0.78E-06
5.0	0.17E-05	0.29E-05	0.15E-05	0.11E-05	0.19E-05	0.80E-06	0.57E-06	0.53E-06
10.0	0.54E-06	0.88E-06	0.48E-06	0.35E-06	0.60E-06	0.26E-06	0.18E-06	0.17E-06
20.0	0.20E-06	0.32E-06	0.17E-06	0.13E-06	0.22E-06	0.94E-07	0.67E-07	0.63E-07
30.0	0.12E-06	0.20E-06	0.11E-06	0.79E-07	0.13E-06	0.57E-07	0.41E-07	0.38E-07
40.0	0.86E-07	0.14E-06	0.74E-07	0.55E-07	0.94E-07	0.40E-07	0.29E-07	0.27E-07
50.0	0.66E-07	0.11E-06	0.57E-07	0.42E-07	0.72E-07	0.31E-07	0.22E-07	0.21E-07
60.0	0.53E-07	0.85E-07	0.46E-07	0.34E-07	0.58E-07	0.25E-07	0.18E-07	0.17E-07
70.0	0.44E-07	0.71E-07	0.38E-07	0.28E-07	0.48E-07	0.21E-07	0.15E-07	0.14E-07
80.0	0.38E-07	0.61E-07	0.33E-07	0.24E-07	0.41E-07	0.18E-07	0.13E-07	0.12E-07

APPENDIX K-5. TIME-INTEGRATED DOSE FROM INHALATION OF AIRBORNE PARTICULATES AND RADON IN THE VICINITY OF BEAR CREEK TO 80 KM

The doses were estimated for a duration of inhalation of 1, 5, 10 or 20 years and integrated to a 70-year life span.

Tables K-5.1--K-5.5. Dose to Whole Body

Tables K-5.6--K-5.10. Dose to Bone

Tables K-5.11--K-5.15. Dose to Lung

Tables K-5.16--K-5.20. Dose to Kidney

Tables K-5.21--K-5.25. Dose to GI System (soluble radionuclides)

Tables K-5.26--K-5.30. Dose to GI System (insoluble radionuclides)

Tables K-5.31--K-5.35. Dose to Liver

Table K-5.1. Time-Integrated Dose (mrem) from Inhalation
Whole Body, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	4.81E-03	4.81E-03	5.03E-01	9.16E-02	4.58E-03	6.09E-01
	5	0.24E-01	0.24E-01	0.25E 01	0.46E 00	0.23E-01	0.30E 01
	10	0.48E-01	0.48E-01	0.47E 01	0.92E 00	0.46E-01	0.58E 01
	20	0.96E-01	0.96E-01	0.89E 01	0.18E 01	0.92E-01	0.11E 02
5	1	2.23E-04	2.23E-04	2.02E-02	3.62E-03	1.81E-04	2.44E-02
	5	0.11E-02	0.11E-02	0.98E-01	0.18E-01	0.91E-03	0.12E 00
	10	0.22E-02	0.22E-02	0.19E 00	0.36E-01	0.18E-02	0.23E 00
	20	0.45E-02	0.45E-02	0.35E 00	0.72E-01	0.36E-02	0.44E 00
10	1	6.79E-05	6.79E-05	5.92E-03	1.06E-03	5.30E-05	7.17E-03
	5	0.34E-03	0.34E-03	0.29E-01	0.53E-02	0.26E-03	0.35E-01
	10	0.68E-03	0.68E-03	0.56E-01	0.11E-01	0.53E-03	0.68E-01
	20	0.14E-02	0.14E-02	0.10E 00	0.21E-01	0.11E-02	0.13E 00
20	1	2.45E-05	2.45E-05	2.09E-03	3.74E-04	1.87E-05	2.53E-03
	5	0.12E-03	0.12E-03	0.10E-01	0.19E-02	0.93E-04	0.12E-01
	10	0.24E-03	0.24E-03	0.20E-01	0.37E-02	0.19E-03	0.24E-01
	20	0.49E-03	0.49E-03	0.37E-01	0.75E-02	0.37E-03	0.46E-01
40	1	1.05E-05	1.05E-05	8.95E-04	1.60E-04	8.00E-06	1.08E-03
	5	0.52E-04	0.52E-04	0.44E-02	0.80E-03	0.40E-04	0.53E-02
	10	0.10E-03	0.10E-03	0.85E-02	0.16E-02	0.80E-04	0.10E-01
	20	0.21E-03	0.21E-03	0.16E-01	0.32E-02	0.16E-03	0.20E-01
80	1	4.60E-06	4.60E-06	3.95E-04	7.05E-05	3.53E-06	4.78E-04
	5	0.23E-04	0.23E-04	0.19E-02	0.35E-03	0.18E-04	0.23E-02
	10	0.46E-04	0.46E-04	0.37E-02	0.71E-03	0.35E-04	0.46E-02
	20	0.92E-04	0.92E-04	0.69E-02	0.14E-02	0.71E-04	0.86E-02

Table K-5.2. Time-Integrated Dose (mrem) from Inhalation
Whole Body, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	3.35E-02	3.35E-02	2.78E 00	4.96E-01	2.48E-02	3.37E 00
	5	0.17E 00	0.17E 00	0.14E 02	0.25E 01	0.12E 00	0.17E 02
	10	0.33E 00	0.33E 00	0.26E 02	0.50E 01	0.25E 00	0.32E 02
	20	0.67E 00	0.67E 00	0.49E 02	0.99E 01	0.50E 00	0.61E 02
5	1	2.00E-03	2.00E-03	1.70E-01	3.04E-02	1.52E-03	2.06E-01
	5	0.10E-01	0.10E-01	0.83E 00	0.15E 00	0.76E-02	0.10E 01
	10	0.20E-01	0.20E-01	0.16E 01	0.30E 00	0.15E-01	0.20E 01
	20	0.40E-01	0.40E-01	0.30E 01	0.61E 00	0.30E-01	0.37E 01
10	1	6.42E-04	6.42E-04	5.47E-02	9.77E-03	4.89E-04	6.63E-02
	5	0.32E-02	0.32E-02	0.27E 00	0.49E-01	0.24E-02	0.32E 00
	10	0.64E-02	0.64E-02	0.52E 00	0.98E-01	0.49E-02	0.63E 00
	20	0.13E-01	0.13E-01	0.96E 00	0.20E 00	0.98E-02	0.12E 01
20	1	2.38E-04	2.38E-04	2.03E-02	3.63E-03	1.81E-04	2.46E-02
	5	0.12E-02	0.12E-02	0.99E-01	0.18E-01	0.91E-03	0.12E 00
	10	0.24E-02	0.24E-02	0.19E 00	0.36E-01	0.18E-02	0.23E 00
	20	0.48E-02	0.48E-02	0.36E 00	0.73E-01	0.36E-02	0.44E 00
40	1	1.01E-04	1.01E-04	8.68E-03	1.55E-03	7.76E-05	1.05E-02
	5	0.51E-03	0.51E-03	0.42E-01	0.78E-02	0.39E-03	0.52E-01
	10	0.10E-02	0.10E-02	0.82E-01	0.16E-01	0.78E-03	0.10E 00
	20	0.20E-02	0.20E-02	0.15E 00	0.31E-01	0.16E-02	0.19E 00
	70	0.20E-02	0.20E-02	0.15E 00	0.31E-01	0.16E-02	0.19E 00
80	1	4.46E-05	4.46E-05	3.83E-03	6.84E-04	3.42E-05	4.63E-03
	5	0.22E-03	0.22E-03	0.19E-01	0.34E-02	0.17E-03	0.23E-01
	10	0.45E-03	0.45E-03	0.36E-01	0.68E-02	0.34E-03	0.44E-01
	20	0.89E-03	0.89E-03	0.67E-01	0.14E-01	0.68E-03	0.83E-01

Table K-5.3. Time-Integrated Dose (mrem) from Inhalation
Whole Body, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.52E-02	2.52E-02	2.09E 00	3.72E-01	1.86E-02	2.53E 00
	5	0.13E 00	0.13E 00	0.10E 02	0.19E 01	0.93E-01	0.12E 02
	10	0.25E 00	0.25E 00	0.20E 02	0.37E 01	0.19E 00	0.24E 02
	20	0.50E 00	0.50E 00	0.37E 02	0.74E 01	0.37E 00	0.46E 02
5	1	1.50E-03	1.50E-03	1.27E-01	2.27E-02	1.13E-03	1.54E-01
	5	0.75E-02	0.75E-02	0.62E 00	0.11E 00	0.57E-02	0.75E 00
	10	0.15E-01	0.15E-01	0.12E 01	0.23E 00	0.11E-01	0.15E 01
	20	0.30E-01	0.30E-01	0.22E 01	0.45E 00	0.23E-01	0.28E 01
10	1	4.83E-04	4.83E-04	4.11E-02	7.34E-03	3.67E-04	4.97E-02
	5	0.24E-02	0.24E-02	0.20E 00	0.37E-01	0.18E-02	0.24E 00
	10	0.48E-02	0.48E-02	0.39E 00	0.73E-01	0.37E-02	0.47E 00
	20	0.97E-02	0.97E-02	0.72E 00	0.15E 00	0.73E-02	0.90E 00
20	1	1.79E-04	1.79E-04	1.53E-02	2.73E-03	1.37E-04	1.85E-02
	5	0.90E-03	0.90E-03	0.75E-01	0.14E-01	0.68E-03	0.91E-01
	10	0.18E-02	0.18E-02	0.14E 00	0.27E-01	0.14E-02	0.18E 00
	20	0.36E-02	0.36E-02	0.27E 00	0.55E-01	0.27E-02	0.33E 00
40	1	7.64E-05	7.64E-05	6.54E-03	1.17E-03	5.85E-05	7.92E-03
	5	0.38E-03	0.38E-03	0.32E-01	0.58E-02	0.29E-03	0.39E-01
	10	0.76E-03	0.76E-03	0.62E-01	0.12E-01	0.58E-03	0.76E-01
	20	0.15E-02	0.15E-02	0.12E 00	0.23E-01	0.12E-02	0.14E 00
80	1	3.36E-05	3.36E-05	2.88E-03	5.15E-04	2.58E-05	3.49E-03
	5	0.17E-03	0.17E-03	0.14E-01	0.26E-02	0.13E-03	0.17E-01
	10	0.34E-03	0.34E-03	0.27E-01	0.52E-02	0.26E-03	0.33E-01
	20	0.67E-03	0.67E-03	0.51E-01	0.10E-01	0.52E-03	0.63E-01

Table K-5.4. Time-Integrated Dose (mrem) from Inhalation
Whole Body, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	9.67E-03	9.67E-03	8.46E-01	1.51E-01	7.57E-03	1.02E 00
	5	0.48E-01	0.48E-01	0.41E 01	0.76E 00	0.38E-01	0.50E 01
	10	0.97E-01	0.97E-01	0.80E 01	0.15E 01	0.76E-01	0.98E 01
	20	0.19E 00	0.19E 00	0.15E 02	0.30E 01	0.15E 00	0.18E 02
5	1	5.54E-04	5.54E-04	4.78E-02	8.54E-03	4.27E-04	5.78E-02
	5	0.28E-02	0.28E-02	0.23E 00	0.43E-01	0.21E-02	0.28E 00
	10	0.55E-02	0.55E-02	0.45E 00	0.85E-01	0.43E-02	0.55E 00
	20	0.11E-01	0.11E-01	0.84E 00	0.17E 00	0.85E-02	0.10E 01
10	1	1.77E-04	1.77E-04	1.52E-02	2.72E-03	1.36E-04	1.84E-02
	5	0.88E-03	0.88E-03	0.74E-01	0.14E-01	0.68E-03	0.90E-01
	10	0.18E-02	0.18E-02	0.14E 00	0.27E-01	0.14E-02	0.18E 00
	20	0.35E-02	0.35E-02	0.27E 00	0.54E-01	0.27E-02	0.33E 00
20	1	6.52E-05	6.52E-05	5.61E-03	1.00E-03	5.02E-05	6.79E-03
	5	0.33E-03	0.33E-03	0.27E-01	0.50E-02	0.25E-03	0.33E-01
	10	0.65E-03	0.65E-03	0.53E-01	0.10E-01	0.50E-03	0.65E-01
	20	0.13E-02	0.13E-02	0.99E-01	0.20E-01	0.10E-02	0.12E 00
40	1	2.78E-05	2.78E-05	2.40E-03	4.29E-04	2.14E-05	2.90E-03
	5	0.14E-03	0.14E-03	0.12E-01	0.21E-02	0.11E-03	0.14E-01
	10	0.28E-03	0.28E-03	0.23E-01	0.43E-02	0.21E-03	0.28E-01
	20	0.56E-03	0.56E-03	0.42E-01	0.86E-02	0.43E-03	0.52E-01
80	1	1.22E-05	1.22E-05	1.06E-03	1.89E-04	9.44E-06	1.28E-03
	5	0.61E-04	0.61E-04	0.51E-02	0.94E-03	0.47E-04	0.63E-02
	10	0.12E-03	0.12E-03	0.10E-01	0.19E-02	0.94E-04	0.12E-01
	20	0.24E-03	0.24E-03	0.19E-01	0.38E-02	0.19E-03	0.23E-01

Table K-5.5. Time-Integrated Dose (mrem) from Inhalation
Whole Body, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.09E-02	1.09E-02	9.75E-01	1.75E-01	8.76E-03	1.18E 00
	5	0.54E-01	0.54E-01	0.48E 01	0.88E 00	0.44E-01	0.58E 01
	10	0.11E 00	0.11E 00	0.92E 01	0.18E 01	0.88E-01	0.11E 02
	20	0.22E 00	0.22E 00	0.17E 02	0.35E 01	0.18E 00	0.21E 02
5	1	6.07E-04	6.07E-04	5.26E-02	9.41E-03	4.71E-04	6.37E-02
	5	0.30E-02	0.30E-02	0.26E 00	0.47E-01	0.24E-02	0.31E 00
	10	0.61E-02	0.61E-02	0.50E 00	0.94E-01	0.47E-02	0.61E 00
	20	0.12E-01	0.12E-01	0.93E 00	0.19E 00	0.94E-02	0.11E 01
10	1	1.93E-04	1.93E-04	1.67E-02	2.99E-03	1.50E-04	2.02E-02
	5	0.97E-03	0.97E-03	0.82E-01	0.15E-01	0.75E-03	0.99E-01
	10	0.19E-02	0.19E-02	0.16E 00	0.30E-01	0.15E-02	0.19E 00
	20	0.39E-02	0.39E-02	0.29E 00	0.60E-01	0.30E-02	0.36E 00
20	1	7.13E-05	7.13E-05	6.17E-03	1.10E-03	5.52E-05	7.47E-03
	5	0.36E-03	0.36E-03	0.30E-01	0.55E-02	0.28E-03	0.37E-01
	10	0.71E-03	0.71E-03	0.58E-01	0.11E-01	0.55E-03	0.71E-01
	20	0.14E-02	0.14E-02	0.11E 00	0.22E-01	0.11E-02	0.13E 00
	70	0.14E-02	0.14E-02	0.11E 00	0.22E-01	0.11E-02	0.13E 00
40	1	3.04E-05	3.04E-05	2.63E-03	4.70E-04	2.35E-05	3.16E-03
	5	0.15E-03	0.15E-03	0.13E-01	0.24E-02	0.12E-03	0.16E-01
	10	0.30E-03	0.30E-03	0.25E-01	0.47E-02	0.24E-03	0.30E-01
	20	0.61E-03	0.61E-03	0.46E-01	0.94E-02	0.47E-03	0.57E-01
80	1	1.34E-05	1.34E-05	1.16E-03	2.07E-04	1.03E-05	1.40E-03
	5	0.67E-04	0.67E-04	0.56E-02	0.10E-02	0.52E-04	0.69E-02
	10	0.13E-03	0.13E-03	0.11E-01	0.21E-02	0.10E-03	0.13E-01
	20	0.27E-03	0.27E-03	0.20E-01	0.41E-02	0.21E-03	0.25E-01

Table K-5.6. Time-Integrated Dose (mrem) from Inhalation
Bone, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	8.70E-02	8.70E-02	1.90E 01	1.10E 00	1.58E-01	2.05E 01
	5	0.43E 00	0.43E 00	0.93E 02	0.55E 01	0.79E 00	0.10E 03
	10	0.87E 00	0.87E 00	0.18E 03	0.11E 02	0.16E 01	0.19E 03
	20	0.17E 01	0.17E 01	0.33E 03	0.22E 02	0.32E 01	0.36E 03
5	1	4.03E-03	4.03E-03	7.62E-01	4.35E-02	6.26E-03	8.20E-01
	5	0.20E-01	0.20E-01	0.37E 01	0.22E 00	0.31E-01	0.40E 01
	10	0.40E-01	0.40E-01	0.72E 01	0.43E 00	0.63E-01	0.78E 01
	20	0.81E-01	0.81E-01	0.13E 02	0.87E 00	0.12E 00	0.15E 02
10	1	1.23E-03	1.23E-03	2.24E-01	1.27E-02	1.83E-03	2.41E-01
	5	0.61E-02	0.61E-02	0.11E 01	0.64E-01	0.92E-02	0.12E 01
	10	0.12E-01	0.12E-01	0.21E 01	0.13E 00	0.18E-01	0.23E 01
	20	0.25E-01	0.25E-01	0.39E 01	0.25E 00	0.37E-01	0.43E 01
20	1	4.42E-04	4.42E-04	7.92E-02	4.49E-03	6.46E-04	8.52E-02
	5	0.22E-02	0.22E-02	0.39E 00	0.22E-01	0.32E-02	0.42E 00
	10	0.44E-02	0.44E-02	0.75E 00	0.45E-01	0.65E-02	0.81E 00
	20	0.88E-02	0.88E-02	0.14E 01	0.90E-01	0.13E-01	0.15E 01
40	1	1.89E-04	1.89E-04	3.39E-02	1.92E-03	2.76E-04	3.64E-02
	5	0.94E-03	0.94E-03	0.16E 00	0.96E-02	0.14E-02	0.18E 00
	10	0.19E-02	0.19E-02	0.32E 00	0.19E-01	0.28E-02	0.34E 00
	20	0.38E-02	0.38E-02	0.59E 00	0.38E-01	0.55E-02	0.65E 00
	70	0.38E-02	0.38E-02	0.59E 00	0.38E-01	0.55E-02	0.65E 00
80	1	8.32E-05	8.32E-05	1.49E-02	8.46E-04	1.22E-04	1.61E-02
	5	0.42E-03	0.42E-03	0.73E-01	0.42E-02	0.61E-03	0.78E-01
	10	0.83E-03	0.83E-03	0.14E 00	0.85E-02	0.12E-02	0.15E 00
	20	0.17E-02	0.17E-02	0.26E 00	0.17E-01	0.24E-02	0.28E 00

Table K-5.7. Time-Integrated Dose (mrem) from Inhalation
Bone, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	6.05E-01	6.05E-01	1.05E 02	5.95E 00	8.56E-01	1.13E 02
	5	0.30E 01	0.30E 01	0.51E 03	0.30E 02	0.43E 01	0.55E 03
	10	0.61E 01	0.61E 01	0.99E 03	0.59E 02	0.86E 01	0.11E 04
	20	0.12E 02	0.12E 02	0.18E 04	0.12E 03	0.17E 02	0.20E 04
5	1	3.62E-02	3.62E-02	6.44E 00	3.65E-01	5.25E-02	6.93E 00
	5	0.18E 00	0.18E 00	0.31E 02	0.18E 01	0.26E 00	0.34E 02
	10	0.36E 00	0.36E 00	0.61E 02	0.37E 01	0.53E 00	0.66E 02
	20	0.72E 00	0.72E 00	0.11E 03	0.73E 01	0.10E 01	0.12E 03
10	1	1.16E-02	1.16E-02	2.07E 00	1.17E-01	1.69E-02	2.23E 00
	5	0.58E-01	0.58E-01	0.10E 02	0.59E 00	0.84E-01	0.11E 02
	10	0.12E 00	0.12E 00	0.19E 02	0.12E 01	0.17E 00	0.21E 02
	20	0.23E 00	0.23E 00	0.36E 02	0.23E 01	0.34E 00	0.39E 02
20	1	4.29E-03	4.29E-03	7.69E-01	4.36E-02	6.27E-03	8.27E-01
	5	0.21E-01	0.21E-01	0.37E 01	0.22E 00	0.31E-01	0.40E 01
	10	0.43E-01	0.43E-01	0.72E 01	0.44E 00	0.63E-01	0.78E 01
	20	0.86E-01	0.86E-01	0.13E 02	0.87E 00	0.13E 00	0.15E 02
40	1	1.83E-03	1.83E-03	3.29E-01	1.86E-02	2.68E-03	3.53E-01
	5	0.92E-02	0.92E-02	0.16E 01	0.93E-01	0.13E-01	0.17E 01
	10	0.18E-01	0.18E-01	0.31E 01	0.19E 00	0.27E-01	0.33E 01
	20	0.37E-01	0.37E-01	0.58E 01	0.37E 00	0.54E-01	0.63E 01
80	1	8.07E-04	8.07E-04	1.45E-01	8.21E-03	1.18E-03	1.56E-01
	5	0.40E-02	0.40E-02	0.70E 00	0.41E-01	0.59E-02	0.76E 00
	10	0.81E-02	0.81E-02	0.14E 01	0.82E-01	0.12E-01	0.15E 01
	20	0.16E-01	0.16E-01	0.25E 01	0.16E 00	0.24E-01	0.28E 01

Table K-5.8. Time-Integrated Dose (mrem) from Inhalation
Bone, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	4.55E-01	4.55E-01	7.90E 01	4.47E 00	6.43E-01	8.51E 01
	5	0.23E 01	0.23E 01	0.39E 03	0.22E 02	0.32E 01	0.42E 03
	10	0.46E 01	0.46E 01	0.74E 03	0.45E 02	0.64E 01	0.80E 03
	20	0.91E 01	0.91E 01	0.14E 04	0.89E 02	0.13E 02	0.15E 04
5	1	2.71E-02	2.71E-02	4.81E 00	2.72E-01	3.92E-02	5.17E 00
	5	0.14E 00	0.14E 00	0.23E 02	0.14E 01	0.20E 00	0.25E 02
	10	0.27E 00	0.27E 00	0.45E 02	0.27E 01	0.39E 00	0.49E 02
	20	0.54E 00	0.54E 00	0.84E 02	0.54E 01	0.78E 00	0.92E 02
10	1	8.72E-03	8.72E-03	1.55E 00	8.81E-02	1.27E-02	1.67E 00
	5	0.44E-01	0.44E-01	0.76E 01	0.44E 00	0.63E-01	0.82E 01
	10	0.87E-01	0.87E-01	0.15E 02	0.88E 00	0.13E 00	0.16E 02
	20	0.17E 00	0.17E 00	0.27E 02	0.18E 01	0.25E 00	0.30E 02
20	1	3.24E-03	3.24E-03	5.79E-01	3.28E-02	4.72E-03	6.23E-01
	5	0.16E-01	0.16E-01	0.28E 01	0.16E 00	0.24E-01	0.30E 01
	10	0.32E-01	0.32E-01	0.55E 01	0.33E 00	0.47E-01	0.59E 01
	20	0.65E-01	0.65E-01	0.10E 02	0.66E 00	0.94E-01	0.11E 02
40	1	1.38E-03	1.38E-03	2.48E-01	1.40E-02	2.02E-03	2.66E-01
	5	0.69E-02	0.69E-02	0.12E 01	0.70E-01	0.10E-01	0.13E 01
	10	0.14E-01	0.14E-01	0.23E 01	0.14E 00	0.20E-01	0.25E 01
	20	0.28E-01	0.28E-01	0.43E 01	0.28E 00	0.40E-01	0.47E 01
80	1	6.08E-04	6.08E-04	1.09E-01	6.18E-03	8.90E-04	1.17E-01
	5	0.30E-02	0.30E-02	0.53E 00	0.31E-01	0.44E-02	0.57E 00
	10	0.61E-02	0.61E-02	0.10E 01	0.62E-01	0.89E-02	0.11E 01
	20	0.12E-01	0.12E-01	0.19E 01	0.12E 00	0.18E-01	0.21E 01

Table K-5.9. Time-Integrated Dose (mrem) from Inhalation
Bone, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.75E-01	1.75E-01	3.20E 01	1.82E 00	2.62E-01	3.44E 01
	5	0.87E 00	0.87E 00	0.16E 03	0.91E 01	0.13E 01	0.17E 03
	10	0.17E 01	0.17E 01	0.30E 03	0.18E 02	0.26E 01	0.33E 03
	20	0.35E 01	0.35E 01	0.56E 03	0.36E 02	0.52E 01	0.61E 03
5	1	1.00E-02	1.00E-02	1.81E 00	1.02E-01	1.48E-02	1.94E 00
	5	0.50E-01	0.50E-01	0.88E 01	0.51E 00	0.74E-01	0.95E 01
	10	0.10E 00	0.10E 00	0.17E 02	0.10E 01	0.15E 00	0.18E 02
	20	0.20E 00	0.20E 00	0.32E 02	0.20E 01	0.29E 00	0.34E 02
10	1	3.19E-03	3.19E-03	5.75E-01	3.26E-02	4.70E-03	6.19E-01
	5	0.16E-01	0.16E-01	0.28E 01	0.16E 00	0.23E-01	0.30E 01
	10	0.32E-01	0.32E-01	0.54E 01	0.33E 00	0.47E-01	0.59E 01
	20	0.64E-01	0.64E-01	0.10E 02	0.65E 00	0.94E-01	0.11E 02
20	1	1.18E-03	1.18E-03	2.12E-01	1.20E-02	1.73E-03	2.28E-01
	5	0.59E-02	0.59E-02	0.10E 01	0.60E-01	0.87E-02	0.11E 01
	10	0.12E-01	0.12E-01	0.20E 01	0.12E 00	0.17E-01	0.22E 01
	20	0.24E-01	0.24E-01	0.37E 01	0.24E 00	0.35E-01	0.40E 01
40	1	5.02E-04	5.02E-04	9.07E-02	5.15E-03	7.41E-04	9.76E-02
	5	0.25E-02	0.25E-02	0.44E 00	0.26E-01	0.37E-02	0.48E 00
	10	0.50E-02	0.50E-02	0.85E 00	0.51E-01	0.74E-02	0.92E 00
	20	0.10E-01	0.10E-01	0.16E 01	0.10E 00	0.15E-01	0.17E 01
80	1	2.21E-04	2.21E-04	3.99E-02	2.27E-03	3.26E-04	4.30E-02
	5	0.11E-02	0.11E-02	0.19E 00	0.11E-01	0.16E-02	0.21E 00
	10	0.22E-02	0.22E-02	0.38E 00	0.23E-01	0.33E-02	0.41E 00
	20	0.44E-02	0.44E-02	0.70E 00	0.45E-01	0.65E-02	0.76E 00

Table K-5.10. Time-Integrated Dose (mrem) from Inhalation
Bone, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.96E-01	1.96E-01	3.69E 01	2.10E 00	3.03E-01	3.97E 01
	5	0.98E 00	0.98E 00	0.18E 03	0.11E 02	0.15E 01	0.19E 03
	10	0.20E 01	0.20E 01	0.35E 03	0.21E 02	0.30E 01	0.38E 03
	20	0.39E 01	0.39E 01	0.65E 03	0.42E 02	0.60E 01	0.70E 03
5	1	1.10E-02	1.10E-02	1.99E 00	1.13E-01	1.63E-02	2.14E 00
	5	0.55E-01	0.55E-01	0.97E 01	0.57E 00	0.81E-01	0.10E 02
	10	0.11E 00	0.11E 00	0.19E 02	0.11E 01	0.16E 00	0.20E 02
	20	0.22E 00	0.22E 00	0.35E 02	0.23E 01	0.32E 00	0.38E 02
10	1	3.49E-03	3.49E-03	6.33E-01	3.59E-02	5.17E-03	6.81E-01
	5	0.17E-01	0.17E-01	0.31E 01	0.18E 00	0.26E-01	0.33E 01
	10	0.35E-01	0.35E-01	0.60E 01	0.36E 00	0.52E-01	0.64E 01
	20	0.70E-01	0.70E-01	0.11E 02	0.72E 00	0.10E 00	0.12E 02
20	1	1.29E-03	1.29E-03	2.33E-01	1.33E-02	1.91E-03	2.51E-01
	5	0.64E-02	0.64E-02	0.11E 01	0.66E-01	0.95E-02	0.12E 01
	10	0.13E-01	0.13E-01	0.22E 01	0.13E 00	0.19E-01	0.24E 01
	20	0.26E-01	0.26E-01	0.41E 01	0.27E 00	0.38E-01	0.44E 01
40	1	5.49E-04	5.49E-04	9.95E-02	5.65E-03	8.13E-04	1.07E-01
	5	0.27E-02	0.27E-02	0.48E 00	0.28E-01	0.41E-02	0.52E 00
	10	0.55E-02	0.55E-02	0.94E 00	0.56E-01	0.81E-02	0.10E 01
	20	0.11E-01	0.11E-01	0.17E 01	0.11E 00	0.16E-01	0.19E 01
80	1	2.41E-04	2.41E-04	4.38E-02	2.48E-03	3.58E-04	4.71E-02
	5	0.12E-02	0.12E-02	0.21E 00	0.12E-01	0.18E-02	0.23E 00
	10	0.24E-02	0.24E-02	0.41E 00	0.25E-01	0.36E-02	0.45E 00
	20	0.48E-02	0.48E-02	0.77E 00	0.50E-01	0.71E-02	0.83E 00

Table K-5.11. Time-Integrated Dose (mrem) from Inhalation
Lung, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.74E-01	2.17E-01	1.89E 00	0.0	6.89E-02	2.35E 00
	5	0.87E 00	0.11E 01	0.94E 01	0.0	0.34E 00	0.12E 02
	10	0.17E 01	0.22E 01	0.19E 02	0.0	0.69E 00	0.23E 02
	20	0.35E 01	0.43E 01	0.38E 02	0.0	0.14E 01	0.47E 02
5	1	8.05E-03	1.01E-02	7.56E-02	0.0	2.72E-03	9.64E-02
	5	0.40E-01	0.50E-01	0.38E 00	0.0	0.14E-01	0.48E 00
	10	0.81E-01	0.10E 00	0.76E 00	0.0	0.27E-01	0.96E 00
	20	0.16E 00	0.20E 00	0.15E 01	0.0	0.54E-01	0.19E 01
10	1	2.45E-03	3.07E-03	2.22E-02	0.0	7.97E-04	2.85E-02
	5	0.12E-01	0.15E-01	0.11E 00	0.0	0.40E-02	0.14E 00
	10	0.25E-01	0.31E-01	0.22E 00	0.0	0.80E-02	0.29E 00
	20	0.49E-01	0.61E-01	0.44E 00	0.0	0.16E-01	0.57E 00
20	1	8.85E-04	1.11E-03	7.85E-03	0.0	2.81E-04	1.01E-02
	5	0.44E-02	0.55E-02	0.39E-01	0.0	0.14E-02	0.51E-01
	10	0.88E-02	0.11E-01	0.78E-01	0.0	0.28E-02	0.10E 00
	20	0.18E-01	0.22E-01	0.16E 00	0.0	0.56E-02	0.20E 00
40	1	3.78E-04	4.72E-04	3.36E-03	0.0	1.20E-04	4.33E-03
	5	0.19E-02	0.24E-02	0.17E-01	0.0	0.60E-03	0.22E-01
	10	0.38E-02	0.47E-02	0.34E-01	0.0	0.12E-02	0.43E-01
	20	0.76E-02	0.94E-02	0.67E-01	0.0	0.24E-02	0.87E-01
80	1	1.66E-04	2.08E-04	1.48E-03	0.0	5.30E-05	1.91E-03
	5	0.83E-03	0.10E-02	0.74E-02	0.0	0.27E-03	0.95E-02
	10	0.17E-02	0.21E-02	0.15E-01	0.0	0.53E-03	0.19E-01
	20	0.33E-02	0.42E-02	0.30E-01	0.0	0.11E-02	0.38E-01

Table K-5.12. Time-Integrated Dose (mrem) from Inhalation
Lung, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.21E 00	1.51E 00	1.04E 01	0.0	3.73E-01	1.35E 01
	5	0.61E 01	0.76E 01	0.52E 02	0.0	0.19E 01	0.68E 02
	10	0.12E 02	0.15E 02	0.10E 03	0.0	0.37E 01	0.14E 03
	20	0.24E 02	0.30E 02	0.21E 03	0.0	0.75E 01	0.27E 03
5	1	7.24E-02	9.05E-02	6.39E-01	0.0	2.29E-02	8.24E-01
	5	0.36E 00	0.45E 00	0.32E 01	0.0	0.11E 00	0.41E 01
	10	0.72E 00	0.90E 00	0.64E 01	0.0	0.23E 00	0.82E 01
	20	0.14E 01	0.18E 01	0.13E 02	0.0	0.46E 00	0.16E 02
10	1	2.32E-02	2.90E-02	2.05E-01	0.0	7.35E-03	2.65E-01
	5	0.12E 00	0.14E 00	0.10E 01	0.0	0.37E-01	0.13E 01
	10	0.23E 00	0.29E 00	0.21E 01	0.0	0.73E-01	0.26E 01
	20	0.46E 00	0.58E 00	0.41E 01	0.0	0.15E 00	0.53E 01
20	1	8.59E-03	1.07E-02	7.62E-02	0.0	2.73E-03	9.82E-02
	5	0.43E-01	0.54E-01	0.38E 00	0.0	0.14E-01	0.49E 00
	10	0.86E-01	0.11E 00	0.76E 00	0.0	0.27E-01	0.98E 00
	20	0.17E 00	0.21E 00	0.15E 01	0.0	0.55E-01	0.20E 01
40	1	3.66E-03	4.58E-03	3.26E-02	0.0	1.17E-03	4.20E-02
	5	0.18E-01	0.23E-01	0.16E 00	0.0	0.58E-02	0.21E 00
	10	0.37E-01	0.46E-01	0.33E 00	0.0	0.12E-01	0.42E 00
	20	0.73E-01	0.92E-01	0.65E 00	0.0	0.23E-01	0.84E 00
80	1	1.61E-03	2.02E-03	1.43E-02	0.0	5.14E-04	1.85E-02
	5	0.81E-02	0.10E-01	0.72E-01	0.0	0.26E-02	0.92E-01
	10	0.16E-01	0.20E-01	0.14E 00	0.0	0.51E-02	0.18E 00
	20	0.32E-01	0.40E-01	0.29E 00	0.0	0.10E-01	0.37E 00

Table K-5.13. Time-Integrated Dose (mrem) from Inhalation
Lung, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	9.11E-01	1.14E 00	7.83E 00	0.0	2.80E-01	1.02E 01
	5	0.46E 01	0.57E 01	0.39E 02	0.0	0.14E 01	0.51E 02
	10	0.91E 01	0.11E 02	0.78E 02	0.0	0.28E 01	0.10E 03
	20	0.18E 02	0.23E 02	0.16E 03	0.0	0.56E 01	0.20E 03
5	1	5.43E-02	6.79E-02	4.77E-01	0.0	1.71E-02	6.16E-01
	5	0.27E 00	0.34E 00	0.24E 01	0.0	0.85E-01	0.31E 01
	10	0.54E 00	0.68E 00	0.48E 01	0.0	0.17E 00	0.62E 01
	20	0.11E 01	0.14E 01	0.95E 01	0.0	0.34E 00	0.12E 02
10	1	1.74E-02	2.18E-02	1.54E-01	0.0	5.52E-03	1.99E-01
	5	0.87E-01	0.11E 00	0 77E 00	0.0	0.28E-01	0.99E 00
	10	0.17E 00	0.22E 00	0.15E 01	0.0	0.55E-01	0.20E 01
	20	0.35E 00	0.44E 00	0.31E 01	0.0	0.11E 00	0.40E 01
20	1	6.47E-03	8.09E-03	5.74E-02	0.0	2.06E-03	7.40E-02
	5	0.32E-01	0.40E-01	0.29E 00	0.0	0.10E-01	0.37E 00
	10	0.65E-01	0.81E-01	0.57E 00	0.0	0.21E-01	0.74E 00
	20	0.13E 00	0.16E 00	0.11E 01	0.0	0.41E-01	0.15E 01
40	1	2.76E-03	3.45E-03	2.45E-02	0.0	8.79E-04	3.16E-02
	5	0.14E-01	0.17E-01	0.12E 00	0.0	0.44E-02	0.16E 00
	10	0.28E-01	0.35E-01	0.25E 00	0.0	0.88E-02	0.32E 00
	20	0.55E-01	0.69E-01	0.49E 00	0.0	0.18E-01	0.63E 00
80	1	1.22E-03	1.52E-03	1.08E-02	0.0	3.87E-04	1.39E-02
	5	0.61E-02	0.76E-02	0.54E-01	0.0	0.19E-02	0.70E-01
	10	0.12E-01	0.15E-01	0.11E 00	0.0	0.39E-02	0.14E 00
	20	0.24E-01	0.30E-01	0.22E 00	0.0	0.77E-02	0.28E 00

Table K-5.14. Time-Integrated Dose (mrem) from Inhalation
Lung, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	3.49E-01	4.37E-01	3.17E 00	0.0	1.14E-01	4.07E 00
	5	0.17E 01	0.22E 01	0.16E 02	0.0	0.57E 00	0.20E 02
	10	0.35E 01	0.44E 01	0.32E 02	0.0	0.11E 01	0.41E 02
	20	0.70E 01	0.87E 01	0.63E 02	0.0	0.23E 01	0.81E 02
5	1	2.00E-02	2.50E-02	1.79E-01	0.0	6.42E-03	2.30E-01
	5	0.10E 00	0.13E 00	0.90E 00	0.0	0.32E-01	0.12E 01
	10	0.20E 00	0.25E 00	0.18E 01	0.0	0.64E-01	0.23E 01
	20	0.40E 00	0.50E 00	0.36E 01	0.0	0.13E 00	0.46E 01
10	1	6.38E-03	7.98E-03	5.70E-02	0.0	2.04E-03	7.34E-02
	5	0.32E-01	0.40E-01	0.29E 00	0.0	0.10E-01	0.37E 00
	10	0.64E-01	0.80E-01	0.57E 00	0.0	0.20E-01	0.73E 00
	20	0.13E 00	0.16E 00	0.11E 01	0.0	0.41E-01	0.15E 01
20	1	2.35E-03	2.94E-03	2.10E-02	0.0	7.54E-04	2.71E-02
	5	0.12E-01	0.15E-01	0.11E 00	0.0	0.38E-02	0.14E 00
	10	0.24E-01	0.29E-01	0.21E 00	0.0	0.75E-02	0.27E 00
	20	0.47E-01	0.59E-01	0.42E 00	0.0	0.15E-01	0.54E 00
40	1	1.00E-03	1.26E-03	8.99E-03	0.0	3.22E-04	1.16E-02
	5	0.50E-02	0.63E-02	0.45E-01	0.0	0.16E-02	0.58E-01
	10	0.10E-01	0.13E-01	0.90E-01	0.0	0.32E-02	0.12E 00
	20	0.20E-01	0.25E-01	0.18E 00	0.0	0.64E-02	0.23E 00
80	1	4.42E-04	5.53E-04	3.96E-03	0.0	1.42E-04	5.10E-03
	5	0.22E-02	0.28E-02	0.20E-01	0.0	0.71E-03	0.25E-01
	10	0.44E-02	0.55E-02	0.40E-01	0.0	0.14E-02	0.51E-01
	20	0.88E-02	0.11E-01	0.79E-01	0.0	0.28E-02	0.10E 00

Table K-5.15. Time-Integrated Dose (mrem) from Inhalation
Lung, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	3.93E-01	4.91E-01	3.66E 00	0.0	1.32E-01	4.67E 00
	5	0.20E 01	0.25E 01	0.18E 02	0.0	0.66E 00	0.23E 02
	10	0.39E 01	0.49E 01	0.37E 02	0.0	0.13E 01	0.47E 02
	20	0.79E 01	0.98E 01	0.73E 02	0.0	0.26E 01	0.93E 02
5	1	2.19E-02	2.74E-02	1.97E-01	0.0	7.08E-03	2.54E-01
	5	0.11E 00	0.14E 00	0.99E 00	0.0	0.35E-01	0.13E 01
	10	0.22E 00	0.27E 00	0.20E 01	0.0	0.71E-01	0.25E 01
	20	0.44E 00	0.55E 00	0.39E 01	0.0	0.14E 00	0.51E 01
10	1	6.98E-03	8.73E-03	6.27E-02	0.0	2.25E-03	8.07E-02
	5	0.35E-01	0.44E-01	0.31E 00	0.0	0.11E-01	0.40E 00
	10	0.70E-01	0.87E-01	0.63E 00	0.0	0.22E-01	0.81E 00
	20	0.14E 00	0.17E 00	0.13E 01	0.0	0.45E-01	0.16E 01
20	1	2.58E-03	3.22E-03	2.31E-02	0.0	8.30E-04	2.98E-02
	5	0.13E-01	0.16E-01	0.12E 00	0.0	0.42E-02	0.15E 00
	10	0.26E-01	0.32E-01	0.23E 00	0.0	0.83E-02	0.30E 00
	20	0.52E-01	0.64E-01	0.46E 00	0.0	0.17E-01	0.60E 00
40	1	1.10E-03	1.37E-03	9.86E-03	0.0	3.54E-04	1.27E-02
	5	0.55E-02	0.69E-02	0.49E-01	0.0	0.18E-02	0.63E-01
	10	0.11E-01	0.14E-01	0.99E-01	0.0	0.35E-02	0.13E 00
	20	0.22E-01	0.27E-01	0.20E 00	0.0	0.71E-02	0.25E 00
80	1	4.83E-04	6.04E-04	4.34E-03	0.0	1.56E-04	5.58E-03
	5	0.24E-02	0.30E-02	0.22E-01	0.0	0.78E-03	0.28E-01
	10	0.48E-02	0.60E-02	0.43E-01	0.0	0.16E-02	0.56E-01
	20	0.97E-02	0.12E-01	0.87E-01	0.0	0.31E-02	0.11E 00

Table K-5.16. Time-Integrated Dose (mrem) from Inhalation
Kidney, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.90E-01	2.17E-02	3.56E 00	0.0	1.37E-01	4.01E 00
	5	0.14E 01	0.11E 00	0.17E 02	0.0	0.69E 00	0.20E 02
	10	0.29E 01	0.22E 00	0.34E 02	0.0	0.14E 01	0.39E 02
	20	0.58E 01	0.43E 00	0.64E 02	0.0	0.27E 01	0.73E 02
5	1	1.34E-02	1.01E-03	1.43E-01	0.0	5.43E-03	1.62E-01
	5	0.67E-01	0.50E-02	0.70E 00	0.0	0.27E-01	0.80E 00
	10	0.13E 00	0.10E-01	0.14E 01	0.0	0.54E-01	0.16E 01
	20	0.27E 00	0.20E-01	0.26E 01	0.0	0.11E 00	0.30E 01
10	1	4.09E-03	3.07E-04	4.19E-02	0.0	1.59E-03	4.79E-02
	5	0.20E-01	0.15E-02	0.21E 00	0.0	0.79E-02	0.24E 00
	10	0.41E-01	0.31E-02	0.40E 00	0.0	0.16E-01	0.46E 00
	20	0.82E-01	0.61E-02	0.76E 00	0.0	0.32E-01	0.88E 00
20	1	1.47E-03	1.11E-04	1.48E-02	0.0	5.61E-04	1.70E-02
	5	0.74E-02	0.55E-03	0.73E-01	0.0	0.28E-02	0.83E-01
	10	0.15E-01	0.11E-02	0.14E 00	0.0	0.56E-02	0.16E 00
	20	0.29E-01	0.22E-02	0.27E 00	0.0	0.11E-01	0.31E 00
40	1	6.30E-04	4.72E-05	6.34E-03	0.0	2.40E-04	7.25E-03
	5	0.31E-02	0.24E-03	0.31E-01	0.0	0.12E-02	0.36E-01
	10	0.63E-02	0.47E-03	0.61E-01	0.0	0.24E-02	0.70E-01
	20	0.13E-01	0.94E-03	0.11E 00	0.0	0.48E-02	0.13E 00
80	1	2.77E-04	2.08E-05	2.79E-03	0.0	1.06E-04	3.20E-03
	5	0.14E-02	0.10E-03	0.14E-01	0.0	0.53E-03	0.16E-01
	10	0.28E-02	0.21E-03	0.27E-01	0.0	0.11E-02	0.31E-01
	20	0.55E-02	0.42E-03	0.50E-01	0.0	0.21E-02	0.59E-01

Table K-5.17. Time-Integrated Dose (mrem) from Inhalation
Kidney, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.02E 00	1.51E-01	1.97E 01	0.0	7.43E-01	2.26E 01
	5	0.10E 02	0.76E 00	0.97E 02	0.0	0.37E 01	0.11E 03
	10	0.20E 02	0.15E 01	0.19E 03	0.0	0.74E 01	0.22E 03
	20	0.40E 02	0.30E 01	0.36E 03	0.0	0.15E 02	0.41E 03
5	1	1.21E-01	9.05E-03	1.21E 00	0.0	4.56E-02	1.38E 00
	5	0.60E 00	0.45E-01	0.59E 01	0.0	0.23E 00	0.68E 01
	10	0.12E 01	0.90E-01	0.12E 02	0.0	0.46E 00	0.13E 02
	20	0.24E 01	0.18E 00	0.22E 02	0.0	0.91E 00	0.25E 02
10	1	3.87E-02	2.90E-03	3.87E-01	0.0	1.47E-02	4.43E-01
	5	0.19E 00	0.14E-01	0.19E 01	0.0	0.73E-01	0.22E 01
	10	0.39E 00	0.29E-01	0.37E 01	0.0	0.15E 00	0.43E 01
	20	0.77E 00	0.58E-01	0.70E 01	0.0	0.29E 00	0.81E 01
20	1	1.43E-02	1.07E-03	1.44E-01	0.0	5.44E-03	1.65E-01
	5	0.72E-01	0.54E-02	0.71E 00	0.0	0.27E-01	0.81E 00
	10	0.14E 00	0.11E-01	0.14E 01	0.0	0.54E-01	0.16E 01
	20	0.29E 00	0.21E-01	0.26E 01	0.0	0.11E 00	0.30E 01
40	1	6.11E-03	4.58E-04	6.15E-02	0.0	2.33E-03	7.04E-02
	5	0.31E-01	0.23E-02	0.30E 00	0.0	0.12E-01	0.35E 00
	10	0.61E-01	0.46E-02	0.59E 00	0.0	0.23E-01	0.68E 00
	20	0.12E 00	0.92E-02	0.11E 01	0.0	0.47E-01	0.13E 01
80	1	2.69E-03	2.02E-04	2.71E-02	0.0	1.03E-03	3.10E-02
	5	0.13E-01	0.10E-02	0.13E 00	0.0	0.51E-02	0.15E 00
	10	0.27E-01	0.20E-02	0.26E 00	0.0	0.10E-01	0.30E 00
	20	0.54E-01	0.40E-02	0.49E 00	0.0	0.21E-01	0.57E 00

Table K-5.18. Time-Integrated Dose (mrem) from Inhalation
Kidney, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.52E 00	1.14E-01	1.48E 01	0.0	5.58E-01	1.70E 01
	5	0.76E 01	0.57E 00	0.73E 02	0.0	0.28E 01	0.83E 02
	10	0.15E 02	0.11E 01	0.14E 03	0.0	0.56E 01	0.16E 03
	20	0.30E 02	0.23E 01	0.27E 03	0.0	0.11E 02	0.31E 03
5	1	9.05E-02	6.79E-03	9.00E-01	0.0	3.40E-02	1.03E 00
	5	0.45E 00	0.34E-01	0.44E 01	0.0	0.17E 00	0.51E 01
	10	0.90E 00	0.68E-01	0.86E 01	0.0	0.34E 00	0.99E 01
	20	0.18E 01	0.14E 00	0.16E 02	0.0	0.68E 00	0.19E 02
10	1	2.91E-02	2.18E-03	2.91E-01	0.0	1.10E-02	3.33E-01
	5	0.15E 00	0.11E-01	0.14E 01	0.0	0.55E-01	0.16E 01
	10	0.29E 00	0.22E-01	0.28E 01	0.0	0.11E 00	0.32E 01
	20	0.58E 00	0.44E-01	0.53E 01	0.0	0.22E 00	0.61E 01
20	1	1.08E-02	8.09E-04	1.08E-01	0.0	4.10E-03	1.24E-01
	5	0.54E-01	0.40E-02	0.53E 00	0.0	0.21E-01	0.61E 00
	10	0.11E 00	0.81E-02	0.10E 01	0.0	0.41E-01	0.12E 01
	20	0.22E 00	0.16E-01	0.20E 01	0.0	0.82E-01	0.23E 01
40	1	4.60E-03	3.45E-04	4.63E-02	0.0	1.75E-03	5.30E-02
	5	0.23E-01	0.17E-02	0.23E 00	0.0	0.88E-02	0.26E 00
	10	0.46E-01	0.35E-02	0.44E 00	0.0	0.18E-01	0.51E 00
	20	0.92E-01	0.69E-02	0.84E 00	0.0	0.35E-01	0.97E 00
80	1	2.03E-03	1.52E-04	2.04E-02	0.0	7.73E-04	2.34E-02
	5	0.10E-01	0.76E-03	0.10E 00	0.0	0.39E-02	0.11E 00
	10	0.20E-01	0.15E-02	0.20E 00	0.0	0.77E-02	0.22E 00
	20	0.41E-01	0.30E-02	0.37E 00	0.0	0.15E-01	0.43E 00

