

NICHOLS RANCH ISR PROJECT

URANIUM SOLUTION MINE

Campbell and Johnson Counties, Wyoming

Volume I
(Technical Report)

U.S.N.R.C. Source Material License Application

Rev. Mar. 2009

TABLE OF CONTENTS

	<u>Page</u>
1.0 PROPOSED ACTIVITIES	TR-1
1.1. INTRODUCTION	TR-1
1.2 GENERAL SOLUTION MINING PROCESS.....	TR-2
1.3 ADVANTAGES OF ISR URANIUM MINING	TR-3
1.4 ORE AMENABILITY OF ISR URANIUM MINING	TR-3
2.0 SITE CHARACTERIZATION.....	TR-5
2.1 SITE LOCATION AND LAYOUT.....	TR-5
2.2 USES OF ADJACENT LANDS AND WATERS.....	TR-6
2.2.1 General.....	TR-6
2.2.2 Agricultural.....	TR-7
2.2.3 Recreation	TR-8
2.2.4 Water Rights	TR-8
2.2.5 Industrial	TR-9
2.2.5.1 General/Oil/Gas	TR-9
2.2.5.2 Coal Bed Methane.....	TR-10
2.3 POPULATION DISTRIBUTION	TR-11
2.4 HISTORIC, SCENIC, AND CULTURAL RESOURCES.....	TR-17
2.4.1 General.....	TR-17
2.4.2 Cultural Resources.....	TR-17
2.4.3 Paleontological Resources	TR-21
2.4.4 Cultural Resource Mitigation.....	TR-22
2.4.5 Scenic Resources	TR-22
2.5 METEOROLOGY	TR-25
2.5.1 Introduction.....	TR-25
2.5.2 Regional Overview	TR-26
2.5.2.1 Temperature	TR-27
2.5.2.2 Precipitation.....	TR-31
2.5.2.3 Wind.....	TR-34
2.5.2.4 Wind Speed.....	TR-35
2.5.2.5 Wind Direction.....	TR-35
2.5.2.6 Humidity	TR-35
2.5.2.7 Evaporation.....	TR-36
2.5.2.8 Severe Weather	TR-36
2.5.2.9 Mixing Height.....	TR-37
2.5.3 Site Specific Analysis	TR-37
2.5.3.1 Temperature	TR-37
2.5.3.2 Precipitation.....	TR-38
2.5.3.3 Wind.....	TR-38
2.5.3.4 Effects of Local Terrain.....	TR-44

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.5.4 Air Quality	TR-45
2.5.4.1 General.....	TR-45
2.5.4.2 Impacts.....	TR-45
2.6 GEOLOGY AND SEISMOLOGY.....	TR-50
2.6.1 Regional Geology	TR-50
2.6.2 Site Geology.....	TR-52
2.6.3 Seismology.....	TR-55
2.7 HYDROLOGY	TR-56
2.7.1 Surface Water.....	TR-56
2.7.1.1 Drainage Basin Description	TR-56
2.7.1.2 Surface-Water Flow	TR-58
2.7.1.3 Surface-Water Quality	TR-62
2.7.1.4 Coal Bed Methane Surface Water.....	TR-63
2.7.1.4.1 Permitted CBM/CBNG Discharge Facilities.....	TR-63
2.7.1.4.2 CBM/CBNG Discharge Parameters	TR-64
2.7.1.4.3 CBM/CBNG Effect on Surface Water/Surficial Aquifer	TR-68
2.7.2 Groundwater Hydrology	TR-70
2.7.2.1 Geologic Setting and Well Construction	TR-71
2.7.2.2 Summary of Aquifer and Aquitard Properties.....	TR-74
2.7.2.2.1 Aquifer Properties.....	TR-74
2.7.2.2.2 Aquitard Properties	TR-77
2.7.2.3 Groundwater Flow	TR-78
2.7.2.3.1 Nichols Ranch Unit Water-Level Changes.....	TR-82
2.7.2.3.2 Hank Unit Water-Level Changes.....	TR-83
2.7.2.3.3 Coal Bed Water-Level Changes.....	TR-84
2.7.2.4 Groundwater Quality	TR-91
2.7.2.4.1 Coal Bed Methane Groundwater Quality	TR-97
2.7.3 Water Rights	TR-101
2.7.4 Coal Bed Methane Wells and Oil/Gas Wells.....	TR-104
2.7.5 Exploration Drill Holes.....	TR-104
2.8 ECOLOGY	TR-105
2.8.1 Topography.....	TR-105
2.8.2 Soils.....	TR-106
2.8.3 Vegetation.....	TR-107
2.8.4 Wildlife	TR-108
2.8.4.1 General.....	TR-108
2.8.4.2 Federal Threatened, Endangered, Proposed and Candidate Species	TR-109
2.8.4.3 BLM Special Status Species	TR-110

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.9 BACKGROUND RADIOLOGICAL CHARACTERISTICS.....	TR-112
2.9.1 Surface Soil, Subsurface Soils and Sediment	TR-112
2.9.1.1 Purpose and Procedure.....	TR-112
2.9.1.2 Sampling Methodology.....	TR-115
2.9.1.3 Nichols Ranch Unit Results.....	TR-115
2.9.1.4 Hank Unit Results	TR-119
2.9.2 Baseline Gamma Survey.....	TR-119
2.9.2.1 Purpose and Procedure.....	TR-119
2.9.2.2 Survey Methodology.....	TR-123
2.9.2.3 Nichols Ranch Unit Results.....	TR-123
2.9.2.4 Hank Unit Results	TR-126
2.9.3 Baseline Radon-222 and Direct Gamma Exposure Rates.....	TR-130
2.9.3.1 Purpose and Procedure.....	TR-130
2.9.3.2 Survey Methodology.....	TR-130
2.9.3.3 Nichols Ranch Unit Results.....	TR-131
2.9.3.4 Hank Unit Results	TR-133
2.9.4 Flora and Fauna.....	TR-133
2.9.4.1 Purpose and Procedure.....	TR-133
2.9.4.2 Methods.....	TR-136
2.9.4.3 Nichols Ranch Unit Results.....	TR-136
2.9.4.4 Hank Unit Results	TR-138
2.9.5 Radon Flux.....	TR-138
2.10 BACKGROUND NONRADIOLOGICAL CHARACTERISTICS	TR-138
2.10.1 Nonradioactive Airborne Effluents.....	TR-138
2.10.2 Nonradioactive Liquid Effluents.....	TR-140
2.10.3 Nonradioactive Baseline Studies	TR-140
2.10.3.1 Soils.....	TR-140
2.10.3.2 Vegetation.....	TR-140
2.10.3.3 Groundwater	TR-141
3.0 DESCRIPTION OF THE FACILITIES	TR-143
3.1 IN SITU RECOVERY PROCESS AND EQUIPMENT.....	TR-143
3.2 SITE FACILITIES LAYOUT	TR-144
3.2.1 Nichols Ranch Unit – Central Processing Plant	TR-144
3.2.2 Hank Unit – Satellite Facility	TR-145
3.2.3 Process Description.....	TR-146
3.2.3.1 Uranium Recovery	TR-146
3.2.3.2 Lixiviant Composition	TR-146
3.2.3.3 Process Plant Circuits	TR-147
3.2.4 Chemical Reactions	TR-148

TABLE OF CONTENTS (Continued)

	<u>Page</u>
3.2.4.1 Underground Recovery	TR-148
3.2.4.2 Ion Exchange	TR-149
3.2.4.3 Elution Process and Resin Handling	TR-149
3.2.4.4 Yellowcake Production	TR-150
3.2.5 Flow and Material Balance	TR-151
3.2.6 Sources of Plant Liquid Effluents and Disposal Methods	TR-151
3.2.7 Airborne Effluents and Solid Wastes	TR-154
3.3 CHEMICAL STORAGE FACILITIES	TR-155
3.3.1 Process Related Chemicals	TR-156
3.3.2 Nonprocess Related Chemicals	TR-157
3.4 WELLFIELDS	TR-158
3.4.1 Ore Zone	TR-158
3.4.2 Wellfield Areas	TR-158
3.4.3 Wellfield Injection and Recovery Patterns	TR-159
3.4.4 Wellfield Operations – Production Areas	TR-161
3.4.5 Well Completion	TR-162
3.4.6 Well Casing Integrity	TR-164
3.4.7 Monitoring of Wellfield Flow and Pressure	TR-165
3.4.8 Monitor Well Ring Gradient Reversal	TR-165
3.5 PLANT EQUIPMENT, INSTRUMENTATION, AND CONTROL	TR-168
3.6 SPILLS AND EXCURSIONS	TR-171
3.6.1 Excursion Reporting	TR-172
3.6.2 Maintenance, Spill Prevention and Spill Reporting	TR-173
3.6.3 Flow Alarms for Leak Detection	TR-174
3.6.4 Inspections for Wellfields and Header Houses	TR-174
4.0 EFFLUENT CONTROL SYSTEMS	TR-175
4.1 GASEOUS AND AIRBORNE PARTICULATES	TR-175
4.1.1 Radon	TR-175
4.1.1.1 General Area Ventilation	TR-175
4.1.1.2 Local Ventilation	TR-176
4.1.2 Particulate	TR-176
4.2 LIQUIDS AND SOLIDS	TR-178
4.2.1 Liquid Effluents	TR-178
4.2.2 Solid Wastes	TR-179
4.2.2.1 Noncontaminated solid waste	TR-179
4.2.2.2 Contaminated solid waste	TR-179
4.3 CONTAMINATED EQUIPMENT	TR-180
4.4 SYSTEM FAILURES	TR-181