Table K-5.19. Time-Integrated Dose (mrem) from Inhalation
Kidney, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.82E-01	4.37E-02	5.98E 00	0.0	2.27E-01	6.84E 00
	5	0.29E 01	0.22E 00	0.29E 02	0.0	0.11E 01	0.34E 02
	10	0.58E 01	0.44E 00	0.57E 02	0.0	0.23E 01	0.66E 02
	20	0.12E 02	0.87E 00	0.11E 03	0.0	0.45E 01	0.13E 03
5	1	3.34E-02	2.50E-03	3.38E-01	0.0	1.28E-02	3.87E-01
	5	0.17E 00	0.13E-01	0.17E 01	0.0	0.64E-01	0.19E 01
	10	0.33E 00	0.25E-01	0.32E 01	0.0	0.13E 00	0.37E 01
	20	0.67E 00	0.50E-01	0.61E 01	0.0	0.26E 00	0.71E 01
10	1	1.06E-02	7.98E-04	1.08E-01	0.0	4.08E-03	1.23E-01
	5	0.53E-01	0.40E-02	0.53E 00	0.0	0.20E-01	0.61E 00
	10	0.11E 00	0.80E-02	0.10E 01	0.0	0.41E-01	0.12E 01
	20	0.21E 00	0.16E-01	0.19E 01	0.0	0.82E-01	0.23E 01
20	1	3.92E-03	2.94E-04	3.97E-02	0.0	1.50E-03	4.54E-02
	5	0.20E-01	0.15E-02	0.19E 00	0.0	0.75E-02	0.22E 00
	10	0.39E-01	0.29E-02	0.38E 00	0.0	0.15E-01	0.44E 00
	20	0.78E-01	0.59E-02	0.72E 00	0.0	0.30E-01	0.83E 00
40	1	1.67E-03	1.26E-04	1.70E-02	0.0	6.43E-04	1.94E-02
	5	0.84E-02	0.63E-03	0.83E-01	0.0	0.32E-02	0.95E-01
	10	0.17E-01	0.13E-02	0.16E 00	0.0	0.64E-02	0.19E 00
	20	0.33E-01	0.25E-02	0.31E 00	0.0	0.13E-01	0.36E 00
80	1	7.37E-04	5.53E-05	7.47E-03	0.0	2.83E-04	8.55E-03
	5	0.37E-02	0.28E-03	0.37E-01	0.0	0.14E-02	0.42E-01
	10	0.74E-02	0.55E-03	0.71E-01	0.0	0.28E-02	0.82E-01
	20	0.15E-01	0.11E-02	0.14E 00	0.0	0.57E-02	0.16E 00

Table K-5.20. Time-Integrated Dose (mrem) from Inhalation
Kidney, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	6.54E-01	4.91E-02	6.90E 00	0.0	2.63E-01	7.87E 00
	5	0.33E 01	0.25E 00	0.34E 02	0.0	0.13E 01	0.39E 02
	10	0.65E 01	0.49E 00	0.66E 02	0.0	0.26E 01	0.76E 02
	20	0.13E 02	0.98E 00	0.12E 03	0.0	0.53E 01	0.14E 03
5	1	3.65E-02	2.74E-03	3.72E-01	0.0	1.41E-02	4.26E-01
	5	0.18E 00	0.14E-01	0.18E 01	0.0	0.71E-01	0.21E 01
	10	0.37E 00	0.27E-01	0.36E 01	0.0	0.14E 00	0.41E 01
	20	0.73E 00	0.55E-01	0.67E 01	0.0	0.28E 00	0.78E 01
10	1	1.16E-02	8.73E-04	1.18E-01	0.0	4.49E-03	1.35E-01
	5	0.58E-01	0.44E-02	0.58E 00	0.0	0.22E-01	0.67E 00
	10	0.12E 00	0.87E-02	0.11E 01	0.0	0.45E-01	0.13E 01
	20	0.23E 00	0.17E-01	0.21E 01	0.0	0.90E-01	0.25E 01
20	1	4.30E-03	3.22E-04	4.37E-02	0.0	1.66E-03	5.00E-02
	5	0.21E-01	0.16E-02	0.21E 00	0.0	0.83E-02	0.25E 00
	10	0.43E-01	0.32E-02	0.42E 00	0.0	0.17E-01	0.48E 00
	20	0.86E-01	0.64E-02	0.79E 00	0.0	0.33E-01	0.91E 00
40	1	1.83E-03	1.37E-04	1.86E-02	0.0	7.06E-04	2.13E-02
	5	0.92E-02	0.69E-03	0.91E-01	0.0	0.35E-02	0.10E 00
	10	0.18E-01	0.14E-02	0.18E 00	0.0	0.71E-02	0.20E 00
	20	0.37E-01	0.27E-02	0.34E 00	0.0	0.14E-01	0.39E 00
80	1	8.05E-04	6.04E-05	8.19E-03	0.0	3.10E-04	9.36E-03
	5	0.40E-02	0.30E-03	0.40E-01	0.0	0.16E-02	0.46E-01
	10	0.80E-02	0.60E-03	0.78E-01	0.0	0.31E-02	0.90E-01
	20	0.16E-01	0.12E-02	0.15E 00	0.0	0.62E-02	0.17E 00

Table K-5.21. Time-Integrated Dose (mrem) from Inhalation GI System (soluble radionuclides), Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.09E-04	1.24E-04	8.07E-05	5.49E-05	1.37E-05	3.83E-04
	5	0.55E-03	0.62E-03	0.40E-03	0.27E-03	0.69E-04	0.19E-02
	10	0.11E-02	0.12E-02	0.81E-03	0.55E-03	0.14E-03	0.38E-02
	20	0.22E-02	0.25E-02	0.16E-02	0.11E-02	0.27E-03	0.77E-02
5	1	5.05E-06	5.74E-06	3.23E-06	2.17E-06	5.43E-07	1.67E-05
	5	0.25E-04	0.29E-04	0.16E-04	0.11E-04	0.27E-05	0.84E-04
	10	0.50E-04	0.57E-04	0.32E-04	0.22E-04	0.54E-05	0.17E-03
	20	0.10E-03	0.11E-03	0.65E-04	0.43E-04	0.11E-04	0.33E-03
10	1	1.54E-06	1.75E-06	9.50E-07	6.36E-07	1.59E-07	5.03E-06
	5	0.77E-05	0.88E-05	0.47E-05	0.32E-05	0.79E-06	0.25E-04
	10	0.15E-04	0.18E-04	0.95E-05	0.64E-05	0.16E-05	0.50E-04
	20	0.31E-04	0.35E-04	0.19E-04	0.13E-04	0.32E-05	0.10E-03
20	1	5.55E-07	6.31E-07	3.36E-07	2.24E-07	5.61E-08	1.80E-06
	5	0.28E-05	0.32E-05	0.17E-05	0.11E-05	0.28E-06	0.90E-05
	10	0.55E-05	0.63E-05	0.34E-05	0.22E-05	0.56E-06	0.18E-04
	20	0.11E-04	0.13E-04	0.67E-05	0.45E-05	0.11E-05	0.36E-04
40	1	2.37E-07	2.69E-07	1.44E-07	9.60E-08	2.40E-08	7.70E-07
	5	0.12E-05	0.13E-05	0.72E-06	0.48E-06	0.12E-06	0.38E-05
	10	0.24E-05	0.27E-05	0.14E-05	0.96E-06	0.24E-06	0.77E-05
	20	0.47E-05	0.54E-05	0.29E-05	0.19E-05	0.48E-06	0.15E-04
80	1	1.04E-07	1.19E-07	6.33E-08	4.23E-08	1.06E-08	3.39E-07
	5	0.52E-06	0.59E-06	0.32E-06	0.21E-06	0.53E-07	0.17E-05
	10	0.10E-05	0.12E-05	0.63E-06	0.42E-06	0.11E-06	0.34E-05
	20	0.21E-05	0.24E-05	0.13E-05	0.85E-06	0.21E-06	0.68E-05

Table K-5.22. Time-Integrated Dose (mrem) from Inhalation GI System (soluble radionuclides), Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	7.59E-04	8.63E-04	4.46E-04	2.97E-04	7.43E-05	2.44E-03
	5	0.38E-02	0.43E-02	0.22E-02	0.15E-02	0.37E-03	0.12E-01
	10	0.76E-02	0.86E-02	0.45E-02	0.30E-02	0.74E-03	0.24E-01
	20	0.15E-01	0.17E-01	0.89E-02	0.59E-02	0.15E-02	0.49E-01
5	1	4.54E-05	5.16E-05	2.73E-05	1.82E-05	4.56E-06	1.47E-04
	5	0.23E-03	0.26E-03	0.14E-03	0.91E-04	0.23E-04	0.74E-03
	10	0.45E-03	0.52E-03	0.27E-03	0.18E-03	0.46E-04	0.15E-02
	20	0.91E-03	0.10E-02	0.55E-03	0.36E-03	0.91E-04	0.29E-02
10	1	1.45E-05	1.65E-05	8.78E-06	5.86E-06	1.47E-06	4.72E-05
	5	0.73E-04	0.83E-04	0.44E-04	0.29E-04	0.73E-05	0.24E-03
	10	0.15E-03	0.17E-03	0.88E-04	0.59E-04	0.15E-04	0.47E-03
	20	0.29E-03	0.33E-03	0.18E-03	0.12E-03	0.29E-04	0.94E-03
20	1	5.38E-06	6.13E-06	3.26E-06	2.18E-06	5.44E-07	1.75E-05
	5	0.27E-04	0.31E-04	0.16E-04	0.11E-04	0.27E-05	0.87E-04
	10	0.54E-04	0.61E-04	0.33E-04	0.22E-04	0.54E-05	0.17E-03
	20	0.11E-03	0.12E-03	0.65E-04	0.44E-04	0.11E-04	0.35E-03
40	1	2.30E-06	2.61E-06	1.39E-06	9.31E-07	2.33E-07	7.47E-06
	5	0.11E-04	0.13E-04	0.70E-05	0.47E-05	0.12E-05	0.37E-04
	10	0.23E-04	0.26E-04	0.14E-04	0.93E-05	0.23E-05	0.75E-04
	20	0.46E-04	0.52E-04	0.28E-04	0.19E-04	0.47E-05	0.15E-03
80	1	1.01E-06	1.15E-06	6.14E-07	4.10E-07	1.03E-07	3.29E-06
	5	0.51E-05	0.58E-05	0.31E 05	0.21E-05	0.51E-06	0.16E-04
	10	0.10E-04	0.12E-04	0.61E-05	0.41E-05	0.10E-05	0.33E-04
	20	0.20E-04	0.23E-04	0.12E-04	0.82E-05	0.21E-05	0.66E-04

Table K-5.23. Time-Integrated Dose (mrem) from Inhalation GI System (soluble radionuclides), Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.71E-04	6.50E-04	3.35E-04	2.23E-04	5.58E-05	1.83E-03
	5	0.29E-02	0.32E-02	0.17E-02	0.11E-02	0.28E-03	0.92E-02
	10	0.57E-02	0.65E-02	0.34E-02	0.22E-02	0.56E-03	0.18E-01
	20	0.11E-01	0.13E-01	0.67E-02	0.45E-02	0.11E-02	0.37E-01
5	1	3.40E-05	3.87E-05	2.04E-05	1.36E-05	3.40E-06	1.10E-04
	5	0.17E-03	0.19E-03	0.10E-03	0.68E-04	0.17E-04	0.55E-03
	10	0.34E-03	0.39E-03	0.20E-03	0.14E-03	0.34E-04	0.11E-02
	20	0.68E-03	0.77E-03	0.41E-03	0.27E-03	0.68E-04	0.22E-02
10	1	1.09E-05	1.24E-05	6.59E-06	4.40E-06	1.10E-06	3.55E-05
	5	0.55E-04	0.62E-04	0.33E-04	0.22E-04	0.55E-05	0.18E-03
	10	0.11E-03	0.12E-03	0.66E-04	0.44E-04	0.11E-04	0.35E-03
	20	0.22E-03	0.25E-03	0.13E-03	0.88E-04	0.22E-04	0.71E-03
20	1	4.06E-06	4.62E-06	2.46E-06	1.64E-06	4.10E-07	1.32E-05
	5	0.20E-04	0.23E-04	0.12E-04	0.82E-05	0.21E-05	0.66E-04
	10	0.41E-04	0.46E-04	0.25E-04	0.16E-04	0.41E-05	0.13E-03
	20	0.81E-04	0.92E-04	0.49E-04	0.33E-04	0.82E-05	0.26E-03
40	1	1.73E-06	1.97E-06	1.05E-06	7.02E-07	1.75E-07	5.63E-06
	5	0.87E-05	0.99E-05	0.53E-05	0.35E-05	0.88E-06	0.28E-04
	10	0.17E-04	0.20E-04	0.11E-04	0.70E-05	0.18E-05	0.56E-04
	20	0.35E-04	0.39E-04	0.21E-04	0.14E-04	0.35E-05	0.11E-03
80	1	7.62E-07	8.67E-07	4.63E-07	3.09E-07	7.73E-08	2.48E-06
	5	0.38E-05	0.43E-05	0.23E-05	0.15E-05	0.39E-06	0.12E-04
	10	0.76E-05	0.87E-05	0.46E-05	0.31E-05	0.77E-06	0.25E-04
	20	0.15E-04	0.17E-04	0.93E-05	0.62E-05	0.15E-05	0.50E-04

Table K-5.24. Time-Integrated Dose (mrem) from Inhalation GI System (soluble radionuclides), Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.19E-04	2.49E-04	1.36E-04	9.09E-05	2.27E-05	7.17E-04
	5	0.11E-02	0.12E-02	0.68E-03	0.45E-03	0.11E-03	0.36E-02
	10	0.22E-02	0.25E-02	0.14E-02	0.91E-03	0.23E-03	0.72E-02
	20	0.44E-02	0.50E-02	0.27E-02	0.18E-02	0.45E-03	0.14E-01
5	1	1.25E-05	1.43E-05	7.66E-06	5.12E-06	1.28E-06	4.09E-05
	5	0.63E-04	0.71E-04	0.38E-04	0.26E-04	0.64E-05	0.20E-03
	10	0.13E-03	0.14E-03	0.77E-04	0.51E-04	0.13E-04	0.41E-03
	20	0.25E-03	0.29E-03	0.15E-03	0.10E-03	0.26E-04	0.82E-03
10	1	4.00E-06	4.55E-06	2.44E-06	1.63E-06	4.08E-07	1.30E-05
	5	0.20E-04	0.23E-04	0.12E-04	0.82E-05	0.20E-05	0.65E-04
	10	0.40E-04	0.46E-04	0.24E-04	0.16E-04	0.41E-05	0.13E-03
	20	0.80E-04	0.91E-04	0.49E-04	0.33E-04	0.82E-05	0.26E-03
20	1	1.48E-06	1.68E-06	9.00E-07	6.02E-07	1.50E-07	4.81E-06
	5	0.74E-05	0.84E-05	0.45E-05	0.30E-05	0.75E-06	0.24E-04
	10	0.15E-04	0.17E-04	0.90E-05	0.60E-05	0.15E-05	0.48E-04
	20	0.30E-04	0.34E-04	0.18E-04	0.12E-04	0.30E-05	0.96E-04
40	1	6.30E-07	7.17E-07	3.85E-07	2.57E-07	6.43E-08	2.05E-06
	5	0.31E-05	0.36E-05	0.19E-05	0.13E-05	0.32E-06	0.10E-04
	10	0.63E-05	0.72E-05	0.38E-05	0.26E-05	0.64E-06	0.21E-04
	20	0.13E-04	0.14E-04	0.77E-05	0.51E-05	0.13E-05	0.41E-04
80	1	2.77E-07	3.15E-07	1.69E-07	1.13E-07	2.83E-08	9.04E-07
	5	0.14E-05	0.16E-05	0.85E-06	0.57E-06	0.14E-06	0.45E-05
	10	0.28E-05	0.32E-05	0.17E-05	0.11E-05	0.28E-06	0.90E-05
	20	0.55E-05	0.63E-05	0.34E-05	0.23E-05	0.57E-06	0.18E-04

Table K-5.25. Time-Integrated Dose (mrem) from Inhalation
GI System (soluble radionuclides), Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.46E-04	2.80E-04	1.56E-04	1.05E-04	2.63E-05	8.14E-04
	5	0.12E-02	0.14E-02	0.78E-03	0.53E-03	0.13E-03	0.41E-02
	10	0.25E-02	0.28E-02	0.16E-02	0.11E-02	0.26E-03	0.81E-02
	20	0.49E-02	0.56E-02	0.31E-02	0.21E-02	0.53E-03	0.16E-01
5	1	1.37E-05	1.56E-05	8.44E-06	5.65E-06	1.41E-06	4.49E-05
	5	0.69E-04	0.78E-04	0.42E-04	0.28E-04	0.71E-05	0.22E-03
	10	0.14E-03	0.16E-03	0.84E-04	0.56E-04	0.14E-04	0.45E-03
	20	0.27E-03	0.31E-03	0.17E-03	0.11E-03	0.28E-04	0.90E-03
10	1	4.38E-06	4.98E-06	2.68E-06	1.79E-06	4.49E-07	1.43E-05
	5	0.22E-04	0.25E-04	0.13E-04	0.90E-05	0.22E-05	0.71E-04
	10	0.44E-04	0.50E-04	0.27E-04	0.18E-04	0.45E-05	0.14E-03
	20	0.88E-04	0.10E-03	0.54E-04	0.36E-04	0.90E-05	0.29E-03
20	1	1.62E-06	1.84E-06	9.90E-07	6.62E-07	1.66E-07	5.27E-06
	5	0.81E-05	0.92E-05	0.50E-05	0.33E-05	0.83E-06	0.26E-04
	10	0.16E-04	0.18E-04	0.99E-05	0.66E-05	0.17E-05	0.53E-04
	20	0.32E-04	0.37E-04	0.20E-04	0.13E-04	0.33E-05	0.11E-03
40	1	6.88E-07	7.83E-07	4.22E-07	2.82E-07	7.06E-08	2.25E-06
	5	0.34E-05	0.39E-05	0.21E-05	0.14E-05	0.35E-06	0.11E-04
	10	0.69E-05	0.78E-05	0.42E-05	0.28E-05	0.71E-06	0.22E-04
	20	0.14E-04	0.16E-04	0.84E-05	0.56E-05	0.14E-05	0.45E-04
80	1	3.03E-07	3.45E-07	1.86E-07	1.24E-07	3.10E-08	9.88E-07
	5	0.15E-05	0.17E-05	0.93E-06	0.62E-06	0.16E-06	0.49E-05
	10	0.30E-05	0.34E-05	0.19E-05	0.12E-05	0.31E-06	0.99E-05
	20	0.61E-05	0.69E-05	0.37E-05	0.25E-05	0.62E-06	0.20E-04

Table K-5.26. Time-Integrated Dose (mrem) from Inhalation
GI System (insoluble radionuclides), Angel = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.57E-04	1.45E-04	9.43E-05	9.16E-05	1.83E-05	5.06E-04
	5	0.78E-03	0.72E-03	0.47E-03	0.46E-03	0.92E-04	0.25E-02
	10	0.16E-02	0.14E-02	0.94E-03	0.92E-03	0.18E-03	0.51E-02
	20	0.31E-02	0.29E-02	0.19E-02	0.18E-02	0.37E-03	0.10E-01
5	1	7.25E-06	6.71E-06	3.78E-06	3.62E-06	7.24E-07	2.21E-05
	5	0.36E-04	0.34E-04	0.19E-04	0.18E-04	0.36E-05	0.11E-03
	10	0.72E-04	0.67E-04	0.38E-04	0.36E-04	0.72E-05	0.22E-03
	20	0.14E-03	0.13E-03	0.76E-04	0.72E-04	0.14E-04	0.44E-03
10	1	2.21E-06	2.04E-06	1.11E-06	1.06E-06	2.12E-07	6.63E-06
	5	0.11E-04	0.10E-04	0.55E-05	0.53E-05	0.11E-05	0.33E-04
	10	0.22E-04	0.20E-04	0.11E-04	0.11E-04	0.21E-05	0.66E-04
	20	0.44E-04	0.41E-04	0.22E-04	0.21E-04	0.42E-05	0.13E-03
20	1	7.96E-07	7.37E-07	3.92E-07	3.74E-07	7.48E-08	2.37E-06
	5	0.40E-05	0.37E-05	0.20E-05	0.19E-05	0.37E-06	0.12E-04
	10	0.80E-05	0.74E-05	0.39E-05	0.37E-05	0.75E-06	0.24E-04
	20	0.16E-04	0.15E-04	0.78E-05	0.75E-05	0.15E-05	0.47E-04
40	1	3.40E-07	3.15E-07	1.68E-07	1.60E-07	3.20E-08	1.01E-06
	5	0.17E-05	0.16E-05	0.84E-06	0.80E-06	0.16E-06	0.51E-05
	10	0.34E-05	0.31E-05	0.17E-05	0.16E-05	0.32E-06	0.10E-04
	20	0.66E-05	0.63E-05	0.34E-05	0.32E-05	0.64E-06	0.20E-04
80	1	1.50E-07	1.39E-07	7.40E-08	7.05E-08	1.41E-08	4.47E-07
	5	0.75E-06	0.69E-06	0.37E-06	0.35E-06	0.71E-07	0.22E-05
	10	0.15E-05	0.14E-05	0.74E-06	0.71E-06	0.14E-06	0.45E-05
	20	0.30E-05	0.28E-05	0.15E-05	0.14E-05	0.28E-06	0.89E-05

Table K-5.27. Time-Integrated Dose (mrem) from Inhalation GI System (insoluble radionuclides), Angel = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.09E-03	1.01E-03	5.22E-04	4.96E-04	9.91E-05	3.21E-03
	5	0.54E-02	0.50E-02	0.26E-02	0.25E-02	0.50E-03	0.16E-01
	10	0.11E-01	0.10E-01	0.52E-02	0.50E-02	0.99E-03	0.32E-01
	20	0.22E-01	0.20E-01	0.10E-01	0.99E-02	0.20E-02	0.64E-01
5	1	6.52E-05	6.03E-05	3.19E-05	3.04E-05	6.08E-06	1.94E-04
	5	0.33E-03	0.30E-03	0.16E-03	0.15E-03	0.30E-04	0.97E-03
	10	0.65E-03	0.60E-03	0.32E-03	0.30E-03	0.61E-04	0.19E-02
	20	0.13E-02	0.12E-02	0.64E-03	0.61E-03	0.12E-03	0.39E-02
10	1	2.09E-05	1.93E-05	1.03E-05	9.77E-06	1.95E-06	6.22E-05
	5	0.10E-03	0.97E-04	0.51E-04	0.49E-04	0.98E-05	0.31E-03
	10	0.21E-03	0.19E-03	0.10E-03	0.98E-04	0.20E-04	0.62E-03
	20	0.42E-03	0.39E-03	0.21E-03	0.20E-03	0.39E-04	0.12E-02
20	1	7.73E-06	7.16E-06	3.81E-06	3.63E-06	7.26E-07	2.30E-05
	5	0.39E-04	0.36E-04	0.19E-04	0.18E-04	0.36E-05	0.12E-03
	10	0.77E-04	0.72E-04	0.38E-04	0.36E-04	0.73E-05	0.23E-03
	20	0.15E-03	0.14E-03	0.76E-04	0.73E-04	0.15E-04	0.46E-03
40	1	3.30E-06	3.05E-06	1.63E-06	1.55E-06	3.10E-07	9.84E-06
	5	0.16E-04	0.15E-04	0.81E-05	0.78E-05	0.16E-05	0.49E-04
	10	0.33E-04	0.31E-04	0.16E-04	0.16E-04	0.31E-05	0.98E-04
	20	0.66E-04	0.61E-04	0.33E-04	0.31E-04	0.62E-05	0.20E-03
80	1	1.45E-06	1.34E-06	7.17E-07	6.84E-07	1.37E-07	4.33E-06
	5	0.73E-05	0.67E-05	0.36E-05	0.34E-05	0.68E-06	0.22E-04
	10	0.15E-04	0.13E-04	0.72E-05	0.68E-05	0.14E-05	0.43E-04
	20	0.29E-04	0.27E-04	0.14E-04	0.14E-04	0.27E-05	0.87E-04

Table K-5.28. Time-Integrated Dose (mrem) from Inhalation GI System (insoluble radionuclides), Angel = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	8.20E-04	7.59E-04	3.92E-04	3.72E-04	7.44E-05	2.42E-03
	5	0.41E-02	0.38E-02	0.20E-02	0.19E-02	0.37E-03	0.12E-01
	10	0.82E-02	0.76E-02	0.39E-02	0.37E-02	0.74E-03	0.24E-01
	20	0.16E-01	0.15E-01	0.78E-02	0.74E-02	0.15E-02	0.48E-01
5	1	4.89E-05	4.52E-05	2.38E-05	2.27E-05	4.54E-06	1.45E-04
	5	0.24E-03	0.23E-03	0.12E-03	0.11E-03	0.23E-04	0.73E-03
	10	0.49E-03	0.45E-03	0.24E-03	0.23E-03	0.45E-04	0.15E-02
	20	0.98E-03	0.90E-03	0.48E-03	0.45E-03	0.91E-04	0.29E-02
10	1	1.57E-05	1.45E-05	7.70E-06	7.34E-06	1.47E-06	4.67E-05
	5	0.79E-04	0.73E-04	0.39E-04	0.37E-04	0.73E-05	0.23E-03
	10	0.16E-03	0.15E-03	0.77E-04	0.73E-04	0.15E-04	0.47E-03
	20	0.31E-03	0.29E-03	0.15E-03	0.15E-03	0.29E-04	0.93E-03
20	1	5.83E-06	5.39E-06	2.87E-06	2.73E-06	5.47E-07	1.74E-05
	5	0.29E-04	0.27E-04	0.14E-04	0.14E-04	0.27E-05	0.87E-04
	10	0.58E-04	0.54E-04	0.29E-04	0.27E-04	0.55E-05	0.17E-03
	20	0.12E-03	0.11E-03	0.57E-04	0.55E-04	0.11E-04	0.35E-03
40	1	2.49E-06	2.30E-06	1.23E-06	1.17E-06	2.34E-07	7.42E-06
	5	0.12E-04	0.12E-04	0.61E-05	0.58E-05	0.12E-05	0.37E-04
	10	0.25E-04	0.23E-04	0.12E-04	0.12E-04	0.23E-05	0.74E-04
	20	0.50E-04	0.46E-04	0.25E-04	0.23E-04	0.47E-05	0.15E-03
80	1	1.09E-06	1.01E-06	5.40E-07	5.15E-07	1.03E-07	3.27E-06
	5	0.55E-05	0.51E-05	0.27E-05	0.26E-05	0.52E-06	0.16E-04
	10	0.11E-04	0.10E-04	0.54E-05	0.52E-05	0.10E-05	0.33E-04
	20	0.22E-04	0.20E-04	0.11E-04	0.10E-04	0.21E-05	0.65E-04

Table K-5.29. Time-Integrated Dose (mrem) from Inhalation GI System (insoluble radionuclides), Angel = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	3.14E-04	2.91E-04	1.59E-04	1.51E-04	3.03E-05	9.46E-04
	5	0.16E-02	0.15E-02	0.79E-03	0.76E-03	0.15E-03	0.47E-02
	10	0.31E-02	0.29E-02	0.16E-02	0.15E-02	0.30E-03	0.95E-02
	20	0.63E-02	0.58E-02	0.32E-02	0.30E-02	0.61E-03	0.19E-01
5	1	1.80E-05	1.67E-05	8.95E-06	8.54E-06	1.71E-06	5.39E-05
	5	0.90E-04	0.83E-04	0.45E-04	0.43E-04	0.85E-05	0.27E-03
	10	0.18E-03	0.17E-03	0.90E-04	0.85E-04	0.17E-04	0.54E-03
	20	0.36E-03	0.33E-03	0.18E-03	0.17E-03	0.34E-04	0.11E-02
10	1	5.74E-06	5.32E-06	2.85E-06	2.72E-06	5.44E-07	1.72E-05
	5	0.29E-04	0.27E-04	0.14E-04	0.14E-04	0.27E-05	0.86E-04
	10	0.57E-04	0.53E-04	0.29E-04	0.27E-04	0.54E-05	0.17E-03
	20	0.11E-03	0.11E-03	0.57E-04	0.54E-04	0.11E-04	0.34E-03
20	1	2.12E-06	1.96E-06	1.05E-06	1.00E-06	2.01E-07	6.34E-06
	5	0.11E-04	0.98E-05	0.53E-05	0.50E-05	0.10E-05	0.32E-04
	10	0.21E-04	0.20E-04	0.11E-04	0.10E-04	0.20E-05	0.63E-04
	20	0.42E-04	0.39E-04	0.21E-04	0.20E-04	0.40E-05	0.13E-03
40	1	9.04E-07	8.37E-07	4.49E-07	4.29E-07	8.57E-08	2.71E-06
	5	0.45E-05	0.42E-05	0.22E-05	0.21E-05	0.43E-06	0.14E-04
	10	0.90E-05	0.84E-05	0.45E-05	0.43E-05	0.86E-06	0.27E-04
	20	0.18E-04	0.17E-04	0.90E-05	0.86E-05	0.17E-05	0.54E-04
80	1	3.98E-07	3.68E-07	1.98E-07	1.89E-07	3.78E-08	1.19E-06
	5	0.20E-05	0.18E-05	0.99E-06	0.94E-06	0.19E-06	0.60E-05
	10	0.40E-05	0.37E-05	0.20E-05	0.19E-05	0.38E-06	0.12E-04
	20	0.80E-05	0.74E-05	0.40E-05	0.38E-05	0.76E-06	0.24E-04

Table K-5.30. Time-Integrated Dose (mrem) from Inhalation GI System (insoluble radionuclides), Angel = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	3.53E-04	3.27E-04	1.83E-04	1.75E-04	3.50E-05	1.07E-03
	5	0.18E-02	0.16E-02	0.91E-03	0.88E-03	0.18E-03	0.54E-02
	10	0.35E-02	0.33E-02	0.18E-02	0.18E-02	0.35E-03	0.11E-01
	20	0.71E-02	0.65E-02	0.37E-02	0.35E-02	0.70E-03	0.21E-01
5	1	1.97E-05	1.83E-05	9.86E-06	9.41E-06	1.88E-06	5.92E-05
	5	0.99E-04	0.91E-04	0.49E-04	0.47E-04	0.94E-05	0.30E-03
	10	0.20E-03	0.18E-03	0.99E-04	0.94E-04	0.19E-04	0.59E-03
	20	0.39E-03	0.37E-03	0.20E-03	0.19E-03	0.38E-04	0.12E-02
10	1	6.28E-06	5.82E-06	3.13E-06	2.99E-06	5.98E-07	1.88E-05
	5	0.31E-04	0.29E-04	0.16E-04	0.15E-04	0.30E-05	0.94E-04
	10	0.63E-04	0.58E-04	0.31E-04	0.30E-04	0.60E-05	0.19E-03
	20	0.13E-03	0.12E-03	0.63E-04	0.60E-04	0.12E-04	0.38E-03
20	1	2.32E-06	2.15E-06	1.16E-06	1.10E-06	2.21E-07	6.95E-06
	5	0.12E-04	0.11E-04	0.58E-05	0.55E-05	0.11E-05	0.35E-04
	10	0.23E-04	0.21E-04	0.12E-04	0.11E-04	0.22E-05	0.69E-04
	20	0.46E-04	0.43E-04	0.23E-04	0.22E-04	0.44E-05	0.14E-03
40	1	9.88E-07	9.15E-07	4.93E-07	4.70E-07	9.41E-08	2.96E-06
	5	0.49E-05	0.46E-05	0.25E-05	0.24E-05	0.47E-06	0.15E-04
	10	0.99E-05	0.92E-05	0.49E-05	0.47E-05	0.94E-06	0.30E-04
	20	0.20E-04	0.18E-04	0.99E-05	0.94E-05	0.19E-05	0.59E-04
80	1	4.35E-07	4.02E-07	2.17E-07	2.07E-07	4.14E-08	1.30E-06
	5	0.22E-05	0.20E-05	0.11E-05	0.10E-05	0.21E-06	0.65E-05
	10	0.43E-05	0.40E-05	0.22E-05	0.21E-05	0.41E-06	0.13E-04
	20	0.87E-05	0.80E-05	0.43E-05	0.41E-05	0.83E-06	0.26E-04

Table K-5.31. Time-Integrated Dose (mrem) from Inhalation
Liver, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	0.0	0.0	1.08E 00	0.0	5.49E-02	1.13E 00
	5	0.0	0.0	0.52E 01	0.0	0.27E 00	0.55E 01
	10	0.0	0.0	0.10E 02	0.0	0.55E 00	0.11E 02
	20	0.0	0.0	0.19E 02	0.0	0.11E 01	0.20E 02
5	1	0.0	0.0	4.31E-02	0.0	2.17E-03	4.53E-02
	5	0.0	0.0	0.21E 00	0.0	0.11E-01	0.22E 00
	10	0.0	0.0	0.41E 00	0.0	0.22E-01	0.43E 00
	20	0.0	0.0	0.76E 00	0.0	0.43E-01	0.80E 00
10	1	0.0	0.0	1.27E-02	0.0	6.36E-04	1.33E-02
	5	0.0	0.0	0.62E-01	0.0	0.32E-02	0.65E-01
	10	0.0	0.0	0.12E 00	0.0	0.64E-02	0.13E 00
	20	0.0	0.0	0.22E 00	0.0	0.13E-01	0.24E 00
20	1	0.0	0.0	4.48E-03	0.0	2.24E-04	4.70E-03
	5	0.0	0.0	0.22E-01	0.0	0.11E-02	0.23E-01
	10	0.0	0.0	0.42E-01	0.0	0.22E-02	0.45E-01
	20	0.0	0.0	0.79E-01	0.0	0.45E-02	0.83E-01
40	1	0.0	0.0	1.92E-03	0.0	9.60E-05	2.01E-03
	5	0.0	0.0	0.93E-02	0.0	0.48E-03	0.98E-02
	10	0.0	0.0	0.18E-01	0.0	0.96E-03	0.19E-01
	20	0.0	0.0	0.34E-01	0.0	0.19E-02	0.36E-01
80	1	0.0	0.0	8.44E-04	0.0	4.23E-05	8.87E-04
	5	0.0	0.0	0.41E-02	0.0	0.21E-03	0.43E-02
	10	0.0	0.0	0.80E-02	0.0	0.42E-03	0.84E-02
	20	0.0	0.0	0.15E-01	0.0	0.85E-03	0.16E-01

Table K-5.32. Time-Integrated Dose (mrem) from Inhalation
Liver, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	0.0	0.0	5.95E 00	0.0	2.97E-01	6.25E 00
	5	0.0	0.0	0.29E 02	0.0	0.15E 01	0.31E 02
	10	0.0	0.0	0.56E 02	0.0	0.30E 01	0.59E 02
	20	0.0	0.0	0.10E 03	0.0	0.59E 01	0.11E 03
5	1	0.0	0.0	3.64E-01	0.0	1.83E-02	3.83E-01
	5	0.0	0.0	0.18E 01	0.0	0.91E-01	0.19E 01
	10	0.0	0.0	0.34E 01	0.0	0.18E 00	0.36E 01
	20	0.0	0.0	0.64E 01	0.0	0.36E 00	0.68E 01
10	1	0.0	0.0	1.17E-01	0.0	5.86E-03	1.23E-01
	5	0.0	0.0	0.57E 00	0.0	0.29E-01	0.60E 00
	10	0.0	0.0	0.11E 01	0.0	0.59E-01	0.12E 01
	20	0.0	0.0	0.21E 01	0.0	0.12E 00	0.22E 01
20	1	0.0	0.0	4.35E-02	0.0	2.18E-03	4.57E-02
	5	0.0	0.0	0.21E 00	0.0	0.11E-01	0.22E 00
	10	0.0	0.0	0.41E 00	0.0	0.22E-01	0.43E 00
	20	0.0	0.0	0.77E 00	0.0	0.44E-01	0.81E 00
40	1	0.0	0.0	1.86E-02	0.0	9.31E-04	1.95E-02
	5	0.0	0.0	0.91E-01	0.0	0.47E-02	0.95E-01
	10	0.0	0.0	0.18E 00	0.0	0.93E-02	0.18E 00
	20	0.0	0.0	0.33E 00	0.0	0.19E-01	0.35E 00
80	1	0.0	0.0	8.19E-03	0.0	4.10E-04	8.60E-03
	5	0.0	0.0	0.4.E-01	0.0	0.21E-02	0.42E-01
	10	0.0	0.0	0.77E-01	0.0	0.41E-02	0.81E-01
	20	0.0	0.0	0.14E 00	0.0	0.82E-02	0.15E 00

Table K-5.33. Time-Integrated Dose (mrem) from Inhalation
Liver, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	0.0	0.0	4.47E 00	0.0	2.23E-01	4.69E 00
	5	0.0	0.0	0.22E 02	0.0	0.11E 01	0.23E 02
	10	0.0	0.0	0.42E 02	0.0	0.22E 01	0.44E 02
	20	0.0	0.0	0.79E 02	0.0	0.45E 01	0.83E 02
5	1	0.0	0.0	2.72E-01	0.0	1.36E-02	2.86E-01
	5	0.0	0.0	0.13E 01	0.0	0.68E-01	0.14E 01
	10	0.0	0.0	0.26E 01	0.0	0.14E 00	0.27E 01
	20	0.0	0.0	0.48E 01	0.0	0.27E 00	0.51E 01
10	1	0.0	0.0	8.79E-02	0.0	4.40E-03	9.23E-02
	5	0.0	0.0	0.43E 00	0.0	0.22E-01	0.45E 00
	10	0.0	0.0	0.83E 00	0.0	0.44E-01	0.87E 00
	20	0.0	0.0	0.15E 01	0.0	0.88E-01	0.16E 01
20	1	0.0	0.0	3.28E-02	0.0	1.64E-03	3.44E-02
	5	0.0	0.0	0.16E 00	0.0	0.82E-02	0.17E 00
	10	0.0	0.0	0.31E 00	0.0	0.16E-01	0.33E 00
	20	0.0	0.0	0.58E 00	0.0	0.33E-01	0.61E 00
40	1	0.0	0.0	1.40E-02	0.0	7.02E-04	1.47E-02
	5	0.0	0.0	0.68E-01	0.0	0.35E-02	0.72E-01
	10	0.0	0.0	0.13E 00	0.0	0.70E-02	0.14E 00
	20	0.0	0.0	0.25E 00	0.0	0.14E-01	0.26E 00
80	1	0.0	0.0	6.17E-03	0.0	3.09E-04	6.48E-03
	5	0.0	0.0	0.30E-01	0.0	0.15E-02	0.32E-01
	10	0.0	0.0	0.58E-01	0.0	0.31E-02	0.61E-01
	20	0.0	0.0	0.11E 00	0.0	0.62E-02	0.11E 00

Table K-5.34. Time-Integrated Dose (mrem) from Inhalation
Liver, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	0.0	0.0	1.81E 00	0.0	9.09E-02	1.90E 00
	5	0.0	0.0	0.88E 01	0.0	0.45E 00	0.93E 01
	10	0.0	0.0	0.17E 02	0.0	0.91E 00	0.18E 02
	20	0.0	0.0	0.32E 02	0.0	0.18E 01	0.34E 02
5	1	0.0	0.0	1.02E-01	0.0	5.12E-03	1.07E-01
	5	0.0	0.0	0.50E 00	0.0	0.26E-01	0.52E 00
	10	0.0	0.0	0.96E 00	0.0	0.51E-01	0.10E 01
	20	0.0	0.0	0.18E 01	0.0	0.10E 00	0.19E 01
10	1	0.0	0.0	3.25E-02	0.0	1.63E-03	3.42E-02
	5	0.0	0.0	0.16E 00	0.0	0.82E-02	0.17E 00
	10	0.0	0.0	0.31E 00	0.0	0.16E-01	0.32E 00
	20	0.0	0.0	0.57E 00	0.0	0.33E-01	0.61E 00
20	1	0.0	0.0	1.20E-02	0.0	6.02E-04	1.26E-02
	5	0.0	0.0	0.59E-01	0.0	0.30E-02	0.62E-01
	10	0.0	0.0	0.11E 00	0.0	0.60E-02	0.12E 00
	20	0.0	0.0	0.21E 00	0.0	0.12E-01	0.22E 00
40	1	0.0	0.0	5.13E-03	0.0	2.57E-04	5.39E-03
	5	0.0	0.0	0.25E-01	0.0	0.13E-02	0.26E-01
	10	0.0	0.0	0.48E-01	0.0	0.26E-02	0.51E-01
	20	0.0	0.0	0.90E-01	0.0	0.51E-02	0.95E-01
80	1	0.0	0.0	2.26E-03	0.0	1.13E-04	2.37E-03
	5	0.0	0.0	0.11E-01	0.0	0.57E-03	0.12E-01
	10	0.0	0.0	0.21E-01	0.0	0.11E-02	0.22E-01
	20	0.0	0.0	0.40E-01	0.0	0.23E-02	0.42E-01

Table K-5.35. Time-Integrated Dose (mrem) from Inhalation
Liver, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	0.0	0.0	2.09E 00	0.0	1.05E-01	2.19E 00
	5	0.0	0.0	0.10E 02	0.0	0.53E 00	0.11E 02
	10	0.0	0.0	0.20E 02	0.0	0.11E 01	0.21E 02
	20	0.0	0.0	0.37E 02	0.0	0.21E 01	0.39E 02
5	1	0.0	0.0	1.13E-01	0.0	5.65E-03	1.18E-01
	5	0.0	0.0	0.55E 00	0.0	0.28E-01	0.58E 00
	10	0.0	0.0	0.11E 01	0.0	0.56E-01	0.11E 01
	20	0.0	0.0	0.20E 01	0.0	0.11E 00	0.21E 01
10	1	0.0	0.0	3.58E-02	0.0	1.80E-03	3.76E-02
	5	0.0	0.0	0.17E 00	0.0	0.90E-02	0.18E 00
	10	0.0	0.0	0.34E 00	0.0	0.18E-01	0.36E 00
	20	0.0	0.0	0.63E 00	0.0	0.36E-01	0.67E 00
20	1	0.0	0.0	1.32E-02	0.0	6.63E-04	1.39E-02
	5	0.0	0.0	0.64E-01	0.0	0.33E-02	0.68E-01
	10	0.0	0.0	0.12E 00	0.0	0.66E-02	0.13E 00
	20	0.0	0.0	0.23E 00	0.0	0.13E-01	0.25E 00
40	1	0.0	0.0	5.63E-03	0.0	2.82E-04	5.91E-03
	5	0.0	0.0	0.27E-01	0.0	0.14E-02	0.29E-01
	10	0.0	0.0	0.53E-01	0.0	0.28E-02	0.56E-01
	20	0.0	0.0	0.99E-01	0.0	0.56E-02	0.10E 00
80	1	0.0	0.0	2.48E-03	0.0	1.24E-04	2.60E-03
	5	0.0	0.0	0.12E-01	0.0	0.62E-03	0.13E-01
	10	0.0	0.0	0.23E-01	0.0	0.12E-02	0.25E-01
	20	0.0	0.0	0.44E-01	0.0	0.25E-02	0.46E-01

APPENDIX K-6. DOSE RATE FROM AIRBORNE AND GROUND-DEPOSITED RADIONUCLIDES

Table K-6.1 Maximum Total Dose Rate from Ground and Cloud--Angle = 45°

Table K-6.2 Total Dose Rate from Ground and Cloud--Angle = 0°

Table K-6.3 Total Dose Rate from Ground and Cloud--Angle = 90°

Table K-6.4 Total Dose Rate from Ground and Cloud--Angle = 180°

Table K-6.5 Total Dose Rate from Ground and Cloud--Angle = 270°

TABLE K-6.1. MAXIMUM TOTAL DOSE RATE (MREM/YEAR) FROM GROUND AND CLOUD
ANGLE = 45°

DISTANCE	SKIN	WHOLE BODY	OVARIES	TESTES	SMALL INTESTINE	LUNG	RED MARROW	SKELETON	SPLEEN
0.1	0.14E 02	0.57E 01	0.27E 01	0.53E 01	0.30E 01	0.34E 01	0.79E 01	0.86E 01	0.35E 01
0.5	0.57E 01	0.24E 01	0.11E 01	0.22E 01	0.13E 01	0.15E 01	0.32E 01	0.35E 01	0.15E 01
1.0	0.15E 01	0.64E 00	0.30E 00	0.58E 00	0.34E 00	0.39E 00	0.87E 00	0.95E 00	0.39E 00
2.0	0.48E 00	0.20E 00	0.94E-01	0.18E 00	0.11E 00	0.12E 00	0.27E 00	0.30E 00	0.12E 00
3.0	0.19E 00	0.79E-01	0.37E-01	0.73E-01	0.42E-01	0.49E-01	0.11E 00	0.12E 00	0.49E-01
4.0	0.10E 00	0.44E-01	0.21E-01	0.41E-01	0.23E-01	0.27E-01	0.60E-01	0.66E-01	0.30E-01
5.0	0.67E-01	0.29E-01	0.13E-01	0.27E-01	0.17E-01	0.21E-01	0.39E-01	0.42E-01	0.18E-01
10.0	0.33E-01	0.16E-01	0.63E-02	0.12E-01	0.68E-02	0.83E-02	0.17E-01	0.19E-01	0.78E-02
20.0	0.10E-01	0.48E-02	0.22E-02	0.44E-02	0.23E-02	0.28E-02	0.59E-02	0.68E-02	0.27E-02
30.0	0.51E-02	0.23E-02	0.11E-02	0.23E-02	0.12E-02	0.17E-02	0.31E-02	0.36E-02	0.13E-02
40.0	0.34E-02	0.18E-02	0.80E-03	0.16E-02	0.76E-03	0.95E-03	0.20E-02	0.22E-02	0.88E-03
50.0	0.25E-02	0.11E-02	0.52E-03	0.11E-02	0.56E-03	0.70E-03	0.15E-02	0.20E-02	0.64E-03
60.0	0.20E-02	0.89E-03	0.42E-03	0.11E-02	0.44E-03	0.53E-03	0.11E-02	0.17E-02	0.51E-03
70.0	0.16E-02	0.70E-03	0.33E-03	0.96E-03	0.36E-03	0.47E-03	0.95E-03	0.17E-02	0.42E-03

TABLE K-6.2. TOTAL DOSE RATE (MREM/YEAR) FROM GROUND AND CLOUD
ANGLE = 0°

DISTANCE	SKIN	WHOLE BODY	OVARIES	TESTES	SMALL INTESTINE	LUNG	RED MARROW	SKELETON	SPLEEN
0.1	0.73E 01	0.30E 01	0.14E 01	0.28E 01	0.15E 01	0.17E 01	0.42E 01	0.46E 01	0.18E 01
0.5	0.16E 01	0.66E 00	0.32E 00	0.61E 00	0.35E 00	0.38E 00	0.92E 00	0.10E 01	0.41E 00
1.0	0.42E 00	0.17E 00	0.83E-01	0.16E 00	0.90E-01	0.10E 00	0.24E 00	0.26E 00	0.11E 00
2.0	0.69E-01	0.30E-01	0.14E-01	0.27E-01	0.15E-01	0.18E-01	0.39E-01	0.43E-01	0.18E-01
3.0	0.24E-01	0.10E-01	0.48E-02	0.93E-02	0.53E-02	0.64E-02	0.14E-01	0.15E-01	0.62E-02
4.0	0.12E-01	0.56E-02	0.26E-02	0.50E-02	0.28E-02	0.35E-02	0.72E-02	0.80E-02	0.32E-02
5.0	0.77E-02	0.36E-02	0.16E-02	0.32E-02	0.17E-02	0.21E-02	0.45E-02	0.51E-02	0.20E-02
10.0	0.33E-02	0.15E-02	0.69E-03	0.15E-02	0.73E-03	0.88E-03	0.19E-02	0.22E-02	0.86E-03
20.0	0.11E-02	0.48E-03	0.23E-03	0.56E-03	0.24E-03	0.30E-03	0.62E-03	0.84E-03	0.28E-03
30.0	0.52E-03	0.24E-03	0.11E-03	0.34E-03	0.12E-03	0.15E-03	0.31E-03	0.50E-03	0.14E-03
40.0	0.34E-03	0.16E-03	0.76E-04	0.27E-03	0.77E-04	0.10E-03	0.20E-03	0.39E-03	0.90E-04
50.0	0.25E-03	0.12E-03	0.56E-04	0.23E-03	0.57E-04	0.75E-04	0.15E-03	0.33E-03	0.67E-04
60.0	0.20E-03	0.94E-04	0.45E-04	0.21E-03	0.45E-04	0.60E-04	0.12E-03	0.29E-03	0.53E-04
70.0	0.16E-03	0.77E-04	0.37E-04	0.19E-03	0.37E-04	0.49E-04	0.99E-04	0.27E-03	0.60E-02