TABLE OF CONTENTS (Continued)

	<u>Page</u>
5.0 OPERATIONS.....	TR-182
5.1 ORGANIZATIONS.....	TR-182
5.1.1 Management.....	TR-182
5.1.2 ALARA.....	TR-185
5.1.2.1 Philosophy.....	TR-186
5.1.2.2 Responsibilities.....	TR-186
5.2 MANAGEMENT CONTROL PROGRAM.....	TR-188
5.2.1 Administrative Procedures.....	TR-188
5.2.1.1 Operating Procedures.....	TR-188
5.2.1.2 Radiation Work Permits.....	TR-188
5.2.1.3 Record Keeping.....	TR-189
5.2.1.4 Reporting.....	TR-190
5.2.2 Safety and Environmental Review Panel.....	TR-190
5.2.2.1 Organization.....	TR-190
5.2.2.2 SERP Procedures.....	TR-191
5.2.2.3 SERP Records.....	TR-191
5.2.2.4 SERP Reports.....	TR-192
5.3 MANAGEMENT AUDIT AND INSPECTION PROGRAM.....	TR-192
5.3.1 Audit.....	TR-192
5.3.2 Inspections.....	TR-193
5.4 QUALIFICATIONS FOR PERSONNEL CONDUCTING THE RADIATION SAFETY PROGRAM.....	TR-193
5.5 RADIATION SAFETY TRAINING.....	TR-195
5.6 SECURITY.....	TR-197
5.7 RADIATION SAFETY CONTROLS AND MONITORING.....	TR-197
5.7.1 Effluent Control Techniques.....	TR-197
5.7.1.1 Airborne Radioactive Effluents.....	TR-197
5.7.1.1.1 Particulate.....	TR-198
5.7.1.1.2 Radon.....	TR-199
5.7.1.2 Liquid Radioactive Effluents.....	TR-199
5.7.1.2.1 Contingency for Unplanned Releases.....	TR-199
5.7.1.3 Surface Releases.....	TR-200
5.7.1.3.1 Subsurface Releases.....	TR-200
5.7.2 External Radiation Exposure Monitoring Program.....	TR-201
5.7.2.1 Personnel Monitoring.....	TR-201
5.7.2.2 Exposure Rate Surveys.....	TR-202
5.7.3 Airborne Radiation Monitoring Program.....	TR-203
5.7.3.1 Airborne Uranium Particulate Monitoring.....	TR-203
5.7.3.1.1 Breathing Zone.....	TR-204
5.7.3.1.2 Area.....	TR-204
5.7.3.1.3 Action Level and Limit.....	TR-205

TABLE OF CONTENTS (Continued)

	<u>Page</u>
5.7.3.2 Radon	TR-205
5.7.3.3 Radon Daughter Concentration Monitoring	TR-205
5.7.3.4 Respiratory Protection Program.....	TR-205
5.7.4 Exposure Calculations	TR-206
5.7.4.1 Uranium	TR-206
5.7.4.2 Radon Daughters.....	TR-207
5.7.4.3 Prenatal and Fetal Radiation Exposure.....	TR-207
5.7.4.4 Recording Radiation Dose	TR-208
5.7.5 Bioassay Program	TR-208
5.7.6 Contamination Control Program.....	TR-209
5.7.6.1 Surveys for Surface Contamination in Restricted Area.....	TR-209
5.7.6.2 Surveys for Surface Contamination in Unrestricted Area	TR-210
5.7.6.3 Surveys for Contamination of Skin and Personal Clothing.....	TR-210
5.7.6.4 Surveys of Equipment Prior to Release to Unrestricted Areas	TR-211
5.7.6.5 Surveys for Contamination on Respirators.....	TR-211
5.7.6.6 Instrumentation	TR-211
5.7.6.7 Survey Record.....	TR-212
5.7.7 Airborne Effluent and Environmental Monitoring	TR-212
5.7.7.1 Stack Sampling	TR-212
5.7.7.2 Air Samples.....	TR-212
5.7.7.3 Water Samples	TR-213
5.7.7.3.1 Surface Water.....	TR-213
5.7.7.3.2 Groundwater	TR-213
5.7.7.4 Vegetation, Food, and Fish Samples.....	TR-213
5.7.7.5 Soil and Sediment Samples.....	TR-214
5.7.7.6 Direct Radiation	TR-214
5.7.8 Groundwater Monitoring Program	TR-214
5.7.8.1 Pre-Operational Wellfield Assessment.....	TR-214
5.7.8.2 Monitor Well Spacing.....	TR-215
5.7.8.3 Production Area Pump Test.....	TR-216
5.7.8.4 Production Area Pump Test Document	TR-216
5.7.8.5 Baseline Water Quality Determination.....	TR-217
5.7.8.5.1 Data Collection	TR-218
5.7.8.6 Statistical Assessment of Baseline Water Quality Data ...	TR-220
5.7.8.7 Restoration Target Values.....	TR-221
5.7.8.8 Upper Control Limits.....	TR-221

TABLE OF CONTENTS (Continued)

	<u>Page</u>
5.7.8.9 Calculation of Upper Control Limits	TR-221
5.7.8.10 Operational Groundwater Monitoring Program.....	TR-222
5.7.8.10.1 Monitoring Frequency and Reporting.....	TR-222
5.7.8.10.2 Water Quality Sampling and Analysis Procedures.....	TR-223
5.7.8.10.3 Excursions.....	TR-223
5.7.9 Quality Assurance.....	TR-224
5.7.9.1 Organization.....	TR-225
5.7.9.2 Procedures.....	TR-225
5.7.9.3 Records	TR-225
5.7.9.4 Quality Control in Sampling.....	TR-225
5.7.9.5 Quality Control in Laboratory	TR-226
5.7.9.5.1 Calibration.....	TR-226
5.7.9.5.2 Performance Checks	TR-226
5.7.9.5.3 Quality Control Samples.....	TR-226
5.7.9.6 Computational Checks	TR-227
5.7.9.7 Review and Analysis of Data.....	TR-227
5.7.9.8 Review of Quality Assurance Program.....	TR-227
6.0 RECLAMATION PLAN.....	TR-228
6.1 GROUNDWATER RESTORATION	TR-228
6.1.1 Water Quality Criteria.....	TR-230
6.1.2 Restoration Criteria.....	TR-230
6.1.3 Groundwater Restoration Methods.....	TR-231
6.1.3.1 Groundwater Transfer.....	TR-233
6.1.3.2 Groundwater Sweep.....	TR-234
6.1.3.3 Groundwater Treatment.....	TR-234
6.1.3.4 Restoration Monitoring.....	TR-236
6.1.3.5 Effectiveness of Groundwater Restoration Techniques....	TR-237
6.1.3.6 Environmental Effects of Groundwater Restoration.....	TR-240
6.1.4 Restoration Stability Monitoring Stage	TR-240
6.1.5 Well Abandonment.....	TR-241
6.2 SURFACE RECLAMATION AND DECOMMISSIONING.....	TR-242
6.2.1 Introduction.....	TR-242
6.2.2 Surface Disturbance.....	TR-242
6.2.3 Topsoil Handling and Replacement.....	TR-243
6.2.4 Vegetation Reclamation Practices	TR-244
6.2.5 Road Reclamation.....	TR-245
6.2.5.1 Access Roads	TR-245
6.2.5.2 Wellfield Access Roads	TR-246

TABLE OF CONTENTS (Continued)