TABLE K-6.3. TOTAL DOSE RATE (MREM/YEAR) FROM GROUND AND CLOUD
ANGLE = 90°

DISTANCE	SKIN	WHOLE BODY	OVARIES	TESTES	SMALL INTESTINE	LUNG	RED MARROW	SKELETON	SPLEEN
0.1	0.12E 02	0.50E 01	0.24E 01	0.46E 01	0.26E 01	0.29E 01	0.70E 01	0.76E 01	0.31E 01
0.5	0.45E 01	0.19E 01	0.88E 00	0.17E 01	0.10E 01	0.11E 01	0.25E 01	0.28E 01	0.12E 01
1.0	0.12E 01	0.51E 00	0.24E 00	0.46E 00	0.27E 00	0.31E 00	0.69E 00	0.76E 00	0.32E 00
2.0	0.36E 00	0.15E 00	0.71E-01	0.14E 00	0.81E-01	0.96E-01	0.20E 00	0.22E 00	0.94E-01
3.0	0.14E 00	0.62E-01	0.28E-01	0.55E-01	0.32E-01	0.38E-01	0.81E-01	0.89E-01	0.37E-01
4.0	0.78E-01	0.35E-01	0.16E-01	0.31E-01	0.18E-01	0.22E-01	0.45E-01	0.50E-01	0.20E-01
5.0	0.51E-01	0.23E-01	0.10E-01	0.20E-01	0.11E-01	0.14E-01	0.29E-01	0.33E-01	0.13E-01
10.0	0.23E-01	0.10E-01	0.47E-02	0.97E-02	0.51E-02	0.61E-02	0.13E-01	0.15E-01	0.59E-02
20.0	0.77E-02	0.35E-02	0.16E-02	0.40E-02	0.17E-02	0.22E-02	0.45E-02	0.61E-02	0.20E-02
30.0	0.38E-02	0.18E-02	0.84E-03	0.25E-02	0.86E-03	0.11E-02	0.23E-02	0.37E-02	0.10E-02
40.0	0.25E-02	0.12E-02	0.56E-03	0.20E-02	0.57E-03	0.75E-03	0.15E-02	0.29E-02	0.67E-03
50.0	0.19E-02	0.88E-03	0.42E-03	0.17E-02	0.42E-03	0.56E-03	0.11E-02	0.24E-02	0.49E-03
60.0	0.15E-02	0.70E-03	0.33E-03	0.15E-02	0.33E-03	0.44E-03	0.89E-03	0.22E-02	0.39E-03
70.0	0.12E-02	0.57E-03	0.27E-03	0.14E-02	0.27E-03	0.37E-03	0.73E-03	0.20E-02	0.84E-02

TABLE K-6.4. TOTAL DOSE RATE (MREM/YEAR) FROM GROUND AND CLOUD
ANGLE = 180°

DISTANCE	SKIN	WHOLE BODY	OVARIES	TESTES	SMALL INTESTINE	LUNG	RED MARROW	SKELETON	SPLEEN
0.1	0.50E 01	0.21E 01	0.98E 00	0.19E 01	0.11E 01	0.12E 01	0.29E 01	0.31E 01	0.13E 01
0.5	0.19E 01	0.78E 00	0.37E 00	0.71E 00	0.42E 00	0.48E 00	0.11E 01	0.12E 01	0.49E 00
1.0	0.48E 00	0.20E 00	0.94E-01	0.18E 00	0.11E 00	0.12E 00	0.27E 00	0.30E 00	0.13E 00
2.0	0.14E 00	0.59E-01	0.27E-01	0.52E-01	0.31E-01	0.36E-01	0.78E-01	0.85E-01	0.36E-01
3.0	0.52E-01	0.23E-01	0.11E-01	0.20E-01	0.12E-01	0.14E-01	0.30E-01	0.33E-01	0.14E-01
4.0	0.29E-01	0.13E-01	0.59E-02	0.11E-01	0.65E-02	0.80E-02	0.17E-01	0.18E-01	0.75E-02
5.0	0.18E-01	0.84E-02	0.38E-02	0.75E-02	0.41E-02	0.50E-02	0.11E-01	0.12E-01	0.48E-02
10.0	0.82E-02	0.37E-02	0.17E-02	0.35E-02	0.18E-02	0.22E-02	0.47E-02	0.56E-02	0.21E-02
20.0	0.28E-02	0.13E-02	0.59E-03	0.14E-02	0.62E-03	0.78E-03	0.16E-02	0.22E-02	0.72E-03
30.0	0.14E-02	0.64E-03	0.30E-03	0.89E-03	0.31E-03	0.40E-03	0.81E-03	0.13E-02	0.36E-03
40.0	0.90E-03	0.42E-03	0.20E-03	0.71E-03	0.20E-03	0.27E-03	0.54E-03	0.10E-02	0.24E-03
50.0	0.67E-03	0.32E-03	0.15E-03	0.61E-03	0.15E-03	0.20E-03	0.40E-03	0.88E-03	0.18E-03
60.0	0.53E-03	0.25E-03	0.12E-03	0.55E-03	0.12E-03	0.16E-03	0.32E-03	0.78E-03	0.14E-03
70.0	0.43E-03	0.20E-03	0.98E-04	0.51E-03	0.98E-04	0.13E-03	0.26E-03	0.71E-03	0.81E-02

TABLE K-6.5. TOTAL DOSE RATE (MREM/YEAR) FROM GROUND AND CLOUD
ANGLE = 270°

DISTANCE	SKIN	WHOLE BODY	OVARIES	TESTES	SMALL INTESTINE	LUNG	RED MARROW	SKELETON	SPLEEN
0.1	0.38E 01	0.16E 01	0.75E 00	0.15E 01	0.83E 00	0.93E 00	0.22E 01	0.24E 01	0.98E 00
0.5	0.20E 01	0.84E 00	0.40E 00	0.77E 00	0.45E 00	0.51E 00	0.12E 01	0.13E 01	0.52E 00
1.0	0.48E 00	0.20E 00	0.94E-01	0.18E 00	0.11E 00	0.12E 00	0.27E 00	0.30E 00	0.12E 00
2.0	0.15E 00	0.64E-01	0.30E-01	0.58E-01	0.34E-01	0.40E-01	0.87E-01	0.95E-01	0.40E-01
3.0	0.57E-01	0.25E-01	0.11E-01	0.22E-01	0.13E-01	0.15E-01	0.33E-01	0.36E-01	0.15E-01
4.0	0.31E-01	0.14E-01	0.63E-02	0.12E-01	0.71E-02	0.85E-02	0.18E-01	0.20E-01	0.82E-02
5.0	0.20E-01	0.89E-02	0.41E-02	0.80E-02	0.45E-02	0.54E-02	0.12E-01	0.13E-01	0.53E-02
10.0	0.89E-02	0.39E-02	0.18E-02	0.38E-02	0.20E-02	0.24E-02	0.51E-02	0.60E-02	0.23E-02
20.0	0.30E-02	0.14E-02	0.64E-03	0.15E-02	0.68E-03	0.84E-03	0.18E-02	0.24E-02	0.79E-03
30.0	0.15E-02	0.69E-03	0.33E-03	0.96E-03	0.34E-03	0.43E-03	0.88E-03	0.14E-02	0.39E-03
40.0	0.99E-03	0.46E-03	0.22E-03	0.76E-03	0.22E-03	0.29E-03	0.59E-03	0.11E-02	0.26E-03
50.0	0.73E-03	0.34E-03	0.16E-03	0.66E-03	0.16E-03	0.22E-03	0.44E-03	0.95E-03	0.19E-03
60.0	0.57E-03	0.27E-03	0.13E-03	0.60E-03	0.13E-03	0.17E-03	0.35E-03	0.85E-03	0.15E-03
70.0	0.47E-03	0.22E-03	0.11E-03	0.55E-03	0.11E-03	0.14E-03	0.28E-03	0.78E-03	0.55E-02

APPENDIX K-7. TIME-INTEGRATED DOSE FROM EXTERNAL EXPOSURE TO AIRBORNE RADIONUCLIDES

Tables K-7.1--K-7.5.	Dose to Whole Body
Tables K-7.6--K-7.10.	Dose to Skin
Tables K-7.11--K-7.15.	Dose to Ovaries
Tables K-7.16--K-7.20.	Dose to Testes
Tables K-7.21--K-7.25.	Dose to Small Intestine
Tables K-7.26--K-7.30.	Dose to Lung
Tables K-7.31--K-7.35.	Dose to Red Marrow
Tables K-7.36--K-7.40.	Dose to Skeleton
Tables K-7.41--K-7.45.	Dose to Spleen

Table K-7.1. Time-Integrated Dose from External Exposure to Airborne Radionuclides Whole Body, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	9.11E-10	7.03E-08	1.35E-09	1.79E-08	1.35E-03	1.35E-03
	5	0.46E-08	0.35E-06	0.68E-08	0.90E-07	0.67E-02	0.67E-02
	10	0.91E-08	0.70E-06	0.14E-07	0.18E-06	0.13E-01	0.13E-01
	20	0.16E-07	0.14E-05	0.27E-07	0.36E-06	0.27E-01	0.27E-01
5	1	4.21E-11	3.26E-09	5.42E-11	7.10E-10	2.14E-04	2.14E-04
	5	0.21E-09	0.16E-07	0.27E-09	0.35E-08	0.11E-02	0.11E-02
	10	0.42E-09	0.33E-07	0.54E-09	0.71E-08	0.21E-02	0.21E-02
	20	0.84E-09	0.65E-07	0.11E-08	0.14E-07	0.43E-02	0.43E-02
10	1	1.28E-11	9.92E-10	1.59E-11	2.08E-10	7.74E-05	7.74E-05
	5	0.64E-10	0.50E-08	0.80E-10	0.10E-08	0.39E-03	0.39E-03
	10	0.13E-09	0.99E-08	0.16E-09	0.21E-08	0.77E-03	0.77E-03
	20	0.26E-09	0.20E-07	0.32E-09	0.42E-08	0.15E-02	0.15E-02
20	1	4.63E-12	3.58E-10	5.63E-12	7.33E-11	3.11E-05	3.11E-05
	5	0.23E-10	0.18E-08	0.28E-10	0.37E-09	0.16E-03	0.16E-03
	10	0.46E-10	0.36E-08	0.56E-10	0.73E-09	0.31E-03	0.31E-03
	20	0.93E-10	0.72E-08	0.11E-09	0.15E-08	0.62E-03	0.62E-03
40	1	1.98E-12	1.53E-10	2.41E-12	3.14E-11	1.41E-05	1.41E-05
	5	0.99E-11	0.76E-09	0.12E-10	0.16E-09	0.70E-04	0.70E-04
	10	0.20E-10	0.15E-08	0.24E-10	0.31E-09	0.14E-03	0.14E-03
	20	0.40E-10	0.31E-08	0.48E-10	0.63E-09	0.28E-03	0.28E-03
80	1	8.70E-13	6.72E-11	1.06E-12	1.38E-11	6.44E-06	6.44E-06
	5	0.44E-11	0.34E-09	0.53E-11	0.69E-10	0.32E-04	0.32E-04
	10	0.87E-11	0.67E-09	0.11E-10	0.14E-09	0.64E-04	0.64E-04
	20	0.17E-10	0.13E-08	0.21E-10	0.28E-09	0.13E-03	0.13E-03

Table K-7.2. Time-Integrated Dose from External Exposure to Airborne Radionuclides Whole Body, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	6.33E-09	4.89E-07	7.49E-09	9.71E-08	1.59E-03	1.59E-03
	5	0.32E-07	0.24E-05	0.37E-07	0.49E-06	0.80E-02	0.80E-02
	10	0.63E-07	0.49E-05	0.75E-07	0.97E-06	0.16E-01	0.16E-01
	20	0.13E-06	0.98E-05	0.15E-06	0.19E-05	0.32E-01	0.32E-01
5	1	3.79E-10	2.93E-08	4.58E-10	5.96E-09	3.13E-04	3.13E-04
	5	0.19E-08	0.15E-06	0.23E-08	0.30E-07	0.16E-02	0.16E-02
	10	0.38E-08	0.29E-06	0.46E-08	0.60E-07	0.31E-02	0.31E-02
	20	0.76E-08	0.59E-06	0.92E-08	0.12E-06	0.63E-02	0.63E-02
10	1	1.21E-10	9.38E-09	1.47E-10	1.92E-09	1.03E-03	1.03E-03
	5	0.61E-09	0.47E-07	0.74E-09	0.96E-08	0.51E-02	0.52E-02
	10	0.12E-08	0.94E-07	0.15E-08	0.19E-07	0.10E-01	0.10E-01
	20	0.24E-08	0.19E-06	0.29E-08	0.38E-07	0.21E-01	0.21E-01
20	1	4.49E-11	3.47E-09	5.47E-11	7.11E-10	3.09E-04	3.09E-04
	5	0.22E-09	0.17E-07	0.27E-09	0.36E-08	0.15E-02	0.15E-02
	10	0.45E-09	0.35E-07	0.55E-09	0.71E-08	0.31E-02	0.31E-02
	20	0.90E-09	0.69E-07	0.11E-08	0.14E-07	0.62E-02	0.62E-02
40	1	1.92E-11	1.48E-09	2.34E-11	3.04E-10	2.18E-04	2.18E-04
	5	0.96E-10	0.74E-08	0.12E-09	0.15E-08	0.11E-02	0.11E-02
	10	0.19E-09	0.15E-07	0.23E-09	0.30E-08	0.22E-02	0.22E-02
	20	0.38E-09	0.30E-07	0.47E-09	0.61E-08	0.44E-02	0.44E-02
80	1	8.44E-12	6.52E-10	1.03E-11	1.34E-10	4.52E-05	4.52E-05
	5	0.42E-10	0.33E-08	0.51E-10	0.67E-09	0.23E-03	0.23E-03
	10	0.84E-10	0.65E-08	0.10E-09	0.13E-08	0.45E-03	0.45E-03
	20	0.17E-09	0.13E-07	0.21E-09	0.27E-08	0.90E-03	0.90E-03

Table K-7.3. Time-Integrated Dose from External Exposure to Airborne Radionuclides Whole Body, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	4.77E-09	3.68E-07	5.62E-09	7.29E-08	5.66E-03	5.66E-03
	5	0.24E-07	0.18E-05	0.28E-07	0.36E-06	0.28E-01	0.28E-01
	10	0.48E-07	0.37E-05	0.56E-07	0.73E-06	0.57E-01	0.57E-01
	20	0.95E-07	0.74E-05	0.11E-06	0.15E-05	0.11E 00	0.11E 00
5	1	2.84E-10	2.19E-08	3.42E-10	4.45E-09	9.81E-04	9.81E-04
	5	0.14E-08	0.11E-06	0.17E-08	0.22E-07	0.49E-02	0.49E-02
	10	0.28E-08	0.22E-06	0.34E-08	0.44E-07	0.98E-02	0.98E-02
	20	0.57E-08	0.44E-06	0.68E-08	0.89E-07	0.20E-01	0.20E-01
10	1	9.13E-11	7.05E-09	1.11E-10	1.44E-09	4.41E-04	4.41E-04
	5	0.46E-09	0.35E-07	0.55E-09	0.72E-08	0.22E-02	0.22E-02
	10	0.91E-09	0.71E-07	0.11E-08	0.14E-07	0.44E-02	0.44E-02
	20	0.18E-08	0.14E-06	0.22E-08	0.29E-07	0.88E-02	0.88E-02
20	1	3.39E-11	2.62E-09	4.12E-11	5.36E-10	2.14E-04	2.14E-04
	5	0.17E-09	0.13E-07	0.21E-09	0.27E-08	0.11E-02	0.11E-02
	10	0.34E-09	0.26E-07	0.41E-09	0.54E-08	0.21E-02	0.21E-02
	20	0.68E-09	0.52E-07	0.82E-09	0.11E-07	0.43E-02	0.43E-02
40	1	1.45E-11	1.12E-09	1.76E-11	2.29E-10	1.06E-04	1.06E-04
	5	0.72E-10	0.56E-08	0.88E-10	0.11E-08	0.53E-03	0.53E-03
	10	0.14E-09	0.11E-07	0.18E-09	0.23E-08	0.11E-02	0.11E-02
	20	0.29E-09	0.22E-07	0.35E-09	0.46E-08	0.21E-02	0.21E-02
80	1	6.36E-12	4.92E-10	7.76E-12	1.01E-10	4.80E-05	4.80E-05
	5	0.32E-10	0.25E-08	0.39E-10	0.50E-09	0.24E-03	0.24E-03
	10	0.64E-10	0.49E-08	0.78E-10	0.10E-08	0.48E-03	0.48E-03
	20	0.13E-09	0.98E-08	0.16E-09	0.20E-08	0.96E-03	0.96E-03

Table K-7.4. Time-Integrated Dose from External Exposure to Airborne Radionuclides Whole Body, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.83E-09	1.41E-07	2.28E-09	2.97E-08	3.17E-03	3.17E-03
	5	0.91E-08	0.71E-06	0.11E-07	0.15E-06	0.16E-01	0.16E-01
	10	0.18E-07	0.14E-05	0.23E-07	0.30E-06	0.32E-01	0.32E-01
	20	0.37E-07	0.28E-05	0.46E-07	0.59E-06	0.63E-01	0.63E-01
5	1	1.05E-10	8.09E-09	1.29E-10	1.67E-09	4.12E-04	4.12E-04
	5	0.52E-09	0.40E-07	0.64E-09	0.84E-08	0.21E-02	0.21E-02
	10	0.10E-08	0.81E-07	0.13E-08	0.17E-07	0.41E-02	0.41E-02
	20	0.21E-08	0.16E-06	0.26E-08	0.33E-07	0.82E-02	0.82E-02
10	1	3.34E-11	2.58E-09	4.09E-11	5.33E-10	1.71E-04	1.71E-04
	5	0.17E-09	0.13E-07	0.20E-09	0.27E-08	0.85E-03	0.85E-03
	10	0.33E-09	0.26E-07	0.41E-09	0.53E-08	0.17E-02	0.17E-02
	20	0.67E-09	0.52E-07	0.82E-09	0.11E-07	0.34E-02	0.34E-02
20	1	1.23E-11	9.52E-10	1.51E-11	1.97E-10	7.89E-05	7.89E-05
	5	0.62E-10	0.48E-08	0.76E-10	0.98E-09	0.39E-03	0.39E-03
	10	0.12E-09	0.95E-08	0.15E-09	0.20E-08	0.79E-03	0.79E-03
	20	0.25E-09	0.19E-07	0.30E-09	0.39E-08	0.16E-02	0.16E-02
40	1	5.26E-12	4.06E-10	6.45E-12	8.40E-11	3.84E-05	3.84E-05
	5	0.26E-10	0.20E-08	0.32E-10	0.42E-09	0.19E-03	0.19E-03
	10	0.53E-10	0.41E-08	0.65E-10	0.84E-09	0.38E-03	0.38E-03
	20	0.11E-09	0.81E-08	0.13E-09	0.17E-08	0.77E-03	0.77E-03
80	1	2.31E-12	1.79E-10	2.84E-12	3.70E-11	1.73E-05	1.73E-05
	5	0.12E-10	0.89E-09	0.14E-10	0.19E-09	0.87E-04	0.87E-04
	10	0.23E-10	0.18E-08	0.28E-10	0.37E-09	0.17E-03	0.17E-03
	20	0.46E-10	0.36E-08	0.57E-10	0.74E-09	0.35E-03	0.35E-03

Table K-7.5. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Whole Body, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	2.05E-09	1.59E-07	2.63E-09	3.43E-08	7.66E-04	7.66E-04
	5	0.10E-07	0.79E-06	0.13E-07	0.17E-06	0.38E-02	0.38E-02
	10	0.21E-07	0.16E-05	0.26E-07	0.34E-06	0.77E-02	0.77E-02
	20	0.41E-07	0.32E-05	0.53E-07	0.69E-06	0.15E-01	0.15E-01
5	1	1.15E-10	8.86E-09	1.42E-10	1.85E-09	2.93E-04	2.93E-04
	5	0.57E-09	0.44E-07	0.71E-09	0.92E-08	0.15E-02	0.15E-02
	10	0.11E-08	0.89E-07	0.14E-08	0.18E-07	0.29E-02	0.29E-02
	20	0.23E-08	0.18E-06	0.28E-08	0.37E-07	0.59E-02	0.59E-02
10	1	3.65E-11	2.82E-09	4.50E-11	5.86E-10	1.51E-04	1.51E-04
	5	0.18E-09	0.14E-07	0.23E-09	0.29E-08	0.75E-03	0.75E-03
	10	0.37E-09	0.28E-07	0.45E-09	0.59E-08	0.15E-02	0.15E-02
	20	0.73E-09	0.56E-07	0.90E-09	0.12E-07	0.30E-02	0.30E-02
20	1	1.35E-11	1.04E-09	1.66E-11	2.16E-10	7.91E-05	7.91E-05
	5	0.67E-10	0.52E-08	0.83E-10	0.11E-08	0.40E-03	0.40E-03
	10	0.13E-09	0.10E-07	0.17E-09	0.22E-08	0.79E-03	0.79E-03
	20	0.27E-09	0.21E-07	0.33E-09	0.43E-08	0.16E-02	0.16E-02
40	1	5.75E-12	4.44E-10	7.08E-12	9.22E-11	4.07E-05	4.07E-05
	5	0.29E-10	0.22E-08	0.35E-10	0.46E-09	0.20E-03	0.20E-03
	10	0.57E-10	0.44E-08	0.71E-10	0.92E-09	0.41E-03	0.41E-03
	20	0.11E-09	0.89E-08	0.14E-09	0.18E-08	0.81E-03	0.81E-03
80	1	2.53E-12	1.95E-10	3.11E-12	4.06E-11	1.86E-05	1.86E-05
	5	0.13E-10	0.98E-09	0.16E-10	0.20E-09	0.93E-04	0.93E-04
	10	0.25E-10	0.20E-08	0.31E-10	0.41E-09	0.19E-03	0.19E-03
	20	0.51E-10	0.39E-08	0.62E-10	0.81E-09	0.37E-03	0.37E-03

Table K-7.6. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Skin, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	6.09E-09	9.60E-08	4.87E-13	2.20E-08	1.02E-03	1.02E-03
	5	0.30E-07	0.48E-06	0.24E-11	0.11E-06	0.51E-02	0.51E-02
	10	0.61E-07	0.96E-06	0.49E-11	0.22E-06	0.10E-01	0.10E-01
	20	0.12E-06	0.19E-05	0.97E-11	0.44E-06	0.20E-01	0.20E-01
5	1	2.82E-10	4.45E-09	1.95E-14	8.69E-10	2.20E-04	2.21E-04
	5	0.14E-08	0.22E-07	0.97E-13	0.43E-08	0.11E-02	0.11E-02
	10	0.28E-08	0.44E-07	0.19E-12	0.87E-08	0.22E-02	0.22E-02
	20	0.56E-08	0.89E-07	0.39E-12	0.17E-07	0.44E-02	0.44E-02
10	1	8.59E-11	1.35E-09	5.72E-15	2.54E-10	8.32E-05	8.32E-05
	5	0.43E-09	0.68E-08	0.29E-13	0.13E-08	0.42E-03	0.42E-03
	10	0.86E-09	0.14E-07	0.57E-13	0.25E-08	0.83E-03	0.83E-03
	20	0.17E-08	0.27E-07	0.11E-12	0.51E-08	0.17E-02	0.17E-02
20	1	3.10E-11	4.88E-10	2.02E-15	8.97E-11	3.43E-05	3.43E-05
	5	0.15E-09	0.24E-08	0.10E-13	0.45E-09	0.17E-03	0.17E-03
	10	0.31E-09	0.49E-08	0.20E-13	0.90E-09	0.34E-03	0.34E-03
	20	0.62E-09	0.98E-08	0.40E-13	0.18E-08	0.69E-03	0.69E-03
40	1	1.32E-11	2.09E-10	8.66E-16	3.84E-11	1.57E-05	1.57E-05
	5	0.66E-10	0.10E-08	0.43E-14	0.19E-09	0.78E-04	0.78E-04
	10	0.13E-09	0.21E-08	0.87E-14	0.38E-09	0.16E-03	0.16E-03
	20	0.26E-09	0.42E-08	0.17E-13	0.77E-09	0.31E-03	0.31E-03
80	1	5.82E-12	9.18E-11	3.82E-16	1.69E-11	7.20E-06	7.20E-06
	5	0.29E-10	0.46E-09	0.19E-14	0.85E-10	0.36E-04	0.36E-04
	10	0.58E-10	0.92E-09	0.38E-14	0.17E-09	0.72E-04	0.72E-04
	20	0.12E-09	0.18E-08	0.76E-14	0.34E-09	0.14E-03	0.14E-03

Table K-7.7. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skin, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	4.24E-08	6.68E-07	2.69E-12	1.19E-07	1.91E-03	1.92E-03
	5	0.21E-06	0.33E-05	0.13E-10	0.59E-06	0.96E-02	0.96E-02
	10	0.42E-06	0.67E-05	0.27E-10	0.12E-05	0.19E-01	0.19E-01
	20	0.85E-06	0.13E-04	0.54E-10	0.24E-05	0.38E-01	0.38E-01
5	1	2.53E-09	4.00E-08	1.65E-13	7.30E-09	3.71E-04	3.71E-04
	5	0.13E-07	0.20E-06	0.82E-12	0.36E-07	0.19E-02	0.19E-02
	10	0.25E-07	0.40E-06	0.16E-11	0.73E-07	0.37E-02	0.37E-02
	20	0.51E-07	0.80E-06	0.33E-11	0.15E-06	0.74E-02	0.74E-02
10	1	8.12E-10	1.28E-08	5.29E-14	2.35E-09	1.24E-03	1.24E-03
	5	0.41E-08	0.64E-07	0.26E-12	0.12E-07	0.62E-02	0.62E-02
	10	0.81E-08	0.13E-06	0.53E-12	0.23E-07	0.12E-01	0.12E-01
	20	0.16E-07	0.26E-06	0.11E-11	0.47E-07	0.25E-01	0.25E-01
20	1	3.01E-10	4.74E-09	1.96E-14	8.71E-10	3.67E-04	3.67E-04
	5	0.15E-08	0.24E-07	0.98E-13	0.44E-08	0.18E-02	0.18E-02
	10	0.30E-08	0.47E-07	0.20E-12	0.87E-08	0.37E-02	0.37E-02
	20	0.60E-08	0.95E-07	0.39E-12	0.17E-07	0.73E-02	0.73E-02
40	1	1.28E-10	2.02E-09	8.40E-15	3.72E-10	2.58E-04	2.58E-04
	5	0.64E-09	0.10E-07	0.42E-13	0.19E-08	0.13E-02	0.13E-02
	10	0.13E-08	0.20E-07	0.84E-13	0.37E-08	0.26E-02	0.26E-02
	20	0.26E-08	0.40E-07	0.17E-12	0.74E-08	0.52E-02	0.52E-02
80	1	5.65E-11	8.90E-10	3.70E-15	1.64E-10	5.34E-05	5.34E-05
	5	0.28E-09	0.45E-08	0.18E-13	0.82E-09	0.27E-03	0.27E-03
	10	0.56E-09	0.89E-08	0.37E-13	0.16E-08	0.53E-03	0.53E-03
	20	0.11E-08	0.18E-07	0.74E-13	0.33E-08	0.11E-02	0.11E-02

Table K-7.8. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skin, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	3.19E-08	5.03E-07	2.02E-12	8.93E-08	2.34E-03	2.34E-03
	5	0.16E-06	0.25E-05	0.10E-10	0.45E-06	0.12E-01	0.12E-01
	10	0.32E-06	0.50E-05	0.20E-10	0.89E-06	0.23E-01	0.23E-01
	20	0.64E-06	0.10E-04	0.40E-10	0.18E-05	0.47E-01	0.47E-01
5	1	1.90E-09	3.00E-08	1.23E-13	5.44E-09	9.97E-04	9.98E-04
	5	0.95E-08	0.15E-06	0.61E-12	0.27E-07	0.50E-02	0.50E-02
	10	0.19E-07	0.30E-06	0.12E-11	0.54E-07	0.10E-01	0.10E-01
	20	0.38E-07	0.60E-06	0.25E-11	0.11E-06	0.20E-01	0.20E-01
10	1	6.11E-10	9.63E-09	3.97E-14	1.76E-09	4.73E-04	4.73E-04
	5	0.31E-08	0.48E-07	0.20E-12	0.88E-08	0.24E-02	0.24E-02
	10	0.61E-08	0.96E-07	0.40E-12	0.18E-07	0.47E-02	0.47E-02
	20	0.12E-07	0.19E-06	0.79E-12	0.35E-07	0.95E-02	0.95E-02
20	1	2.27E-10	3.57E-09	1.48E-14	6.56E-10	2.35E-04	2.35E-04
	5	0.11E-08	0.18E-07	0.74E-13	0.33E-08	0.12E-02	0.12E-02
	10	0.23E-08	0.36E-07	0.15E-12	0.66E-08	0.24E-02	0.24E-02
	20	0.45E-08	0.71E-07	0.30E-12	0.13E-07	0.47E-02	0.47E-02
40	1	9.67E-11	1.52E-09	6.33E-15	2.81E-10	1.18E-04	1.18E-04
	5	0.48E-09	0.76E-08	0.32E-13	0.14E-08	0.59E-03	0.59E-03
	10	0.97E-09	0.15E-07	0.63E-13	0.28E-08	0.12E-02	0.12E-02
	20	0.19E-08	0.30E-07	0.13E-12	0.56E-08	0.24E-02	0.24E-02
80	1	4.26E-11	6.71E-10	2.79E-15	1.24E-10	5.37E-05	5.37E-05
	5	0.21E-09	0.34E-08	0.14E-13	0.62E-09	0.27E-03	0.27E-03
	10	0.43E-09	0.67E-08	0.28E-13	0.12E-08	0.54E-03	0.54E-03
	20	0.85E-09	0.13E-07	0.56E-13	0.25E-08	0.11E-02	0.11E-02

Table K-7.9. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skin, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.22E-08	1.93E-07	8.16E-13	3.63E-08	1.18E-03	1.18E-03
	5	0.61E-07	0.96E-06	0.41E-11	0.18E-06	0.59E-02	0.59E-02
	10	0.12E-06	0.19E-05	0.82E-11	0.36E-06	0.12E-01	0.12E-01
	20	0.24E-06	0.39E-05	0.16E-10	0.73E-06	0.24E-01	0.24E-01
5	1	7.00E-10	1.10E-08	4.62E-14	2.05E-09	4.14E-04	4.14E-04
	5	0.35E-08	0.55E-07	0.23E-12	0.10E-07	0.21E-02	0.21E-02
	10	0.70E-08	0.11E-06	0.46E-12	0.20E-07	0.41E-02	0.41E-02
	20	0.14E-07	0.22E-06	0.92E-12	0.41E-07	0.83E-02	0.83E-02
10	1	2.23E-10	3.52E-09	1.47E-14	6.53E-10	1.83E-04	1.83E-04
	5	0.11E-08	0.18E-07	0.74E-13	0.33E-08	0.91E-03	0.91E-03
	10	0.22E-08	0.35E-07	0.15E-12	0.65E-08	0.18E-02	0.18E-02
	20	0.45E-08	0.70E-07	0.29E-12	0.13E-07	0.37E-02	0.37E-02
20	1	8.24E-11	1.30E-09	5.43E-15	2.41E-10	8.69E-05	8.69E-05
	5	0.41E-09	0.65E-08	0.27E-13	0.12E-08	0.43E-03	0.43E-03
	10	0.82E-09	0.13E-07	0.54E-13	0.24E-08	0.87E-03	0.87E-03
	20	0.16E-08	0.26E-07	0.11E-12	0.48E-08	0.17E-02	0.17E-02
40	1	3.52E-11	5.55E-10	2.32E-15	1.03E-10	4.28E-05	4.28E-05
	5	0.18E-09	0.28E-08	0.12E-13	0.51E-09	0.21E-03	0.21E-03
	10	0.35E-09	0.55E-08	0.23E-13	0.10E-08	0.43E-03	0.43E-03
	20	0.70E-09	0.11E-07	0.46E-13	0.21E-08	0.86E-03	0.86E-03
80	1	1.55E-11	2.44E-10	1.02E-15	4.53E-11	1.94E-05	1.94E-05
	5	0.77E-10	0.12E-08	0.51E-14	0.23E-09	0.97E-04	0.97E-04
	10	0.15E-09	0.24E-08	0.10E-13	0.45E-09	0.19E-03	0.19E-03
	20	0.31E-09	0.49E-08	0.20E-13	0.91E-09	0.39E-03	0.39E-03

Table K-7.10. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skin, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.37E-08	2.17E-07	9.43E-13	4.20E-08	4.57E-04	4.57E-04
	5	0.69E-07	0.11E-05	0.47E-11	0.21E-06	0.23E-02	0.23E-02
	10	0.14E-06	0.22E-05	0.94E-11	0.42E-06	0.46E-02	0.46E-02
	20	0.27E-06	0.43E-05	0.19E-10	0.84E-06	0.91E-02	0.91E-02
5	1	7.67E-10	1.21E-08	5.09E-14	2.26E-09	2.99E-04	2.99E-04
	5	0.38E-08	0.61E-07	0.25E-12	0.11E-07	0.15E-02	0.15E-02
	10	0.77E-08	0.12E-06	0.51E-12	0.23E-07	0.30E-02	0.30E-02
	20	0.15E-07	0.24E-06	0.10E-11	0.45E-07	0.60E-02	0.60E-02
10	1	2.44E-10	3.85E-09	1.62E-14	7.18E-10	1.62E-04	1.62E-04
	5	0.12E-08	0.19E-07	0.81E-13	0.36E-08	0.81E-03	0.81E-03
	10	0.24E-08	0.39E-07	0.16E-12	0.72E-08	0.16E-02	0.16E-02
	20	0.49E-08	0.77E-07	0.32E-12	0.14E-07	0.32E-02	0.32E-02
20	1	9.02E-11	1.42E-09	5.97E-15	2.65E-10	8.72E-05	8.72E-05
	5	0.45E-09	0.71E-08	0.30E-13	0.13E-08	0.44E-03	0.44E-03
	10	0.90E-09	0.14E-07	0.60E-13	0.26E-08	0.87E-03	0.87E-03
	20	0.18E-08	0.28E-07	0.12E-12	0.53E-08	0.17E-02	0.17E-02
40	1	3.84E-11	6.06E-10	2.54E-15	1.13E-10	4.53E-05	4.53E-05
	5	0.19E-09	0.30E-08	0.13E-13	0.56E-09	0.23E-03	0.23E-03
	10	0.38E-09	0.61E-08	0.25E-13	0.11E-08	0.45E-03	0.45E-03
	20	0.77E-09	0.12E-07	0.51E-13	0.23E-08	0.91E-03	0.91E-03
80	1	1.69E-11	2.67E-10	1.12E-15	4.97E-11	2.08E-05	2.08E-05
	5	0.85E-10	0.13E-08	0.56E-14	0.25E-09	0.10E-03	0.10E-03
	10	0.17E-09	0.27E-08	0.11E-13	0.50E-09	0.21E-03	0.21E-03
	20	0.34E-09	0.53E-08	0.22E-13	0.99E-09	0.42E-03	0.42E-03

Table K-7.11. Time-Integrated Dose from External Exposure to Airborne Radionuclides Ovaries, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.69E-10	3.66E-08	5.73E-10	9.63E-09	7.52E-04	7.52E-04
	5	0.85E-09	0.18E-06	0.29E-08	0.48E-07	0.38E-02	0.38E-02
	10	0.17E-08	0.37E-06	0.57E-08	0.96E-07	0.75E-02	0.75E-02
	20	0.34E-08	0.73E-06	0.11E-07	0.19E-06	0.15E-01	0.15E-01
5	1	7.84E-12	1.70E-09	2.30E-11	3.81E-10	1.42E-04	1.42E-04
	5	0.39E-10	0.85E-08	0.11E-09	0.19E-08	0.71E-03	0.71E-03
	10	0.78E-10	0.17E-07	0.23E-09	0.38E-08	0.14E-02	0.14E-02
	20	0.16E-09	0.34E-07	0.46E-09	0.76E-08	0.28E-02	0.28E-02
10	1	2.39E-12	5.17E-10	6.75E-12	1.11E-10	5.28E-05	5.28E-05
	5	0.12E-10	0.26E-08	0.34E-10	0.56E-09	0.26E-03	0.26E-03
	10	0.24E-10	0.52E-08	0.67E-10	0.11E-08	0.53E-03	0.53E-03
	20	0.48E-10	0.10E-07	0.13E-09	0.22E-08	0.11E-02	0.11E-02
20	1	8.61E-13	1.86E-10	2.38E-12	3.93E-11	2.17E-05	2.17E-05
	5	0.43E-11	0.93E-09	0.12E-10	0.20E-09	0.11E-03	0.11E-03
	10	0.86E-11	0.19E-08	0.24E-10	0.39E-09	0.22E-03	0.22E-03
	20	0.17E-10	0.37E-08	0.48E-10	0.79E-09	0.43E-03	0.43E-03
40	1	3.68E-13	7.95E-11	1.02E-12	1.68E-11	9.95E-06	9.95E-06
	5	0.18E-11	0.40E-09	0.51E-11	0.84E-10	0.50E-04	0.50E-04
	10	0.37E-11	0.80E-09	0.10E-10	0.17E-09	0.10E-03	0.10E-03
	20	0.74E-11	0.16E-08	0.20E-10	0.34E-09	0.20E-03	0.20E-03
80	1	1.62E-13	3.50E-11	4.50E-13	7.42E-12	4.58E-06	4.58E-06
	5	0.81E-12	0.18E-09	0.22E-11	0.37E-10	0.23E-04	0.23E-04
	10	0.16E-11	0.35E-09	0.45E-11	0.74E-10	0.46E-04	0.46E-04
	20	0.32E-11	0.70E-09	0.90E-11	0.15E-09	0.92E-04	0.92E-04

Table K-7.12. Time-Integrated Dose from External Exposure to Airborne Radionuclides Ovaries, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.18E-09	2.55E-07	3.17E-09	5.21E-08	9.88E-04	9.88E-04
	5	0.59E-08	0.13E-05	0.16E-07	0.26E-06	0.49E-02	0.49E-02
	10	0.12E-07	0.25E-05	0.32E-07	0.52E-06	0.99E-02	0.99E-02
	20	0.24E-07	0.51E-05	0.63E-07	0.10E-05	0.20E-01	0.20E-01
5	1	7.05E-11	1.52E-08	1.94E-10	3.20E-09	2.24E-04	2.24E-04
	5	0.35E-09	0.76E-07	0.97E-09	0.16E-07	0.11E-02	0.11E-02
	10	0.70E-09	0.15E-06	0.19E-08	0.32E-07	0.22E-02	0.22E-02
	20	0.14E-08	0.30E-06	0.39E-08	0.64E-07	0.45E-02	0.45E-02
10	1	2.26E-11	4.88E-09	6.24E-11	1.03E-09	6.52E-04	6.52E-04
	5	0.11E-09	0.24E-07	0.31E-09	0.51E-08	0.33E-02	0.33E-02
	10	0.23E-09	0.49E-07	0.62E-09	0.10E-07	0.65E-02	0.65E-02
	20	0.45E-09	0.98E-07	0.12E-08	0.21E-07	0.13E-01	0.13E-01
20	1	8.36E-12	1.81E-09	2.32E-11	3.82E-10	2.19E-04	2.19E-04
	5	0.42E-10	0.90E-08	0.12E-09	0.19E-08	0.11E-02	0.11E-02
	10	0.84E-10	0.18E-07	0.23E-09	0.38E-08	0.22E-02	0.22E-02
	20	0.17E-09	0.36E-07	0.46E-09	0.76E-08	0.44E-02	0.44E-02
40	1	3.57E-12	7.72E-10	9.90E-12	1.63E-10	1.54E-04	1.54E-04
	5	0.18E-10	0.39E-08	0.49E-10	0.82E-09	0.77E-03	0.77E-03
	10	0.36E-10	0.77E-08	0.99E-10	0.16E-08	0.15E-02	0.15E-02
	20	0.71E-10	0.15E-07	0.20E-09	0.33E-08	0.31E-02	0.31E-02
80	1	1.57E-12	3.40E-10	4.36E-12	7.19E-11	3.29E-05	3.29E-05
	5	0.79E-11	0.17E-08	0.22E-10	0.36E-09	0.16E-03	0.16E-03
	10	0.16E-10	0.34E-08	0.44E-10	0.72E-09	0.33E-03	0.33E-03
	20	0.31E-10	0.68E-08	0.87E-10	0.14E-08	0.66E-03	0.66E-03

Table K-7.13. Time-Integrated Dose from External Exposure to Airborne Radionuclides Ovaries, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	8.86E-10	1.92E-07	2.38E-09	3.91E-08	2.63E-03	2.63E-03
	5	0.44E-08	0.96E-06	0.12E-07	0.20E-06	0.13E-01	0.13E-01
	10	0.89E-08	0.19E-05	0.24E-07	0.39E-06	0.26E-01	0.26E-01
	20	0.18E-07	0.38E-05	0.48E-07	0.78E-06	0.53E-01	0.53E-01
5	1	5.28E-11	1.14E-08	1.45E-10	2.39E-09	6.44E-04	6.44E-04
	5	0.26E-09	0.57E-07	0.72E-09	0.12E-07	0.32E-02	0.32E-02
	10	0.53E-09	0.11E-06	0.14E-08	0.24E-07	0.64E-02	0.64E-02
	20	0.11E-08	0.23E-06	0.29E-08	0.48E-07	0.13E-01	0.13E-01
10	1	1.70E-11	3.67E-09	4.68E-11	7.72E-10	3.01E-04	3.01E-04
	5	0.85E-10	0.18E-07	0.23E-09	0.39E-08	0.15E-02	0.15E-02
	10	0.17E-09	0.37E-07	0.47E-09	0.77E-08	0.30E-02	0.30E-02
	20	0.34E-09	0.73E-07	0.94E-09	0.15E-07	0.60E-02	0.60E-02
20	1	6.30E-12	1.36E-09	1.74E-11	2.88E-10	1.49E-04	1.49E-04
	5	0.32E-10	0.68E-08	0.87E-10	0.14E-08	0.75E-03	0.75E-03
	10	0.63E-10	0.14E-07	0.17E-09	0.29E-08	0.15E-02	0.15E-02
	20	0.13E-09	0.27E-07	0.35E-09	0.58E-08	0.30E-02	0.30E-02
40	1	2.69E-12	5.82E-10	7.46E-12	1.23E-10	7.48E-05	7.48E-05
	5	0.13E-10	0.29E-08	0.37E-10	0.62E-09	0.37E-03	0.37E-03
	10	0.27E-10	0.58E-08	0.75E-10	0.12E-08	0.75E-03	0.75E-03
	20	0.54E-10	0.12E-07	0.15E-09	0.25E-08	0.15E-02	0.15E-02
80	1	1.18E-12	2.56E-10	3.29E-12	5.42E-11	3.41E-05	3.41E-05
	5	0.59E-11	0.13E-08	0.16E-10	0.27E-09	0.17E-03	0.17E-03
	10	0.12E-10	0.26E-08	0.33E-10	0.54E-09	0.34E-03	0.34E-03
	20	0.24E-10	0.51E-08	0.66E-10	0.11E-08	0.68E-03	0.68E-03

Table K-7.14. Time-Integrated Dose from External Exposure to Airborne Radionuclides Ovaries, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	3.40E-10	7.36E-08	9.64E-10	1.59E-08	1.40E-03	1.40E-03
	5	0.17E-08	0.37E-06	0.48E-08	0.80E-07	0.70E-02	0.70E-02
	10	0.34E-08	0.74E-06	0.96E-08	0.16E-06	0.14E-01	0.14E-01
	20	0.68E-08	0.15E-05	0.19E-07	0.32E-06	0.28E-01	0.28E-01
5	1	1.95E-11	4.21E-09	5.44E-11	8.98E-10	2.68E-04	2.68E-04
	5	0.97E-10	0.21E-07	0.27E-09	0.45E-08	0.13E-02	0.13E-02
	10	0.19E-09	0.42E-07	0.54E-09	0.90E-08	0.27E-02	0.27E-02
	20	0.39E-09	0.84E-07	0.11E-08	0.18E-07	0.54E-02	0.54E-02
10	1	6.21E-12	1.34E-09	1.73E-11	2.86E-10	1.16E-04	1.16E-04
	5	0.31E-10	0.67E-08	0.87E-10	0.14E-08	0.58E-03	0.58E-03
	10	0.62E-10	0.13E-07	0.17E-09	0.29E-08	0.12E-02	0.12E-02
	20	0.12E-09	0.27E-07	0.35E-09	0.57E-08	0.23E-02	0.23E-02
20	1	2.29E-12	4.96E-10	6.39E-12	1.06E-10	5.51E-05	5.51E-05
	5	0.11E-10	0.25E-08	0.32E-10	0.53E-09	0.28E-03	0.28E-03
	10	0.23E-10	0.50E-08	0.64E-10	0.11E-08	0.55E-03	0.55E-03
	20	0.46E-10	0.99E-08	0.13E-09	0.21E-08	0.11E-02	0.11E-02
40	1	9.78E-13	2.12E-10	2.73E-12	4.51E-11	2.72E-05	2.72E-05
	5	0.49E-11	0.11E-08	0.14E-10	0.23E-09	0.14E-03	0.14E-03
	10	0.98E-11	0.21E-08	0.27E-10	0.45E-09	0.27E-03	0.27E-03
	20	0.20E-10	0.42E-08	0.55E-10	0.90E-09	0.54E-03	0.54E-03
80	1	4.30E-13	9.31E-11	1.20E-12	1.99E-11	1.23E-05	1.23E-05
	5	0.22E-11	0.47E-09	0.60E-11	0.99E-10	0.62E-04	0.62E-04
	10	0.43E-11	0.93E-09	0.12E-10	0.20E-09	0.12E-03	0.12E-03
	20	0.86E-11	0.19E-08	0.24E-10	0.40E-09	0.25E-03	0.25E-03

Table K-7.15. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Ovaries, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	3.82E-10	8.27E-08	1.11E-09	1.84E-08	3.88E-04	3.88E-04
	5	0.19E-08	0.41E-06	0.56E-08	0.92E-07	0.19E-02	0.19E-02
	10	0.38E-08	0.83E-06	0.11E-07	0.18E-06	0.39E-02	0.39E-02
	20	0.76E-08	0.17E-05	0.22E-07	0.37E-06	0.78E-02	0.78E-02
5	1	2.13E-11	4.62E-09	6.00E-11	9.90E-10	1.93E-04	1.93E-04
	5	0.11E-09	0.23E-07	0.30E-09	0.50E-08	0.96E-03	0.96E-03
	10	0.21E-09	0.46E-07	0.60E-09	0.99E-08	0.19E-02	0.19E-02
	20	0.43E-09	0.92E-07	0.12E-08	0.20E-07	0.39E-02	0.39E-02
10	1	6.80E-12	1.47E-09	1.91E-11	3.15E-10	1.03E-04	1.03E-04
	5	0.34E-10	0.74E-08	0.95E-10	0.16E-08	0.51E-03	0.51E-03
	10	0.68E-10	0.15E-07	0.19E-09	0.31E-08	0.10E-02	0.10E-02
	20	0.14E-09	0.29E-07	0.38E-09	0.63E-08	0.21E-02	0.21E-02
20	1	2.51E-12	5.43E-10	7.03E-12	1.16E-10	5.53E-05	5.53E-05
	5	0.13E-10	0.27E-08	0.35E-10	0.58E-09	0.28E-03	0.28E-03
	10	0.25E-10	0.54E-08	0.70E-10	0.12E-08	0.55E-03	0.55E-03
	20	0.50E-10	0.11E-07	0.14E-09	0.23E-08	0.11E-02	0.11E-02
40	1	1.07E-12	2.31E-10	3.00E-12	4.95E-11	2.88E-05	2.88E-05
	5	0.53E-11	0.12E-08	0.15E-10	0.25E-09	0.14E-03	0.14E-03
	10	0.11E-10	0.23E-08	0.30E-10	0.49E-09	0.29E-03	0.29E-03
	20	0.21E-10	0.46E-08	0.60E-10	0.99E-09	0.58E-03	0.58E-03
80	1	4.70E-13	1.02E-10	1.32E-12	2.18E-11	1.32E-05	1.32E-05
	5	0.24E-11	0.51E-09	0.66E-11	0.11E-09	0.66E-04	0.66E-04
	10	0.47E-11	0.10E-08	0.13E-10	0.22E-09	0.13E-03	0.13E-03
	20	0.94E-11	0.20E-08	0.26E-10	0.44E-09	0.26E-03	0.26E-03

Table K-7.16. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Testes, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	7.48E-10	6.45E-08	1.20E-09	2.30E-08	1.34E-03	1.34E-03
	5	0.37E-08	0.32E-06	0.60E-08	0.11E-06	0.67E-02	0.67E-02
	10	0.75E-08	0.64E-06	0.12E-07	0.23E-06	0.13E-01	0.13E-01
	20	0.15E-07	0.13E-05	0.24E-07	0.46E-06	0.27E-01	0.27E-01
5	1	3.46E-11	2.98E-09	4.79E-11	9.08E-10	1.96E-04	1.96E-04
	5	0.17E-09	0.15E-07	0.24E-09	0.45E-08	0.98E-03	0.98E-03
	10	0.35E-09	0.30E-07	0.48E-09	0.91E-08	0.20E-02	0.20E-02
	20	0.69E-09	0.60E-07	0.96E-09	0.18E-07	0.39E-02	0.39E-02
10	1	1.06E-11	9.09E-10	1.41E-11	2.66E-10	6.96E-05	6.96E-05
	5	0.53E-10	0.45E-08	0.70E-10	0.13E-08	0.35E-03	0.35E-03
	10	0.11E-09	0.91E-08	0.14E-09	0.27E-08	0.70E-03	0.70E-03
	20	0.21E-09	0.18E-07	0.28E-09	0.53E-08	0.14E-02	0.14E-02
20	1	3.80E-12	3.28E-10	4.97E-12	9.37E-11	2.75E-05	2.75E-05
	5	0.19E-10	0.16E-08	0.25E-10	0.47E-09	0.14E-03	0.14E-03
	10	0.38E-10	0.33E-08	0.50E-10	0.94E-09	0.28E-03	0.28E-03
	20	0.76E-10	0.66E-08	0.99E-10	0.19E-08	0.55E-03	0.55E-03
40	1	1.62E-12	1.40E-10	2.13E-12	4.01E-11	1.23E-05	1.23E-05
	5	0.81E-11	0.70E-09	0.11E-10	0.20E-09	0.62E-04	0.62E-04
	10	0.16E-10	0.14E-08	0.21E-10	0.40E-09	0.12E-03	0.12E-03
	20	0.32E-10	0.28E-08	0.43E-10	0.80E-09	0.25E-03	0.25E-03
80	1	7.15E-13	6.16E-11	9.38E-13	1.77E-11	5.62E-06	5.62E-06
	5	0.36E-11	0.31E-09	0.47E-11	0.88E-10	0.28E-04	0.28E-04
	10	0.72E-11	0.62E-09	0.94E-11	0.18E-09	0.56E-04	0.56E-04
	20	0.14E-10	0.12E-08	0.19E-10	0.35E-09	0.11E-03	0.11E-03

Table K-7.17. Time-Integrated Dose from External Exposure to Airborne Radionuclides Testes, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	5.20E-09	4.49E-07	6.61E-09	1.24E-07	1.56E-03	1.56E-03
	5	0.26E-07	0.22E-05	0.33E-07	0.62E-06	0.78E-02	0.78E-02
	10	0.52E-07	0.45E-05	0.66E-07	0.12E-05	0.16E-01	0.16E-01
	20	0.10E-06	0.90E-05	0.13E-06	0.25E-05	0.31E-01	0.31E-01
5	1	3.11E-10	2.68E-08	4.05E-10	7.63E-09	2.74E-04	2.74E-04
	5	0.16E-08	0.13E-06	0.20E-08	0.38E-07	0.14E-02	0.14E-02
	10	0.31E-08	0.27E-06	0.40E-08	0.76E-07	0.27E-02	0.27E-02
	20	0.62E-08	0.54E-06	0.81E-08	0.15E-06	0.55E-02	0.55E-02
10	1	9.97E-11	8.60E-09	1.30E-10	2.45E-09	9.93E-04	9.93E-04
	5	0.50E-09	0.43E-07	0.65E-09	0.12E-07	0.50E-02	0.50E-02
	10	0.10E-08	0.86E-07	0.13E-08	0.25E-07	0.99E-02	0.99E-02
	20	0.20E-08	0.17E-06	0.26E-08	0.49E-07	0.20E-01	0.20E-01
20	1	3.69E-11	3.18E-09	4.83E-11	9.10E-10	2.74E-04	2.74E-04
	5	0.18E-09	0.16E-07	0.24E-09	0.46E-08	0.14E-02	0.14E-02
	10	0.37E-09	0.32E-07	0.48E-09	0.91E-08	0.27E-02	0.27E-02
	20	0.74E-09	0.64E-07	0.97E-09	0.18E-07	0.55E-02	0.55E-02
40	1	1.58E-11	1.36E-09	2.06E-11	3.89E-10	1.93E-04	1.93E-04
	5	0.79E-10	0.68E-08	0.10E-09	0.19E-08	0.96E-03	0.96E-03
	10	0.16E-09	0.14E-07	0.21E-09	0.39E-08	0.19E-02	0.19E-02
	20	0.32E-09	0.27E-07	0.41E-09	0.78E-08	0.39E-02	0.39E-02
80	1	6.94E-12	5.98E-10	9.09E-12	1.71E-10	3.89E-05	3.89E-05
	5	0.35E-10	0.30E-08	0.45E-10	0.86E-09	0.19E-03	0.19E-03
	10	0.69E-10	0.60E-08	0.91E-10	0.17E-08	0.39E-03	0.39E-03
	20	0.14E-09	0.12E-07	0.18E-09	0.34E-08	0.78E-03	0.78E-03

Table K-7.18. Time-Integrated Dose from External Exposure to Airborne Radionuclides Testes, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	3.92E-09	3.38E-07	4.97E-09	9.33E-08	5.96E-03	5.96E-03
	5	0.20E-07	0.17E-05	0.25E-07	0.47E-06	0.30E-01	0.30E-01
	10	0.39E-07	0.34E-05	0.50E-07	0.93E-06	0.60E-01	0.60E-01
	20	0.78E-07	0.68E-05	0.99E-07	0.19E-05	0.12E 00	0.12E 00
5	1	2.33E-10	2.01E-08	3.02E-10	5.69E-09	9.02E-04	9.02E-04
	5	0.12E-08	0.10E-06	0.15E-08	0.28E-07	0.45E-02	0.45E-02
	10	0.23E-08	0.20E-06	0.30E-08	0.57E-07	0.90E-02	0.90E-02
	20	0.47E-08	0.40E-06	0.60E-08	0.11E-06	0.18E-01	0.18E-01
10	1	7.50E-11	6.47E-09	9.76E-11	1.84E-09	3.97E-04	3.97E-04
	5	0.38E-09	0.32E-07	0.49E-09	0.92E-08	0.20E-02	0.20E-02
	10	0.75E-09	0.65E-07	0.98E-09	0.18E-07	0.40E-02	0.40E-02
	20	0.15E-08	0.13E-06	0.20E-08	0.37E-07	0.79E-02	0.79E-02
20	1	2.78E-11	2.40E-09	3.64E-11	6.86E-10	1.89E-04	1.89E-04
	5	0.14E-09	0.12E-07	0.18E-09	0.34E-08	0.95E-03	0.95E-03
	10	0.28E-09	0.24E-07	0.36E-09	0.69E-08	0.19E-02	0.19E-02
	20	0.56E-09	0.48E-07	0.73E-09	0.14E-07	0.38E-02	0.38E-02
40	1	1.19E-11	1.02E-09	1.56E-11	2.93E-10	9.27E-05	9.27E-05
	5	0.59E-10	0.51E-08	0.78E-10	0.15E-08	0.46E-03	0.46E-03
	10	0.12E-09	0.10E-07	0.16E-09	0.29E-08	0.93E-03	0.93E-03
	20	0.24E-09	0.20E-07	0.31E-09	0.59E-08	0.19E-02	0.19E-02
80	1	5.23E-12	4.51E-10	6.85E-12	1.29E-10	4.19E-05	4.19E-05
	5	0.26E-10	0.23E-08	0.34E-10	0.65E-09	0.21E-03	0.21E-03
	10	0.52E-10	0.45E-08	0.69E-10	0.13E-08	0.42E-03	0.42E-03
	20	0.10E-09	0.90E-08	0.14E-09	0.26E-08	0.84E-03	0.84E-03

Table K-7.19. Time-Integrated Dose from External Exposure to Airborne Radionuclides Testes, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.50E-09	1.29E-07	2.01E-09	3.80E-08	3.40E-03	3.40E-03
	5	0.75E-08	0.65E-06	0.10E-07	0.19E-06	0.17E-01	0.17E-01
	10	0.15E-07	0.13E-05	0.20E-07	0.38E-06	0.34E-01	0.34E-01
	20	0.30E-07	0.26E-05	0.40E-07	0.76E-06	0.68E-01	0.68E-01
5	1	8.60E-11	7.42E-09	1.13E-10	2.14E-09	3.80E-04	3.80E-04
	5	0.43E-09	0.37E-07	0.57E-09	0.11E-07	0.19E-02	0.19E-02
	10	0.86E-09	0.74E-07	0.11E-08	0.21E-07	0.38E-02	0.38E-02
	20	0.17E-08	0.15E-06	0.23E-08	0.43E-07	0.76E-02	0.76E-02
10	1	2.74E-11	2.36E-09	3.61E-11	6.82E-10	1.54E-04	1.54E-04
	5	0.14E-09	0.12E-07	0.18E-09	0.34E-08	0.77E-03	0.77E-03
	10	0.27E-09	0.24E-07	0.36E-09	0.68E-08	0.15E-02	0.15E-02
	20	0.55E-09	0.47E-07	0.72E-09	0.14E-07	0.31E-02	0.31E-02
20	1	1.01E-11	8.73E-10	1.33E-11	2.52E-10	6.99E-05	6.99E-05
	5	0.51E-10	0.44E-08	0.67E-10	0.13E-08	0.35E-03	0.35E-03
	10	0.10E-09	0.87E-08	0.13E-09	0.25E-08	0.70E-03	0.70E-03
	20	0.20E-09	0.17E-07	0.27E-09	0.50E-08	0.14E-02	0.14E-02
40	1	4.32E-12	3.72E-10	5.70E-12	1.08E-10	3.37E-05	3.37E-05
	5	0.22E-10	0.19E-08	0.28E-10	0.54E-09	0.17E-03	0.17E-03
	10	0.43E-10	0.37E-08	0.57E-10	0.11E-08	0.34E-03	0.34E-03
	20	0.86E-10	0.74E-08	0.11E-09	0.22E-08	0.67E-03	0.67E-03
80	1	1.90E-12	1.64E-10	2.51E-12	4.74E-11	1.51E-05	1.51E-05
	5	0.95E-11	0.82E-09	0.13E-10	0.24E-09	0.76E-04	0.76E-04
	10	0.19E-10	0.16E-08	0.25E-10	0.47E-09	0.15E-03	0.15E-03
	20	0.38E-10	0.33E-08	0.50E-10	0.95E-09	0.30E-03	0.30E-03

Table K-7.20. Time-Integrated Dose from External Exposure to Airborne Radionuclides Testes, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.69E-09	1.46E-07	2.32E-09	4.39E-08	7.88E-04	7.89E-04
	5	0.84E-08	0.73E-06	0.12E-07	0.22E-06	0.39E-02	0.39E-02
	10	0.17E-07	0.15E-05	0.23E-07	0.44E-06	0.79E-02	0.79E-02
	20	0.34E-07	0.29E-05	0.46E-07	0.88E-06	0.16E-01	0.16E-01
5	1	9.43E-11	8.13E-09	1.25E-10	2.36E-09	2.70E-04	2.70E-04
	5	0.47E-09	0.41E-07	0.63E-09	0.12E-07	0.13E-02	0.13E-02
	10	0.94E-09	0.81E-07	0.13E-08	0.24E-07	0.27E-02	0.27E-02
	20	0.19E-08	0.16E-06	0.25E-08	0.47E-07	0.54E-02	0.54E-02
10	1	3.00E-11	2.59E-09	3.97E-11	7.50E-10	1.36E-04	1.36E-04
	5	0.15E-09	0.13E-07	0.20E-09	0.38E-08	0.68E-03	0.68E-03
	10	0.30E-09	0.26E-07	0.40E-09	0.75E-08	0.14E-02	0.14E-02
	20	0.60E-09	0.52E-07	0.79E-09	0.15E-07	0.27E-02	0.27E-02
20	1	1.11E-11	9.55E-10	1.47E-11	2.77E-10	7.01E-05	7.01E-05
	5	0.55E-10	0.48E-08	0.73E-10	0.14E-08	0.35E-03	0.35E-03
	10	0.11E-09	0.96E-08	0.15E-09	0.28E-08	0.70E-03	0.70E-03
	20	0.22E-09	0.19E-07	0.29E-09	0.55E-08	0.14E-02	0.14E-02
40	1	4.72E-12	4.07E-10	6.25E-12	1.18E-10	3.57E-05	3.57E-05
	5	0.24E-10	0.20E-08	0.31E-10	0.59E-09	0.18E-03	0.18E-03
	10	0.47E-10	0.41E-08	0.63E-10	0.12E-08	0.36E-03	0.36E-03
	20	0.94E-10	0.81E-08	0.13E-09	0.24E-08	0.71E-03	0.71E-03
80	1	2.08E-12	1.79E-10	2.75E-12	5.19E-11	1.63E-05	1.63E-05
	5	0.10E-10	0.89E-09	0.14E-10	0.26E-09	0.81E-04	0.81E-04
	10	0.21E-10	0.18E-08	0.27E-10	0.52E-09	0.16E-03	0.16E-03
	20	0.42E-10	0.36E-08	0.55E-10	0.10E-08	0.33E-03	0.33E-03

Table K-7.21. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Small Intestine, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.41E-10	4.87E-08	5.02E-10	1.26E-08	9.91E-04	9.91E-04
	5	0.70E-09	0.24E-06	0.25E-08	0.63E-07	0.50E-02	0.50E-02
	10	0.14E-08	0.49E-06	0.50E-08	0.13E-06	0.99E-02	0.99E-02
	20	0.28E-08	0.97E-06	0.10E-07	0.25E-06	0.20E-01	0.20E-01
5	1	6.52E-12	2.25E-09	2.01E-11	4.98E-10	1.60E-04	1.60E-04
	5	0.33E-10	0.11E-07	0.10E-09	0.25E-08	0.80E-03	0.80E-03
	10	0.65E-10	0.23E-07	0.20E-09	0.50E-08	0.16E-02	0.16E-02
	20	0.13E-09	0.45E-07	0.40E-09	0.10E-07	0.32E-02	0.32E-02
10	1	1.99E-12	6.86E-10	5.90E-12	1.46E-10	5.79E-05	5.79E-05
	5	0.99E-11	0.34E-08	0.30E-10	0.73E-09	0.29E-03	0.29E-03
	10	0.20E-10	0.69E-08	0.59E-10	0.15E-08	0.58E-03	0.58E-03
	20	0.40E-10	0.14E-07	0.12E-09	0.29E-08	0.12E-02	0.12E-02
20	1	7.17E-13	2.47E-10	2.09E-12	5.14E-11	2.33E-05	2.33E-05
	5	0.36E-11	0.12E-08	0.10E-10	0.26E-09	0.12E-03	0.12E-03
	10	0.72E-11	0.25E-08	0.21E-10	0.51E-09	0.23E-03	0.23E-03
	20	0.14E-10	0.49E-08	0.42E-10	0.10E-08	0.47E-03	0.47E-03
40	1	3.06E-13	1.06E-10	8.93E-13	2.20E-11	1.06E-05	1.06E-05
	5	0.15E-11	0.53E-09	0.45E-11	0.11E-09	0.53E-04	0.53E-04
	10	0.31E-11	0.11E-08	0.89E-11	0.22E-09	0.11E-03	0.11E-03
	20	0.61E-11	0.21E-08	0.18E-10	0.44E-09	0.21E-03	0.21E-03
80	1	1.35E-13	4.65E-11	3.93E-13	9.70E-12	4.84E-06	4.84E-06
	5	0.67E-12	0.23E-09	0.20E-11	0.49E-10	0.24E-04	0.24E-04
	10	0.13E-11	0.47E-09	0.39E-11	0.97E-10	0.48E-04	0.48E-04
	20	0.27E-11	0.93E-09	0.79E-11	0.19E-09	0.97E-04	0.97E-04

Table K-7.22. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Small Intestine, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	9.80E-10	3.39E-07	2.77E-09	6.82E-08	1.17E-03	1.17E-03
	5	0.49E-08	0.17E-05	0.14E-07	0.34E-06	0.58E-02	0.58E-02
	10	0.98E-08	0.34E-05	0.28E-07	0.68E-06	0.12E-01	0.12E-01
	20	0.20E-07	0.68E-05	0.55E-07	0.14E-05	0.23E-01	0.23E-01
5	1	5.86E-11	2.02E-08	1.70E-10	4.18E-09	2.35E-04	2.35E-04
	5	0.29E-09	0.10E-06	0.85E-09	0.21E-07	0.12E-02	0.12E-02
	10	0.59E-09	0.20E-06	0.17E-08	0.42E-07	0.23E-02	0.23E-02
	20	0.12E-08	0.40E-06	0.34E-08	0.84E-07	0.47E-02	0.47E-02
10	1	1.88E-11	6.49E-09	5.46E-11	1.34E-09	7.57E-04	7.57E-04
	5	0.94E-10	0.32E-07	0.27E-09	0.67E-08	0.38E-02	0.38E-02
	10	0.19E-09	0.65E-07	0.55E-09	0.13E-07	0.76E-02	0.76E-02
	20	0.38E-09	0.13E-06	0.11E-08	0.27E-07	0.15E-01	0.15E-01
20	1	6.96E-12	2.40E-09	2.03E-11	4.99E-10	2.32E-04	2.32E-04
	5	0.35E-10	0.12E-07	0.10E-09	0.25E-08	0.12E-02	0.12E-02
	10	0.70E-10	0.24E-07	0.20E-09	0.50E-08	0.23E-02	0.23E-02
	20	0.14E-09	0.48E-07	0.41E-09	0.10E-07	0.46E-02	0.46E-02
40	1	2.97E-12	1.02E-09	8.66E-12	2.14E-10	1.63E-04	1.63E-04
	5	0.15E-10	0.51E-08	0.43E-10	0.11E-08	0.82E-03	0.82E-03
	10	0.30E-10	0.10E-07	0.87E-10	0.21E-08	0.16E-02	0.16E-02
	20	0.59E-10	0.20E-07	0.17E-09	0.43E-08	0.33E-02	0.33E-02
80	1	1.31E-12	4.51E-10	3.81E-12	9.41E-11	3.40E-05	3.40E-05
	5	0.65E-11	0.23E-08	0.19E-10	0.47E-09	0.17E-03	0.17E-03
	10	0.13E-10	0.45E-08	0.38E-10	0.94E-09	0.34E-03	0.34E-03
	20	0.26E-10	0.90E-08	0.76E-10	0.19E-08	0.68E-03	0.68E-03

Table K-7.23. Time-Integrated Dose from External Exposure to Airborne Radionuclides Small Intestine, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	7.38E-10	2.55E-07	2.06E-09	5.12E-08	4.13E-03	4.13E-03
	5	0.37E-08	0.13E-05	0.10E-07	0.26E-06	0.21E-01	0.21E-01
	10	0.74E-08	0.25E-05	0.21E-07	0.51E-06	0.41E-01	0.41E-01
	20	0.15E-07	0.51E-05	0.42E-07	0.10E-05	0.83E-01	0.83E-01
5	1	4.40E-11	1.52E-08	1.27E-10	3.12E-09	7.31E-04	7.31E-04
	5	0.22E-09	0.76E-07	0.63E-09	0.16E-07	0.37E-02	0.37E-02
	10	0.44E-09	0.15E-06	0.13E-08	0.31E-07	0.73E-02	0.73E-02
	20	0.88E-09	0.30E-06	0.25E-08	0.62E-07	0.15E-01	0.15E-01
10	1	1.41E-11	4.88E-09	4.10E-11	1.01E-09	3.30E-04	3.30E-04
	5	0.71E-10	0.24E-07	0.20E-09	0.50E-08	0.17E-02	0.17E-02
	10	0.14E-09	0.49E-07	0.41E-09	0.10E-07	0.33E-02	0.33E-02
	20	0.28E-09	0.98E-07	0.82E-09	0.20E-07	0.66E-02	0.66E-02
20	1	5.24E-12	1.81E-09	1.53E-11	3.76E-10	1.60E-04	1.60E-04
	5	0.26E-10	0.91E-08	0.76E-10	0.19E-08	0.80E-03	0.80E-03
	10	0.52E-10	0.18E-07	0.15E-09	0.38E-08	0.16E-02	0.16E-02
	20	0.10E-09	0.36E-07	0.31E-09	0.75E-08	0.32E-02	0.32E-02
40	1	2.24E-12	7.73E-10	6.53E-12	1.61E-10	7.94E-05	7.94E-05
	5	0.11E-10	0.39E-08	0.33E-10	0.80E-09	0.40E-03	0.40E-03
	10	0.22E-10	0.77E-08	0.65E-10	0.16E-08	0.79E-03	0.79E-03
	20	0.45E-10	0.15E-07	0.13E-09	0.32E-08	0.16E-02	0.16E-02
80	1	9.85E-13	3.40E-10	2.87E-12	7.09E-11	3.61E-05	3.61E-05
	5	0.49E-11	0.17E-08	0.14E-10	0.35E-09	0.18E-03	0.18E-03
	10	0.98E-11	0.34E-08	0.29E-10	0.71E-09	0.36E-03	0.36E-03
	20	0.20E-10	0.68E-08	0.57E-10	0.14E-08	0.72E-03	0.72E-03

Table K-7.24. Time-Integrated Dose from External Exposure to Airborne Radionuclides Small Intestine, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	2.83E-10	9.77E-08	8.43E-10	2.08E-08	2.30E-03	2.30E-03
	5	0.14E-08	0.49E-06	0.42E-08	0.10E-06	0.12E-01	0.12E-01
	10	0.28E-08	0.98E-06	0.84E-08	0.21E-06	0.23E-01	0.23E-01
	20	0.57E-08	0.20E-05	0.17E-07	0.42E-06	0.46E-01	0.46E-01
5	1	1.62E-11	5.60E-09	4.76E-11	1.17E-09	3.07E-04	3.07E-04
	5	0.81E-10	0.28E-07	0.24E-09	0.59E-08	0.15E-02	0.15E-02
	10	0.16E-09	0.56E-07	0.48E-09	0.12E-07	0.31E-02	0.31E-02
	20	0.32E-09	0.11E-06	0.95E-09	0.23E-07	0.61E-02	0.61E-02
10	1	5.17E-12	1.78E-09	1.52E-11	3.74E-10	1.28E-04	1.28E-04
	5	0.26E-10	0.89E-08	0.76E-10	0.19E-08	0.64E-03	0.64E-03
	10	0.52E-10	0.18E-07	0.15E-09	0.37E-08	0.13E-02	0.13E-02
	20	0.10E-09	0.36E-07	0.30E-09	0.75E-08	0.26E-02	0.26E-02
20	1	1.91E-12	6.59E-10	5.60E-12	1.38E-10	5.92E-05	5.92E-05
	5	0.95E-11	0.33E-08	0.28E-10	0.69E-09	0.30E-03	0.30E-03
	10	0.19E-10	0.66E-08	0.56E-10	0.14E-08	0.59E-03	0.59E-03
	20	0.38E-10	0.13E-07	0.11E-09	0.28E-08	0.12E-02	0.12E-02
40	1	8.14E-13	2.81E-10	2.39E-12	5.90E-11	2.89E-05	2.89E-05
	5	0.41E-11	0.14E-08	0.12E-10	0.29E-09	0.14E-03	0.14E-03
	10	0.81E-11	0.28E-08	0.24E-10	0.59E-09	0.29E-03	0.29E-03
	20	0.16E-10	0.56E-08	0.48E-10	0.12E-08	0.58E-03	0.58E-03
80	1	3.58E-13	1.24E-10	1.05E-12	2.60E-11	1.30E-05	1.30E-05
	5	0.18E-11	0.62E-09	0.53E-11	0.13E-09	0.65E-04	0.65E-04
	10	0.36E-11	0.12E-08	0.11E-10	0.26E-09	0.13E-03	0.13E-03
	20	0.72E-11	0.25E-08	0.21E-10	0.52E-09	0.26E-03	0.26E-03

Table K-7.25. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Small Intestine, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	3.18E-10	1.10E-07	9.73E-10	2.41E-08	5.60E-04	5.60E-04
	5	0.16E-08	0.55E-06	0.49E-08	0.12E-06	0.28E-02	0.28E-02
	10	0.32E-08	0.11E-05	0.97E-08	0.24E-06	0.56E-02	0.56E-02
	20	0.64E-08	0.22E-05	0.19E-07	0.48E-06	0.11E-01	0.11E-01
5	1	1.78E-11	6.13E-09	5.25E-11	1.30E-09	2.19E-04	2.19E-04
	5	0.89E-10	0.31E-07	0.26E-09	0.65E-08	0.11E-02	0.11E-02
	10	0.18E-09	0.61E-07	0.52E-09	0.13E-07	0.22E-02	0.22E-02
	20	0.36E-09	0.12E-06	0.10E-08	0.26E-07	0.44E-02	0.44E-02
10	1	5.66E-12	1.95E-09	1.67E-11	4.12E-10	1.13E-04	1.13E-04
	5	0.28E-10	0.98E-08	0.83E-10	0.21E-08	0.56E-03	0.56E-03
	10	0.57E-10	0.20E-07	0.17E-09	0.41E-08	0.11E-02	0.11E-02
	20	0.11E-09	0.39E-07	0.33E-09	0.82E-08	0.23E-02	0.23E-02
20	1	2.09E-12	7.21E-10	6.16E-12	1.52E-10	5.94E-05	5.94E-05
	5	0.10E-10	0.36E-08	0.31E-10	0.76E-09	0.30E-03	0.30E-03
	10	0.21E-10	0.72E-08	0.62E-10	0.15E-08	0.59E-03	0.59E-03
	20	0.42E-10	0.14E-07	0.12E-09	0.30E-08	0.12E-02	0.12E-02
40	1	8.90E-13	3.07E-10	2.62E-12	6.47E-11	3.05E-05	3.05E-05
	5	0.44E-11	0.15E-08	0.13E-10	0.32E-09	0.15E-03	0.15E-03
	10	0.89E-11	0.31E-08	0.26E-10	0.65E-09	0.31E-03	0.31E-03
	20	0.18E-10	0.61E-08	0.52E-10	0.13E-08	0.61E-03	0.61E-03
80	1	3.91E-13	1.35E-10	1.15E-12	2.85E-11	1.40E-05	1.40E-05
	5	0.20E-11	0.68E-09	0.58E-11	0.14E-09	0.70E-04	0.70E-04
	10	0.39E-11	0.14E-08	0.12E-10	0.28E-09	0.14E-03	0.14E-03
	20	0.78E-11	0.27E-08	0.23E-10	0.57E-09	0.28E-03	0.28E-03

Table K-7.26. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Lung, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	2.77E-10	6.13E-08	7.92E-10	1.59E-08	1.26E-03	1.26E-03
	5	0.14E-08	0.31E-06	0.40E-08	0.79E-07	0.63E-02	0.63E-02
	10	0.28E-08	0.61E-06	0.79E-08	0.16E-06	0.13E-01	0.13E-01
	20	0.55E-08	0.12E-05	0.16E-07	0.32E-06	0.25E-01	0.25E-01
5	1	1.28E-11	2.84E-09	3.17E-11	6.27E-10	2.02E-04	2.02E-04
	5	0.64E-10	0.14E-07	0.16E-09	0.31E-08	0.10E-02	0.10E-02
	10	0.13E-09	0.28E-07	0.32E-09	0.63E-08	0.20E-02	0.20E-02
	20	0.26E-09	0.57E-07	0.63E-09	0.13E-07	0.40E-02	0.40E-02
10	1	3.90E-12	8.64E-10	9.32E-12	1.84E-10	7.28E-05	7.28E-05
	5	0.20E-10	0.43E-08	0.47E-10	0.92E-09	0.36E-03	0.36E-03
	10	0.39E-10	0.86E-08	0.93E-10	0.18E-08	0.73E-03	0.73E-03
	20	0.78E-10	0.17E-07	0.19E-09	0.37E-08	0.15E-02	0.15E-02
20	1	1.41E-12	3.12E-10	3.29E-12	6.47E-11	2.93E-05	2.93E-05
	5	0.70E-11	0.16E-08	0.16E-10	0.32E-09	0.15E-03	0.15E-03
	10	0.14E-10	0.31E-08	0.33E-10	0.65E-09	0.29E-03	0.29E-03
	20	0.28E-10	0.62E-08	0.66E-10	0.13E-08	0.59E-03	0.59E-03
40	1	6.01E-13	1.33E-10	1.41E-12	2.77E-11	1.32E-05	1.32E-05
	5	0.30E-11	0.67E-09	0.70E-11	0.14E-09	0.66E-04	0.66E-04
	10	0.60E-11	0.13E-08	0.14E-10	0.28E-09	0.13E-03	0.13E-03
	20	0.12E-10	0.27E-08	0.28E-10	0.55E-09	0.26E-03	0.26E-03
80	1	2.64E-13	5.86E-11	6.21E-13	1.22E-11	6.06E-06	6.06E-06
	5	0.13E-11	0.29E-09	0.31E-11	0.61E-10	0.30E-04	0.30E-04
	10	0.26E-11	0.59E-09	0.62E-11	0.12E-09	0.61E-04	0.61E-04
	20	0.53E-11	0.12E-08	0.12E-10	0.24E-09	0.12E-03	0.12E-03

Table K-7.27. Time-Integrated Dose from External Exposure to Airborne Radionuclides Lung, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.92E-09	4.26E-07	4.38E-09	8.58E-08	1.48E-03	1.48E-03
	5	0.96E-08	0.21E-05	0.22E-07	0.43E-06	0.74E-02	0.74E-02
	10	0.19E-07	0.43E-05	0.44E-07	0.86E-06	0.15E-01	0.15E-01
	20	0.38E-07	0.85E-05	0.88E-07	0.17E-05	0.30E-01	0.30E-01
5	1	1.15E-10	2.55E-08	2.68E-10	5.27E-09	2.94E-04	2.94E-04
	5	0.58E-09	0.13E-06	0.13E-08	0.26E-07	0.15E-02	0.15E-02
	10	0.12E-08	0.25E-06	0.27E-08	0.53E-07	0.29E-02	0.29E-02
	20	0.23E-08	0.51E-06	0.54E-08	0.11E-06	0.59E-02	0.59E-02
10	1	3.69E-11	8.17E-09	8.61E-11	1.69E-09	9.59E-04	9.59E-04
	5	0.18E-09	0.41E-07	0.43E-09	0.85E-08	0.48E-02	0.48E-02
	10	0.37E-09	0.82E-07	0.86E-09	0.17E-07	0.96E-02	0.96E-02
	20	0.74E-09	0.16E-06	0.17E-08	0.34E-07	0.19E-01	0.19E-01
20	1	1.37E-11	3.02E-09	3.20E-11	6.29E-10	2.91E-04	2.91E-04
	5	0.68E-10	0.15E-07	0.16E-09	0.31E-08	0.15E-02	0.15E-02
	10	0.14E-09	0.30E-07	0.32E-09	0.63E-08	0.29E-02	0.29E-02
	20	0.27E-09	0.60E-07	0.64E-09	0.13E-07	0.58E-02	0.58E-02
40	1	5.83E-12	1.29E-09	1.37E-11	2.69E-10	2.05E-04	2.05E-04
	5	0.29E-10	0.65E-08	0.68E-10	0.13E-08	0.10E-02	0.10E-02
	10	0.58E-10	0.13E-07	0.14E-09	0.27E-08	0.20E-02	0.20E-02
	20	0.12E-09	0.26E-07	0.27E-09	0.54E-08	0.41E-02	0.41E-02
80	1	2.56E-12	5.68E-10	6.02E-12	1.18E-10	4.25E-05	4.25E-05
	5	0.13E-10	0.28E-08	0.30E-10	0.59E-09	0.21E-03	0.21E-03
	10	0.26E-10	0.57E-08	0.60E-10	0.12E-08	0.43E-03	0.43E-03
	20	0.51E-10	0.11E-07	0.12E-09	0.24E-08	0.85E-03	0.85E-03

Table K-7.28. Time-Integrated Dose from External Exposure to Airborne Radionuclides Lung, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.45E-09	3.21E-07	3.29E-09	6.44E-08	5.32E-03	5.32E-03
	5	0.72E-08	0.16E-05	0.16E-07	0.32E-06	0.27E-01	0.27E-01
	10	0.14E-07	0.32E-05	0.33E-07	0.64E-06	0.53E-01	0.53E-01
	20	0.29E-07	0.64E-05	0.66E-07	0.13E-05	0.11E 00	0.11E 00
5	1	8.63E-11	1.91E-08	2.00E-10	3.93E-09	9.22E-04	9.22E-04
	5	0.43E-09	0.96E-07	0.10E-08	0.20E-07	0.46E-02	0.46E-02
	10	0.86E-09	0.19E-06	0.20E-08	0.39E-07	0.92E-02	0.92E-02
	20	0.17E-08	0.38E-06	0.40E-08	0.79E-07	0.18E-01	0.18E-01
10	1	2.77E-11	6.14E-09	6.47E-11	1.27E-09	4.15E-04	4.15E-04
	5	0.14E-09	0.31E-07	0.32E-09	0.64E-08	0.21E-02	0.21E-02
	10	0.28E-09	0.61E-07	0.65E-09	0.13E-07	0.42E-02	0.42E-02
	20	0.55E-09	0.12E-06	0.13E-08	0.25E-07	0.83E-02	0.83E-02
20	1	1.03E-11	2.26E-09	2.41E-11	4.74E-10	2.01E-04	2.01E-04
	5	0.51E-10	0.11E-07	0.12E-09	0.24E-08	0.10E-02	0.10E-02
	10	0.10E-09	0.23E-07	0.24E-09	0.47E-08	0.20E-02	0.20E-02
	20	0.21E-09	0.46E-07	0.48E-09	0.95E-08	0.40E-02	0.40E-02
40	1	4.39E-12	9.73E-10	1.03E-11	2.03E-10	9.96E-05	9.96E-05
	5	0.22E-10	0.49E-08	0.52E-10	0.10E-08	0.50E-03	0.50E-03
	10	0.44E-10	0.97E-08	0.10E-09	0.20E-08	0.10E-02	0.10E-02
	20	0.88E-10	0.19E-07	0.21E-09	0.41E-08	0.20E-02	0.20E-02
80	1	1.93E-12	4.28E-10	4.54E-12	8.92E-11	4.52E-05	4.52E-05
	5	0.97E-11	0.21E-08	0.23E-10	0.45E-09	0.23E-03	0.23E-03
	10	0.19E-10	0.43E-08	0.45E-10	0.89E-09	0.45E-03	0.45E-03
	20	0.39E-10	0.86E-08	0.91E-10	0.18E-08	0.90E-03	0.90E-03

Table K-7.29. Time-Integrated Dose from External Exposure to Airborne Radionuclides Lung, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	5.55E-10	1.23E-07	1.33E-09	2.62E-08	2.97E-03	2.97E-03
	5	0.28E-08	0.62E-06	0.67E-08	0.13E-06	0.15E-01	0.15E-01
	10	0.56E-08	0.12E-05	0.13E-07	0.26E-06	0.30E-01	0.30E-01
	20	0.11E-07	0.25E-05	0.27E-07	0.52E-06	0.59E-01	0.59E-01
5	1	3.18E-11	7.05E-09	7.52E-11	1.48E-09	3.87E-04	3.87E-04
	5	0.16E-09	0.35E-07	0.38E-09	0.74E-08	0.19E-02	0.19E-02
	10	0.32E-09	0.70E-07	0.75E-09	0.15E-07	0.39E-02	0.39E-02
	20	0.64E-09	0.14E-06	0.15E-08	0.30E-07	0.77E-02	0.77E-02
10	1	1.01E-11	2.25E-09	2.39E-11	4.71E-10	1.61E-04	1.61E-04
	5	0.51E-10	0.11E-07	0.12E-09	0.24E-08	0.80E-03	0.80E-03
	10	0.10E-09	0.22E-07	0.24E-09	0.47E-08	0.16E-02	0.16E-02
	20	0.20E-09	0.45E-07	0.48E-09	0.94E-08	0.32E-02	0.32E-02
20	1	3.74E-12	8.29E-10	8.83E-12	1.74E-10	7.43E-05	7.43E-05
	5	0.19E-10	0.41E-08	0.44E-10	0.87E-09	0.37E-03	0.37E-03
	10	0.37E-10	0.83E-08	0.88E-10	0.17E-08	0.74E-03	0.74E-03
	20	0.75E-10	0.17E-07	0.18E-09	0.35E-08	0.15E-02	0.15E-02
40	1	1.60E-12	3.54E-10	3.78E-12	7.43E-11	3.62E-05	3.62E-05
	5	0.80E-11	0.18E-08	0.19E-10	0.37E-09	0.18E-03	0.18E-03
	10	0.16E-10	0.35E-08	0.38E-10	0.74E-09	0.36E-03	0.36E-03
	20	0.32E-10	0.71E-08	0.76E-10	0.15E-08	0.72E-03	0.72E-03
80	1	7.03E-13	1.56E-10	1.66E-12	3.27E-11	1.63E-05	1.63E-05
	5	0.35E-11	0.78E-09	0.83E-11	0.16E-09	0.81E-04	0.81E-04
	10	0.70E-11	0.16E-08	0.17E-10	0.33E-09	0.16E-03	0.16E-03
	20	0.14E-10	0.31E-08	0.33E-10	0.65E-09	0.33E-03	0.33E-03

Table K-7.30. Time-Integrated Dose from External Exposure to Airborne Radionuclides Lung, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	6.24E-10	1.38E-07	1.54E-09	3.03E-08	7.18E-04	7.19E-04
	5	0.31E-08	0.69E-06	0.77E-08	0.15E-06	0.36E-02	0.36E-02
	10	0.62E-08	0.14E-05	0.15E-07	0.30E-06	0.72E-02	0.72E-02
	20	0.12E-07	0.28E-05	0.31E-07	0.61E-06	0.14E-01	0.14E-01
5	1	3.49E-11	7.72E-09	8.28E-11	1.63E-09	2.76E-04	2.76E-04
	5	0.17E-09	0.39E-07	0.41E-09	0.82E-08	0.14E-02	0.14E-02
	10	0.35E-09	0.77E-07	0.83E-09	0.16E-07	0.28E-02	0.28E-02
	20	0.70E-09	0.15E-06	0.17E-08	0.33E-07	0.55E-02	0.55E-02
10	1	1.11E-11	2.46E-09	2.63E-11	5.18E-10	1.42E-04	1.42E-04
	5	0.56E-10	0.12E-07	0.13E-09	0.26E-08	0.71E-03	0.71E-03
	10	0.11E-09	0.25E-07	0.26E-09	0.52E-08	0.14E-02	0.14E-02
	20	0.22E-09	0.49E-07	0.53E-09	0.10E-07	0.28E-02	0.28E-02
20	1	4.10E-12	9.08E-10	9.72E-12	1.91E-10	7.45E-05	7.45E-05
	5	0.20E-10	0.45E-08	0.49E-10	0.96E-09	0.37E-03	0.37E-03
	10	0.41E-10	0.91E-08	0.97E-10	0.19E-08	0.74E-03	0.74E-03
	20	0.82E-10	0.18E-07	0.19E-09	0.38E-08	0.15E-02	0.15E-02
40	1	1.75E-12	3.87E-10	4.14E-12	8.15E-11	3.83E-05	3.83E-05
	5	0.87E-11	0.19E-08	0.21E-10	0.41E-09	0.19E-03	0.19E-03
	10	0.17E-10	0.39E-08	0.41E-10	0.81E-09	0.38E-03	0.38E-03
	20	0.35E-10	0.77E-08	0.83E-10	0.16E-08	0.77E-03	0.77E-03
80	1	7.68E-13	1.70E-10	1.82E-12	3.58E-11	1.75E-05	1.75E-05
	5	0.38E-11	0.85E-09	0.91E-11	0.18E-09	0.88E-04	0.88E-04
	10	0.77E-11	0.17E-08	0.18E-10	0.36E-09	0.18E-03	0.18E-03
	20	0.15E-10	0.34E-08	0.36E-10	0.72E-09	0.35E-03	0.35E-03

Table K-7.31. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Red Marrow, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	7.83E-10	9.14E-08	1.82E-09	2.56E-08	1.52E-03	1.52E-03
	5	0.39E-08	0.46E-06	0.91E-08	0.13E-06	0.76E-02	0.76E-02
	10	0.78E-08	0.91E-06	0.18E-07	0.26E-06	0.15E-01	0.15E-01
	20	0.16E-07	0.18E-05	0.36E-07	0.51E-06	0.30E-01	0.30E-01
5	1	3.62E-11	4.23E-09	7.30E-11	1.01E-09	2.33E-04	2.33E-04
	5	0.18E-09	0.21E-07	0.36E-09	0.51E-08	0.12E-02	0.12E-02
	10	0.36E-09	0.42E-07	0.73E-09	0.10E-07	0.23E-02	0.23E-02
	20	0.72E-09	0.85E-07	0.15E-08	0.20E-07	0.47E-02	0.47E-02
10	1	1.10E-11	1.29E-09	2.14E-11	2.96E-10	8.34E-05	8.34E-05
	5	0.55E-10	0.64E-08	0.11E-09	0.15E-08	0.42E-03	0.42E-03
	10	0.11E-09	0.13E-07	0.21E-09	0.30E-08	0.83E-03	0.83E-03
	20	0.22E-09	0.26E-07	0.43E-09	0.59E-08	0.17E-02	0.17E-02
20	1	3.98E-12	4.65E-10	7.58E-12	1.04E-10	3.32E-05	3.32E-05
	5	0.20E-10	0.23E-08	0.38E-10	0.52E-09	0.17E-03	0.17E-03
	10	0.40E-10	0.46E-08	0.76E-10	0.10E-08	0.33E-03	0.33E-03
	20	0.80E-10	0.93E-08	0.15E-09	0.21E-08	0.66E-03	0.66E-03
40	1	1.70E-12	1.99E-10	3.24E-12	4.47E-11	1.49E-05	1.49E-05
	5	0.85E-11	0.99E-09	0.16E-10	0.22E-09	0.75E-04	0.75E-04
	10	0.17E-10	0.20E-08	0.32E-10	0.45E-09	0.15E-03	0.15E-03
	20	0.34E-10	0.40E-08	0.65E-10	0.89E-09	0.30E-03	0.30E-03
80	1	7.48E-13	8.74E-11	1.43E-12	1.97E-11	6.83E-06	6.83E-06
	5	0.37E-11	0.44E-09	0.71E-11	0.98E-10	0.34E-04	0.34E-04
	10	0.75E-11	0.87E-09	0.14E-10	0.20E-09	0.68E-04	0.68E-04
	20	0.15E-10	0.17E-08	0.29E-10	0.39E-09	0.14E-03	0.14E-03

Table K-7.32. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Red Marrow, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	5.45E-09	6.36E-07	1.01E-08	1.38E-07	1.82E-03	1.82E-03
	5	0.27E-07	0.32E-05	0.50E-07	0.69E-06	0.91E-02	0.91E-02
	10	0.54E-07	0.64E-05	0.10E-06	0.14E-05	0.18E-01	0.18E-01
	20	0.11E-06	0.13E-04	0.20E-06	0.28E-05	0.36E-01	0.36E-01
5	1	3.26E-10	3.80E-08	6.17E-10	8.49E-09	3.34E-04	3.34E-04
	5	0.16E-08	0.19E-06	0.31E-08	0.42E-07	0.17E-02	0.17E-02
	10	0.33E-08	0.38E-06	0.62E-08	0.85E-07	0.33E-02	0.33E-02
	20	0.65E-08	0.76E-06	0.12E-07	0.17E-06	0.67E-02	0.67E-02
10	1	1.04E-10	1.22E-08	1.98E-10	2.73E-09	1.17E-03	1.17E-03
	5	0.52E-09	0.61E-07	0.99E-09	0.14E-07	0.58E-02	0.58E-02
	10	0.10E-08	0.12E-06	0.20E-08	0.27E-07	0.12E-01	0.12E-01
	20	0.21E-08	0.24E-06	0.40E-08	0.55E-07	0.23E-01	0.23E-01
20	1	3.86E-11	4.51E-09	7.36E-11	1.01E-09	3.32E-04	3.32E-04
	5	0.19E-09	0.23E-07	0.37E-09	0.51E-08	0.17E-02	0.17E-02
	10	0.39E-09	0.45E-07	0.74E-09	0.10E-07	0.33E-02	0.33E-02
	20	0.77E-09	0.90E-07	0.15E-08	0.20E-07	0.66E-02	0.66E-02
40	1	1.65E-11	1.93E-09	3.14E-11	4.33E-10	2.34E-04	2.34E-04
	5	0.82E-10	0.96E-08	0.16E-09	0.22E-08	0.12E-02	0.12E-02
	10	0.16E-09	0.19E-07	0.31E-09	0.43E-08	0.23E-02	0.23E-02
	20	0.33E-09	0.39E-07	0.63E-09	0.87E-08	0.47E-02	0.47E-02
80	1	7.26E-12	8.48E-10	1.39E-11	1.91E-10	4.77E-05	4.77E-05
	5	0.36E-10	0.42E-08	0.69E-10	0.95E-09	0.24E-03	0.24E-03
	10	0.73E-10	0.85E-08	0.14E-09	0.19E-08	0.48E-03	0.48E-03
	20	0.15E-09	0.17E-07	0.28E-09	0.38E-08	0.95E-03	0.95E-03

Table K-7.33. Time-Integrated Dose from External Exposure to Airborne Radionuclides Red Marrow, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	4.10E-09	4.79E-07	7.57E-09	1.04E-07	6.51E-03	6.51E-03
	5	0.20E-07	0.24E-05	0.38E-07	0.52E-06	0.33E-01	0.33E-01
	10	0.41E-07	0.48E-05	0.76E-07	0.10E-05	0.65E-01	0.65E-01
	20	0.82E-07	0.96E-05	0.15E-06	0.21E-05	0.13E 00	0.13E 00
5	1	2.44E-10	2.85E-08	4.60E-10	6.33E-09	1.07E-03	1.07E-03
	5	0.12E-08	0.14E-06	0.23E-08	0.32E-07	0.53E-02	0.53E-02
	10	0.24E-08	0.29E-06	0.46E-08	0.63E-07	0.11E-01	0.11E-01
	20	0.49E-08	0.57E-06	0.92E-08	0.13E-06	0.21E-01	0.21E-01
10	1	7.85E-11	9.17E-09	1.49E-10	2.05E-09	4.76E-04	4.76E-04
	5	0.39E-09	0.46E-07	0.74E-09	0.10E-07	0.24E-02	0.24E-02
	10	0.79E-09	0.92E-07	0.15E-08	0.20E-07	0.48E-02	0.48E-02
	20	0.16E-08	0.18E-06	0.30E-08	0.41E-07	0.95E-02	0.95E-02
20	1	2.91E-11	3.40E-09	5.54E-11	7.64E-10	2.28E-04	2.28E-04
	5	0.15E-09	0.17E-07	0.28E-09	0.38E-08	0.11E-02	0.11E-02
	10	0.29E-09	0.34E-07	0.55E-09	0.76E-08	0.23E-02	0.23E-02
	20	0.58E-09	0.68E-07	0.11E-08	0.15E-07	0.46E-02	0.46E-02
40	1	1.24E-11	1.45E-09	2.37E-11	3.26E-10	1.12E-04	1.12E-04
	5	0.62E-10	0.73E-08	0.12E-09	0.16E-08	0.56E-03	0.56E-03
	10	0.12E-09	0.15E-07	0.24E-09	0.33E-08	0.11E-02	0.11E-02
	20	0.25E-09	0.29E-07	0.47E-09	0.65E-08	0.22E-02	0.22E-02
80	1	5.47E-12	6.39E-10	1.04E-11	1.44E-10	5.09E-05	5.09E-05
	5	0.27E-10	0.32E-08	0.52E-10	0.72E-09	0.25E-03	0.25E-03
	10	0.55E-10	0.64E-08	0.10E-09	0.14E-08	0.51E-03	0.51E-03
	20	0.11E-09	0.13E-07	0.21E-09	0.29E-08	0.10E-02	0.10E-02

Table K-7.34. Time-Integrated Dose from External Exposure to Airborne Radionuclides Red Marrow, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.57E-09	1.84E-07	3.06E-09	4.23E-08	3.68E-03	3.68E-03
	5	0.79E-08	0.92E-06	0.15E-07	0.21E-06	0.18E-01	0.18E-01
	10	0.16E-07	0.18E-05	0.31E-07	0.42E-06	0.37E-01	0.37E-01
	20	0.31E-07	0.37E-05	0.61E-07	0.85E-06	0.74E-01	0.74E-01
5	1	9.00E-11	1.05E-08	1.73E-10	2.38E-09	4.49E-04	4.49E-04
	5	0.45E-09	0.53E-07	0.86E-09	0.12E-07	0.22E-02	0.22E-02
	10	0.90E-09	0.11E-06	0.17E-08	0.24E-07	0.45E-02	0.45E-02
	20	0.18E-08	0.21E-06	0.35E-08	0.48E-07	0.90E-02	0.90E-02
10	1	2.87E-11	3.35E-09	5.51E-11	7.59E-10	1.84E-04	1.84E-04
	5	0.14E-09	0.17E-07	0.28E-09	0.38E-08	0.92E-03	0.92E-03
	10	0.29E-09	0.34E-07	0.55E-09	0.76E-08	0.18E-02	0.18E-02
	20	0.57E-09	0.67E-07	0.11E-08	0.15E-07	0.37E-02	0.37E-02
20	1	1.06E-11	1.24E-09	2.03E-11	2.80E-10	8.43E-05	8.43E-05
	5	0.53E-10	0.62E-08	0.10E-09	0.14E-08	0.42E-03	0.42E-03
	10	0.11E-09	0.12E-07	0.20E-09	0.28E-08	0.84E-03	0.84E-03
	20	0.21E-09	0.25E-07	0.41E-09	0.56E-08	0.17E-02	0.17E-02
40	1	4.52E-12	5.28E-10	8.68E-12	1.20E-10	4.08E-05	4.08E-05
	5	0.23E-10	0.26E-08	0.43E-10	0.60E-09	0.20E-03	0.20E-03
	10	0.45E-10	0.53E-08	0.87E-10	0.12E-08	0.41E-03	0.41E-03
	20	0.90E-10	0.11E-07	0.17E-09	0.24E-08	0.82E-03	0.82E-03
80	1	1.99E-12	2.32E-10	3.82E-12	5.27E-11	1.83E-05	1.83E-05
	5	0.99E-11	0.12E-08	0.19E-10	0.26E-09	0.92E-04	0.92E-04
	10	0.20E-10	0.23E-08	0.38E-10	0.53E-09	0.18E-03	0.18E-03
	20	0.40E-10	0.46E-08	0.76E-10	0.11E-08	0.37E-03	0.37E-03

Table K-7.35. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Red Marrow, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.77E-09	2.06E-07	3.53E-09	4.89E-08	8.77E-04	8.77E-04
	5	0.88E-08	0.10E-05	0.18E-07	0.24E-06	0.44E-02	0.44E-02
	10	0.18E-07	0.21E-05	0.35E-07	0.49E-06	0.88E-02	0.88E-02
	20	0.35E-07	0.41E-05	0.71E-07	0.98E-06	0.18E-01	0.18E-01
5	1	9.67E-11	1.15E-08	1.91E-10	2.63E-09	3.19E-04	3.19E-04
	5	0.49E-09	0.58E-07	0.95E-09	0.13E-07	0.16E-02	0.16E-02
	10	0.99E-09	0.12E-06	0.19E-08	0.26E-07	0.32E-02	0.32E-02
	20	0.20E-08	0.23E-06	0.38E-08	0.53E-07	0.64E-02	0.64E-02
10	1	3.14E-11	3.67E-09	6.06E-11	8.35E-10	1.63E-04	1.63E-04
	5	0.16E-09	0.18E-07	0.30E-09	0.42E-08	0.81E-03	0.81E-03
	10	0.31E-09	0.37E-07	0.61E-09	0.84E-08	0.16E-02	0.16E-02
	20	0.63E-09	0.73E-07	0.12E-08	0.17E-07	0.33E-02	0.33E-02
20	1	1.16E-11	1.35E-09	2.24E-11	3.08E-10	8.45E-05	8.45E-05
	5	0.58E-10	0.68E-08	0.11E-09	0.15E-08	0.42E-03	0.42E-03
	10	0.12E-09	0.14E-07	0.22E-09	0.31E-08	0.85E-03	0.85E-03
	20	0.23E-09	0.27E-07	0.45E-09	0.62E-08	0.17E-02	0.17E-02
40	1	4.94E-12	5.77E-10	9.53E-12	1.31E-10	4.32E-05	4.32E-05
	5	0.25E-10	0.29E-08	0.48E-10	0.66E-09	0.22E-03	0.22E-03
	10	0.49E-10	0.58E-08	0.95E-10	0.13E-08	0.43E-03	0.43E-03
	20	0.99E-10	0.12E-07	0.19E-09	0.26E-08	0.86E-03	0.86E-03
80	1	2.17E-12	2.54E-10	4.19E-12	5.78E-11	1.98E-05	1.98E-05
	5	0.11E-10	0.13E-08	0.21E-10	0.29E-09	0.99E-04	0.99E-04
	10	0.22E-10	0.25E-08	0.42E-10	0.58E-09	0.20E-03	0.20E-03
	20	0.43E-10	0.51E-08	0.84E-10	0.12E-08	0.40E-03	0.40E-03

Table K-7.36. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Skeleton, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	8.87E-10	9.96E-08	2.00E-09	2.75E-08	1.62E-03	1.62E-03
	5	0.44E-08	0.50E-06	0.10E-07	0.14E-06	0.81E-02	0.81E-02
	10	0.89E-08	0.10E-05	0.20E-07	0.28E-06	0.16E-01	0.16E-01
	20	0.18E-07	0.20E-05	0.40E-07	0.55E-06	0.32E-01	0.32E-01
5	1	4.11E-11	4.61E-09	8.02E-11	1.09E-09	2.49E-04	2.49E-04
	5	0.21E-09	0.23E-07	0.40E-09	0.54E-08	0.12E-02	0.12E-02
	10	0.41E-09	0.46E-07	0.80E-09	0.11E-07	0.25E-02	0.25E-02
	20	0.82E-09	0.92E-07	0.16E-08	0.22E-07	0.50E-02	0.50E-02
10	1	1.25E-11	1.40E-09	2.36E-11	3.19E-10	8.93E-05	8.93E-05
	5	0.63E-10	0.70E-08	0.12E-09	0.16E-08	0.45E-03	0.45E-03
	10	0.13E-09	0.14E-07	0.24E-09	0.32E-08	0.89E-03	0.89E-03
	20	0.25E-09	0.28E-07	0.47E-09	0.64E-08	0.18E-02	0.18E-02
20	1	4.51E-12	5.07E-10	8.33E-12	1.12E-10	3.56E-05	3.56E-05
	5	0.23E-10	0.25E-08	0.42E-10	0.56E-09	0.18E-03	0.18E-03
	10	0.45E-10	0.51E-08	0.83E-10	0.11E-08	0.36E-03	0.36E-03
	20	0.90E-10	0.10E-07	0.17E-09	0.22E-08	0.71E-03	0.71E-03
40	1	1.93E-12	2.16E-10	3.56E-12	4.81E-11	1.60E-05	1.60E-05
	5	0.96E-11	0.11E-08	0.18E-10	0.24E-09	0.80E-04	0.80E-04
	10	0.19E-10	0.22E-08	0.36E-10	0.48E-09	0.16E-03	0.16E-03
	20	0.39E-10	0.43E-08	0.71E-10	0.96E-09	0.32E-03	0.32E-03
80	1	8.48E-13	9.52E-11	1.57E-12	2.12E-11	7.32E-06	7.32E-06
	5	0.42E-11	0.48E-09	0.79E-11	0.11E-09	0.37E-04	0.37E-04
	10	0.85E-11	0.95E-09	0.16E-10	0.21E-09	0.73E-04	0.73E-04
	20	0.17E-10	0.19E-08	0.31E-10	0.42E-09	0.15E-03	0.15E-03

Table K-7.37. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skeleton, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	6.17E-09	6.93E-07	1.11E-08	1.49E-07	1.95E-03	1.95E-03
	5	0.31E-07	0.35E-05	0.55E-07	0.75E-06	0.98E-02	0.98E-02
	10	0.62E-07	0.69E-05	0.11E-06	0.15E-05	0.20E-01	0.20E-01
	20	0.12E-06	0.14E-04	0.22E-06	0.30E-05	0.39E-01	0.39E-01
5	1	3.69E-10	4.14E-08	6.78E-10	9.15E-09	3.58E-04	3.58E-04
	5	0.18E-08	0.21E-06	0.34E-08	0.46E-07	0.18E-02	0.18E-02
	10	0.37E-08	0.41E-06	0.68E-08	0.91E-07	0.36E-02	0.36E-02
	20	0.74E-08	0.83E-06	0.14E-07	0.18E-06	0.72E-02	0.72E-02
10	1	1.18E-10	1.33E-08	2.18E-10	2.94E-09	1.25E-03	1.25E-03
	5	0.59E-09	0.66E-07	0.11E-08	0.15E-07	0.63E-02	0.63E-02
	10	0.12E-08	0.13E-06	0.22E-08	0.29E-07	0.13E-01	0.13E-01
	20	0.24E-08	0.27E-06	0.44E-08	0.59E-07	0.25E-01	0.25E-01
20	1	4.38E-11	4.92E-09	8.09E-11	1.09E-09	3.57E-04	3.57E-04
	5	0.22E-09	0.25E-07	0.40E-09	0.55E-08	0.18E-02	0.18E-02
	10	0.44E-09	0.49E-07	0.81E-09	0.11E-07	0.36E-02	0.36E-02
	20	0.88E-09	0.98E-07	0.16E-08	0.22E-07	0.71E-02	0.71E-02
40	1	1.87E-11	2.10E-09	3.46E-11	4.67E-10	2.51E-04	2.51E-04
	5	0.93E-10	0.10E-07	0.17E-09	0.23E-08	0.13E-02	0.13E-02
	10	0.19E-09	0.21E-07	0.35E-09	0.47E-08	0.25E-02	0.25E-02
	20	0.37E-09	0.42E-07	0.69E-09	0.93E-08	0.50E-02	0.50E-02
80	1	8.23E-12	9.23E-10	1.52E-11	2.06E-10	5.12E-05	5.12E-05
	5	0.41E-10	0.46E-08	0.76E-10	0.10E-08	0.26E-03	0.26E-03
	10	0.82E-10	0.92E-08	0.15E-09	0.21E-08	0.51E-03	0.51E-03
	20	0.16E-09	0.18E-07	0.30E-09	0.41E-08	0.10E-02	0.10E-02

Table K-7.38. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skeleton, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	4.64E-09	5.21E-07	8.32E-09	1.12E-07	6.88E-03	6.88E-03
	5	0.23E-07	0.26E-05	0.42E-07	0.56E-06	0.34E-01	0.34E-01
	10	0.46E-07	0.52E-05	0.83E-07	0.11E-05	0.69E-01	0.69E-01
	20	0.93E-07	0.10E-04	0.17E-06	0.22E-05	0.14E 00	0.14E 00
5	1	2.77E-10	3.11E-08	5.06E-10	6.82E-09	1.14E-03	1.14E-03
	5	0.14E-08	0.16E-06	0.25E-08	0.34E-07	0.57E-02	0.57E-02
	10	0.28E-08	0.31E-06	0.51E-08	0.68E-07	0.11E-01	0.11E-01
	20	0.55E-08	0.62E-06	0.10E-07	0.14E-06	0.23E-01	0.23E-01
10	1	8.90E-11	9.99E-09	1.64E-10	2.21E-09	5.10E-04	5.10E-04
	5	0.44E-09	0.50E-07	0.82E-09	0.11E-07	0.25E-02	0.25E-02
	10	0.89E-09	0.10E-06	0.16E-08	0.22E-07	0.51E-02	0.51E-02
	20	0.18E-08	0.20E-06	0.33E-08	0.44E-07	0.10E-01	0.10E-01
20	1	3.30E-11	3.71E-09	6.09E-11	8.23E-10	2.45E-04	2.45E-04
	5	0.17E-09	0.19E-07	0.30E-09	0.41E-08	0.12E-02	0.12E-02
	10	0.33E-09	0.37E-07	0.61E-09	0.82E-08	0.24E-02	0.24E-02
	20	0.66E-09	0.74E-07	0.12E-08	0.16E-07	0.49E-02	0.49E-02
40	1	1.41E-11	1.58E-09	2.61E-11	3.52E-10	1.21E-04	1.21E-04
	5	0.70E-10	0.79E-08	0.13E-09	0.18E-08	0.60E-03	0.60E-03
	10	0.14E-09	0.16E-07	0.26E-09	0.35E-08	0.12E-02	0.12E-02
	20	0.28E-09	0.32E-07	0.52E-09	0.70E-08	0.24E-02	0.24E-02
80	1	6.20E-12	6.96E-10	1.15E-11	1.55E-10	5.46E-05	5.46E-05
	5	0.31E-10	0.35E-08	0.57E-10	0.77E-09	0.27E-03	0.27E-03
	10	0.62E-10	0.70E-08	0.11E-09	0.15E-08	0.55E-03	0.55E-03
	20	0.12E-09	0.14E-07	0.23E-09	0.31E-08	0.11E-02	0.11E-02

Table K-7.39. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skeleton, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.78E-09	2.00E-07	3.37E-09	4.55E-08	3.88E-03	3.89E-03
	5	0.89E-08	0.10E-05	0.17E-07	0.23E-06	0.19E-01	0.19E-01
	10	0.18E-07	0.20E-05	0.34E-07	0.46E-06	0.39E-01	0.39E-01
	20	0.36E-07	0.40E-05	0.67E-07	0.91E-06	0.78E-01	0.78E-01
5	1	1.02E-10	1.15E-08	1.90E-10	2.57E-09	4.80E-04	4.80E-04
	5	0.51E-09	0.57E-07	0.95E-09	0.13E-07	0.24E-02	0.24E-02
	10	0.10E-08	0.11E-06	0.19E-08	0.26E-07	0.48E-02	0.48E-02
	20	0.20E-08	0.23E-06	0.38E-08	0.51E-07	0.96E-02	0.96E-02
10	1	3.25E-11	3.65E-09	6.05E-11	8.18E-10	1.97E-04	1.97E-04
	5	0.16E-09	0.18E-07	0.30E-09	0.41E-08	0.99E-03	0.99E-03
	10	0.33E-09	0.37E-07	0.61E-09	0.82E-08	0.20E-02	0.20E-02
	20	0.65E-09	0.73E-07	0.12E-08	0.16E-07	0.39E-02	0.39E-02
20	1	1.20E-11	1.35E-09	2.23E-11	3.02E-10	9.04E-05	9.04E-05
	5	0.60E-10	0.67E-08	0.11E-09	0.15E-08	0.45E-03	0.45E-03
	10	0.12E-09	0.13E-07	0.22E-09	0.30E-08	0.90E-03	0.90E-03
	20	0.24E-09	0.27E-07	0.45E-09	0.60E-08	0.18E-02	0.18E-02
40	1	5.12E-12	5.75E-10	9.55E-12	1.29E-10	4.38E-05	4.38E-05
	5	0.26E-10	0.29E-08	0.48E-10	0.64E-09	0.22E-03	0.22E-03
	10	0.51E-10	0.58E-08	0.95E-10	0.13E-08	0.44E-03	0.44E-03
	20	0.10E-09	0.12E-07	0.19E-09	0.26E-08	0.88E-03	0.88E-03
80	1	2.26E-12	2.53E-10	4.20E-12	5.68E-11	1.97E-05	1.97E-05
	5	0.11E-10	0.13E-08	0.21E-10	0.28E-09	0.98E-04	0.98E-04
	10	0.23E-10	0.25E-08	0.42E-10	0.57E-09	0.20E-03	0.20E-03
	20	0.45E-10	0.51E-08	0.84E-10	0.11E-08	0.39E-03	0.39E-03

Table K-7.40. Time-Integrated Dose from External Exposure to Airborne Radionuclides Skeleton, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	2.00E-09	2.25E-07	3.80E-09	5.27E-08	9.29E-04	9.29E-04
	5	0.10E-07	0.11E-05	0.19E-07	0.26E-06	0.46E-02	0.46E-02
	10	0.20E-07	0.22E-05	0.39E-07	0.53E-06	0.93E-02	0.93E-02
	20	0.40E-07	0.45E-05	0.78E-07	0.11E-05	0.19E-01	0.19E-01
5	1	1.12E-10	1.26E-08	2.09E-10	2.83E-09	3.42E-04	3.42E-04
	5	0.56E-09	0.63E-07	0.10E-08	0.14E-07	0.17E-02	0.17E-02
	10	0.11E-08	0.13E-06	0.21E-08	0.28E-07	0.34E-02	0.34E-02
	20	0.22E-08	0.25E-06	0.42E-08	0.57E-07	0.68E-02	0.68E-02
10	1	3.56E-11	4.00E-09	6.66E-11	9.00E-10	1.74E-04	1.74E-04
	5	0.18E-09	0.20E-07	0.33E-09	0.45E-08	0.87E-03	0.87E-03
	10	0.36E-09	0.40E-07	0.67E-09	0.90E-08	0.17E-02	0.17E-02
	20	0.71E-09	0.80E-07	0.13E-08	0.18E-07	0.35E-02	0.35E-02
20	1	1.31E-11	1.48E-09	2.46E-11	3.32E-10	9.07E-05	9.07E-05
	5	0.66E-10	0.74E-08	0.12E-09	0.17E-08	0.45E-03	0.45E-03
	10	0.13E-09	0.15E-07	0.25E-09	0.33E-08	0.91E-03	0.91E-03
	20	0.26E-09	0.30E-07	0.49E-09	0.66E-08	0.18E-02	0.18E-02
40	1	5.60E-12	6.29E-10	1.05E-11	1.42E-10	4.63E-05	4.63E-05
	5	0.28E-10	0.31E-08	0.52E-10	0.71E-09	0.23E-03	0.23E-03
	10	0.56E-10	0.63E-08	0.10E-09	0.14E-08	0.46E-03	0.46E-03
	20	0.11E-09	0.13E-07	0.21E-09	0.28E-08	0.93E-03	0.93E-03
80	1	2.46E-12	2.76E-10	4.61E-12	6.22E-11	2.12E-05	2.12E-05
	5	0.12E-10	0.14E-08	0.23E-10	0.31E-09	0.11E-03	0.11E-03
	10	0.25E-10	0.28E-08	0.46E-10	0.62E-09	0.21E-03	0.21E-03
	20	0.49E-10	0.55E-08	0.92E-10	0.12E-08	0.42E-03	0.42E-03

Table K-7.41. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Spleen, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.87E-10	5.62E-08	6.30E-10	1.44E-08	1.35E-03	1.35E-03
	5	0.93E-09	0.28E-06	0.31E-08	0.72E-07	0.68E-02	0.68E-02
	10	0.19E-08	0.56E-06	0.63E-08	0.14E-06	0.14E-01	0.14E-01
	20	0.37E-08	0.11E-05	0.13E-07	0.29E-06	0.27E-01	0.27E-01
5	1	8.64E-12	2.60E-09	2.52E-11	5.69E-10	2.12E-04	2.12E-04
	5	0.43E-10	0.13E-07	0.13E-09	0.28E-08	0.11E-02	0.11E-02
	10	0.86E-10	0.26E-07	0.25E-09	0.57E-08	0.21E-02	0.21E-02
	20	0.17E-09	0.52E-07	0.50E-09	0.11E-07	0.42E-02	0.42E-02
10	1	2.63E-12	7.92E-10	7.41E-12	1.67E-10	7.64E-05	7.65E-05
	5	0.13E-10	0.40E-08	0.37E-10	0.83E-09	0.38E-03	0.38E-03
	10	0.26E-10	0.79E-08	0.74E-10	0.17E-08	0.76E-03	0.76E-03
	20	0.53E-10	0.16E-07	0.15E-09	0.33E-08	0.15E-02	0.15E-02
20	1	9.50E-13	2.86E-10	2.62E-12	5.88E-11	3.07E-05	3.07E-05
	5	0.47E-11	0.14E-08	0.13E-10	0.29E-09	0.15E-03	0.15E-03
	10	0.95E-11	0.29E-08	0.26E-10	0.59E-09	0.31E-03	0.31E-03
	20	0.19E-10	0.57E-08	0.52E-10	0.12E-08	0.61E-03	0.61E-03
40	1	4.05E-13	1.22E-10	1.12E-12	2.51E-11	1.39E-05	1.39E-05
	5	0.20E-11	0.61E-09	0.56E-11	0.13E-09	0.69E-04	0.69E-04
	10	0.41E-11	0.12E-08	0.11E-10	0.25E-09	0.14E-03	0.14E-03
	20	0.81E-11	0.24E-08	0.22E-10	0.50E-09	0.28E-03	0.28E-03
80	1	1.79E-13	5.37E-11	4.94E-13	1.11E-11	6.35E-06	6.35E-06
	5	0.89E-12	0.27E-09	0.25E-11	0.55E-10	0.32E-04	0.32E-04
	10	0.18E-11	0.54E-09	0.49E-11	0.11E-09	0.64E-04	0.64E-04
	20	0.36E-11	0.11E-08	0.99E-11	0.22E-09	0.13E-03	0.13E-03

Table K-7.42. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Spleen, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	1.30E-09	3.91E-07	3.48E-09	7.79E-08	1.54E-03	1.54E-03
	5	0.65E-08	0.20E-05	0.17E-07	0.39E-06	0.77E-02	0.77E-02
	10	0.13E-07	0.39E-05	0.35E-07	0.78E-06	0.15E-01	0.15E-01
	20	0.26E-07	0.78E-05	0.70E-07	0.16E-05	0.31E-01	0.31E-01
5	1	7.77E-11	2.34E-08	2.13E-10	4.78E-09	3.07E-04	3.07E-04
	5	0.39E-09	0.12E-06	0.11E-08	0.24E-07	0.15E-02	0.15E-02
	10	0.78E-09	0.23E-06	0.21E-08	0.48E-07	0.31E-02	0.31E-02
	20	0.16E-08	0.47E-06	0.43E-08	0.96E-07	0.61E-02	0.61E-02
10	1	2.49E-11	7.49E-09	6.85E-11	1.54E-09	9.97E-04	9.97E-04
	5	0.12E-09	0.37E-07	0.34E-09	0.77E-08	0.50E-02	0.50E-02
	10	0.25E-09	0.75E-07	0.69E-09	0.15E-07	0.10E-01	0.10E-01
	20	0.50E-09	0.15E-06	0.14E-08	0.31E-07	0.20E-01	0.20E-01
20	1	9.22E-12	2.77E-09	2.54E-11	5.71E-10	3.03E-04	3.03E-04
	5	0.46E-10	0.14E-07	0.13E-09	0.29E-08	0.15E-02	0.15E-02
	10	0.92E-10	0.28E-07	0.25E-09	0.57E-08	0.30E-02	0.30E-02
	20	0.18E-09	0.55E-07	0.51E-09	0.11E-07	0.61E-02	0.61E-02
40	1	3.93E-12	1.18E-09	1.09E-11	2.44E-10	2.13E-04	2.13E-04
	5	0.20E-10	0.59E-08	0.54E-10	0.12E-08	0.11E-02	0.11E-02
	10	0.39E-10	0.12E-07	0.11E-09	0.24E-08	0.21E-02	0.21E-02
	20	0.79E-10	0.24E-07	0.22E-09	0.49E-08	0.43E-02	0.43E-02
80	1	1.73E-12	5.21E-10	4.79E-12	1.07E-10	4.44E-05	4.44E-05
	5	0.87E-11	0.26E-08	0.24E-10	0.54E-09	0.22E-03	0.22E-03
	10	0.17E-10	0.52E-08	0.48E-10	0.11E-08	0.44E-03	0.44E-03
	20	0.35E-10	0.10E-07	0.96E-10	0.21E-08	0.89E-03	0.89E-03

Table K-7.43. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Spleen, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	9.77E-10	2.94E-07	2.62E-09	5.85E-08	5.81E-03	5.81E-03
	5	0.49E-08	0.15E-05	0.13E-07	0.29E-06	0.29E-01	0.29E-01
	10	0.98E-08	0.29E-05	0.26E-07	0.58E-06	0.58E-01	0.58E-01
	20	0.20E-07	0.59E-05	0.52E-07	0.12E-05	0.12E 00	0.12E 00
5	1	5.83E-11	1.75E-08	1.59E-10	3.57E-09	9.71E-04	9.71E-04
	5	0.29E-09	0.88E-07	0.80E-09	0.18E-07	0.49E-02	0.49E-02
	10	0.58E-09	0.18E-06	0.16E-08	0.36E-07	0.97E-02	0.97E-02
	20	0.12E-08	0.35E-06	0.32E-08	0.71E-07	0.19E-01	0.19E-01
10	1	1.87E-11	5.63E-09	5.14E-11	1.15E-09	4.36E-04	4.36E-04
	5	0.94E-10	0.28E-07	0.26E-09	0.58E-08	0.22E-02	0.22E-02
	10	0.19E-09	0.56E-07	0.51E-09	0.12E-07	0.44E-02	0.44E-02
	20	0.37E-09	0.11E-06	0.10E-08	0.23E-07	0.87E-02	0.87E-02
20	1	6.95E-12	2.09E-09	1.92E-11	4.30E-10	2.11E-04	2.11E-04
	5	0.35E-10	0.10E-07	0.96E-10	0.21E-08	0.11E-02	0.11E-02
	10	0.69E-10	0.21E-07	0.19E-09	0.43E-08	0.21E-02	0.21E-02
	20	0.14E-09	0.42E-07	0.38E-09	0.86E-08	0.42E-02	0.42E-02
40	1	2.96E-12	8.92E-10	8.19E-12	1.84E-10	1.04E-04	1.04E-04
	5	0.15E-10	0.45E-08	0.41E-10	0.92E-09	0.52E-03	0.52E-03
	10	0.30E-10	0.89E-08	0.82E-10	0.18E-08	0.10E-02	0.10E-02
	20	0.59E-10	0.18E-07	0.16E-09	0.37E-08	0.21E-02	0.21E-02
80	1	1.30E-12	3.92E-10	3.61E-12	8.10E-11	4.73E-05	4.73E-05
	5	0.65E-11	0.20E-08	0.18E-10	0.40E-09	0.24E-03	0.24E-03
	10	0.13E-10	0.39E-08	0.36E-10	0.81E-09	0.47E-03	0.47E-03
	20	0.26E-10	0.78E-08	0.72E-10	0.16E-08	0.95E-03	0.95E-03

Table K-7.44. Time-Integrated Dose from External Exposure to Airborne Radionuclides
Spleen, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	3.75E-10	1.13E-07	1.06E-09	2.38E-08	3.26E-03	3.26E-03
	5	0.19E-08	0.56E-06	0.53E-08	0.12E-06	0.16E-01	0.16E-01
	10	0.37E-08	0.11E-05	0.11E-07	0.24E-06	0.33E-01	0.33E-01
	20	0.75E-08	0.23E-05	0.21E-07	0.48E-06	0.65E-01	0.65E-01
5	1	2.15E-11	6.46E-09	5.98E-11	1.34E-09	4.08E-04	4.08E-04
	5	0.11E-09	0.32E-07	0.30E-09	0.67E-08	0.20E-02	0.20E-02
	10	0.21E-09	0.65E-07	0.60E-09	0.13E-07	0.41E-02	0.41E-02
	20	0.43E-09	0.13E-06	0.12E-08	0.27E-07	0.82E-02	0.82E-02
10	1	6.85E-12	2.06E-09	1.90E-11	4.27E-10	1.69E-04	1.69E-04
	5	0.34E-10	0.10E-07	0.95E-10	0.21E-08	0.84E-03	0.84E-03
	10	0.68E-10	0.21E-07	0.19E-09	0.43E-08	0.17E-02	0.17E-02
	20	0.14E-09	0.41E-07	0.38E-09	0.85E-08	0.34E-02	0.34E-02
20	1	2.53E-12	7.60E-10	7.03E-12	1.58E-10	7.79E-05	7.79E-05
	5	0.13E-10	0.38E-08	0.35E-10	0.79E-09	0.39E-03	0.39E-03
	10	0.25E-10	0.76E-08	0.70E-10	0.16E-08	0.78E-03	0.78E-03
	20	0.51E-10	0.15E-07	0.14E-09	0.32E-08	0.16E-02	0.16E-02
40	1	1.08E-12	3.24E-10	3.00E-12	6.74E-11	3.79E-05	3.79E-05
	5	0.54E-11	0.16E-08	0.15E-10	0.34E-09	0.19E-03	0.19E-03
	10	0.11E-10	0.32E-08	0.30E-10	0.67E-09	0.38E-03	0.38E-03
	20	0.22E-10	0.65E-08	0.60E-10	0.13E-08	0.76E-03	0.76E-03
80	1	4.75E-13	1.43E-10	1.32E-12	2.97E-11	1.71E-05	1.71E-05
	5	0.24E-11	0.71E-09	0.66E-11	0.15E-09	0.85E-04	0.85E-04
	10	0.47E-11	0.14E-08	0.13E-10	0.30E-09	0.17E-03	0.17E-03
	20	0.95E-11	0.29E-08	0.26E-10	0.59E-09	0.34E-03	0.34E-03

Table K-7.45. Time-Integrated Dose from External Exposure to Airborne Radionuclides Spleen, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	RN222-PB210	TOTAL DOSE
1	1	4.21E-10	1.27E-07	1.22E-09	2.75E-08	7.76E-04	7.76E-04
	5	0.21E-08	0.63E-06	0.61E-08	0.14E-06	0.39E-02	0.39E-02
	10	0.42E-08	0.13E-05	0.12E-07	0.28E-06	0.78E-02	0.78E-02
	20	0.84E-08	0.25E-05	0.24E-07	0.55E-06	0.16E-01	0.16E-01
5	1	2.35E-11	7.08E-09	6.59E-11	1.48E-09	2.90E-04	2.90E-04
	5	0.12E-09	0.35E-07	0.33E-09	0.74E-08	0.15E-02	0.15E-02
	10	0.24E-09	0.71E-07	0.66E-09	0.15E-07	0.29E-02	0.29E-02
	20	0.47E-09	0.14E-06	0.13E-08	0.30E-07	0.58E-02	0.58E-02
10	1	7.49E-12	2.25E-09	2.09E-11	4.70E-10	1.49E-04	1.49E-04
	5	0.37E-10	0.11E-07	0.10E-09	0.24E-08	0.75E-03	0.75E-03
	10	0.75E-10	0.23E-07	0.21E-09	0.47E-08	0.15E-02	0.15E-02
	20	0.15E-09	0.45E-07	0.42E-09	0.94E-08	0.30E-02	0.30E-02
20	1	2.77E-12	8.32E-10	7.73E-12	1.74E-10	7.81E-05	7.81E-05
	5	0.14E-10	0.42E-08	0.39E-10	0.87E-09	0.39E-03	0.39E-03
	10	0.28E-10	0.83E-08	0.77E-10	0.17E-08	0.78E-03	0.78E-03
	20	0.55E-10	0.17E-07	0.15E-09	0.35E-08	0.16E-02	0.16E-02
40	1	1.18E-12	3.54E-10	3.29E-12	7.40E-11	4.01E-05	4.01E-05
	5	0.59E-11	0.18E-08	0.16E-10	0.37E-09	0.20E-03	0.20E-03
	10	0.12E-10	0.35E-08	0.33E-10	0.74E-09	0.40E-03	0.40E-03
	20	0.24E-10	0.71E-08	0.66E-10	0.15E-08	0.80E-03	0.80E-03
80	1	5.18E-13	1.56E-10	1.45E-12	3.25E-11	1.84E-05	1.84E-05
	5	0.26E-11	0.78E-09	0.72E-11	0.16E-09	0.92E-04	0.92E-04
	10	0.52E-11	0.16E-08	0.14E-10	0.33E-09	0.18E-03	0.18E-03
	20	0.10E-10	0.31E-08	0.29E-10	0.65E-09	0.37E-03	0.37E-03

APPENDIX K-8. TIME-INTEGRATED DOSE FROM EXTERNAL EXPOSURE TO SURFACE ACTIVITY DURING THE PERIOD OF BEAR CREEK URANIUM MILLING OPERATION

Tables K-8.1--K-8.5.	Dose to Whole Body
Tables K-8.6--K-8.10.	Dose to Skin
Tables K-8.11--K-8.15.	Dose to Ovaries
Tables K-8.16--K-8.20.	Dose to Testes
Tables K-8.21--K-8.25.	Dose to Small Intestine
Tables K-8.26--K-8.30.	Dose to Lung
Tables K-8.31--K-8.35.	Dose to Red Marrow
Tables K-8.36--K-8.40.	Dose to Skeleton
Tables K-8.41--K-8.45.	Dose to Spleen

Table K-8.1. Time-Integrated Dose from External Exposure to Surface Activity
Whole Body, Angle = 0°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	6.34E-05	6.75E-04	1.00E-04	1.53E-04	3.66E-04	1.36E-03
	5	0.16E-02	0.17E-01	0.25E-02	0.38E-02	0.90E-02	0.33E-01
	10	0.61E-02	0.65E-01	0.96E-02	0.15E-01	0.35E-01	0.13E 00
	20	0.47E-01	0.50E 00	0.73E-01	0.11E 00	0.27E 00	0.10E 01
	40	0.85E-01	0.91E 00	0.13E 00	0.21E 00	0.49E 00	0.18E 01
	70	0.13E 00	0.14E 01	0.20E 00	0.31E 00	0.73E 00	0.27E 01
5	1	1.37E-06	1.46E-05	1.52E-06	2.25E-06	5.40E-06	2.51E-05
	5	0.34E-04	0.36E-03	0.37E-04	0.55E-04	0.13E-03	0.62E-03
	10	0.13E-03	0.14E-02	0.15E-03	0.22E-03	0.52E-03	0.24E-02
	20	0.10E-02	0.11E-01	0.11E-02	0.17E-02	0.40E-02	0.18E-01
	40	0.18E-02	0.20E-01	0.20E-02	0.30E-02	0.73E-02	0.34E-01
	70	0.27E-02	0.29E-01	0.30E-02	0.45E-02	0.11E-01	0.50E-01
10	1	5.90E-07	6.29E-06	6.39E-07	9.47E-07	2.27E-06	1.07E-05
	5	0.14E-04	0.15E-03	0.16E-04	0.23E-04	0.56E-04	0.26E-03
	10	0.57E-04	0.60E-03	0.61E-04	0.91E-04	0.22E-03	0.10E-02
	20	0.43E-03	0.46E-02	0.47E-03	0.70E-03	0.17E-02	0.79E-02
	40	0.79E-03	0.85E-02	0.86E-03	0.13E-02	0.31E-02	0.14E-01
	70	0.12E-02	0.13E-01	0.13E-02	0.19E-02	0.45E-02	0.21E-01
20	1	1.92E-07	2.05E-06	2.02E-07	2.98E-07	7.15E-07	3.46E-06
	5	0.47E-05	0.50E-04	0.50E-05	0.73E-05	0.18E-04	0.85E-04
	10	0.18E-04	0.20E-03	0.19E-04	0.29E-04	0.69E-04	0.33E-03
	20	0.14E-03	0.15E-02	0.15E-03	0.22E-03	0.53E-03	0.25E-02
	40	0.26E-03	0.28E-02	0.27E-03	0.40E-03	0.96E-03	0.47E-02
	70	0.38E-03	0.41E-02	0.40E-03	0.60E-03	0.14E-02	0.69E-02
40	1	6.20E-08	6.61E-07	6.46E-08	9.54E-08	2.29E-07	1.11E-06
	5	0.15E-05	0.16E-04	0.16E-05	0.23E-05	0.56E-05	0.27E-04
	10	0.60E-05	0.63E-04	0.62E-05	0.92E-05	0.22E-04	0.11E-03
	20	0.46E-04	0.49E-03	0.47E-04	0.70E-04	0.17E-03	0.82E-03
	40	0.84E-04	0.89E-03	0.87E-04	0.13E-03	0.31E-03	0.15E-02
	70	0.12E-03	0.13E-02	0.13E-03	0.19E-03	0.46E-03	0.22E-02

Table K-8.2. Time-Integrated Dose from External Exposure to Surface Activity
Whole Body, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.72E-04	2.90E-03	3.03E-04	4.51E-04	1.08E-03	5.00E-03
	5	0.67E-02	0.71E-01	0.74E-02	0.11E-01	0.27E-01	0.12E 00
	10	0.26E-01	0.28E 00	0.29E-01	0.43E-01	0.10E 00	0.48E 00
	20	0.20E 00	0.21E 01	0.22E 00	0.33E 00	0.79E 00	0.37E 01
	40	0.37E 00	0.39E 01	0.41E 00	0.61E 00	0.15E 01	0.67E 01
	70	0.54E 00	0.58E 01	0.61E 00	0.90E 00	0.22E 01	0.10E 02
5	1	1.24E-05	1.32E-04	1.28E-05	1.89E-05	4.54E-05	2.22E-04
	5	0.30E-03	0.32E-02	0.31E-03	0.46E-03	0.11E-02	0.54E-02
	10	0.12E-02	0.13E-01	0.12E-02	0.18E-02	0.44E-02	0.21E-01
	20	0.91E-02	0.97E-01	0.94E-02	0.14E-01	0.33E-01	0.16E 00
	40	0.17E-01	0.18E 00	0.17E-01	0.25E-01	0.61E-01	0.30E 00
	70	0.25E-01	0.26E 00	0.26E-01	0.38E-01	0.91E-01	0.44E 00
10	1	5.52E-06	5.89E-05	5.72E-06	8.44E-06	2.02E-05	9.88E-05
	5	0.14E-03	0.14E-02	0.14E-03	0.21E-03	0.50E-03	0.24E-02
	10	0.53E-03	0.56E-02	0.55E-03	0.81E-03	0.19E-02	0.95E-02
	20	0.41E-02	0.43E-01	0.42E-02	0.62E-02	0.15E-01	0.73E-01
	40	0.74E-02	0.79E-01	0.77E-02	0.11E-01	0.27E-01	0.13E 00
	70	0.11E-01	0.12E 00	0.11E-01	0.17E-01	0.40E-01	0.20E 00
20	1	1.88E-06	2.00E-05	1.95E-06	2.88E-06	6.90E-06	3.36E-05
	5	0.46E-04	0.49E-03	0.48E-04	0.71E-04	0.17E-03	0.83E-03
	10	0.18E-03	0.19E-02	0.19E-03	0.28E-03	0.66E-03	0.32E-02
	20	0.14E-02	0.15E-01	0.14E-02	0.21E-02	0.51E-02	0.25E-01
	40	0.25E-02	0.27E-01	0.26E-02	0.39E-02	0.93E-02	0.45E-01
	70	0.38E-02	0.40E-01	0.39E-02	0.58E-02	0.14E-01	0.67E-01
40	1	6.13E-07	6.54E-06	6.39E-07	9.44E-07	2.26E-06	1.10E-05
	5	0.15E-04	0.16E-03	0.16E-04	0.23E-04	0.56E-04	0.27E-03
	10	0.59E-04	0.63E-03	0.61E-04	0.91E-04	0.22E-03	0.11E-02
	20	0.45E-03	0.48E-02	0.47E-03	0.69E-03	0.17E-02	0.81E-02
	40	0.83E-03	0.88E-02	0.86E-03	0.13E-02	0.30E-02	0.15E-01
	70	0.12E-02	0.13E-01	0.13E-02	0.19E-02	0.45E-02	0.22E-01

Table K-8.3. Time-Integrated Dose from External Exposure to Surface Activity
Whole Body, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U236	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.12E-04	2.26E-03	2.44E-04	3.63E-04	8.71E-04	3.95E-03
	5	0.52E-02	0.55E-01	0.60E-02	0.89E-02	0.21E-01	0.97E-01
	10	0.20E-01	0.22E 00	0.23E-01	0.35E-01	0.84E-01	0.38E 00
	20	0.16E 00	0.17E 01	0.18E 00	0.27E 00	0.64E 00	0.29E 01
	40	0.29E 00	0.30E 01	0.33E 00	0.49E 00	0.12E 01	0.53E 01
	70	0.42E 00	0.45E 01	0.49E 00	0.73E 00	0.17E 01	0.79E 01
5	1	9.25E-06	9.86E-05	9.52E-06	1.40E-05	3.37E-05	1.65E-04
	5	0.23E-03	0.24E-02	0.23E-03	0.34E-03	0.83E-03	0.41E-02
	10	0.89E-03	0.95E-02	0.91E-03	0.13E-02	0.32E-02	0.16E-01
	20	0.68E-02	0.72E-01	0.70E-02	0.10E-01	0.25E-01	0.12E 00
	40	0.12E-01	0.13E 00	0.13E-01	0.19E-01	0.45E-01	0.22E 00
	70	0.19E-01	0.20E 00	0.19E-01	0.28E-01	0.67E-01	0.33E 00
10	1	4.13E-06	4.40E-05	4.26E-06	6.29E-06	1.51E-05	7.37E-05
	5	0.10E-03	0.11E-02	0.10E-03	0.15E-03	0.37E-03	0.18E-02
	10	0.40E-03	0.42E-02	0.41E-03	0.60E-03	0.14E-02	0.71E-02
	20	0.30E-02	0.32E-01	0.31E-02	0.46E-02	0.11E-01	0.54E-01
	40	0.56E-02	0.59E-01	0.57E-02	0.85E-02	0.20E-01	0.99E-01
	70	0.83E-02	0.88E-01	0.85E-02	0.13E-01	0.30E-01	0.15E 00
20	1	1.41E-06	1.50E-05	1.46E-06	2.16E-06	5.17E-06	2.52E-05
	5	0.35E-04	0.37E-03	0.36E-04	0.53E-04	0.13E-03	0.62E-03
	10	0.14E-03	0.14E-02	0.14E-03	0.21E-03	0.50E-03	0.24E-02
	20	0.10E-02	0.11E-01	0.11E-02	0.16E-02	0.38E-02	0.18E-01
	40	0.19E-02	0.20E-01	0.20E-02	0.29E-02	0.70E-02	0.34E-01
	70	0.28E-02	0.30E-01	0.29E-02	0.43E-02	0.10E-01	0.50E-01
40	1	4.60E-07	4.90E-06	4.79E-07	7.08E-07	1.70E-06	8.25E-06
	5	0.11E-04	0.12E-03	0.12E-04	0.17E-04	0.42E-04	0.20E-03
	10	0.44E-04	0.47E-03	0.46E-04	0.68E-04	0.16E-03	0.79E-03
	20	0.34E-03	0.36E-02	0.35E-03	0.52E-03	0.12E-02	0.61E-02
	40	0.62E-03	0.66E-02	0.65E-03	0.95E-03	0.23E-02	0.11E-01
	70	0.92E-03	0.98E-02	0.96E-03	0.14E-02	0.34E-02	0.16E-01

Table K-8.4. Time-Integrated Dose from External Exposure to Surface Activity
Whole Body, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	8.19E-05	8.73E-04	9.89E-05	1.48E-04	3.55E-04	1.56E-03
	5	0.20E-02	0.21E-01	0.24E-02	0.36E-02	0.87E-02	0.38E-01
	10	0.79E-02	0.84E-01	0.95E-02	0.14E-01	0.34E-01	0.15E 00
	20	0.60E-01	0.64E 00	0.73E-01	0.11E 00	0.26E 00	0.11E 01
	40	0.11E 00	0.12E 01	0.13E 00	0.20E 00	0.48E 00	0.21E 01
	70	0.16E 00	0.17E 01	0.20E 00	0.30E 00	0.71E 00	0.31E 01
5	1	3.35E-06	3.57E-05	3.50E-06	5.16E-06	1.24E-05	6.01E-05
	5	0.82E-04	0.88E-03	0.86E-04	0.13E-03	0.30E-03	0.15E-02
	10	0.32E-03	0.34E-02	0.34E-03	0.50E-03	0.12E-02	0.58E-02
	20	0.25E-02	0.26E-01	0.26E-02	0.38E-02	0.91E-02	0.44E-01
	40	0.45E-02	0.48E-01	0.47E-02	0.70E-02	0.17E-01	0.81E-01
	70	0.67E-02	0.71E-01	0.70E-02	0.10E-01	0.25E-01	0.12E 00
10	1	1.49E-06	1.59E-05	1.55E-06	2.29E-06	5.49E-06	2.67E-05
	5	0.37E-04	0.39E-03	0.38E-04	0.56E-04	0.13E-03	0.65E-03
	10	0.14E-03	0.15E-02	0.15E-03	0.22E-03	0.53E-03	0.26E-02
	20	0.11E-02	0.12E-01	0.11E-02	0.17E-02	0.40E-02	0.20E-01
	40	0.20E-02	0.21E-01	0.21E-02	0.31E-02	0.74E-02	0.36E-01
	70	0.30E-02	0.32E-01	0.31E-02	0.46E-02	0.11E-01	0.53E-01
20	1	5.04E-07	5.37E-06	5.24E-07	7.75E-07	1.86E-06	9.03E-06
	5	0.12E-04	0.13E-03	0.13E-04	0.19E-04	0.46E-04	0.22E-03
	10	0.48E-04	0.52E-03	0.50E-04	0.74E-04	0.18E-03	0.87E-03
	20	0.37E-03	0.39E-02	0.39E-03	0.57E-03	0.14E-02	0.66E-02
	40	0.68E-03	0.72E-02	0.71E-03	0.10E-02	0.25E-02	0.12E-01
	70	0.10E-02	0.11E-01	0.10E-02	0.15E-02	0.37E-02	0.18E-01
40	1	1.64E-07	1.75E-06	1.71E-07	2.53E-07	6.06E-07	2.95E-06
	5	0.40E-05	0.43E-04	0.42E-05	0.62E-05	0.15E-04	0.72E-04
	10	0.16E-04	0.17E-03	0.16E-04	0.24E-04	0.58E-04	0.28E-03
	20	0.12E-03	0.13E-02	0.13E-03	0.19E-03	0.45E-03	0.22E-02
	40	0.22E-03	0.24E-02	0.23E-03	0.34E-03	0.82E-03	0.40E-02
	70	0.33E-03	0.35E-02	0.34E-03	0.51E-03	0.12E-02	0.59E-02

Table K-8.5. Time-Integrated Dose from External Exposure to Surface Activity
Whole Body, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	8.40E-05	8.95E-04	9.75E-05	1.46E-04	3.49E-04	1.57E-03
	5	0.21E-02	0.22E-01	0.24E-02	0.36E-02	0.86E-02	0.39E-01
	10	0.81E-02	0.86E-01	0.94E-02	0.14E-01	0.33E-01	0.15E 00
	20	0.62E-01	0.66E 00	0.72E-01	0.11E 00	0.26E 00	0.12E 01
	40	0.11E 00	0.12E 01	0.13E 00	0.20E 00	0.47E 00	0.21E 01
	70	0.17E 00	0.18E 01	0.20E 00	0.29E 00	0.70E 00	0.31E 01
5	1	3.67E-06	3.91E-05	3.84E-06	5.67E-06	1.36E-05	6.59E-05
	5	0.90E-04	0.96E-03	0.94E-04	0.14E-03	0.33E-03	0.16E-02
	10	0.35E-03	0.38E-02	0.37E-03	0.54E-03	0.13E-02	0.63E-02
	20	0.27E-02	0.29E-01	0.28E-02	0.42E-02	0.10E-01	0.48E-01
	40	0.49E-02	0.53E-01	0.52E-02	0.76E-02	0.18E-01	0.89E-01
	70	0.73E-02	0.78E-01	0.77E-02	0.11E-01	0.27E-01	0.13E 00
10	1	1.63E-06	1.73E-05	1.70E-06	2.51E-06	6.02E-06	2.92E-05
	5	0.40E-04	0.43E-03	0.42E-04	0.62E-04	0.15E-03	0.72E-03
	10	0.16E-03	0.17E-02	0.16E-03	0.24E-03	0.58E-03	0.28E-02
	20	0.12E-02	0.13E-01	0.12E-02	0.18E-02	0.44E-02	0.21E-01
	40	0.22E-02	0.23E-01	0.23E-02	0.34E-02	0.81E-02	0.39E-01
	70	0.33E-02	0.35E-01	0.34E-02	0.50E-02	0.12E-01	0.58E-01
20	1	5.50E-07	5.87E-06	5.74E-07	8.48E-07	2.03E-06	9.87E-06
	5	0.14E-04	0.14E-03	0.14E-04	0.21E-04	0.50E-04	0.24E-03
	10	0.53E-04	0.56E-03	0.55E-04	0.81E-04	0.20E-03	0.95E-03
	20	0.40E-03	0.43E-02	0.42E-03	0.62E-03	0.15E-02	0.72E-02
	40	0.74E-03	0.79E-02	0.77E-03	0.11E-02	0.27E-02	0.13E-01
	70	0.11E-02	0.12E-01	0.11E-02	0.17E-02	0.41E-02	0.20E-01
40	1	1.79E-07	1.91E-06	1.87E-07	2.76E-07	6.62E-07	3.21E-06
	5	0.44E-05	0.47E-04	0.46E-05	0.68E-05	0.16E-04	0.79E-04
	10	0.17E-04	0.18E-03	0.18E-04	0.27E-04	0.64E-04	0.31E-03
	20	0.13E-03	0.14E-02	0.14E-03	0.20E-03	0.49E-03	0.24E-02
	40	0.24E-03	0.26E-02	0.25E-03	0.37E-03	0.89E-03	0.43E-02
	70	0.36E-03	0.38E-02	0.37E-03	0.55E-03	0.13E-02	0.64E-02

Table K-8.6. Time-Integrated Dose from External Exposure to Surface Activity
Skin, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	4.26E-04	1.26E-03	3.59E-04	1.87E-04	1.07E-03	3.31E-03
	5	0.10E-01	0.31E-01	0.88E-02	0.46E-02	0.26E-01	0.81E-01
	10	0.41E-01	0.12E 00	0.34E-01	0.18E-01	0.10E 00	0.32E 00
	20	0.31E 00	0.92E 00	0.26E 00	0.14E 00	0.79E 00	0.24E 01
	40	0.57E 00	0.17E 01	0.48E 00	0.25E 00	0.14E 01	0.45E 01
	70	0.85E 00	0.25E 01	0.72E 00	0.37E 00	0.21E 01	0.66E 01
5	1	9.20E-06	2.72E-05	5.45E-06	2.76E-06	1.58E-05	6.04E-05
	5	0.23E-03	0.67E-03	0.13E-03	0.68E-04	0.39E-03	0.15E-02
	10	0.88E-03	0.26E-02	0.52E-03	0.26E-03	0.15E-02	0.58E-02
	20	0.68E-02	0.20E-01	0.40E-02	0.20E-02	0.12E-01	0.44E-01
	40	0.12E-01	0.37E-01	0.73E-02	0.37E-02	0.21E-01	0.81E-01
	70	0.18E-01	0.54E-01	0.11E-01	0.55E-02	0.32E-01	0.12E 00
10	1	3.96E-06	1.17E-05	2.30E-06	1.16E-06	6.65E-06	2.58E-05
	5	0.97E-04	0.29E-03	0.56E-04	0.28E-04	0.16E-03	0.63E-03
	10	0.38E-03	0.11E-02	0.22E-03	0.11E-03	0.64E-03	0.25E-02
	20	0.29E-02	0.86E-02	0.17E-02	0.85E-03	0.49E-02	0.19E-01
	40	0.53E-02	0.16E-01	0.31E-02	0.16E-02	0.90E-02	0.35E-01
	70	0.79E-02	0.23E-01	0.46E-02	0.23E-02	0.13E-01	0.52E-01
20	1	1.29E-06	3.82E-06	7.26E-07	3.65E-07	2.09E-06	8.30E-06
	5	0.32E-04	0.94E-04	0.18E-04	0.90E-05	0.51E-04	0.20E-03
	10	0.12E-03	0.37E-03	0.70E-04	0.35E-04	0.20E-03	0.80E-03
	20	0.95E-03	0.28E-02	0.53E-03	0.27E-03	0.15E-02	0.61E-02
	40	0.17E-02	0.51E-02	0.98E-03	0.49E-03	0.28E-02	0.11E-01
	70	0.26E-02	0.76E-02	0.15E-02	0.73E-03	0.42E-02	0.17E-01
40	1	4.17E-07	1.23E-06	2.32E-07	1.17E-07	6.70E-07	2.67E-06
	5	0.10E-04	0.30E-04	0.57E-05	0.29E-05	0.16E-04	0.65E-04
	10	0.40E-04	0.12E-03	0.22E-04	0.11E-04	0.64E-04	0.26E-03
	20	0.31E-03	0.91E-03	0.17E-03	0.86E-04	0.49E-03	0.20E-02
	40	0.56E-03	0.17E-02	0.31E-03	0.16E-03	0.90E-03	0.36E-02
	70	0.83E-03	0.25E-02	0.46E-03	0.23E-03	0.13E-02	0.53E-02

Table K-8.7. Time-Integrated Dose from External Exposure to Surface Activity Skin, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.83E-03	5.40E-03	1.09E-03	5.52E-04	3.17E-03	1.20E-02
	5	0.45E-01	0.13E 00	0.27E-01	0.14E-01	0.78E-01	0.30E 00
	10	0.18E 00	0.52E 00	0.10E 00	0.53E-01	0.30E 00	0.12E 01
	20	0.13E 01	0.40E 01	0.80E 00	0.41E 00	0.23E 01	0.88E 01
	40	0.25E 01	0.73E 01	0.15E 01	0.74E 00	0.43E 01	0.16E 02
	70	0.37E 01	0.11E 02	0.22E 01	0.11E 01	0.63E 01	0.24E 02
5	1	8.33E-05	2.46E-04	4.61E-05	2.32E-05	1.33E-04	5.32E-04
	5	0.20E-02	0.60E-02	0.11E-02	0.57E-03	0.33E-02	0.13E-01
	10	0.80E-02	0.24E-01	0.44E-02	0.22E-02	0.13E-01	0.51E-01
	20	0.61E-01	0.18E 00	0.34E-01	0.17E-01	0.98E-01	0.39E 00
	40	0.11E 00	0.33E 00	0.62E-01	0.31E-01	0.18E 00	0.72E 00
	70	0.17E 00	0.49E 00	0.92E-01	0.46E-01	0.27E 00	0.11E 01
10	1	3.71E-05	1.10E-04	2.06E-05	1.03E-05	5.93E-05	2.37E-04
	5	0.91E-03	0.27E-02	0.50E-03	0.25E-03	0.15E-02	0.58E-02
	10	0.36E-02	0.11E-01	0.20E-02	0.99E-03	0.57E-02	0.23E-01
	20	0.27E-01	0.81E-01	0.15E-01	0.76E-02	0.44E-01	0.17E 00
	40	0.50E-01	0.15E 00	0.28E-01	0.14E-01	0.80E-01	0.32E 00
	70	0.74E-01	0.22E 00	0.41E-01	0.21E-01	0.12E 00	0.47E 00
20	1	1.26E-05	3.73E-05	7.01E-06	3.53E-06	2.02E-05	8.07E-05
	5	0.31E-03	0.92E-03	0.17E-03	0.87E-04	0.50E-03	0.20E-02
	10	0.12E-02	0.36E-02	0.67E-03	0.34E-03	0.19E-02	0.77E-02
	20	0.93E-02	0.27E-01	0.51E-02	0.26E-02	0.15E-01	0.59E-01
	40	0.17E-01	0.50E-01	0.94E-02	0.48E-02	0.27E-01	0.11E 00
	70	0.25E-01	0.75E-01	0.14E-01	0.71E-02	0.40E-01	0.16E 00
40	1	4.12E-06	1.22E-05	2.30E-06	1.16E-06	6.63E-06	2.64E-05
	5	0.10E-03	0.30E-03	0.56E-04	0.28E-04	0.16E-03	0.65E-03
	10	0.40E-03	0.12E-02	0.22E-03	0.11E-03	0.64E-03	0.25E-02
	20	0.30E-02	0.90E-02	0.17E-02	0.85E-03	0.49E-02	0.19E-01
	40	0.56E-02	0.16E-01	0.31E-02	0.16E-02	0.89E-02	0.36E-01
	70	0.82E-02	0.24E-01	0.46E-02	0.23E-02	0.13E-01	0.53E-01

Table K-8.8. Time-Integrated Dose from External Exposure to Surface Activity Skin, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.43E-03	4.22E-03	8.76E-04	4.45E-04	2.55E-03	9.51E-03
	5	0.35E-01	0.10E 00	0.21E-01	0.11E-01	0.63E-01	0.23E 00
	10	0.14E 00	0.40E 00	0.84E-01	0.43E-01	0.24E 00	0.91E 00
	20	0.10E 01	0.31E 01	0.64E 00	0.33E 00	0.19E 01	0.70E 01
	40	0.19E 01	0.57E 01	0.12E 01	0.60E 00	0.34E 01	0.13E 02
	70	0.29E 01	0.84E 01	0.18E 01	0.89E 00	0.51E 01	0.19E 02
5	1	6.22E-05	1.84E-04	3.42E-05	1.72E-05	9.86E-05	3.96E-04
	5	0.15E-02	0.45E-02	0.84E-03	0.42E-03	0.24E-02	0.97E-02
	10	0.60E-02	0.18E-01	0.33E-02	0.17E-02	0.95E-02	0.38E-01
	20	0.46E-01	0.13E 00	0.25E-01	0.13E-01	0.72E-01	0.29E 00
	40	0.84E-01	0.25E 00	0.46E-01	0.23E-01	0.13E 00	0.53E 00
	70	0.12E 00	0.37E 00	0.68E-01	0.34E-01	0.20E 00	0.79E 00
10	1	2.77E-05	8.20E-05	1.53E-05	7.70E-06	4.41E-05	1.77E-04
	5	0.68E-03	0.20E-02	0.38E-03	0.19E-03	0.11E-02	0.43E-02
	10	0.27E-02	0.79E-02	0.15E-02	0.74E-03	0.42E-02	0.17E-01
	20	0.20E-01	0.60E-01	0.11E-01	0.57E-02	0.32E-01	0.13E 00
	40	0.37E-01	0.11E 00	0.21E-01	0.10E-01	0.59E-01	0.24E 00
	70	0.55E-01	0.16E 00	0.31E-01	0.15E-01	0.88E-01	0.35E 00
20	1	9.45E-06	2.80E-05	5.25E-06	2.64E-06	1.51E-05	6.04E-05
	5	0.23E-03	0.69E-03	0.13E-03	0.65E-04	0.37E-03	0.15E-02
	10	0.91E-03	0.27E-02	0.50E-03	0.25E-03	0.15E-02	0.58E-02
	20	0.69E-02	0.21E-01	0.39E-02	0.19E-02	0.11E-01	0.44E-01
	40	0.13E-01	0.38E-01	0.71E-02	0.36E-02	0.20E-01	0.81E-01
	70	0.19E-01	0.56E-01	0.10E-01	0.53E-02	0.30E-01	0.12E 00
40	1	3.09E-06	9.14E-06	1.72E-06	8.67E-07	4.97E-06	1.98E-05
	5	0.76E-04	0.22E-03	0.42E-04	0.21E-04	0.12E-03	0.49E-03
	10	0.30E-03	0.88E-03	0.17E-03	0.83E-04	0.48E-03	0.19E-02
	20	0.23E-02	0.67E-02	0.13E-02	0.64E-03	0.36E-02	0.15E-01
	40	0.42E-02	0.12E-01	0.23E-02	0.12E-02	0.67E-02	0.27E-01
	70	0.62E-02	0.18E-01	0.34E-02	0.17E-02	0.99E-02	0.40E-01

Table K-8.9. Time-Integrated Dose from External Exposure to Surface Activity Skin, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.51E-04	1.63E-03	3.55E-04	1.81E-04	1.04E-03	3.76E-03
	5	0.14E-01	0.40E-01	0.87E-02	0.45E-02	0.26E-01	0.92E-01
	10	0.53E-01	0.16E 00	0.34E-01	0.17E-01	0.10E 00	0.36E 00
	20	0.40E 00	0.12E 01	0.26E 00	0.13E 00	0.76E 00	0.28E 01
	40	0.74E 00	0.22E 01	0.48E 00	0.24E 00	0.14E 01	0.51E 01
	70	0.11E 01	0.33E 01	0.71E 00	0.36E 00	0.21E 01	0.75E 01
5	1	2.25E-05	6.66E-05	1.26E-05	6.32E-06	3.63E-05	1.44E-04
	5	0.55E-03	0.16E-02	0.31E-03	0.16E-03	0.89E-03	0.35E-02
	10	0.22E-02	0.64E-02	0.12E-02	0.61E-03	0.35E-02	0.14E-01
	20	0.17E-01	0.49E-01	0.92E-02	0.46E-02	0.27E-01	0.11E 00
	40	0.30E-01	0.90E-01	0.17E-01	0.85E-02	0.49E-01	0.19E 00
	70	0.45E-01	0.13E 00	0.25E-01	0.13E-01	0.73E-01	0.29E 00
10	1	1.00E-05	2.96E-05	5.57E-06	2.81E-06	1.61E-05	6.41E-05
	5	0.25E-03	0.73E-03	0.14E-03	0.69E-04	0.39E-03	0.16E-02
	10	0.96E-03	0.28E-02	0.53E-03	0.27E-03	0.15E-02	0.61E-02
	20	0.73E-02	0.22E-01	0.41E-02	0.21E-02	0.12E-01	0.47E-01
	40	0.13E-01	0.40E-01	0.75E-02	0.38E-02	0.22E-01	0.86E-01
	70	0.20E-01	0.59E-01	0.11E-01	0.56E-02	0.32E-01	0.13E 00
20	1	3.39E-06	1.00E-05	1.89E-06	9.49E-07	5.44E-06	2.17E-05
	5	0.83E-04	0.25E-03	0.46E-04	0.23E-04	0.13E-03	0.53E-03
	10	0.33E-03	0.96E-03	0.18E-03	0.91E-04	0.52E-03	0.21E-02
	20	0.25E-02	0.74E-02	0.14E-02	0.70E-03	0.40E-02	0.16E-01
	40	0.46E-02	0.13E-01	0.25E-02	0.13E-02	0.73E-02	0.29E-01
	70	0.68E-02	0.20E-01	0.38E-02	0.19E-02	0.11E-01	0.43E-01
40	1	1.10E-06	3.27E-06	6.15E-07	3.10E-07	1.78E-06	7.07E-06
	5	0.27E-04	0.80E-04	0.15E-04	0.76E-05	0.44E-04	0.17E-03
	10	0.11E-03	0.31E-03	0.59E-04	0.30E-04	0.17E-03	0.68E-03
	20	0.81E-03	0.24E-02	0.45E-03	0.23E-03	0.13E-02	0.52E-02
	40	0.15E-02	0.44E-02	0.83E-03	0.42E-03	0.24E-02	0.95E-02
	70	0.22E-02	0.65E-02	0.12E-02	0.62E-03	0.36E-02	0.14E-01

Table K-8.10. Time-Integrated Dose from External Exposure to Surface Activity Skin, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.64E-04	1.67E-03	3.51E-04	1.78E-04	1.02E-03	3.78E-03
	5	0.14E-01	0.41E-01	0.86E-02	0.44E-02	0.25E-01	0.93E-01
	10	0.54E-01	0.16E 00	0.34E-01	0.17E-01	0.98E-01	0.36E 00
	20	0.41E 00	0.12E 01	0.26E 00	0.13E 00	0.75E 00	0.28E 01
	40	0.76E 00	0.22E 01	0.47E 00	0.24E 00	0.14E 01	0.51E 01
	70	0.11E 01	0.33E 01	0.70E 00	0.36E 00	0.20E 01	0.76E 01
5	1	2.46E-05	7.29E-05	1.38E-05	6.95E-06	3.98E-05	1.58E-04
	5	0.60E-03	0.18E-02	0.34E-03	0.17E-03	0.98E-03	0.39E-02
	10	0.24E-02	0.70E-02	0.13E-02	0.67E-03	0.38E-02	0.15E-01
	20	0.18E-01	0.54E-01	0.10E-01	0.51E-02	0.29E-01	0.12E 00
	40	0.33E-01	0.98E-01	0.19E-01	0.94E-02	0.54E-01	0.21E 00
	70	0.49E-01	0.15E 00	0.28E-01	0.14E-01	0.80E-01	0.32E 00
10	1	1.09E-05	3.23E-05	6.11E-06	3.07E-06	1.76E-05	7.01E-05
	5	0.27E-03	0.79E-03	0.15E-03	0.75E-04	0.43E-03	0.17E-02
	10	0.10E-02	0.31E-02	0.59E-03	0.30E-03	0.17E-02	0.67E-02
	20	0.80E-02	0.24E-01	0.45E-02	0.23E-02	0.13E-01	0.51E-01
	40	0.15E-01	0.44E-01	0.82E-02	0.41E-02	0.24E-01	0.94E-01
	70	0.22E-01	0.65E-01	0.12E-01	0.61E-02	0.35E-01	0.14E 00
20	1	3.70E-06	1.09E-05	2.06E-06	1.04E-06	5.96E-06	2.37E-05
	5	0.91E-04	0.27E-03	0.51E-04	0.25E-04	0.15E-03	0.58E-03
	10	0.35E-03	0.10E-02	0.20E-03	0.10E-03	0.57E-03	0.23E-02
	20	0.27E-02	0.80E-02	0.15E-02	0.76E-03	0.44E-02	0.17E-01
	40	0.50E-02	0.15E-01	0.28E-02	0.14E-02	0.80E-02	0.32E-01
	70	0.74E-02	0.22E-01	0.41E-02	0.21E-02	0.12E-01	0.47E-01
40	1	1.20E-06	3.56E-06	6.72E-07	3.38E-07	1.94E-06	7.72E-06
	5	0.30E-04	0.87E-04	0.16E-04	0.83E-05	0.48E-04	0.19E-03
	10	0.12E-03	0.34E-03	0.65E-04	0.32E-04	0.19E-03	0.74E-03
	20	0.88E-03	0.26E-02	0.49E-03	0.25E-03	0.14E-02	0.57E-02
	40	0.16E-02	0.48E-02	0.91E-03	0.46E-03	0.26E-02	0.10E-01
	70	0.24E-02	0.71E-02	0.13E-02	0.68E-03	0.39E-02	0.15E-01

Table K-8.11. Time-Integrated Dose from External Exposure to Surface Activity
Ovaries, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.18E-05	3.18E-04	4.25E-05	8.18E-05	1.94E-04	6.47E-04
	5	0.29E-03	0.78E-02	0.10E-02	0.20E-02	0.48E-02	0.16E-01
	10	0.11E-02	0.30E-01	0.41E-02	0.79E-02	0.19E-01	0.62E-01
	20	0.86E-02	0.23E 00	0.31E-01	0.60E-01	0.14E 00	0.48E 00
	40	0.16E-01	0.43E 00	0.57E-01	0.11E 00	0.26E 00	0.87E 00
	70	0.24E-01	0.64E 00	0.85E-01	0.16E 00	0.39E 00	0.13E 01
5	1	2.54E-07	6.86E-06	6.44E-07	1.21E-06	2.86E-06	1.18E-05
	5	0.62E-05	0.17E-03	0.16E-04	0.30E-04	0.70E-04	0.29E-03
	10	0.24E-04	0.66E-03	0.62E-04	0.12E-03	0.27E-03	0.11E-02
	20	0.19E-03	0.50E-02	0.47E-03	0.89E-03	0.21E-02	0.87E-02
	40	0.34E-03	0.92E-02	0.87E-03	0.16E-02	0.38E-02	0.16E-01
	70	0.51E-03	0.14E-01	0.13E-02	0.24E-02	0.57E-02	0.24E-01
10	1	1.10E-07	2.96E-06	2.71E-07	5.07E-07	1.20E-06	5.04E-06
	5	0.27E-05	0.73E-04	0.67E-05	0.12E-04	0.29E-04	0.12E-03
	10	0.11E-04	0.28E-03	0.26E-04	0.49E-04	0.12E-03	0.48E-03
	20	0.80E-04	0.22E-02	0.20E-03	0.37E-03	0.88E-03	0.37E-02
	40	0.15E-03	0.40E-02	0.37E-03	0.68E-03	0.16E-02	0.68E-02
	70	0.22E-03	0.59E-02	0.54E-03	0.10E-02	0.24E-02	0.10E-01
20	1	3.57E-08	9.63E-07	8.58E-08	1.60E-07	3.78E-07	1.62E-06
	5	0.88E-06	0.24E-04	0.21E-05	0.39E-05	0.93E-05	0.40E-04
	10	0.34E-05	0.92E-04	0.82E-05	0.15E-04	0.36E-04	0.16E-03
	20	0.26E-04	0.71E-03	0.63E-04	0.12E-03	0.28E-03	0.12E-02
	40	0.48E-04	0.13E-02	0.12E-03	0.22E-03	0.51E-03	0.22E-02
	70	0.71E-04	0.19E-02	0.17E-03	0.32E-03	0.76E-03	0.32E-02
40	1	1.15E-08	3.11E-07	2.74E-08	5.11E-08	1.21E-07	5.22E-07
	5	0.28E-06	0.76E-05	0.67E-06	0.13E-05	0.30E-05	0.13E-04
	10	0.11E-05	0.30E-04	0.26E-05	0.49E-05	0.12E-04	0.50E-04
	20	0.85E-05	0.23E-03	0.20E-04	0.37E-04	0.89E-04	0.38E-03
	40	0.16E-04	0.42E-03	0.37E-04	0.69E-04	0.16E-03	0.70E-03
	70	0.23E-04	0.62E-03	0.55E-04	0.10E-03	0.24E-03	0.10E-02

Table K-8.12. Time-Integrated Dose from External Exposure to Surface Activity
Ovaries, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.05E-05	1.36E-03	1.29E-04	2.41E-04	5.72E-04	2.35E-03
	5	0.12E-02	0.33E-01	0.32E-02	0.59E-02	0.14E-01	0.58E-01
	10	0.48E-02	0.13E 00	0.12E-01	0.23E-01	0.55E-01	0.23E 00
	20	0.37E-01	0.10E 01	0.95E-01	0.18E 00	0.42E 00	0.17E 01
	40	0.68E-01	0.18E 01	0.17E 00	0.33E 00	0.77E 00	0.32E 01
	70	0.10E 00	0.27E 01	0.26E 00	0.48E 00	0.11E 01	0.47E 01
5	1	2.30E-06	6.21E-05	5.45E-06	1.01E-05	2.40E-05	1.04E-04
	5	0.57E-04	0.15E-02	0.13E-03	0.25E-03	0.59E-03	0.26E-02
	10	0.22E-03	0.60E-02	0.52E-03	0.97E-03	0.23E-02	0.10E-01
	20	0.17E-02	0.46E-01	0.40E-02	0.74E-02	0.18E-01	0.76E-01
	40	0.31E-02	0.84E-01	0.73E-02	0.14E-01	0.32E-01	0.14E 00
	70	0.46E-02	0.12E 00	0.11E-01	0.20E-01	0.48E-01	0.21E 00
10	1	1.03E-06	2.77E-05	2.43E-06	4.52E-06	1.07E-05	4.63E-05
	5	0.25E-04	0.68E-03	0.60E-04	0.11E-03	0.26E-03	0.11E-02
	10	0.98E-04	0.27E-02	0.23E-03	0.43E-03	0.10E-02	0.44E-02
	20	0.75E-03	0.20E-01	0.18E-02	0.33E-02	0.79E-02	0.34E-01
	40	0.14E-02	0.37E-01	0.33E-02	0.61E-02	0.14E-01	0.62E-01
	70	0.21E-02	0.55E-01	0.49E-02	0.90E-02	0.21E-01	0.93E-01
20	1	3.49E-07	9.41E-06	8.29E-07	1.54E-06	3.65E-06	1.58E-05
	5	0.86E-05	0.23E-03	0.20E-04	0.38E-04	0.90E-04	0.39E-03
	10	0.33E-04	0.90E-03	0.80E-04	0.15E-03	0.35E-03	0.15E-02
	20	0.26E-03	0.69E-02	0.61E-03	0.11E-02	0.27E-02	0.12E-01
	40	0.47E-03	0.13E-01	0.11E-02	0.21E-02	0.49E-02	0.21E-01
	70	0.70E-03	0.19E-01	0.17E-02	0.31E-02	0.73E-02	0.32E-01
40	1	1.14E-07	3.07E-06	2.71E-07	5.05E-07	1.20E-06	5.16E-06
	5	0.28E-05	0.75E-04	0.67E-05	0.12E-04	0.29E-04	0.13E-03
	10	0.11E-04	0.29E-03	0.26E-04	0.48E-04	0.11E-03	0.50E-03
	20	0.84E-04	0.23E-02	0.20E-03	0.37E-03	0.88E-03	0.38E-02
	40	0.15E-03	0.41E-02	0.37E-03	0.68E-03	0.16E-02	0.70E-02
	70	0.23E-03	0.61E-02	0.54E-03	0.10E-02	0.24E-02	0.10E-01

Table K-8.13. Time-Integrated Dose from External Exposure to Surface Activity Ovaries, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	3.94E-05	1.06E-03	1.03E-04	1.94E-04	4.60E-04	1.86E-03
	5	0.97E-03	0.26E-01	0.25E-02	0.48E-02	0.11E-01	0.46E-01
	10	0.38E-02	0.10E 00	0.99E-02	0.19E-01	0.44E-01	0.18E 00
	20	0.29E-01	0.78E 00	0.76E-01	0.14E 00	0.34E 00	0.14E 01
	40	0.53E-01	0.14E 01	0.14E 00	0.26E 00	0.62E 00	0.25E 01
	70	0.79E-01	0.21E 01	0.21E 00	0.39E 00	0.92E 00	0.37E 01
5	1	1.72E-06	4.63E-05	4.04E-06	7.52E-06	1.78E-05	7.74E-05
	5	0.42E-04	0.11E-02	0.99E-04	0.18E-03	0.44E-03	0.19E-02
	10	0.16E-03	0.44E-02	0.39E-03	0.72E-03	0.17E-02	0.74E-02
	20	0.13E-02	0.34E-01	0.30E-02	0.55E-02	0.13E-01	0.57E-01
	40	0.23E-02	0.62E-01	0.54E-02	0.10E-01	0.24E-01	0.10E 00
	70	0.34E-02	0.93E-01	0.81E-02	0.15E-01	0.36E-01	0.15E 00
10	1	7.67E-07	2.07E-05	1.81E-06	3.37E-06	7.97E-06	3.46E-05
	5	0.19E-04	0.51E-03	0.44E-04	0.83E-04	0.20E-03	0.85E-03
	10	0.74E-04	0.20E-02	0.17E-03	0.32E-03	0.76E-03	0.33E-02
	20	0.56E-03	0.15E-01	0.13E-02	0.25E-02	0.58E-02	0.25E-01
	40	0.10E-02	0.28E-01	0.24E-02	0.45E-02	0.11E-01	0.47E-01
	70	0.15E-02	0.41E-01	0.36E-02	0.67E-02	0.16E-01	0.69E-01
20	1	2.61E-07	7.05E-06	6.20E-07	1.15E-06	2.73E-06	1.18E-05
	5	0.64E-05	0.17E-03	0.15E-04	0.28E-04	0.67E-04	0.29E-03
	10	0.25E-04	0.68E-03	0.60E-04	0.11E-03	0.26E-03	0.11E-02
	20	0.19E-03	0.52E-02	0.46E-03	0.85E-03	0.20E-02	0.87E-02
	40	0.35E-03	0.95E-02	0.84E-03	0.16E-02	0.37E-02	0.16E-01
	70	0.52E-03	0.14E-01	0.12E-02	0.23E-02	0.55E-02	0.24E-01
40	1	8.55E-08	2.30E-06	2.04E-07	3.79E-07	8.97E-07	3.87E-06
	5	0.21E-05	0.57E-04	0.50E-05	0.93E-05	0.22E-04	0.95E-04
	10	0.82E-05	0.22E-03	0.20E-04	0.36E-04	0.86E-04	0.37E-03
	20	0.63E-04	0.17E-02	0.15E-03	0.28E-03	0.66E-03	0.28E-02
	40	0.12E-03	0.31E-02	0.27E-03	0.51E-03	0.12E-02	0.52E-02
	70	0.17E-03	0.46E-02	0.41E-03	0.76E-03	0.18E-02	0.77E-02

Table K-8.14. Time-Integrated Dose from External Exposure to Surface Activity Ovaries, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.52E-05	4.10E-04	4.20E-05	7.93E-05	1.88E-04	7.35E-04
	5	0.37E-03	0.10E-01	0.10E-02	0.19E-02	0.46E-02	0.18E-01
	10	0.15E-02	0.39E-01	0.40E-02	0.76E-02	0.18E-01	0.70E-01
	20	0.11E-01	0.30E 00	0.31E-01	0.58E-01	0.14E 00	0.54E 00
	40	0.21E-01	0.55E 00	0.57E-01	0.11E 00	0.25E 00	0.99E 00
	70	0.30E-01	0.82E 00	0.84E-01	0.16E 00	0.38E 00	0.15E 01
5	1	6.23E-07	1.68E-05	1.48E-06	2.76E-06	6.54E-06	2.82E-05
	5	0.15E-04	0.41E-03	0.36E-04	0.68E-04	0.16E-03	0.69E-03
	10	0.60E-04	0.16E-02	0.14E-03	0.27E-03	0.63E-03	0.27E-02
	20	0.46E-03	0.12E-01	0.11E-02	0.20E-02	0.48E-02	0.21E-01
	40	0.84E-03	0.23E-01	0.20E-02	0.37E-02	0.88E-02	0.38E-01
	70	0.12E-02	0.34E-01	0.30E-02	0.55E-02	0.13E-01	0.56E-01
10	1	2.77E-07	7.46E-06	6.59E-07	1.23E-06	2.90E-06	1.25E-05
	5	0.68E-05	0.18E-03	0.16E-04	0.30E-04	0.71E-04	0.31E-03
	10	0.27E-04	0.72E-03	0.63E-04	0.12E-03	0.28E-03	0.12E-02
	20	0.20E-03	0.55E-02	0.48E-03	0.90E-03	0.21E-02	0.92E-02
	40	0.37E-03	0.10E-01	0.89E-03	0.17E-02	0.39E-02	0.17E-01
	70	0.55E-03	0.15E-01	0.13E-02	0.25E-02	0.58E-02	0.25E-01
20	1	9.37E-08	2.52E-06	2.23E-07	4.15E-07	9.81E-07	4.24E-06
	5	0.23E-05	0.62E-04	0.55E-05	0.10E-04	0.24E-04	0.10E-03
	10	0.90E-05	0.24E-03	0.21E-04	0.40E-04	0.94E-04	0.41E-03
	20	0.69E-04	0.19E-02	0.16E-03	0.30E-03	0.72E-03	0.31E-02
	40	0.13E-03	0.34E-02	0.30E-03	0.56E-03	0.13E-02	0.57E-02
	70	0.19E-03	0.50E-02	0.45E-03	0.83E-03	0.20E-02	0.85E-02
40	1	3.05E-08	8.23E-07	7.27E-08	1.35E-07	3.20E-07	1.38E-06
	5	0.75E-06	0.20E-04	0.18E-05	0.33E-05	0.79E-05	0.34E-04
	10	0.29E-05	0.79E-04	0.70E-05	0.13E-04	0.31E-04	0.13E-03
	20	0.22E-04	0.60E-03	0.53E-04	0.99E-04	0.24E-03	0.10E-02
	40	0.41E-04	0.11E-02	0.98E-04	0.18E-03	0.43E-03	0.19E-02
	70	0.61E-04	0.16E-02	0.15E-03	0.27E-03	0.64E-03	0.28E-02

Table K-8.15. Time-Integrated Dose from External Exposure to Surface Activity
Ovaries, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.56E-05	4.21E-04	4.14E-05	7.79E-05	1.84E-04	7.40E-04
	5	0.38E-03	0.10E-01	0.10E-02	0.19E-02	0.45E-02	0.18E-01
	10	0.15E-02	0.40E-01	0.40E-02	0.75E-02	0.18E-01	0.71E-01
	20	0.11E-01	0.31E 00	0.30E-01	0.57E-01	0.14E 00	0.54E 00
	40	0.21E-01	0.57E 00	0.56E-01	0.10E 00	0.25E 00	0.10E 01
	70	0.31E-01	0.84E 00	0.83E-01	0.16E 00	0.37E 00	0.15E 01
5	1	6.82E-07	1.84E-05	1.63E-06	3.04E-06	7.19E-06	3.09E-05
	5	0.17E-04	0.45E-03	0.40E-04	0.75E-04	0.18E-03	0.76E-03
	10	0.65E-04	0.18E-02	0.16E-03	0.29E-03	0.69E-03	0.30E-02
	20	0.50E-03	0.13E-01	0.12E-02	0.22E-02	0.53E-02	0.23E-01
	40	0.92E-03	0.25E-01	0.22E-02	0.41E-02	0.97E-02	0.42E-01
	70	0.14E-02	0.37E-01	0.33E-02	0.61E-02	0.14E-01	0.62E-01
10	1	3.02E-07	8.15E-06	7.22E-07	1.34E-06	3.18E-06	1.37E-05
	5	0.74E-05	0.20E-03	0.18E-04	0.33E-04	0.78E-04	0.34E-03
	10	0.29E-04	0.78E-03	0.69E-04	0.13E-03	0.31E-03	0.13E-02
	20	0.22E-03	0.60E-02	0.53E-03	0.99E-03	0.23E-02	0.10E-01
	40	0.41E-03	0.11E-01	0.97E-03	0.18E-02	0.43E-02	0.18E-01
	70	0.60E-03	0.16E-01	0.14E-02	0.27E-02	0.64E-02	0.27E-01
20	1	1.02E-07	2.76E-06	2.44E-07	4.54E-07	1.07E-06	4.63E-06
	5	0.25E-05	0.68E-04	0.60E-05	0.11E-04	0.26E-04	0.11E-03
	10	0.98E-05	0.26E-03	0.23E-04	0.44E-04	0.10E-03	0.44E-03
	20	0.75E-04	0.20E-02	0.18E-03	0.33E-03	0.79E-03	0.34E-02
	40	0.14E-03	0.37E-02	0.33E-03	0.61E-03	0.14E-02	0.62E-02
	70	0.20E-03	0.55E-02	0.49E-03	0.91E-03	0.21E-02	0.93E-02
40	1	3.33E-08	8.98E-07	7.94E-08	1.48E-07	3.50E-07	1.51E-06
	5	0.82E-06	0.22E-04	0.19E-05	0.36E-05	0.86E-05	0.37E-04
	10	0.32E-05	0.86E-04	0.76E-05	0.14E-04	0.34E-04	0.14E-03
	20	0.24E-04	0.66E-03	0.58E-04	0.11E-03	0.26E-03	0.11E-02
	40	0.45E-04	0.12E-02	0.11E-03	0.20E-03	0.47E-03	0.20E-02
	70	0.67E-04	0.18E-02	0.16E-03	0.30E-03	0.70E-03	0.30E-02

Table K-8.16. Time-Integrated Dose from External Exposure to Surface Activity
Testes, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.20E-05	6.12E-04	8.82E-05	1.95E-04	3.07E-04	1.25E-03
	5	0.13E-02	0.15E-01	0.22E-02	0.48E-02	0.75E-02	0.31E-01
	10	0.50E-02	0.59E-01	0.85E-02	0.19E-01	0.29E-01	0.12E 00
	20	0.38E-01	0.45E 00	0.65E-01	0.14E 00	0.23E 00	0.92E 00
	40	0.70E-01	0.82E 00	0.12E 00	0.26E 00	0.41E 00	0.17E 01
	70	0.10E 00	0.12E 01	0.18E 00	0.39E 00	0.61E 00	0.25E 01
5	1	1.12E-06	1.32E-05	1.34E-06	2.88E-06	4.52E-06	2.31E-05
	5	0.28E-04	0.32E-03	0.33E-04	0.71E-04	0.11E-03	0.57E-03
	10	0.11E-03	0.13E-02	0.13E-03	0.28E-03	0.43E-03	0.22E-02
	20	0.82E-03	0.97E-02	0.98E-03	0.21E-02	0.33E-02	0.17E-01
	40	0.15E-02	0.18E-01	0.18E-02	0.39E-02	0.61E-02	0.31E-01
	70	0.22E-02	0.26E-01	0.27E-02	0.58E-02	0.90E-02	0.46E-01
10	1	4.84E-07	5.69E-06	5.64E-07	1.21E-06	1.90E-06	9.85E-06
	5	0.12E-04	0.14E-03	0.14E-04	0.30E-04	0.47E-04	0.24E-03
	10	0.46E-04	0.55E-03	0.54E-04	0.12E-03	0.18E-03	0.95E-03
	20	0.36E-03	0.42E-02	0.41E-03	0.89E-03	0.14E-02	0.72E-02
	40	0.65E-03	0.77E-02	0.76E-03	0.16E-02	0.26E-02	0.13E-01
	70	0.97E-03	0.11E-01	0.11E-02	0.24E-02	0.38E-02	0.20E-01
20	1	1.58E-07	1.86E-06	1.78E-07	3.81E-07	5.99E-07	3.17E-06
	5	0.39E-05	0.46E-04	0.44E-05	0.94E-05	0.15E-04	0.78E-04
	10	0.15E-04	0.18E-03	0.17E-04	0.37E-04	0.57E-04	0.30E-03
	20	0.12E-03	0.14E-02	0.13E-03	0.28E-03	0.44E-03	0.23E-02
	40	0.21E-03	0.25E-02	0.24E-03	0.51E-03	0.81E-03	0.43E-02
	70	0.32E-03	0.37E-02	0.36E-03	0.76E-03	0.12E-02	0.63E-02
40	1	5.09E-08	5.99E-07	5.70E-08	1.22E-07	1.91E-07	1.02E-06
	5	0.12E-05	0.15E-04	0.14E-05	0.30E-05	0.47E-05	0.25E-04
	10	0.49E-05	0.57E-04	0.55E-05	0.12E-04	0.18E-04	0.98E-04
	20	0.37E-04	0.44E-03	0.42E-04	0.89E-04	0.14E-03	0.75E-03
	40	0.69E-04	0.81E-03	0.77E-04	0.16E-03	0.26E-03	0.14E-02
	70	0.10E-03	0.12E-02	0.11E-03	0.24E-03	0.38E-03	0.20E-02

Table K-8.17. Time-Integrated Dose from External Exposure to Surface Activity Testes, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.23E-04	2.62E-03	2.68E-04	5.76E-04	9.05E-04	4.60E-03
	5	0.55E-02	0.64E-01	0.66E-02	0.14E-01	0.22E-01	0.11E 00
	10	0.21E-01	0.25E 00	0.26E-01	0.55E-01	0.87E-01	0.44E 00
	20	0.16E 00	0.19E 01	0.20E 00	0.42E 00	0.66E 00	0.34E 01
	40	0.30E 00	0.35E 01	0.36E 00	0.78E 00	0.12E 01	0.62E 01
	70	0.45E 00	0.52E 01	0.54E 00	0.12E 01	0.18E 01	0.92E 01
5	1	1.02E-05	1.20E-04	1.13E-05	2.42E-05	3.80E-05	2.03E-04
	5	0.25E-03	0.29E-02	0.28E-03	0.59E-03	0.93E-03	0.50E-02
	10	0.98E-03	0.11E-01	0.11E-02	0.23E-02	0.36E-02	0.20E-01
	20	0.75E-02	0.88E-01	0.83E-02	0.18E-01	0.28E-01	0.15E 00
	40	0.14E-01	0.16E 00	0.15E-01	0.33E-01	0.51E-01	0.27E 00
	70	0.20E-01	0.24E 00	0.23E-01	0.48E-01	0.76E-01	0.41E 00
10	1	4.53E-06	5.33E-05	5.05E-06	1.08E-05	1.69E-05	9.06E-05
	5	0.11E-03	0.13E-02	0.12E-03	0.26E-03	0.42E-03	0.22E-02
	10	0.43E-03	0.51E-02	0.48E-03	0.10E-02	0.16E-02	0.87E-02
	20	0.33E-02	0.39E-01	0.37E-02	0.79E-02	0.12E-01	0.67E-01
	40	0.61E-02	0.72E-01	0.68E-02	0.15E-01	0.23E-01	0.12E 00
	70	0.91E-02	0.11E 00	0.10E-01	0.22E-01	0.34E-01	0.18E 00
20	1	1.54E-06	1.81E-05	1.72E-06	3.68E-06	5.78E-06	3.08E-05
	5	0.38E-04	0.44E-03	0.42E-04	0.90E-04	0.14E-03	0.76E-03
	10	0.15E-03	0.17E-02	0.17E-03	0.35E-03	0.55E-03	0.30E-02
	20	0.11E-02	0.13E-01	0.13E-02	0.27E-02	0.42E-02	0.23E-01
	40	0.21E-02	0.24E-01	0.23E-02	0.50E-02	0.78E-02	0.42E-01
	70	0.31E-02	0.36E-01	0.34E-02	0.74E-02	0.12E-01	0.62E-01
40	1	5.03E-07	5.92E-06	5.64E-07	1.21E-06	1.89E-06	1.01E-05
	5	0.12E-04	0.15E-03	0.14E-04	0.30E-04	0.46E-04	0.25E-03
	10	0.48E-04	0.57E-03	0.54E-04	0.12E-03	0.18E-03	0.97E-03
	20	0.37E-03	0.43E-02	0.41E-03	0.89E-03	0.14E-02	0.74E-02
	40	0.68E-03	0.80E-02	0.76E-03	0.16E-02	0.26E-02	0.14E-01
	70	0.10E-02	0.12E-01	0.11E-02	0.24E-02	0.38E-02	0.20E-01

Table K-8.18. Time-Integrated Dose from External Exposure to Surface Activity Testes, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.74E-04	2.05E-03	2.15E-04	4.64E-04	7.29E-04	3.63E-03
	5	0.43E-02	0.50E-01	0.53E-02	0.11E-01	0.18E-01	0.89E-01
	10	0.17E-01	0.20E 00	0.21E-01	0.45E-01	0.70E-01	0.35E 00
	20	0.13E 00	0.15E 01	0.16E 00	0.34E 00	0.54E 00	0.27E 01
	40	0.23E 00	0.28E 01	0.29E 00	0.63E 00	0.98E 00	0.49E 01
	70	0.35E 00	0.41E 01	0.43E 00	0.93E 00	0.15E 01	0.73E 01
5	1	7.59E-06	8.93E-05	8.40E-06	1.79E-05	2.82E-05	1.51E-04
	5	0.19E-03	0.22E-02	0.21E-03	0.44E-03	0.69E-03	0.37E-02
	10	0.73E-03	0.86E-02	0.81E-03	0.17E-02	0.27E-02	0.15E-01
	20	0.56E-02	0.66E-01	0.62E-02	0.13E-01	0.21E-01	0.11E 00
	40	0.10E-01	0.12E 00	0.11E-01	0.24E-01	0.38E-01	0.20E 00
	70	0.15E-01	0.18E 00	0.17E-01	0.36E-01	0.56E-01	0.30E 00
10	1	3.38E-06	3.98E-05	3.76E-06	8.03E-06	1.26E-05	6.76E-05
	5	0.83E-04	0.98E-03	0.92E-04	0.20E-03	0.31E-03	0.17E-02
	10	0.32E-03	0.38E-02	0.36E-03	0.77E-03	0.12E-02	0.65E-02
	20	0.25E-02	0.29E-01	0.28E-02	0.59E-02	0.93E-02	0.50E-01
	40	0.46E-02	0.54E-01	0.51E-02	0.11E-01	0.17E-01	0.91E-01
	70	0.68E-02	0.80E-01	0.75E-02	0.16E-01	0.25E-01	0.14E 00
20	1	1.15E-06	1.36E-05	1.29E-06	2.75E-06	4.33E-06	2.31E-05
	5	0.28E-04	0.33E-03	0.32E-04	0.68E-04	0.11E-03	0.57E-03
	10	0.11E-03	0.13E-02	0.12E-03	0.26E-03	0.42E-03	0.22E-02
	20	0.85E-03	0.10E-01	0.95E-03	0.20E-02	0.32E-02	0.17E-01
	40	0.16E-02	0.18E-01	0.17E-02	0.37E-02	0.58E-02	0.31E-01
	70	0.23E-02	0.27E-01	0.26E-02	0.55E-02	0.87E-02	0.46E-01
40	1	3.77E-07	4.44E-06	4.23E-07	9.04E-07	1.42E-06	7.57E-06
	5	0.93E-05	0.11E-03	0.10E-04	0.22E-04	0.35E-04	0.19E-03
	10	0.36E-04	0.43E-03	0.41E-04	0.87E-04	0.14E-03	0.73E-03
	20	0.28E-03	0.33E-02	0.31E-03	0.66E-03	0.10E-02	0.56E-02
	40	0.51E-03	0.60E-02	0.57E-03	0.12E-02	0.19E-02	0.10E-01
	70	0.75E-03	0.89E-02	0.85E-03	0.18E-02	0.28E-02	0.15E-01

Table K-8.19. Time-Integrated Dose from External Exposure to Surface Activity Testes, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	6.72E-05	7.91E-04	8.72E-05	1.89E-04	2.97E-04	1.43E-03
	5	0.16E-02	0.19E-01	0.21E-02	0.46E-02	0.73E-02	0.35E-01
	10	0.64E-02	0.76E-01	0.84E-02	0.18E-01	0.29E-01	0.14E 00
	20	0.49E-01	0.58E 00	0.64E-01	0.14E 00	0.22E 00	0.11E 01
	40	0.91E-01	0.11E 01	0.12E 00	0.25E 00	0.40E 00	0.19E 01
	70	0.13E 00	0.16E 01	0.17E 00	0.38E 00	0.59E 00	0.29E 01
5	1	2.75E-06	3.24E-05	3.08E-06	6.60E-06	1.04E-05	5.52E-05
	5	0.68E-04	0.79E-03	0.76E-04	0.16E-03	0.25E-03	0.14E-02
	10	0.26E-03	0.31E-02	0.30E-03	0.63E-03	0.99E-03	0.53E-02
	20	0.20E-02	0.24E-01	0.23E-02	0.48E-02	0.76E-02	0.41E-01
	40	0.37E-02	0.44E-01	0.42E-02	0.89E-02	0.14E-01	0.74E-01
	70	0.55E-02	0.65E-01	0.62E-02	0.13E-01	0.21E-01	0.11E 00
10	1	1.22E-06	1.44E-05	1.37E-06	2.93E-06	4.59E-06	2.45E-05
	5	0.30E-04	0.35E-03	0.34E-04	0.72E-04	0.11E-03	0.60E-03
	10	0.12E-03	0.14E-02	0.13E-03	0.28E-03	0.44E-03	0.23E-02
	20	0.90E-03	0.11E-01	0.10E-02	0.21E-02	0.34E-02	0.18E-01
	40	0.16E-02	0.19E-01	0.18E-02	0.39E-02	0.62E-02	0.33E-01
	70	0.24E-02	0.29E-01	0.27E-02	0.59E-02	0.92E-02	0.49E-01
20	1	4.13E-07	4.87E-06	4.63E-07	9.90E-07	1.55E-06	8.29E-06
	5	0.10E-04	0.12E-03	0.11E-04	0.24E-04	0.38E-04	0.20E-03
	10	0.40E-04	0.47E-03	0.44E-04	0.95E-04	0.15E-03	0.80E-03
	20	0.30E-03	0.36E-02	0.34E-03	0.73E-03	0.11E-02	0.61E-02
	40	0.56E-03	0.66E-02	0.62E-03	0.13E-02	0.21E-02	0.11E-01
	70	0.83E-03	0.97E-02	0.93E-03	0.20E-02	0.31E-02	0.17E-01
40	1	1.35E-07	1.59E-06	1.51E-07	3.23E-07	5.07E-07	2.70E-06
	5	0.33E-05	0.39E-04	0.37E-05	0.79E-05	0.12E-04	0.66E-04
	10	0.13E-04	0.15E-03	0.14E-04	0.31E-04	0.49E-04	0.26E-03
	20	0.99E-04	0.12E-02	0.11E-03	0.24E-03	0.37E-03	0.20E-02
	40	0.18E-03	0.21E-02	0.20E-03	0.44E-03	0.68E-03	0.36E-02
	70	0.27E-03	0.32E-02	0.30E-03	0.65E-03	0.10E-02	0.54E-02

Table K-8.20. Time-Integrated Dose from External Exposure to Surface Activity Testes, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	6.89E-05	8.10E-04	8.60E-05	1.86E-04	2.92E-04	1.44E-03
	5	0.17E-02	0.20E-01	0.21E-02	0.46E-02	0.72E-02	0.35E-01
	10	0.66E-02	0.78E-01	0.83E-02	0.18E-01	0.28E-01	0.14E 00
	20	0.51E-01	0.60E 00	0.63E-01	0.14E 00	0.21E 00	0.11E 01
	40	0.93E-01	0.11E 01	0.12E 00	0.25E 00	0.39E 00	0.19E 01
	70	0.14E 00	0.16E 01	0.17E 00	0.37E 00	0.58E 00	0.29E 01
5	1	3.01E-06	3.54E-05	3.39E-06	7.25E-06	1.14E-05	6.04E-05
	5	0.74E-04	0.87E-03	0.83E-04	0.18E-03	0.28E-03	0.15E-02
	10	0.29E-03	0.34E-02	0.33E-03	0.70E-03	0.11E-02	0.58E-02
	20	0.22E-02	0.26E-01	0.25E-02	0.53E-02	0.84E-02	0.44E-01
	40	0.41E-02	0.48E-01	0.46E-02	0.98E-02	0.15E-01	0.81E-01
	70	0.60E-02	0.71E-01	0.68E-02	0.14E-01	0.23E-01	0.12E 00
10	1	1.33E-06	1.57E-05	1.50E-06	3.21E-06	5.04E-06	2.68E-05
	5	0.33E-04	0.39E-03	0.37E-04	0.79E-04	0.12E-03	0.66E-03
	10	0.13E-03	0.15E-02	0.14E-03	0.31E-03	0.48E-03	0.26E-02
	20	0.98E-03	0.12E-01	0.11E-02	0.24E-02	0.37E-02	0.20E-01
	40	0.18E-02	0.21E-01	0.20E-02	0.43E-02	0.68E-02	0.36E-01
	70	0.27E-02	0.31E-01	0.30E-02	0.64E-02	0.10E-01	0.54E-01
20	1	4.51E-07	5.31E-06	5.07E-07	1.08E-06	1.70E-06	9.06E-06
	5	0.11E-04	0.13E-03	0.12E-04	0.27E-04	0.42E-04	0.22E-03
	10	0.43E-04	0.51E-03	0.49E-04	0.10E-03	0.16E-03	0.87E-03
	20	0.33E-03	0.39E-02	0.37E-03	0.80E-03	0.12E-02	0.66E-02
	40	0.61E-03	0.72E-02	0.68E-03	0.15E-02	0.23E-02	0.12E-01
	70	0.90E-03	0.11E-01	0.10E-02	0.22E-02	0.34E-02	0.18E-01
40	1	1.47E-07	1.73E-06	1.65E-07	3.53E-07	5.54E-07	2.95E-06
	5	0.36E-05	0.42E-04	0.40E-05	0.87E-05	0.14E-04	0.72E-04
	10	0.14E-04	0.17E-03	0.16E-04	0.34E-04	0.53E-04	0.28E-03
	20	0.11E-03	0.13E-02	0.12E-03	0.26E-03	0.41E-03	0.22E-02
	40	0.20E-03	0.23E-02	0.22E-03	0.48E-03	0.75E-03	0.40E-02
	70	0.29E-03	0.35E-02	0.33E-03	0.71E-03	0.11E-02	0.59E-02

Table K-8.21. Time-Integrated Dose from External Exposure to Surface Activity
Small Intestine, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	9.80E-06	4.18E-04	3.71E-05	1.07E-04	1.36E-04	7.08E-04
	5	0.24E-03	0.10E-01	0.91E-03	0.26E-02	0.33E-02	0.17E-01
	10	0.94E-03	0.40E-01	0.36E-02	0.10E-01	0.13E-01	0.68E-01
	20	0.72E-02	0.31E 00	0.27E-01	0.79E-01	0.10E 00	0.52E 00
	40	0.13E-01	0.56E 00	0.50E-01	0.14E 00	0.18E 00	0.95E 00
	70	0.20E-01	0.84E 00	0.74E-01	0.21E 00	0.27E 00	0.14E 01
5	1	2.12E-07	9.03E-06	5.63E-07	1.58E-06	2.01E-06	1.34E-05
	5	0.52E-05	0.22E-03	0.14E-04	0.39E-04	0.49E-04	0.33E-03
	10	0.20E-04	0.87E-03	0.54E-04	0.15E-03	0.19E-03	0.13E-02
	20	0.16E-03	0.66E-02	0.41E-03	0.12E-02	0.15E-02	0.98E-02
	40	0.28E-03	0.12E-01	0.76E-03	0.21E-02	0.27E-02	0.18E-01
	70	0.42E-03	0.18E-01	0.11E-02	0.32E-02	0.40E-02	0.27E-01
10	1	9.12E-08	3.89E-06	2.37E-07	6.63E-07	8.45E-07	5.73E-06
	5	0.22E-05	0.95E-04	0.58E-05	0.16E-04	0.21E-04	0.14E-03
	10	0.88E-05	0.37E-03	0.23E-04	0.64E-04	0.81E-04	0.55E-03
	20	0.67E-04	0.29E-02	0.17E-03	0.49E-03	0.62E-03	0.42E-02
	40	0.12E-03	0.52E-02	0.32E-03	0.89E-03	0.11E-02	0.77E-02
	70	0.18E-03	0.78E-02	0.47E-03	0.13E-02	0.17E-02	0.11E-01
20	1	2.97E-08	1.27E-06	7.49E-08	2.09E-07	2.66E-07	1.85E-06
	5	0.73E-06	0.31E-04	0.18E-05	0.51E-05	0.65E-05	0.45E-04
	10	0.29E-05	0.12E-03	0.72E-05	0.20E-04	0.26E-04	0.18E-03
	20	0.22E-04	0.93E-03	0.55E-04	0.15E-03	0.20E-03	0.14E-02
	40	0.40E-04	0.17E-02	0.10E-03	0.28E-03	0.36E-03	0.25E-02
	70	0.59E-04	0.25E-02	0.15E-03	0.42E-03	0.53E-03	0.37E-02
40	1	9.59E-09	4.09E-07	2.40E-08	6.68E-08	8.51E-08	5.95E-07
	5	0.24E-06	0.10E-04	0.59E-06	0.16E-05	0.21E-05	0.15E-04
	10	0.92E-06	0.39E-04	0.23E-05	0.64E-05	0.82E-05	0.57E-04
	20	0.70E-05	0.30E-03	0.18E-04	0.49E-04	0.62E-04	0.44E-03
	40	0.13E-04	0.55E-03	0.32E-04	0.90E-04	0.11E-03	0.80E-03
	70	0.19E-04	0.82E-03	0.48E-04	0.13E-03	0.17E-03	0.12E-02

Table K-8.22. Time-Integrated Dose from External Exposure to Surface Activity
Small Intestine, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	4.20E-05	1.79E-03	1.12E-04	3.16E-04	4.02E-04	2.67E-03
	5	0.10E-02	0.44E-01	0.28E-02	0.77E-02	0.99E-02	0.65E-01
	10	0.40E-02	0.17E 00	0.11E-01	0.30E-01	0.39E-01	0.26E 00
	20	0.31E-01	0.13E 01	0.83E-01	0.23E 00	0.30E 00	0.20E 01
	40	0.57E-01	0.24E 01	0.15E 00	0.43E 00	0.54E 00	0.36E 01
	70	0.84E-01	0.36E 01	0.22E 00	0.63E 00	0.80E 00	0.53E 01
5	1	1.92E-06	8.18E-05	4.76E-06	1.32E-05	1.69E-05	1.19E-04
	5	0.47E-04	0.20E-02	0.12E-03	0.33E-03	0.41E-03	0.29E-02
	10	0.18E-03	0.79E-02	0.46E-03	0.13E-02	0.16E-02	0.11E-01
	20	0.14E-02	0.60E-01	0.35E-02	0.97E-02	0.12E-01	0.87E-01
	40	0.26E-02	0.11E 00	0.64E-02	0.18E-01	0.23E-01	0.16E 00
	70	0.38E-02	0.16E 00	0.95E-02	0.26E-01	0.34E-01	0.24E 00
10	1	8.54E-07	3.64E-05	2.12E-06	5.91E-06	7.54E-06	5.29E-05
	5	0.21E-04	0.89E-03	0.52E-04	0.15E-03	0.18E-03	0.13E-02
	10	0.82E-04	0.35E-02	0.20E-03	0.57E-03	0.72E-03	0.51E-02
	20	0.63E-03	0.27E-01	0.16E-02	0.43E-02	0.55E-02	0.39E-01
	40	0.12E-02	0.49E-01	0.29E-02	0.80E-02	0.10E-01	0.71E-01
	70	0.17E-02	0.73E-01	0.42E-02	0.12E-01	0.15E-01	0.11E 00
20	1	2.90E-07	1.24E-05	7.24E-07	2.02E-06	2.57E-06	1.80E-05
	5	0.71E-05	0.30E-03	0.18E-04	0.49E-04	0.63E-04	0.44E-03
	10	0.28E-04	0.12E-02	0.69E-04	0.19E-03	0.25E-03	0.17E-02
	20	0.21E-03	0.91E-02	0.53E-03	0.15E-02	0.19E-02	0.13E-01
	40	0.39E-03	0.17E-01	0.97E-03	0.27E-02	0.35E-02	0.24E-01
	70	0.58E-03	0.25E-01	0.14E-02	0.40E-02	0.51E-02	0.36E-01
40	1	9.48E-08	4.05E-06	2.37E-07	6.61E-07	8.42E-07	5.88E-06
	5	0.23E-05	0.99E-04	0.58E-05	0.16E-04	0.21E-04	0.14E-03
	10	0.91E-05	0.39E-03	0.23E-04	0.63E-04	0.81E-04	0.56E-03
	20	0.70E-04	0.30E-02	0.17E-03	0.49E-03	0.62E-03	0.43E-02
	40	0.13E-03	0.55E-02	0.32E-03	0.89E-03	0.11E-02	0.79E-02
	70	0.19E-03	0.81E-02	0.47E-03	0.13E-02	0.17E-02	0.12E-01

Table K-8.23. Time-Integrated Dose from External Exposure to Surface Activity
Small Intestine, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	3.28E-05	1.40E-03	9.04E-05	2.54E-04	3.24E-04	2.10E-03
	5	0.81E-03	0.34E-01	0.22E-02	0.62E-02	0.80E-02	0.52E-01
	10	0.31E-02	0.13E 00	0.87E-02	0.24E-01	0.31E-01	0.20E 00
	20	0.24E-01	0.10E 01	0.66E-01	0.19E 00	0.24E 00	0.15E 01
	40	0.44E-01	0.19E 01	0.12E 00	0.34E 00	0.44E 00	0.28E 01
	70	0.66E-01	0.28E 01	0.18E 00	0.51E 00	0.65E 00	0.42E 01
5	1	1.43E-06	6.10E-05	3.93E-06	9.83E-06	1.25E-05	8.83E-05
	5	0.35E-04	0.15E-02	0.87E-04	0.24E-03	0.31E-03	0.22E-02
	10	0.14E-03	0.59E-02	0.34E-03	0.94E-03	0.12E-02	0.85E-02
	20	0.10E-02	0.45E-01	0.26E-02	0.72E-02	0.92E-02	0.65E-01
	40	0.19E-02	0.82E-01	0.48E-02	0.13E-01	0.17E-01	0.12E 00
	70	0.29E-02	0.12E 00	0.71E-02	0.20E-01	0.25E-01	0.18E 00
10	1	6.38E-07	2.72E-05	1.56E-06	4.40E-06	5.61E-06	3.95E-05
	5	0.16E-04	0.67E-03	0.39E-04	0.11E-03	0.14E-03	0.97E-03
	10	0.61E-04	0.26E-02	0.15E-03	0.42E-03	0.54E-03	0.38E-02
	20	0.47E-03	0.20E-01	0.12E-02	0.32E-02	0.41E-02	0.29E-01
	40	0.86E-03	0.37E-01	0.21E-02	0.59E-02	0.76E-02	0.53E-01
	70	0.13E-02	0.54E-01	0.32E-02	0.88E-02	0.11E-01	0.79E-01
20	1	2.17E-07	9.28E-06	5.42E-07	1.51E-06	1.92E-06	1.35E-05
	5	0.53E-05	0.23E-03	0.13E-04	0.37E-04	0.47E-04	0.33E-03
	10	0.21E-04	0.89E-03	0.52E-04	0.14E-03	0.18E-03	0.13E-02
	20	0.16E-03	0.68E-02	0.40E-03	0.11E-02	0.14E-02	0.99E-02
	40	0.29E-03	0.13E-01	0.73E-03	0.20E-02	0.26E-02	0.18E-01
	70	0.44E-03	0.19E-01	0.11E-02	0.30E-02	0.38E-02	0.27E-01
40	1	7.11E-08	3.03E-06	1.78E-07	4.95E-07	6.32E-07	4.41E-06
	5	0.17E-05	0.74E-04	0.44E-05	0.12E-04	0.15E-04	0.11E-03
	10	0.68E-05	0.29E-03	0.17E-04	0.48E-04	0.61E-04	0.42E-03
	20	0.52E-04	0.22E-02	0.13E-03	0.36E-03	0.46E-03	0.32E-02
	40	0.96E-04	0.41E-02	0.24E-03	0.67E-03	0.85E-03	0.59E-02
	70	0.14E-03	0.61E-02	0.36E-03	0.99E-03	0.13E-02	0.88E-02

Table K-8.24. Time-Integrated Dose from External Exposure to Surface Activity
Small Intestine, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.27E-05	5.40E-04	3.67E-05	1.04E-04	1.32E-04	8.26E-04
	5	0.31E-03	0.13E-01	0.90E-03	0.25E-02	0.32E-02	0.20E-01
	10	0.12E-02	0.52E-01	0.35E-02	0.99E-02	0.13E-01	0.79E-01
	20	0.93E-02	0.40E 00	0.27E-01	0.76E-01	0.97E-01	0.61E 00
	40	0.17E-01	0.73E 00	0.49E-01	0.14E 00	0.18E 00	0.11E 01
	70	0.25E-01	0.11E 01	0.73E-01	0.21E 00	0.26E 00	0.17E 01
5	1	5.18E-07	2.21E-05	1.30E-06	3.61E-06	4.61E-06	3.22E-05
	5	0.13E-04	0.54E-03	0.32E-04	0.89E-04	0.11E-03	0.79E-03
	10	0.50E-04	0.21E-02	0.12E-03	0.35E-03	0.44E-03	0.31E-02
	20	0.38E-03	0.16E-01	0.95E-03	0.27E-02	0.34E-02	0.24E-01
	40	0.70E-03	0.30E-01	0.17E-02	0.49E-02	0.62E-02	0.43E-01
	70	0.10E-02	0.44E-01	0.26E-02	0.72E-02	0.92E-02	0.64E-01
10	1	2.30E-07	9.82E-06	5.75E-07	1.60E-06	2.04E-06	1.43E-05
	5	0.56E-05	0.24E-03	0.14E-04	0.39E-04	0.50E-04	0.35E-03
	10	0.22E-04	0.94E-03	0.55E-04	0.15E-03	0.20E-03	0.14E-02
	20	0.17E-03	0.72E-02	0.42E-03	0.12E-02	0.15E-02	0.10E-01
	40	0.31E-03	0.13E-01	0.77E-03	0.22E-02	0.28E-02	0.19E-01
	70	0.46E-03	0.20E-01	0.12E-02	0.32E-02	0.41E-02	0.29E-01
20	1	7.79E-08	3.32E-06	1.95E-07	5.42E-07	6.91E-07	4.83E-06
	5	0.19E-05	0.82E-04	0.48E-05	0.13E-04	0.17E-04	0.12E-03
	10	0.75E-05	0.32E-03	0.19E-04	0.52E-04	0.66E-04	0.46E-03
	20	0.57E-04	0.24E-02	0.14E-03	0.40E-03	0.51E-03	0.35E-02
	40	0.10E-03	0.45E-02	0.26E-03	0.73E-03	0.93E-03	0.65E-02
	70	0.16E-03	0.66E-02	0.39E-03	0.11E-02	0.14E-02	0.97E-02
40	1	2.54E-08	1.08E-06	6.35E-08	1.77E-07	2.26E-07	1.58E-06
	5	0.62E-06	0.27E-04	0.16E-05	0.43E-05	0.55E-05	0.39E-04
	10	0.24E-05	0.10E-03	0.61E-05	0.17E-04	0.22E-04	0.15E-03
	20	0.19E-04	0.80E-03	0.47E-04	0.13E-03	0.17E-03	0.12E-02
	40	0.34E-04	0.15E-02	0.86E-04	0.24E-03	0.30E-03	0.21E-02
	70	0.51E-04	0.22E-02	0.13E-03	0.35E-03	0.45E-03	0.32E-02

Table K-8.25. Time-Integrated Dose from External Exposure to Surface Activity
Small Intestine, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.30E-05	5.54E-04	3.62E-05	1.02E-04	1.30E-04	8.35E-04
	5	0.32E-03	0.14E-01	0.89E-03	0.25E-02	0.32E-02	0.20E-01
	10	0.12E-02	0.53E-01	0.35E-02	0.98E-02	0.12E-01	0.80E-01
	20	0.95E-02	0.41E 00	0.27E-01	0.75E-01	0.95E-01	0.61E 00
	40	0.17E-01	0.75E 00	0.49E-01	0.14E 00	0.17E 00	0.11E 01
	70	0.26E-01	0.11E 01	0.72E-01	0.20E 00	0.26E 00	0.17E 01
5	1	5.67E-07	2.42E-05	1.42E-06	3.97E-06	5.06E-06	3.52E-05
	5	0.14E-04	0.59E-03	0.35E-04	0.97E-04	0.12E-03	0.86E-03
	10	0.54E-04	0.23E-02	0.14E-03	0.38E-03	0.49E-03	0.34E-02
	20	0.42E-03	0.18E-01	0.10E-02	0.29E-02	0.37E-02	0.26E-01
	40	0.76E-03	0.33E-01	0.19E-02	0.53E-02	0.68E-02	0.47E-01
	70	0.11E-02	0.48E-01	0.28E-02	0.79E-02	0.10E-01	0.70E-01
10	1	2.51E-07	1.07E-05	6.30E-07	1.76E-06	2.24E-06	1.56E-05
	5	0.62E-05	0.26E-03	0.15E-04	0.43E-04	0.55E-04	0.38E-03
	10	0.24E-04	0.10E-02	0.60E-04	0.17E-03	0.21E-03	0.15E-02
	20	0.18E-03	0.79E-02	0.46E-03	0.13E-02	0.16E-02	0.11E-01
	40	0.34E-03	0.14E-01	0.85E-03	0.24E-02	0.30E-02	0.21E-01
	70	0.50E-03	0.21E-01	0.13E-02	0.35E-02	0.45E-02	0.31E-01
20	1	8.51E-08	3.63E-06	2.13E-07	5.94E-07	7.57E-07	5.28E-06
	5	0.21E-05	0.89E-04	0.52E-05	0.15E-04	0.19E-04	0.13E-03
	10	0.82E-05	0.35E-03	0.20E-04	0.57E-04	0.73E-04	0.51E-03
	20	0.62E-04	0.27E-02	0.16E-03	0.44E-03	0.56E-03	0.39E-02
	40	0.11E-03	0.49E-02	0.29E-03	0.80E-03	0.10E-02	0.71E-02
	70	0.17E-03	0.73E-02	0.43E-03	0.12E-02	0.15E-02	0.11E-01
40	1	2.77E-08	1.18E-06	6.94E-08	1.93E-07	2.46E-07	1.72E-06
	5	0.68E-06	0.29E-04	0.17E-05	0.47E-05	0.60E-05	0.42E-04
	10	0.27E-05	0.11E-03	0.67E-05	0.19E-04	0.24E-04	0.16E-03
	20	0.20E-04	0.87E-03	0.51E-04	0.14E-03	0.18E-03	0.13E-02
	40	0.37E-04	0.16E-02	0.93E-04	0.26E-03	0.33E-03	0.23E-02
	70	0.55E-04	0.24E-02	0.14E-03	0.39E-03	0.49E-03	0.34E-02

Table K-8.26. Time-Integrated Dose from External Exposure to Surface Activity
Lung, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.92E-05	5.41E-04	5.86E-05	1.35E-04	2.32E-05	7.77E-04
	5	0.47E-03	0.13E-01	0.14E-02	0.33E-02	0.57E-03	0.19E-01
	10	0.18E-02	0.52E-01	0.56E-02	0.13E-01	0.22E-02	0.75E-01
	20	0.14E-01	0.40E 00	0.43E-01	0.99E-01	0.17E-01	0.57E 00
	40	0.26E-01	0.73E 00	0.79E-01	0.18E 00	0.31E-01	0.10E 01
	70	0.38E-01	0.11E 01	0.12E 00	0.27E 00	0.46E-01	0.16E 01
5	1	4.15E-07	1.17E-05	8.90E-07	1.99E-06	3.43E-07	1.53E-05
	5	0.10E-04	0.29E-03	0.22E-04	0.49E-04	0.84E-05	0.38E-03
	10	0.40E-04	0.11E-02	0.85E-04	0.19E-03	0.33E-04	0.15E-02
	20	0.30E-03	0.86E-02	0.65E-03	0.15E-02	0.25E-03	0.11E-01
	40	0.56E-03	0.16E-01	0.12E-02	0.27E-02	0.46E-03	0.21E-01
	70	0.83E-03	0.23E-01	0.18E-02	0.40E-02	0.69E-03	0.31E-01
10	1	1.79E-07	5.04E-06	3.75E-07	8.36E-07	1.44E-07	6.57E-06
	5	0.44E-05	0.12E-03	0.92E-05	0.21E-04	0.35E-05	0.16E-03
	10	0.17E-04	0.48E-03	0.36E-04	0.80E-04	0.14E-04	0.63E-03
	20	0.13E-03	0.37E-02	0.28E-03	0.61E-03	0.11E-03	0.48E-02
	40	0.24E-03	0.68E-02	0.50E-03	0.11E-02	0.19E-03	0.89E-02
	70	0.36E-03	0.10E-01	0.75E-03	0.17E-02	0.29E-03	0.13E-01
20	1	5.84E-08	1.64E-06	1.18E-07	2.63E-07	4.54E-08	2.13E-06
	5	0.14E-05	0.40E-04	0.29E-05	0.65E-05	0.11E-05	0.52E-04
	10	0.56E-05	0.16E-03	0.11E-04	0.25E-04	0.44E-05	0.20E-03
	20	0.43E-04	0.12E-02	0.87E-04	0.19E-03	0.33E-04	0.16E-02
	40	0.79E-04	0.22E-02	0.16E-03	0.35E-03	0.61E-04	0.29E-02
	70	0.12E-03	0.33E-02	0.24E-03	0.53E-03	0.91E-04	0.43E-02
40	1	1.88E-08	5.30E-07	3.79E-08	8.42E-08	1.45E-08	6.85E-07
	5	0.46E-06	0.13E-04	0.93E-06	0.21E-05	0.36E-06	0.17E-04
	10	0.18E-05	0.51E-04	0.36E-05	0.81E-05	0.14E-05	0.66E-04
	20	0.14E-04	0.39E-03	0.28E-04	0.62E-04	0.11E-04	0.50E-03
	40	0.25E-04	0.71E-03	0.51E-04	0.11E-03	0.20E-04	0.92E-03
	70	0.38E-04	0.11E-02	0.76E-04	0.17E-03	0.29E-04	0.14E-02

Table K-8.27. Time-Integrated Dose from External Exposure to Surface Activity Lung, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	8.25E-05	2.32E-03	1.78E-04	3.98E-04	6.86E-05	3.05E-03
	5	0.20E-02	0.57E-01	0.44E-02	0.98E-02	0.17E-02	0.75E-01
	10	0.79E-02	0.22E 00	0.17E-01	0.38E-01	0.66E-02	0.29E 00
	20	0.61E-01	0.17E 01	0.13E 00	0.29E 00	0.50E-01	0.22E 01
	40	0.11E 00	0.31E 01	0.24E 00	0.54E 00	0.92E-01	0.41E 01
	70	0.16E 00	0.46E 01	0.36E 00	0.80E 00	0.14E 00	0.61E 01
5	1	3.76E-06	1.06E-04	7.52E-06	1.67E-05	2.88E-06	1.37E-04
	5	0.92E-04	0.26E-02	0.18E-03	0.41E-03	0.71E-04	0.34E-02
	10	0.36E-03	0.10E-01	0.72E-03	0.16E-02	0.28E-03	0.13E-01
	20	0.28E-02	0.78E-01	0.55E-02	0.12E-01	0.21E-02	0.10E 00
	40	0.51E-02	0.14E 00	0.10E-01	0.23E-01	0.39E-02	0.18E 00
	70	0.75E-02	0.21E 00	0.15E-01	0.33E-01	0.58E-02	0.27E 00
10	1	1.68E-06	4.72E-05	3.36E-06	7.45E-06	1.28E-06	6.09E-05
	5	0.41E-04	0.12E-02	0.82E-04	0.18E-03	0.32E-04	0.15E-02
	10	0.16E-03	0.45E-02	0.32E-03	0.72E-03	0.12E-03	0.58E-02
	20	0.12E-02	0.35E-01	0.25E-02	0.55E-02	0.94E-03	0.45E-01
	40	0.23E-02	0.64E-01	0.45E-02	0.10E-01	0.17E-02	0.82E-01
	70	0.34E-02	0.94E-01	0.67E-02	0.15E-01	0.26E-02	0.12E 00
20	1	5.70E-07	1.60E-05	1.14E-06	2.54E-06	4.38E-07	2.07E-05
	5	0.14E-04	0.39E-03	0.28E-04	0.62E-04	0.11E-04	0.51E-03
	10	0.55E-04	0.15E-02	0.11E-03	0.24E-03	0.42E-04	0.20E-02
	20	0.42E-03	0.12E-01	0.84E-03	0.19E-02	0.32E-03	0.15E-01
	40	0.77E-03	0.22E-01	0.15E-02	0.34E-02	0.59E-03	0.28E-01
	70	0.11E-02	0.32E-01	0.23E-02	0.51E-02	0.88E-03	0.41E-01
40	1	1.86E-07	5.24E-06	3.75E-07	8.33E-07	1.43E-07	6.78E-06
	5	0.46E-05	0.13E-03	0.92E-05	0.20E-04	0.35E-05	0.17E-03
	10	0.18E-04	0.50E-03	0.36E-04	0.80E-04	0.14E-04	0.65E-03
	20	0.14E-03	0.38E-02	0.28E-03	0.61E-03	0.11E-03	0.50E-02
	40	0.25E-03	0.71E-02	0.50E-03	0.11E-02	0.19E-03	0.91E-02
	70	0.37E-03	0.10E-01	0.75E-03	0.17E-02	0.29E-03	0.14E-01

Table K-8.28. Time-Integrated Dose from External Exposure to Surface Activity Lung, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	6.44E-05	1.81E-03	1.43E-04	3.21E-04	5.52E-05	2.40E-03
	5	0.16E-02	0.44E-01	0.35E-02	0.79E-02	0.14E-02	0.59E-01
	10	0.62E-02	0.17E 00	0.14E-01	0.31E-01	0.53E-02	0.23E 00
	20	0.47E-01	0.13E 01	0.10E 00	0.24E 00	0.41E-01	0.18E 01
	40	0.87E-01	0.24E 01	0.19E 00	0.43E 00	0.74E-01	0.32E 01
	70	0.13E 00	0.36E 01	0.29E 00	0.64E 00	0.11E 00	0.48E 01
5	1	2.81E-06	7.90E-05	5.58E-06	1.24E-05	2.13E-06	1.02E-04
	5	0.69E-04	0.19E-02	0.14E-03	0.30E-03	0.52E-04	0.25E-02
	10	0.27E-03	0.76E-02	0.54E-03	0.12E-02	0.20E-03	0.98E-02
	20	0.21E-02	0.58E-01	0.41E-02	0.91E-02	0.16E-02	0.75E-01
	40	0.38E-02	0.11E 00	0.75E-02	0.17E-01	0.29E-02	0.14E 00
	70	0.56E-02	0.16E 00	0.11E-01	0.25E-01	0.43E-02	0.20E 00
10	1	1.25E-06	3.52E-05	2.50E-06	5.55E-06	9.56E-07	4.55E-05
	5	0.31E-04	0.86E-03	0.61E-04	0.14E-03	0.23E-04	0.11E-02
	10	0.12E-03	0.34E-02	0.24E-03	0.53E-03	0.92E-04	0.44E-02
	20	0.92E-03	0.26E-01	0.18E-02	0.41E-02	0.70E-03	0.33E-01
	40	0.17E-02	0.47E-01	0.34E-02	0.75E-02	0.13E-02	0.61E-01
	70	0.25E-02	0.70E-01	0.50E-02	0.11E-01	0.19E-02	0.91E-01
20	1	4.27E-07	1.20E-05	8.57E-07	1.90E-06	3.28E-07	1.55E-05
	5	0.10E-04	0.29E-03	0.21E-04	0.47E-04	0.80E-05	0.38E-03
	10	0.41E-04	0.12E-02	0.82E-04	0.18E-03	0.31E-04	0.15E-02
	20	0.31E-03	0.88E-02	0.63E-03	0.14E-02	0.24E-03	0.11E-01
	40	0.58E-03	0.16E-01	0.12E-02	0.26E-02	0.44E-03	0.21E-01
	70	0.85E-03	0.24E-01	0.17E-02	0.38E-02	0.65E-03	0.31E-01
40	1	1.40E-07	3.93E-06	2.81E-07	6.25E-07	1.08E-07	5.08E-06
	5	0.34E-05	0.96E-04	0.69E-05	0.15E-04	0.26E-05	0.12E-03
	10	0.13E-04	0.38E-03	0.27E-04	0.60E-04	0.10E-04	0.49E-03
	20	0.10E-03	0.29E-02	0.21E-03	0.46E-03	0.79E-04	0.37E-02
	40	0.19E-03	0.53E-02	0.38E-03	0.84E-03	0.14E-03	0.68E-02
	70	0.28E-03	0.79E-02	0.56E-03	0.12E-02	0.22E-03	0.10E-01

Table K-8.29. Time-Integrated Dose from External Exposure to Surface Activity
Lung, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.49E-05	7.00E-04	5.80E-05	1.31E-04	2.25E-05	9.36E-04
	5	0.61E-03	0.17E-01	0.14E-02	0.32E-02	0.55E-03	0.23E-01
	10	0.24E-02	0.67E-01	0.56E-02	0.13E-01	0.22E-02	0.90E-01
	20	0.18E-01	0.51E 00	0.43E-01	0.96E-01	0.17E-01	0.69E 00
	40	0.33E-01	0.94E 00	0.78E-01	0.18E 00	0.30E-01	0.13E 01
	70	0.50E-01	0.14E 01	0.12E 00	0.26E 00	0.45E-01	0.19E 01
5	1	1.02E-06	2.86E-05	2.05E-06	4.56E-06	7.85E-07	3.70E-05
	5	0.25E-04	0.70E-03	0.50E-04	0.11E-03	0.19E-04	0.91E-03
	10	0.98E-04	0.27E-02	0.20E-03	0.44E-03	0.75E-04	0.36E-02
	20	0.75E-03	0.21E-01	0.15E-02	0.33E-02	0.58E-03	0.27E-01
	40	0.14E-02	0.39E-01	0.28E-02	0.61E-02	0.11E-02	0.50E-01
	70	0.20E-02	0.57E-01	0.41E-02	0.91E-02	0.16E-02	0.74E-01
10	1	4.52E-07	1.27E-05	9.10E-07	2.02E-06	3.48E-07	1.64E-05
	5	0.11E-04	0.31E-03	0.22E-04	0.50E-04	0.85E-05	0.40E-03
	10	0.43E-04	0.12E-02	0.87E-04	0.19E-03	0.33E-04	0.16E-02
	20	0.33E-03	0.93E-02	0.67E-03	0.15E-02	0.26E-03	0.12E-01
	40	0.61E-03	0.17E-01	0.12E-02	0.27E-02	0.47E-03	0.22E-01
	70	0.90E-03	0.25E-01	0.18E-02	0.40E-02	0.70E-03	0.33E-01
20	1	1.53E-07	4.30E-06	3.08E-07	6.84E-07	1.18E-07	5.57E-06
	5	0.38E-05	0.11E-03	0.76E-05	0.17E-04	0.29E-05	0.14E-03
	10	0.15E-04	0.41E-03	0.30E-04	0.66E-04	0.11E-04	0.53E-03
	20	0.11E-03	0.32E-02	0.23E-03	0.50E-03	0.86E-04	0.41E-02
	40	0.21E-03	0.58E-02	0.41E-03	0.92E-03	0.16E-03	0.75E-02
	70	0.31E-03	0.86E-02	0.62E-03	0.14E-02	0.24E-03	0.11E-01
40	1	4.99E-08	1.40E-06	1.00E-07	2.23E-07	3.84E-08	1.82E-06
	5	0.12E-05	0.34E-04	0.25E-05	0.55E-05	0.94E-06	0.45E-04
	10	0.48E-05	0.13E-03	0.96E-05	0.21E-04	0.37E-05	0.17E-03
	20	0.37E-04	0.10E-02	0.74E-04	0.16E-03	0.28E-04	0.13E-02
	40	0.67E-04	0.19E-02	0.14E-03	0.30E-03	0.52E-04	0.24E-02
	70	0.10E-03	0.28E-02	0.20E-03	0.45E-03	0.77E-04	0.36E-02

Table K-8.30. Time-Integrated Dose from External Exposure to Surface Activity
Lung, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.55E-05	7.17E-04	5.72E-05	1.28E-04	2.21E-05	9.50E-04
	5	0.63E-03	0.18E-01	0.14E-02	0.32E-02	0.54E-03	0.23E-01
	10	0.24E-02	0.69E-01	0.55E-02	0.12E-01	0.21E-02	0.91E-01
	20	0.19E-01	0.53E 00	0.42E-01	0.94E-01	0.16E-01	0.70E 00
	40	0.34E-01	0.97E 00	0.77E-01	0.17E 00	0.30E-01	0.13E 01
	70	0.51E-01	0.14E 01	0.11E 00	0.26E 00	0.44E-01	0.19E 01
5	1	1.11E-06	3.13E-05	2.25E-06	5.01E-06	8.62E-07	4.06E-05
	5	0.27E-04	0.77E-03	0.55E-04	0.12E-03	0.21E-04	0.10E-02
	10	0.11E-03	0.30E-02	0.22E-03	0.48E-03	0.83E-04	0.39E-02
	20	0.82E-03	0.23E-01	0.17E-02	0.37E-02	0.63E-03	0.30E-01
	40	0.15E-02	0.42E-01	0.30E-02	0.67E-02	0.12E-02	0.55E-01
	70	0.22E-02	0.63E-01	0.45E-02	0.10E-01	0.17E-02	0.81E-01
10	1	4.94E-07	1.39E-05	9.97E-07	2.22E-06	3.82E-07	1.80E-05
	5	0.12E-04	0.34E-03	0.24E-04	0.54E-04	0.94E-05	0.44E-03
	10	0.47E-04	0.13E-02	0.96E-04	0.21E-03	0.37E-04	0.17E-02
	20	0.36E-03	0.10E-01	0.73E-03	0.16E-02	0.28E-03	0.13E-01
	40	0.67E-03	0.19E-01	0.13E-02	0.30E-02	0.51E-03	0.24E-01
	70	0.99E-03	0.28E-01	0.20E-02	0.44E-02	0.76E-03	0.36E-01
20	1	1.67E-07	4.70E-06	3.37E-07	7.49E-07	1.29E-07	6.08E-06
	5	0.41E-05	0.12E-03	0.83E-05	0.18E-04	0.32E-05	0.15E-03
	10	0.16E-04	0.45E-03	0.32E-04	0.72E-04	0.12E-04	0.58E-03
	20	0.12E-03	0.35E-02	0.25E-03	0.55E-03	0.95E-04	0.45E-02
	40	0.23E-03	0.63E-02	0.45E-03	0.10E-02	0.17E-03	0.82E-02
	70	0.33E-03	0.94E-02	0.67E-03	0.15E-02	0.26E-03	0.12E-01
40	1	5.44E-08	1.53E-06	1.10E-07	2.44E-07	4.20E-08	1.98E-06
	5	0.13E-05	0.38E-04	0.27E-05	0.60E-05	0.10E-05	0.49E-04
	10	0.52E-05	0.15E-03	0.11E-04	0.23E-04	0.40E-05	0.19E-03
	20	0.40E-04	0.11E-02	0.81E-04	0.18E-03	0.31E-04	0.15E-02
	40	0.73E-04	0.21E-02	0.15E-03	0.33E-03	0.57E-04	0.27E-02
	70	0.11E-03	0.31E-02	0.22E-03	0.49E-03	0.84E-04	0.40E-02

Table K-8.31. Time-Integrated Dose from External Exposure to Surface Activity
Red Marrow, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.46E-05	9.03E-04	1.35E-04	2.18E-04	5.75E-04	1.88E-03
	5	0.13E-02	0.22E-01	0.33E-02	0.53E-02	0.14E-01	0.46E-01
	10	0.52E-02	0.87E-01	0.13E-01	0.21E-01	0.55E-01	0.18E 00
	20	0.40E-01	0.66E 00	0.99E-01	0.16E 00	0.42E 00	0.14E 01
	40	0.74E-01	0.12E 01	0.18E 00	0.29E 00	0.77E 00	0.25E 01
	70	0.11E 00	0.18E 01	0.27E 00	0.44E 00	0.11E 01	0.38E 01
5	1	1.18E-06	1.95E-05	2.04E-06	3.21E-06	8.47E-06	3.44E-05
	5	0.29E-04	0.48E-03	0.50E-04	0.79E-04	0.21E-03	0.84E-03
	10	0.11E-03	0.19E-02	0.20E-03	0.31E-03	0.81E-03	0.33E-02
	20	0.87E-03	0.14E-01	0.15E-02	0.24E-02	0.62E-02	0.25E-01
	40	0.16E-02	0.26E-01	0.28E-02	0.43E-02	0.11E-01	0.46E-01
	70	0.24E-02	0.39E-01	0.41E-02	0.64E-02	0.17E-01	0.69E-01
10	1	5.08E-07	8.40E-06	8.60E-07	1.35E-06	3.56E-06	1.47E-05
	5	0.12E-04	0.21E-03	0.21E-04	0.33E-04	0.87E-04	0.36E-03
	10	0.49E-04	0.81E-03	0.83E-04	0.13E-03	0.34E-03	0.14E-02
	20	0.37E-03	0.62E-02	0.63E-03	0.99E-03	0.26E-02	0.11E-01
	40	0.68E-03	0.11E-01	0.12E-02	0.18E-02	0.48E-02	0.20E-01
	70	0.10E-02	0.17E-01	0.17E-02	0.27E-02	0.71E-02	0.29E-01
20	1	1.66E-07	2.74E-06	2.72E-07	4.25E-07	1.12E-06	4.72E-06
	5	0.41E-05	0.67E-04	0.67E-05	0.10E-04	0.28E-04	0.12E-03
	10	0.16E-04	0.26E-03	0.26E-04	0.41E-04	0.11E-03	0.45E-03
	20	0.12E-03	0.20E-02	0.20E-03	0.31E-03	0.82E-03	0.35E-02
	40	0.22E-03	0.37E-02	0.37E-03	0.57E-03	0.15E-02	0.64E-02
	70	0.33E-03	0.55E-02	0.54E-03	0.85E-03	0.22E-02	0.94E-02
40	1	5.34E-08	8.84E-07	8.70E-08	1.36E-07	3.59E-07	1.52E-06
	5	0.13E-05	0.22E-04	0.21E-05	0.33E-05	0.88E-05	0.37E-04
	10	0.51E-05	0.85E-04	0.83E-05	0.13E-04	0.34E-04	0.15E-03
	20	0.39E-04	0.65E-03	0.64E-04	0.10E-03	0.26E-03	0.11E-02
	40	0.72E-04	0.12E-02	0.12E-03	0.18E-03	0.48E-03	0.20E-02
	70	0.11E-03	0.18E-02	0.17E-03	0.27E-03	0.72E-03	0.30E-02

Table K-8.32. Time-Integrated Dose from External Exposure to Surface Activity
Red Marrow, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.34E-04	3.87E-03	4.08E-04	6.43E-04	1.70E-03	6.85E-03
	5	0.57E-02	0.95E-01	0.10E-01	0.16E-01	0.42E-01	0.17E 00
	10	0.22E-01	0.37E 00	0.39E-01	0.62E-01	0.16E 00	0.66E 00
	20	0.17E 00	0.28E 01	0.30E 00	0.47E 00	0.12E 01	0.50E 01
	40	0.32E 00	0.52E 01	0.55E 00	0.87E 00	0.23E 01	0.92E 01
	70	0.47E 00	0.77E 01	0.82E 00	0.13E 01	0.34E 01	0.14E 02
5	1	1.07E-05	1.77E-04	1.73E-05	2.70E-05	7.11E-05	3.03E-04
	5	0.26E-03	0.43E-02	0.42E-03	0.66E-03	0.17E-02	0.74E-02
	10	0.10E-02	0.17E-01	0.17E-02	0.26E-02	0.68E-02	0.29E-01
	20	0.78E-02	0.13E 00	0.13E-01	0.20E-01	0.52E-01	0.22E 00
	40	0.14E-01	0.24E 00	0.23E-01	0.36E-01	0.96E-01	0.41E 00
	70	0.21E-01	0.35E 00	0.35E-01	0.54E-01	0.14E 00	0.61E 00
10	1	4.76E-06	7.87E-05	7.70E-06	1.20E-05	3.17E-05	1.35E-04
	5	0.12E-03	0.19E-02	0.19E-03	0.30E-03	0.78E-03	0.33E-02
	10	0.46E-03	0.75E-02	0.74E-03	0.12E-02	0.30E-02	0.13E-01
	20	0.35E-02	0.58E-01	0.57E-02	0.88E-02	0.23E-01	0.99E-01
	40	0.64E-02	0.11E 00	0.10E-01	0.16E-01	0.43E-01	0.18E 00
	70	0.95E-02	0.16E 00	0.15E-01	0.24E-01	0.63E-01	0.27E 00
20	1	1.62E-06	2.67E-05	2.63E-06	4.11E-06	1.08E-05	4.59E-05
	5	0.40E-04	0.66E-03	0.64E-04	0.10E-03	0.27E-03	0.11E-02
	10	0.16E-03	0.26E-02	0.25E-03	0.39E-03	0.10E-02	0.44E-02
	20	0.12E-02	0.20E-01	0.19E-02	0.30E-02	0.79E-02	0.34E-01
	40	0.22E-02	0.36E-01	0.35E-02	0.55E-02	0.15E-01	0.62E-01
	70	0.32E-02	0.53E-01	0.53E-02	0.82E-02	0.22E-01	0.92E-01
40	1	5.28E-07	8.74E-06	8.60E-07	1.35E-06	3.55E-06	1.50E-05
	5	0.13E-04	0.21E-03	0.21E-04	0.33E-04	0.87E-04	0.37E-03
	10	0.51E-04	0.84E-03	0.83E-04	0.13E-03	0.34E-03	0.14E-02
	20	0.39E-03	0.64E-02	0.63E-03	0.99E-03	0.26E-02	0.11E-01
	40	0.71E-03	0.12E-01	0.12E-02	0.18E-02	0.48E-02	0.20E-01
	70	0.11E-02	0.17E-01	0.17E-02	0.27E-02	0.71E-02	0.30E-01

Table K-8.33. Time-Integrated Dose from External Exposure to Surface Activity
Red Marrow, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.83E-04	3.02E-03	3.28E-04	5.18E-04	1.37E-03	5.42E-03
	5	0.45E-02	0.74E-01	0.80E-02	0.13E-01	0.34E-01	0.13E 00
	10	0.18E-01	0.29E 00	0.31E-01	0.50E-01	0.13E 00	0.52E 00
	20	0.13E 00	0.22E 01	0.24E 00	0.38E 00	0.10E 01	0.40E 01
	40	0.25E 00	0.41E 01	0.44E 00	0.70E 00	0.18E 01	0.73E 01
	70	0.37E 00	0.60E 01	0.66E 00	0.10E 01	0.27E 01	0.11E 02
5	1	7.97E-06	1.32E-04	1.28E-05	2.00E-05	5.28E-05	2.25E-04
	5	0.20E-03	0.32E-02	0.31E-03	0.49E-03	0.13E-02	0.55E-02
	10	0.76E-03	0.13E-01	0.12E-02	0.19E-02	0.51E-02	0.22E-01
	20	0.58E-02	0.97E-01	0.94E-02	0.15E-01	0.39E-01	0.17E 00
	40	0.11E-01	0.18E 00	0.17E-01	0.27E-01	0.71E-01	0.30E 00
	70	0.16E-01	0.26E 00	0.26E-01	0.40E-01	0.11E 00	0.45E 00
10	1	3.55E-06	5.88E-05	5.74E-06	8.96E-06	2.36E-05	1.01E-04
	5	0.87E-04	0.14E-02	0.14E-03	0.22E-03	0.58E-03	0.25E-02
	10	0.34E-03	0.56E-02	0.55E-03	0.86E-03	0.23E-02	0.97E-02
	20	0.26E-02	0.43E-01	0.42E-02	0.66E-02	0.17E-01	0.74E-01
	40	0.48E-02	0.79E-01	0.77E-02	0.12E-01	0.32E-01	0.14E 00
	70	0.71E-02	0.12E 00	0.11E-01	0.18E-01	0.47E-01	0.20E 00
20	1	1.21E-06	2.00E-05	1.97E-06	3.07E-06	8.11E-06	3.44E-05
	5	0.30E-04	0.49E-03	0.48E-04	0.75E-04	0.20E-03	0.84E-03
	10	0.12E-03	0.19E-02	0.19E-03	0.29E-03	0.78E-03	0.33E-02
	20	0.89E-03	0.15E-01	0.14E-02	0.23E-02	0.60E-02	0.25E-01
	40	0.16E-02	0.27E-01	0.26E-02	0.41E-02	0.11E-01	0.46E-01
	70	0.24E-02	0.40E-01	0.39E-02	0.61E-02	0.16E-01	0.69E-01
40	1	3.96E-07	6.55E-06	6.45E-07	1.01E-06	2.66E-06	1.13E-05
	5	0.97E-05	0.16E-03	0.16E-04	0.25E-04	0.65E-04	0.28E-03
	10	0.38E-04	0.63E-03	0.62E-04	0.97E-04	0.26E-03	0.11E-02
	20	0.29E-03	0.48E-02	0.47E-03	0.74E-03	0.20E-02	0.83E-02
	40	0.53E-03	0.88E-02	0.87E-03	0.14E-02	0.36E-02	0.15E-01
	70	0.79E-03	0.13E-01	0.13E-02	0.20E-02	0.53E-02	0.23E-01

Table K-8.34. Time-Integrated Dose from External Exposure to Surface Activity
Red Marrow, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	7.06E-05	1.17E-03	1.33E-04	2.11E-04	5.57E-04	2.14E-03
	5	0.17E-02	0.29E-01	0.33E-02	0.52E-02	0.14E-01	0.52E-01
	10	0.68E-02	0.11E 00	0.13E-01	0.20E-01	0.53E-01	0.21E 00
	20	0.52E-01	0.86E 00	0.98E-01	0.16E 00	0.41E 00	0.16E 01
	40	0.95E-01	0.16E 01	0.18E 00	0.28E 00	0.75E 00	0.29E 01
	70	0.14E 00	0.23E 01	0.27E 00	0.42E 00	0.11E 01	0.43E 01
5	1	2.89E-06	4.78E-05	4.71E-06	7.36E-06	1.94E-05	8.21E-05
	5	0.71E-04	0.12E-02	0.12E-03	0.18E-03	0.48E-03	0.20E-02
	10	0.28E-03	0.46E-02	0.45E-03	0.71E-03	0.19E-02	0.79E-02
	20	0.21E-02	0.35E-01	0.35E-02	0.54E-02	0.14E-01	0.60E-01
	40	0.39E-02	0.64E-01	0.63E-02	0.99E-02	0.26E-01	0.11E 00
	70	0.58E-02	0.96E-01	0.94E-02	0.15E-01	0.39E-01	0.16E 00
10	1	1.28E-06	2.12E-05	2.09E-06	3.26E-06	8.61E-06	3.64E-05
	5	0.31E-04	0.52E-03	0.51E-04	0.80E-04	0.21E-03	0.89E-03
	10	0.12E-03	0.20E-02	0.20E-03	0.31E-03	0.83E-03	0.35E-02
	20	0.94E-03	0.16E-01	0.15E-02	0.24E-02	0.63E-02	0.27E-01
	40	0.17E-02	0.29E-01	0.28E-02	0.44E-02	0.12E-01	0.49E-01
	70	0.26E-02	0.42E-01	0.42E-02	0.65E-02	0.17E-01	0.73E-01
20	1	4.34E-07	7.18E-06	7.06E-07	1.10E-06	2.91E-06	1.23E-05
	5	0.11E-04	0.18E-03	0.17E-04	0.27E-04	0.71E-04	0.30E-03
	10	0.42E-04	0.69E-03	0.68E-04	0.11E-03	0.28E-03	0.12E-02
	20	0.32E-03	0.53E-02	0.52E-03	0.81E-03	0.21E-02	0.91E-02
	40	0.58E-03	0.97E-02	0.95E-03	0.15E-02	0.39E-02	0.17E-01
	70	0.87E-03	0.14E-01	0.14E-02	0.22E-02	0.58E-02	0.25E-01
40	1	1.42E-07	2.34E-06	2.31E-07	3.60E-07	9.51E-07	4.02E-06
	5	0.35E-05	0.57E-04	0.57E-05	0.88E-05	0.23E-04	0.99E-04
	10	0.14E-04	0.22E-03	0.22E-04	0.35E-04	0.91E-04	0.39E-03
	20	0.10E-03	0.17E-02	0.17E-03	0.26E-03	0.70E-03	0.30E-02
	40	0.19E-03	0.32E-02	0.31E-03	0.49E-03	0.13E-02	0.54E-02
	70	0.28E-03	0.47E-02	0.46E-03	0.72E-03	0.19E-02	0.80E-02

Table K-8.35. Time-Integrated Dose from External Exposure to Surface Activity
Red Marrow, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	7.23E-05	1.20E-03	1.31E-04	2.08E-04	5.47E-04	2.15E-03
	5	0.18E-02	0.29E-01	0.32E-02	0.51E-02	0.13E-01	0.53E-01
	10	0.69E-02	0.11E 00	0.13E-01	0.20E-01	0.53E-01	0.21E 00
	20	0.53E-01	0.88E 00	0.96E-01	0.15E 00	0.40E 00	0.16E 01
	40	0.97E-01	0.16E 01	0.18E 00	0.28E 00	0.74E 00	0.29E 01
	70	0.14E 00	0.24E 01	0.26E 00	0.42E 00	0.11E 01	0.43E 01
5	1	3.16E-06	5.22E-05	5.17E-06	8.09E-06	2.13E-05	9.00E-05
	5	0.78E-04	0.13E-02	0.13E-03	0.20E-03	0.52E-03	0.22E-02
	10	0.30E-03	0.50E-02	0.50E-03	0.78E-03	0.20E-02	0.86E-02
	20	0.23E-02	0.38E-01	0.38E-02	0.59E-02	0.16E-01	0.66E-01
	40	0.43E-02	0.70E-01	0.70E-02	0.11E-01	0.29E-01	0.12E 00
	70	0.63E-02	0.10E 00	0.10E-01	0.16E-01	0.43E-01	0.18E 00
10	1	1.40E-06	2.32E-05	2.29E-06	3.58E-06	9.44E-06	3.99E-05
	5	0.34E-04	0.57E-03	0.56E-04	0.88E-04	0.23E-03	0.98E-03
	10	0.13E-03	0.22E-02	0.22E-03	0.34E-03	0.91E-03	0.38E-02
	20	0.10E-02	0.17E-01	0.17E-02	0.26E-02	0.69E-02	0.29E-01
	40	0.19E-02	0.31E-01	0.31E-02	0.48E-02	0.13E-01	0.54E-01
	70	0.26E-02	0.46E-01	0.46E-02	0.72E-02	0.19E-01	0.80E-01
20	1	4.74E-07	7.84E-06	7.73E-07	1.21E-06	3.19E-06	1.35E-05
	5	0.12E-04	0.19E-03	0.19E-04	0.30E-04	0.78E-04	0.33E-03
	10	0.45E-04	0.75E-03	0.74E-04	0.12E-03	0.31E-03	0.13E-02
	20	0.35E-03	0.58E-02	0.57E-03	0.89E-03	0.23E-02	0.99E-02
	40	0.64E-03	0.11E-01	0.10E-02	0.16E-02	0.43E-02	0.18E-01
	70	0.95E-03	0.16E-01	0.15E-02	0.24E-02	0.64E-02	0.27E-01
40	1	1.54E-07	2.55E-06	2.52E-07	3.94E-07	1.04E-06	4.39E-06
	5	0.38E-05	0.63E-04	0.62E-05	0.97E-05	0.25E-04	0.11E-03
	10	0.15E-04	0.25E-03	0.24E-04	0.38E-04	0.10E-03	0.42E-03
	20	0.11E-03	0.19E-02	0.18E-03	0.29E-03	0.76E-03	0.32E-02
	40	0.21E-03	0.34E-02	0.34E-03	0.53E-03	0.14E-02	0.59E-02
	70	0.31E-03	0.51E-02	0.50E-03	0.79E-03	0.21E-02	0.88E-02

Table K-8.36. Time-Integrated Dose from External Exposure to Surface Activity
Skeleton, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	6.16E-05	9.86E-04	1.48E-04	2.34E-04	6.29E-04	2.06E-03
	5	0.15E-02	0.24E-01	0.36E-02	0.57E-02	0.15E-01	0.51E-01
	10	0.59E-02	0.95E-01	0.14E-01	0.22E-01	0.60E-01	0.20E 00
	20	0.45E-01	0.72E 00	0.11E 00	0.17E 00	0.46E 00	0.15E 01
	40	0.83E-01	0.13E 01	0.20E 00	0.32E 00	0.85E 00	0.28E 01
	70	0.12E 00	0.20E 01	0.30E 00	0.47E 00	0.13E 01	0.41E 01
5	1	1.33E-06	2.13E-05	2.25E-06	3.45E-06	9.28E-06	3.76E-05
	5	0.33E-04	0.52E-03	0.55E-04	0.85E-04	0.23E-03	0.92E-03
	10	0.13E-03	0.20E-02	0.22E-03	0.33E-03	0.89E-03	0.36E-02
	20	0.98E-03	0.16E-01	0.16E-02	0.25E-02	0.66E-02	0.28E-01
	40	0.18E-02	0.29E-01	0.30E-02	0.46E-02	0.13E-01	0.51E-01
	70	0.27E-02	0.43E-01	0.45E-02	0.69E-02	0.19E-01	0.75E-01
10	1	5.73E-07	9.18E-06	9.46E-07	1.45E-06	3.90E-06	1.60E-05
	5	0.14E-04	0.23E-03	0.23E-04	0.36E-04	0.96E-04	0.39E-03
	10	0.55E-04	0.88E-03	0.91E-04	0.14E-03	0.37E-03	0.15E-02
	20	0.42E-03	0.67E-02	0.69E-03	0.11E-02	0.29E-02	0.12E-01
	40	0.77E-03	0.12E-01	0.13E-02	0.20E-02	0.53E-02	0.22E-01
	70	0.11E-02	0.18E-01	0.19E-02	0.29E-02	0.78E-02	0.32E-01
20	1	1.87E-07	2.99E-06	2.99E-07	4.57E-07	1.23E-06	5.16E-06
	5	0.46E-05	0.73E-04	0.73E-05	0.11E-04	0.30E-04	0.13E-03
	10	0.18E-04	0.29E-03	0.29E-04	0.44E-04	0.12E-03	0.50E-03
	20	0.14E-03	0.22E-02	0.22E-03	0.34E-03	0.90E-03	0.38E-02
	40	0.25E-03	0.40E-02	0.40E-03	0.62E-03	0.17E-02	0.70E-02
	70	0.37E-03	0.60E-02	0.60E-03	0.91E-03	0.25E-02	0.10E-01
40	1	6.03E-08	9.65E-07	9.56E-08	1.46E-07	3.93E-07	1.66E-06
	5	0.15E-05	0.24E-04	0.23E-05	0.36E-05	0.96E-05	0.41E-04
	10	0.58E-05	0.93E-04	0.92E-05	0.14E-04	0.38E-04	0.16E-03
	20	0.44E-04	0.71E-03	0.70E-04	0.11E-03	0.29E-03	0.12E-02
	40	0.81E-04	0.13E-02	0.13E-03	0.20E-03	0.53E-03	0.22E-02
	70	0.12E-03	0.19E-02	0.19E-03	0.29E-03	0.79E-03	0.33E-02

Table K-8.37. Time-Integrated Dose from External Exposure to Surface Activity Skeleton, Angle = 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.64E-04	4.23E-03	4.49E-04	6.91E-04	1.86E-03	7.49E-03
	5	0.65E-02	0.10E 00	0.11E-01	0.17E-01	0.46E-01	0.18E 00
	10	0.25E-01	0.41E 00	0.43E-01	0.66E-01	0.18E 00	0.72E 00
	20	0.19E 00	0.31E 01	0.33E 00	0.51E 00	0.14E 01	0.55E 01
	40	0.36E 00	0.57E 01	0.60E 00	0.93E 00	0.25E 01	0.10E 02
	70	0.53E 00	0.85E 01	0.90E 00	0.14E 01	0.37E 01	0.15E 02
5	1	1.20E-05	1.93E-04	1.90E-05	2.90E-05	7.79E-05	3.31E-04
	5	0.30E-03	0.47E-02	0.47E-03	0.71E-03	0.19E-02	0.81E-02
	10	0.12E-02	0.19E-01	0.18E-02	0.28E-02	0.75E-02	0.32E-01
	20	0.88E-02	0.14E 00	0.14E-01	0.21E-01	0.57E-01	0.24E 00
	40	0.16E-01	0.26E 00	0.26E-01	0.39E-01	0.10E 00	0.45E 00
	70	0.24E-01	0.39E 00	0.38E-01	0.58E-01	0.16E 00	0.66E 00
10	1	5.37E-06	8.59E-05	8.47E-06	1.29E-05	3.48E-05	1.47E-04
	5	0.13E-03	0.21E-02	0.21E-03	0.32E-03	0.85E-03	0.36E-02
	10	0.52E-03	0.82E-02	0.81E-03	0.12E-02	0.33E-02	0.14E-01
	20	0.39E-02	0.63E-01	0.62E-02	0.95E-02	0.26E-01	0.11E 00
	40	0.72E-02	0.12E 00	0.11E-01	0.17E-01	0.47E-01	0.20E 00
	70	0.11E-01	0.17E 00	0.17E-01	0.26E-01	0.70E-01	0.29E 00
20	1	1.82E-06	2.92E-05	2.89E-06	4.41E-06	1.19E-05	5.02E-05
	5	0.45E-04	0.72E-03	0.71E-04	0.11E-03	0.29E-03	0.12E-02
	10	0.18E-03	0.28E-02	0.28E-03	0.42E-03	0.11E-02	0.48E-02
	20	0.13E-02	0.21E-01	0.21E-02	0.32E-02	0.87E-02	0.37E-01
	40	0.25E-02	0.39E-01	0.39E-02	0.59E-02	0.16E-01	0.68E-01
	70	0.36E-02	0.58E-01	0.58E-02	0.88E-02	0.24E-01	0.10E 00
40	1	5.96E-07	9.55E-06	9.46E-07	1.44E-06	3.89E-06	1.64E-05
	5	0.15E-04	0.23E-03	0.23E-04	0.35E-04	0.95E-04	0.40E-03
	10	0.57E-04	0.92E-03	0.91E-04	0.14E-03	0.37E-03	0.16E-02
	20	0.44E-03	0.70E-02	0.69E-03	0.11E-02	0.29E-02	0.12E-01
	40	0.80E-03	0.13E-01	0.13E-02	0.19E-02	0.52E-02	0.22E-01
	70	0.12E-02	0.19E-01	0.19E-02	0.29E-02	0.78E-02	0.33E-01

Table K-8.38. Time-Integrated Dose from External Exposure to Surface Activity Skeleton, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	2.06E-04	3.30E-03	3.61E-04	5.56E-04	1.50E-03	5.92E-03
	5	0.51E-02	0.81E-01	0.89E-02	0.14E-01	0.37E-01	0.15E 00
	10	0.20E-01	0.32E 00	0.35E-01	0.53E-01	0.14E 00	0.57E 00
	20	0.15E 00	0.24E 01	0.26E 00	0.41E 00	0.11E 01	0.43E 01
	40	0.28E 00	0.44E 01	0.49E 00	0.75E 00	0.20E 01	0.80E 01
	70	0.41E 00	0.66E 01	0.72E 00	0.11E 01	0.30E 01	0.12E 02
5	1	8.99E-06	1.44E-04	1.41E-05	2.15E-05	5.78E-05	2.46E-04
	5	0.22E-03	0.35E-02	0.35E-03	0.53E-03	0.14E-02	0.60E-02
	10	0.86E-03	0.14E-01	0.14E-02	0.21E-02	0.55E-02	0.24E-01
	20	0.66E-02	0.11E 00	0.10E-01	0.16E-01	0.42E-01	0.18E 00
	40	0.12E-01	0.19E 00	0.19E-01	0.29E-01	0.78E-01	0.33E 00
	70	0.18E-01	0.29E 00	0.28E-01	0.43E-01	0.12E 00	0.49E 00
10	1	4.01E-06	6.42E-05	6.31E-06	9.63E-06	2.59E-05	1.10E-04
	5	0.98E-04	0.16E-02	0.15E-03	0.24E-03	0.64E-03	0.27E-02
	10	0.38E-03	0.62E-02	0.61E-03	0.92E-03	0.25E-02	0.11E-01
	20	0.29E-02	0.47E-01	0.46E-02	0.71E-02	0.19E-01	0.81E-01
	40	0.54E-02	0.87E-01	0.85E-02	0.13E-01	0.35E-01	0.15E 00
	70	0.80E-02	0.13E 00	0.13E-01	0.19E-01	0.52E-01	0.22E 00
20	1	1.37E-06	2.19E-05	2.16E-06	3.30E-06	8.88E-06	3.76E-05
	5	0.34E-04	0.54E-03	0.53E-04	0.81E-04	0.22E-03	0.92E-03
	10	0.13E-03	0.21E-02	0.21E-03	0.32E-03	0.85E-03	0.36E-02
	20	0.10E-02	0.16E-01	0.16E-02	0.24E-02	0.65E-02	0.28E-01
	40	0.18E-02	0.29E-01	0.29E-02	0.44E-02	0.12E-01	0.51E-01
	70	0.27E-02	0.44E-01	0.43E-02	0.66E-02	0.18E-01	0.75E-01
40	1	4.47E-07	7.16E-06	7.09E-07	1.08E-06	2.91E-06	1.23E-05
	5	0.11E-04	0.18E-03	0.17E-04	0.27E-04	0.72E-04	0.30E-03
	10	0.48E-04	0.69E-03	0.68E-04	0.10E-03	0.28E-03	0.12E-02
	20	0.33E-03	0.53E-02	0.52E-03	0.80E-03	0.21E-02	0.90E-02
	40	0.60E-03	0.96E-02	0.96E-03	0.15E-02	0.39E-02	0.17E-01
	70	0.89E-03	0.14E-01	0.14E-02	0.22E-02	0.58E-02	0.25E-01

Table K-8.39. Time-Integrated Dose from External Exposure to Surface Activity Skeleton, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	7.96E-05	1.27E-03	1.46E-04	2.27E-04	6.10E-04	2.34E-03
	5	0.20E-02	0.31E-01	0.36E-02	0.56E-02	0.15E-01	0.57E-01
	10	0.76E-02	0.12E 00	0.14E-01	0.22E-01	0.59E-01	0.22E 00
	20	0.58E-01	0.94E 00	0.11E 00	0.17E 00	0.45E 00	0.17E 01
	40	0.11E 00	0.17E 01	0.20E 00	0.31E 00	0.82E 00	0.31E 01
	70	0.16E 00	0.25E 01	0.29E 00	0.45E 00	0.12E 01	0.47E 01
5	1	3.26E-06	5.22E-05	5.17E-06	7.90E-06	2.13E-05	8.98E-05
	5	0.80E-04	0.13E-02	0.13E-03	0.19E-03	0.52E-03	0.22E-02
	10	0.31E-03	0.50E-02	0.50E-03	0.76E-03	0.20E-02	0.86E-02
	20	0.24E-02	0.38E-01	0.38E-02	0.56E-02	0.16E-01	0.66E-01
	40	0.44E-02	0.70E-01	0.70E-02	0.11E-01	0.29E-01	0.12E 00
	70	0.65E-02	0.10E 00	0.10E-01	0.16E-01	0.43E-01	0.18E 00
10	1	1.45E-06	2.32E-05	2.30E-06	3.51E-06	9.43E-06	3.98E-05
	5	0.36E-04	0.57E-03	0.56E-04	0.86E-04	0.23E-03	0.98E-03
	10	0.14E-03	0.22E-02	0.22E-03	0.34E-03	0.91E-03	0.38E-02
	20	0.11E-02	0.17E-01	0.17E-02	0.26E-02	0.69E-02	0.29E-01
	40	0.19E-02	0.31E-01	0.31E-02	0.47E-02	0.13E-01	0.54E-01
	70	0.29E-02	0.46E-01	0.46E-02	0.70E-02	0.19E-01	0.80E-01
20	1	4.90E-07	7.84E-06	7.76E-07	1.19E-06	3.19E-06	1.35E-05
	5	0.12E-04	0.19E-03	0.19E-04	0.29E-04	0.78E-04	0.33E-03
	10	0.47E-04	0.75E-03	0.75E-04	0.11E-03	0.31E-03	0.13E-02
	20	0.36E-03	0.58E-02	0.57E-03	0.87E-03	0.23E-02	0.99E-02
	40	0.66E-03	0.11E-01	0.10E-02	0.16E-02	0.43E-02	0.18E-01
	70	0.98E-03	0.16E-01	0.16E-02	0.24E-02	0.64E-02	0.27E-01
40	1	1.60E-07	2.56E-06	2.53E-07	3.87E-07	1.04E-06	4.40E-06
	5	0.39E-05	0.63E-04	0.62E-05	0.95E-05	0.26E-04	0.11E-03
	10	0.15E-04	0.25E-03	0.24E-04	0.37E-04	0.10E-03	0.42E-03
	20	0.12E-03	0.19E-02	0.19E-03	0.28E-03	0.76E-03	0.32E-02
	40	0.22E-03	0.34E-02	0.34E-03	0.52E-03	0.14E-02	0.59E-02
	70	0.32E-03	0.51E-02	0.51E-03	0.77E-03	0.21E-02	0.88E-02

Table K-8.40. Time-Integrated Dose from External Exposure to Surface Activity Skeleton, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	8.16E-05	1.31E-03	1.44E-04	2.23E-04	5.99E-04	2.35E-03
	5	0.20E-02	0.32E-01	0.35E-02	0.55E-02	0.15E-01	0.58E-01
	10	0.78E-02	0.13E 00	0.14E-01	0.21E-01	0.58E-01	0.23E 00
	20	0.60E-01	0.96E 00	0.11E 00	0.16E 00	0.44E 00	0.17E 01
	40	0.11E 00	0.18E 01	0.19E 00	0.30E 00	0.81E 00	0.32E 01
	70	0.16E 00	0.26E 01	0.29E 00	0.45E 00	0.12E 01	0.47E 01
5	1	3.56E-06	5.71E-05	5.66E-06	8.68E-06	2.34E-05	9.84E-05
	5	0.87E-04	0.14E-02	0.14E-03	0.21E-03	0.57E-03	0.24E-02
	10	0.34E-03	0.55E-02	0.55E-03	0.83E-03	0.22E-02	0.94E-02
	20	0.26E-02	0.42E-01	0.42E-02	0.64E-02	0.17E-01	0.72E-01
	40	0.48E-02	0.77E-01	0.77E-02	0.12E-01	0.31E-01	0.13E 00
	70	0.71E-02	0.11E 00	0.11E-01	0.17E-01	0.47E-01	0.20E 00
10	1	1.58E-06	2.53E-05	2.52E-06	3.84E-06	1.03E-05	4.36E-05
	5	0.39E-04	0.62E-03	0.62E-04	0.94E-04	0.25E-03	0.11E-02
	10	0.15E-03	0.24E-02	0.24E-03	0.37E-03	0.99E-03	0.42E-02
	20	0.12E-02	0.19E-01	0.18E-02	0.28E-02	0.76E-02	0.32E-01
	40	0.21E-02	0.34E-01	0.34E-02	0.52E-02	0.14E-01	0.59E-01
	70	0.32E-02	0.51E-01	0.50E-02	0.77E-02	0.21E-01	0.87E-01
20	1	5.35E-07	8.57E-06	8.50E-07	1.30E-06	3.49E-06	1.47E-05
	5	0.13E-04	0.21E-03	0.21E-04	0.32E-04	0.86E-04	0.36E-03
	10	0.51E-04	0.82E-03	0.82E-04	0.12E-03	0.34E-03	0.14E-02
	20	0.39E-03	0.63E-02	0.62E-03	0.95E-03	0.26E-02	0.11E-01
	40	0.72E-03	0.12E-01	0.11E-02	0.17E-02	0.47E-02	0.20E-01
	70	0.11E-02	0.17E-01	0.17E-02	0.26E-02	0.70E-02	0.29E-01
40	1	1.74E-07	2.79E-06	2.77E-07	4.23E-07	1.14E-06	4.80E-06
	5	0.43E-05	0.68E-04	0.68E-05	0.10E-04	0.28E-04	0.12E-03
	10	0.17E-04	0.27E-03	0.27E-04	0.41E-04	0.11E-03	0.46E-03
	20	0.13E-03	0.20E-02	0.20E-03	0.31E-03	0.84E-03	0.35E-02
	40	0.23E-03	0.38E-02	0.37E-03	0.57E-03	0.15E-02	0.65E-02
	70	0.35E-03	0.56E-02	0.55E-03	0.85E-03	0.23E-02	0.96E-02

Table K-8.41. Time-Integrated Dose from External Exposure to Surface Activity
Spleen, Angle = 0° (north)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.30E-05	4.67E-04	4.66E-05	1.22E-04	1.87E-04	8.36E-04
	5	0.32E-03	0.11E-01	0.11E-02	0.30E-02	0.46E-02	0.21E-01
	10	0.12E-02	0.45E-01	0.45E-02	0.12E-01	0.18E-01	0.80E-01
	20	0.95E-02	0.34E 00	0.34E-01	0.90E-01	0.14E 00	0.61E 00
	40	0.17E-01	0.63E 00	0.63E-01	0.16E 00	0.25E 00	0.11E 01
	70	0.26E-01	0.93E 00	0.93E-01	0.24E 00	0.37E 00	0.17E 01
5	1	2.80E-07	1.01E-05	7.06E-07	1.80E-06	2.76E-06	1.56E-05
	5	0.69E-05	0.25E-03	0.17E-04	0.44E-04	0.68E-04	0.38E-03
	10	0.27E-04	0.97E-03	0.68E-04	0.17E-03	0.26E-03	0.15E-02
	20	0.21E-03	0.74E-02	0.52E-03	0.13E-02	0.20E-02	0.11E-01
	40	0.38E-03	0.14E-01	0.95E-03	0.24E-02	0.37E-02	0.21E-01
	70	0.56E-03	0.20E-01	0.14E-02	0.36E-02	0.55E-02	0.31E-01
10	1	1.21E-07	4.35E-06	2.97E-07	7.58E-07	1.16E-06	6.69E-06
	5	0.30E-05	0.11E-03	0.73E-05	0.19E-04	0.28E-04	0.16E-03
	10	0.12E-04	0.42E-03	0.29E-04	0.73E-04	0.11E-03	0.64E-03
	20	0.89E-04	0.32E-02	0.22E-03	0.56E-03	0.85E-03	0.49E-02
	40	0.16E-03	0.59E-02	0.40E-03	0.10E-02	0.16E-02	0.90E-02
	70	0.24E-03	0.87E-02	0.59E-03	0.15E-02	0.23E-02	0.13E-01
20	1	3.94E-08	1.42E-06	9.40E-08	2.39E-07	3.65E-07	2.16E-06
	5	0.97E-06	0.35E-04	0.23E-05	0.59E-05	0.90E-05	0.53E-04
	10	0.38E-05	0.14E-03	0.90E-05	0.23E-04	0.35E-04	0.21E-03
	20	0.29E-04	0.10E-02	0.69E-04	0.18E-03	0.27E-03	0.16E-02
	40	0.53E-04	0.19E-02	0.13E-03	0.32E-03	0.49E-03	0.29E-02
	70	0.79E-04	0.28E-02	0.19E-03	0.48E-03	0.73E-03	0.43E-02
40	1	1.27E-08	4.57E-07	3.01E-08	7.63E-08	1.17E-07	6.93E-07
	5	0.31E-06	0.11E-04	0.74E-06	0.19E-05	0.29E-05	0.17E-04
	10	0.12E-05	0.44E-04	0.29E-05	0.73E-05	0.11E-04	0.67E-04
	20	0.93E-05	0.34E-03	0.22E-04	0.56E-04	0.86E-04	0.51E-03
	40	0.17E-04	0.62E-03	0.41E-04	0.10E-03	0.16E-03	0.93E-03
	70	0.25E-04	0.91E-03	0.60E-04	0.15E-03	0.23E-03	0.14E-02

Table K-8.42. Time-Integrated Dose from External Exposure to Surface Activity
Spleen, Angle 45°

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	5.56E-05	2.00E-03	1.41E-04	3.61E-04	5.52E-04	3.11E-03
	5	0.14E-02	0.49E-01	0.35E-02	0.89E-02	0.14E-01	0.76E-01
	10	0.53E-02	0.19E 00	0.14E-01	0.35E-01	0.53E-01	0.30E 00
	20	0.41E-01	0.15E 01	0.10E 00	0.27E 00	0.41E 00	0.23E 01
	40	0.75E-01	0.27E 01	0.19E 00	0.49E 00	0.74E 00	0.42E 01
	70	0.11E 00	0.40E 01	0.28E 00	0.72E 00	0.11E 01	0.62E 01
5	1	2.54E-06	9.14E-05	5.97E-06	1.51E-05	2.32E-05	1.38E-04
	5	0.62E-04	0.22E-02	0.15E-03	0.37E-03	0.57E-03	0.34E-02
	10	0.24E-03	0.88E-02	0.57E-03	0.15E-02	0.22E-02	0.13E-01
	20	0.19E-02	0.67E-01	0.44E-02	0.11E-01	0.17E-01	0.10E 00
	40	0.34E-02	0.12E 00	0.80E-02	0.20E-01	0.31E-01	0.19E 00
	70	0.51E-02	0.18E 00	0.12E-01	0.30E-01	0.46E-01	0.28E 00
10	1	1.13E-06	4.07E-05	2.66E-06	6.76E-06	1.03E-05	6.16E-05
	5	0.28E-04	0.10E-02	0.65E-04	0.17E-03	0.25E-03	0.15E-02
	10	0.11E-03	0.39E-02	0.26E-03	0.65E-03	0.99E-03	0.59E-02
	20	0.83E-03	0.30E-01	0.20E-02	0.50E-02	0.76E-02	0.45E-01
	40	0.15E-02	0.55E-01	0.36E-02	0.91E-02	0.14E-01	0.83E-01
	70	0.23E-02	0.81E-01	0.53E-02	0.14E-01	0.21E-01	0.12E 00
20	1	3.84E-07	1.38E-05	9.08E-07	2.31E-06	3.53E-06	2.10E-05
	5	0.94E-05	0.34E-03	0.22E-04	0.57E-04	0.87E-04	0.51E-03
	10	0.37E-04	0.13E-02	0.87E-04	0.22E-03	0.34E-03	0.20E-02
	20	0.28E-03	0.10E-01	0.67E-03	0.17E-02	0.26E-02	0.15E-01
	40	0.52E-03	0.19E-01	0.12E-02	0.31E-02	0.48E-02	0.28E-01
	70	0.77E-03	0.28E-01	0.18E-02	0.46E-02	0.71E-02	0.42E-01
40	1	1.26E-07	4.52E-06	2.98E-07	7.55E-07	1.16E-06	6.86E-06
	5	0.31E-05	0.11E-03	0.73E-05	0.19E-04	0.28E-04	0.17E-03
	10	0.12E-04	0.43E-03	0.29E-04	0.72E-04	0.11E-03	0.66E-03
	20	0.92E-04	0.33E-02	0.22E-03	0.55E-03	0.85E-03	0.50E-02
	40	0.17E-03	0.61E-02	0.40E-03	0.10E-02	0.16E-02	0.92E-02
	70	0.25E-03	0.90E-02	0.60E-03	0.15E-02	0.23E-02	0.14E-01

Table K-8.43. Time-Integrated Dose from External Exposure to Surface Activity
Spleen, Angle = 90° (east)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	4.34E-05	1.56E-03	1.13E-04	2.91E-04	4.45E-04	2.46E-03
	5	0.11E-02	0.38E-01	0.28E-02	0.71E-02	0.11E-01	0.60E-01
	10	0.42E-02	0.15E 00	0.11E-01	0.28E-01	0.43E-01	0.24E 00
	20	0.32E-01	0.11E 01	0.83E-01	0.21E 00	0.33E 00	0.18E 01
	40	0.59E-01	0.21E 01	0.15E 00	0.39E 00	0.60E 00	0.33E 01
	70	0.87E-01	0.31E 01	0.23E 00	0.58E 00	0.89E 00	0.49E 01
5	1	1.89E-06	6.82E-05	4.43E-06	1.12E-05	1.72E-05	1.03E-04
	5	0.46E-04	0.17E-02	0.11E-03	0.28E-03	0.42E-03	0.25E-02
	10	0.18E-03	0.65E-02	0.43E-03	0.11E-02	0.17E-02	0.99E-02
	20	0.14E-02	0.50E-01	0.33E-02	0.83E-02	0.13E-01	0.76E-01
	40	0.26E-02	0.92E-01	0.60E-02	0.15E-01	0.23E-01	0.14E 00
	70	0.38E-02	0.14E 00	0.89E-02	0.22E-01	0.34E-01	0.21E 00
10	1	8.45E-07	3.04E-05	1.98E-06	5.03E-06	7.70E-06	4.60E-05
	5	0.21E-04	0.75E-03	0.49E-04	0.12E-03	0.19E-03	0.11E-02
	10	0.81E-04	0.29E-02	0.19E-03	0.48E-03	0.74E-03	0.44E-02
	20	0.62E-03	0.22E-01	0.15E-02	0.37E-02	0.57E-02	0.34E-01
	40	0.11E-02	0.41E-01	0.27E-02	0.68E-02	0.10E-01	0.62E-01
	70	0.17E-02	0.61E-01	0.40E-02	0.10E-01	0.15E-01	0.92E-01
20	1	2.88E-07	1.04E-05	6.80E-07	1.73E-06	2.64E-06	1.57E-05
	5	0.71E-05	0.25E-03	0.17E-04	0.42E-04	0.65E-04	0.39E-03
	10	0.28E-04	0.10E-02	0.65E-04	0.17E-03	0.25E-03	0.15E-02
	20	0.21E-03	0.76E-02	0.50E-03	0.13E-02	0.19E-02	0.12E-01
	40	0.39E-03	0.14E-01	0.92E-03	0.23E-02	0.36E-02	0.21E-01
	70	0.58E-03	0.21E-01	0.14E-02	0.35E-02	0.53E-02	0.31E-01
40	1	9.42E-08	3.39E-06	2.23E-07	5.66E-07	8.67E-07	5.14E-06
	5	0.23E-05	0.83E-04	0.55E-05	0.14E-04	0.21E-04	0.13E-03
	10	0.90E-05	0.33E-03	0.21E-04	0.54E-04	0.83E-04	0.49E-03
	20	0.69E-04	0.25E-02	0.16E-03	0.42E-03	0.64E-03	0.38E-02
	40	0.13E-03	0.46E-02	0.30E-03	0.76E-03	0.12E-02	0.69E-02
	70	0.19E-03	0.68E-02	0.45E-03	0.11E-02	0.17E-02	0.10E-01

Table K-8.44. Time-Integrated Dose from External Exposure to Surface Activity
Spleen, Angle = 180° (south)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.68E-05	6.04E-04	4.60E-05	1.19E-04	1.81E-04	9.67E-04
	5	0.41E-03	0.15E-01	0.11E-02	0.29E-02	0.45E-02	0.24E-01
	10	0.16E-02	0.58E-01	0.44E-02	0.11E-01	0.17E-01	0.93E-01
	20	0.12E-01	0.44E 00	0.34E-01	0.87E-01	0.13E 00	0.71E 00
	40	0.23E-01	0.81E 00	0.62E-01	0.16E 00	0.24E 00	0.13E 01
	70	0.34E-01	0.12E 01	0.92E-01	0.24E 00	0.36E 00	0.19E 01
5	1	6.87E-07	2.47E-05	1.63E-06	4.13E-06	6.32E-06	3.75E-05
	5	0.17E-04	0.61E-03	0.40E-04	0.10E-03	0.16E-03	0.92E-03
	10	0.66E-04	0.24E-02	0.16E-03	0.40E-03	0.61E-03	0.36E-02
	20	0.50E-03	0.18E-01	0.12E-02	0.30E-02	0.46E-02	0.28E-01
	40	0.92E-03	0.33E-01	0.22E-02	0.56E-02	0.85E-02	0.51E-01
	70	0.14E-02	0.49E-01	0.33E-02	0.83E-02	0.13E-01	0.75E-01
10	1	3.05E-07	1.10E-05	7.22E-07	1.83E-06	2.81E-06	1.66E-05
	5	0.75E-05	0.27E-03	0.18E-04	0.45E-04	0.69E-04	0.41E-03
	10	0.29E-04	0.11E-02	0.69E-04	0.18E-03	0.27E-03	0.16E-02
	20	0.22E-03	0.81E-02	0.53E-03	0.13E-02	0.21E-02	0.12E-01
	40	0.41E-03	0.15E-01	0.97E-03	0.25E-02	0.38E-02	0.22E-01
	70	0.61E-03	0.22E-01	0.14E-02	0.37E-02	0.56E-02	0.33E-01
20	1	1.03E-07	3.72E-06	2.44E-07	6.20E-07	9.49E-07	5.63E-06
	5	0.25E-05	0.91E-04	0.60E-05	0.15E-04	0.23E-04	0.14E-03
	10	0.99E-05	0.36E-03	0.23E-04	0.59E-04	0.91E-04	0.54E-03
	20	0.76E-04	0.27E-02	0.18E-03	0.46E-03	0.70E-03	0.41E-02
	40	0.14E-03	0.50E-02	0.33E-03	0.84E-03	0.13E-02	0.76E-02
	70	0.21E-03	0.74E-02	0.49E-03	0.12E-02	0.19E-02	0.11E-01
40	1	3.36E-08	1.21E-06	7.97E-08	2.02E-07	3.10E-07	1.84E-06
	5	0.83E-06	0.30E-04	0.20E-05	0.50E-05	0.76E-05	0.45E-04
	10	0.32E-05	0.12E-03	0.77E-05	0.19E-04	0.30E-04	0.18E-03
	20	0.25E-04	0.89E-03	0.59E-04	0.15E-03	0.23E-03	0.13E-02
	40	0.45E-04	0.16E-02	0.11E-03	0.27E-03	0.42E-03	0.25E-02
	70	0.67E-04	0.24E-02	0.16E-03	0.40E-03	0.62E-03	0.37E-02

Table K-8.45. Time-Integrated Dose from External Exposure to Surface Activity
Spleen, Angle = 270° (west)

DISTANCE(KM)	TIME(YR)	U238	U234	TH230	RA226	PB210	TOTAL DOSE
1	1	1.72E-05	6.19E-04	4.54E-05	1.17E-04	1.78E-04	9.76E-04
	5	0.42E-03	0.15E-01	0.11E-02	0.29E-02	0.44E-02	0.24E-01
	10	0.16E-02	0.59E-01	0.44E-02	0.11E-01	0.17E-01	0.94E-01
	20	0.13E-01	0.45E 00	0.33E-01	0.86E-01	0.13E 00	0.72E 00
	40	0.23E-01	0.83E 00	0.61E-01	0.16E 00	0.24E 00	0.13E 01
	70	0.34E-01	0.12E 01	0.91E-01	0.23E 00	0.36E 00	0.20E 01
5	1	7.51E-07	2.70E-05	1.79E-06	4.54E-06	6.95E-06	4.11E-05
	5	0.18E-04	0.66E-03	0.44E-04	0.11E-03	0.17E-03	0.10E-02
	10	0.72E-04	0.26E-02	0.17E-03	0.44E-03	0.67E-03	0.39E-02
	20	0.55E-03	0.20E-01	0.13E-02	0.33E-02	0.51E-02	0.30E-01
	40	0.10E-02	0.36E-01	0.24E-02	0.61E-02	0.94E-02	0.55E-01
	70	0.15E-02	0.54E-01	0.36E-02	0.91E-02	0.14E-01	0.82E-01
10	1	3.33E-07	1.20E-05	7.91E-07	2.01E-06	3.07E-06	1.82E-05
	5	0.82E-05	0.29E-03	0.19E-04	0.49E-04	0.75E-04	0.45E-03
	10	0.32E-04	0.12E-02	0.76E-04	0.19E-03	0.30E-03	0.17E-02
	20	0.24E-03	0.88E-02	0.58E-03	0.15E-02	0.23E-02	0.13E-01
	40	0.45E-03	0.16E-01	0.11E-02	0.27E-02	0.41E-02	0.25E-01
	70	0.67E-03	0.24E-01	0.16E-02	0.40E-02	0.61E-02	0.36E-01
20	1	1.13E-07	4.06E-06	2.67E-07	6.79E-07	1.04E-06	6.16E-06
	5	0.28E-05	0.10E-03	0.66E-05	0.17E-04	0.25E-04	0.15E-03
	10	0.11E-04	0.39E-03	0.26E-04	0.65E-04	0.10E-03	0.59E-03
	20	0.83E-04	0.30E-02	0.20E-03	0.50E-03	0.76E-03	0.45E-02
	40	0.15E-03	0.55E-02	0.36E-03	0.91E-03	0.14E-02	0.83E-02
	70	0.23E-03	0.81E-02	0.53E-03	0.14E-02	0.21E-02	0.12E-01
40	1	3.67E-08	1.32E-06	8.71E-08	2.21E-07	3.38E-07	2.00E-06
	5	0.90E-06	0.32E-04	0.21E-05	0.54E-05	0.83E-05	0.49E-04
	10	0.35E-05	0.13E-03	0.84E-05	0.21E-04	0.32E-04	0.19E-03
	20	0.27E-04	0.97E-03	0.64E-04	0.16E-03	0.25E-03	0.15E-02
	40	0.49E-04	0.18E-02	0.12E-03	0.30E-03	0.46E-03	0.27E-02
	70	0.73E-04	0.26E-02	0.17E-03	0.44E-03	0.68E-03	0.40E-02

APPENDIX K-9. FOOD PATHWAY - FISH

Traces of the radionuclides considered heretofore are present at times in natural waters, so the possibility of ingestion of radioactive substances by eating fish from such waters should be considered. Fish concentrate the radionuclides they ingest from water; the accumulation factors for uranium, thorium, radium and lead are reported as 2, 30, 50 and 100, respectively.[1,2] These radionuclides concentrate mainly in the bones; thus the fraction found in the flesh will be small--about 1×10^{-4}.[3-5] Inasmuch as man consumes only the flesh of fish, the amount of radioactivity received from a fish diet is minor. These considerations, plus the large distances of the Bear Creek Project from major Wyoming rivers, which minimize the probability of stream contamination, indicate that man's exposure to activity from the radionuclides in fish will be negligible.

References for Appendix K-9

1. "Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, appendix I," Regulatory Guide 1.109, Nuclear Regulatory Commission, Washington, D. C., 1976.

2. Y. C. Ng et al., "Predication of the Maximum Dosage to Man from the Fallout of Nuclear Devices-IV. Handbook for Estimating the Maximum Internal Dose from Radionuclides Released to the Biosphere," UCRL-50163, Lawrence Radiation Laboratory, Berkeley, Calif., 1968.

3. S. E. Thompson, C. A. Burton, D. J. Quinn, and W. C. Ny, "Concentration Factor of Chemical Elements in Edible Aquatic Organisms," U. S. AEC Report, UCRL-50564, Rev. 1, U. S. Atomic Energy Commission, Washington, D. C., 1972.

4. K. D. Carlander, "Handbook of Freshwater Fishing Biology," Vol. 1, p. 852, Iowa State University Press, Ames, Iowa, 1969.

5. "Food Chains of Uranium in Aquatic and Terraneous Organisms," in "Radioecological Concentration Processes," B. Aberg and F. P. Hungate, eds., Pergamon Press, Oxford, 1976.

APPENDIX L. NPDES PERMIT FOR BEAR CREEK URANIUM PROJECT

MI
Permit No. Wy-0026263

AUTHORIZATION TO DISCHARGE UNDER THE
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Federal Water Pollution Control Act, as amended, (33 U.S.C. 1251 et. seq; the "Act"). and the Wyoming Environmental Quality Act (35-502 et. seq., Wyoming Statutes 1957, Cumulative Supplement 1973),

the Rocky Mountain Energy Company

is authorized to discharge from a facility located at

the Bear Creek Uranium Project

to receiving waters named

Bear Creek via an unnamed drainage(discharge 001)
Dry Fork of the Cheyenne River via an unnamed drainage(discharge 002)
Gene Draw(discharge 003)

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on the date of issuance.

This permit and the authorization to discharge shall expire at midnight,

June 30, 1978

Signed this 16thday of September, 1976.

William S. Ahearn

B. Runoff from Disturbed Areas

Effective immediately and lasting through June 30, 1978, the permittee shall control all runoff from disturbed areas by structures of sufficient design or by other control measures so as to provide removal of suspended solids in such discharges.

Disturbed areas are defined as the areas from which overburden has been removed or on which it has been deposited, ore stockpile areas, tailings areas, and all other nonpublic areas or facilities caused to be disturbed by the permittee's operations. This does not apply to reclaimed and revegetated areas.

Sufficient design shall be defined by the following criteria:

a. Structures or control measures shall be sized to handle the runoff resulting from precipitation, an equivalent snow melt or a combination of precipitation and resulting snow melt from a storm with an intensity equal to 2.8 inches of rainfall in twenty-four hours.

b. Impoundment structures and sediment retention basins shall be designed to provide for full recovery down to the permanent pool storage elevation within fifteen (15) days after the runoff condition above by decanting, pumping, irrigation, or other measures. These basins shall be designed to give a minimum of five (5) days retention prior to drawing down to the permanent pool.

In addition, the permittee shall operate and maintain sediment control facilities such that:

a. sluicing of collected sediments does not occur, and

b. scouring or erosion of the bottom of outlet channels does not occur, and

c. where sedimentation basins or checks are used, cleaning and disposal of accumulated sediments shall be accomplished to restore the total design sediment storage when active storage levels reach sixty (60) percent of the design sediment storage capacity, and

d. the permanent pool storage elevation, which shall be a minimum of 2 feet above the active sediment storage elevation, is attained following a runoff event within the design period specified in "sufficient design criteria" part (b) above.

The official weather station identified with this permit shall be the Bill 4S station operated by the official observer designated by the U.S. Department of Commerce. The permittee has the option of maintaining additional precipitation gages at his facility.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning immediately and lasting through June 30, 1978, the permittee is authorized to discharge from outfall(s) serial number(s) 001, 002, and 003.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations * kg/day (lbs/day)		Concentration mg/l		Monitoring Requirements Measurement Frequency	Sample Type
	Daily Avg	Daily Max	Daily Avg	Daily Max		
Flow—m^3/Day (MGD)	N/A	N/A	N/A	N/A	Continuous	Weir, Flume or calculated from pumping time and pump rating characteristics
Total Suspended Solids	N/A	N/A	20	30	Monthly	Composite
Total Cadmium	N/A	N/A	.05	.1	Quarterly	Grab
Total Zinc	N/A	N/A	.5	1.0	Quarterly	Grab
Total Arsenic	N/A	N/A	.5	1.0	Quarterly	Grab
Total Radium 226	N/A	N/A	3.0(pc/1)	10.0(pc/1)	Monthly	Composite
Total Uranium	N/A	N/A	2.0	4.0	Monthly	Composite

The oil and grease shall not exceed 10 mg/l in any single grab sample and shall be monitored monthly visually.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly with a grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): At the outfall from the final treatment unit and prior to admixture with dilutent waters or the receiving stream.

In addition to the above daily maximum concentration limitation, the analysis of any single properly preserved grab sample, shall not exceed 150 percent of the daily maximum concentration (1.5 times the limitation) for the parameter(s) Total Suspended Solids and Uranium.

*Any untreated overflow from facilities designed, constructed, and operated to treat the mine drainage and the runoff at the treatment facility resulting from the 10 year-24 hour precipitation event(2.8 inches) shall not be subject to those limitations.

C. MONITORING AND REPORTING

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Reporting

Monitoring results obtained during the previous 3 months shall be summarized for each month and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the complete! reporting period. The first report is due on January 28, 1977 Duplicate signed copies of these, and all other reports required herein, shall be submitted to the Regional Administrator and the State at the following addresses:

U.S. Environmental Protection Agency
1860 Lincoln Street, Suite 900
Denver, Colorado 80203
Attention: Enforcement - Permits
Telephone: (303) 837-4901

Wyoming Department of Environmental Quality
Water Quality Division
Hathaway Building
Cheyenne, Wyoming 82002
Telephone: (307) 777-7781

If no discharge occurs during the reporting period, "no discharge" shall be reported.

3. Definitions

a. The "daily average" discharge means the total discharge by weight determined by the arithmetic mean(geometric mean in the case of the fecal coliform parameter) of a minimum of three(3) samples taken on three(3) separate days during a calender month.

b. The "daily maximum" shall be determined by the analyses of a properly preserved composite sample composed of a minimum of four(4) grab samples collected at equally spaced two(2) hour intervals and proportioned according to flow at the time of sampling.

c. The "daily average" concentration means the average concentration determined by the arithmetic mean(geometric mean in the case of the fecal coliform parameter) of a minimum of three(3) samples taken on three(3) separate days during a calender month.

d. The "daily maximum" concentration shall be determined by the analysis of a properly preserved composite sample composed of a minimum of four(4) grab samples collected at equally spaced two(2) hour intervals and proportioned according to flow at the time of sampling.

4. Test Procedures

Test procedures for the analysis of pollutants shall conform to regulations published pursuant to Section 304(g) of the Act, under which such procedures may be required.

5. Recording of Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The exact place, date, and time of sampling;

b. The dates the analyses were performed;

c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

6. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form (EPA No. 3320-1). Such increased frequency shall also be indicated.

7. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three(3) years, or longer if requested by the Regional Administrator or the State water pollution control agency.

3. Definitions (continued)

e. "Net" value, noted under Effluent Characteristics are calculated on the basis of the net increase of the individual parameter over the quantity of that same parameter present in the intake water measured prior to any contamination or use in the process of this facility. Any contaminants contained in any intake water obtained from underground wells shall not be adjusted for as described above and therefore shall be considered as process input to the final effluent. Limitations in which "net" is not noted are calculated on the basis of gross measurements, of each parameter in the discharge irrespective of the quantity or quality of those parameters in the intake waters.

f. A "composite" sample, for monitoring requirements, is defined as a minimum of four(4) grab samples collected at equally spaced two (2) hour intervals and proportioned according to flow.

g. Discharge Point 001 - The discharge from the north mining area, Section 35, T39N, R73W

h. Discharge Point 002 - The discharge from the east mining area, Section 18, T38N, R72W

i. Discharge Point 003 - The discharge from the main mining area, Section 10, T38N, R73W

A. MANAGEMENT REQUIREMENTS

1. Change in Discharge

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the permit issuing authority of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. Noncompliance Notification

If, for any reason, the permittee does not comply with or will be unable to comply with any daily maximum effluent limitation specified in this permit, the permittee shall provide the Regional Administrator and the State with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. Facilities Operation

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. Bypassing (See additional requirements under PART III)

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Regional Administrator and the State in writing of each such diversion or bypass.

6. *Removed Substances*

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

7. *Power Failures*

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. *Right of Entry*

The permittee shall allow the head of the State water pollution control agency, the Regional Administrator, and/or their authorized representatives, upon the presentation of credentials:

a. To enter upon the permittee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. *Transfer of Ownership or Control*

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Regional Administrator and the State water pollution control agency.

3. *Availability of Reports*

Except for data determined to be confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public

inspection at the offices of the State water pollution control agency and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Act.

4. *Permit Modification*

After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

5. *Toxic Pollutants*

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. *Civil and Criminal Liability*

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. *Oil and Hazardous Substance Liability*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Act.

8. *State Laws*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation.

9. *Property Rights*

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

10. *Severability*

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

PART III

OTHER REQUIREMENTS

Additional Bypassing Requirements

If, for other reasons, a partial or complete bypass is considered necessary, a request for such bypass shall be submitted to the State of Wyoming and to the Environmental Protection Agency at least sixty (60) days prior to the proposed bypass. If the proposed bypass is judged acceptable by the State of Wyoming and by the Environmental Protection Agency, the bypass will be allowed subject to limitations imposed by the State of Wyoming and the Environmental Protection Agency.

If, after review and consideration, the proposed bypass is determined to be unacceptable by the State of Wyoming and the Environmental Protection Agency, or if limitations imposed on an approved bypass are violated, such bypass shall be considered a violation of this permit; and the fact that application was made, or that a partial bypass was approved, shall not be a defense to any action brought thereunder.