	<u>Page</u>
6.2.6 Site Decontamination and Decommissioning.....	TR-246
6.2.6.1 Reclaiming Disturbed Lands.....	TR-246
6.2.6.2 Removing and Disposing of Structures and Equipment...	TR-247
6.2.7 Final Contouring.....	TR-248
6.2.8 Financial Assurance.....	TR-248
7.0 ENVIRONMENTAL EFFECTS.....	TR-252
7.1 SITE PREPARATION AND CONSTRUCTION.....	TR-252
7.2 EFFECTS OF OPERATION.....	TR-253
7.2.1 Surface Water Impacts.....	TR-254
7.2.2 Ephemeral Drainages Impacts.....	TR-255
7.2.3 Groundwater Impacts.....	TR-257
7.2.4 Air Quality.....	TR-258
7.2.5 Wildlife Impacts.....	TR-260
7.2.5.1 Endangered Species.....	TR-260
7.2.5.2 Wildlife.....	TR-260
7.2.5.2.1 Big Game.....	TR-261
7.2.5.2.2 Upland Game Birds.....	TR-262
7.2.5.2.3 Waterfowl and Shorebirds.....	TR-262
7.2.5.2.4 Mammalian Predators.....	TR-263
7.2.5.2.5 Lagomorphs.....	TR-263
7.2.5.2.6 Small Mammals.....	TR-263
7.2.5.2.7 Raptors.....	TR-264
7.2.5.2.8 Nongame/Migratory Birds.....	TR-264
7.2.5.2.9 Reptiles and Amphibians.....	TR-265
7.2.5.2.10 Threatened, Endangered, Proposed, and Candidate Species and Special Status Species.....	TR-265
7.3 RADIOLOGICAL EFFECTS.....	TR-266
7.3.1 Exposure Pathways.....	TR-266
7.3.1.1 Exposures from Water Pathways.....	TR-266
7.3.1.2 Exposures from Air Pathways.....	TR-267
7.3.1.2.1 Site Description.....	TR-268
7.3.1.2.2 Population Distribution.....	TR-268
7.3.1.2.3 Individual Receptor Locations.....	TR-269
7.3.1.2.4 Time Parameters.....	TR-270
7.3.1.2.5 Food Pathway Parameters.....	TR-270
7.3.1.2.6 Meteorological Parameters.....	TR-272
7.3.1.2.7 Source Terms.....	TR-272
7.3.1.2.8 Results.....	TR-272

TABLE OF CONTENTS (Continued)

	<u>Page</u>
7.3.1.2.8.1 Individual Receptor Dose.....	TR-275
7.3.1.2.8.2 Population Dose	TR-276
7.3.1.3 Exposures from External Radiation.....	TR-277
7.3.1.4 Total Human Exposures.....	TR-277
7.3.1.5 Exposure to Flora and Fauna	TR-278
7.4 NONRADIOLOGICAL EFFECTS	TR-279
7.4.1 Nonradioactive Airborne Effluents.....	TR-279
7.4.2 Nonradioactive Liquid Effluents.....	TR-280
7.5 EFFECTS OF ACCIDENTS	TR-280
7.5.1 Transportation Incidents	TR-281
7.5.1.1 Shipment of Refined Yellowcake	TR-281
7.5.1.2 Shipments of Loaded Resin	TR-284
7.5.1.3 Shipment of Process Chemicals.....	TR-285
7.5.1.4 Shipment of 11e(2) By-product Material for Disposal	TR-286
7.5.1.5 Transporting Employees To and From Project Site.....	TR-287
7.5.2 Tank Failure	TR-288
7.5.3 Pipeline Failure	TR-289
7.5.3.1 Process Pipelines.....	TR-289
7.5.3.2 Coal Bed Methane Gas Pipeline Failure.....	TR-290
7.5.4 Fires and Explosions	TR-290
7.5.5 Tornadoes	TR-291
7.5.6 Well Casing Failure	TR-293
7.5.7 Aquifer Communication Through Old Exploration Holes	TR-294
7.5.8 Aquifer Communication Through Coal Bed Methane and Oil/Gas Wells.....	TR-295
7.5.9 Occupational Incidents.....	TR-295a
7.6 ECONOMIC AND SOCIAL EFFECTS OF CONSTRUCTION AND OPERATION	TR-296
7.6.1 Benefits	TR-296
7.6.1.1 Employment.....	TR-296
7.6.1.2 Taxes.....	TR-296
7.6.1.3 Roads.....	TR-296
7.6.1.4 United States Nuclear Energy Supply.....	TR-296
7.6.2 Socioeconomic Costs.....	TR-297
7.6.2.1 Public Facilities and Services	TR-297
7.6.2.2 Housing.....	TR-297
7.6.2.3 Impairment of Historical, Scenic, and Recreation Values	TR-297
7.7 MINERAL RESOURCE IMPACTS	TR-298

TABLE OF CONTENTS (Continued)

	<u>Page</u>
8.0 ALTERNATIVES TO THE PROPOSED ACTION.....	TR-299
8.1 ALTERNATIVE MINING METHODS.....	TR-299
8.2 ALTERNATIVE SITES.....	TR-300
8.3 ALTERNATIVE RECOVERY SOLUTIONS.....	TR-300
8.4 GROUNDWATER RESTORATION ALTERNATIVES.....	TR-301
8.5 LIQUID EFFLUENT DISPOSAL ALTERNATIVES.....	TR-301
9.0 BENEFIT-COST SUMMARY.....	TR-302
9.1 GENERAL.....	TR-302
9.2 QUANTIFIABLE ECONOMIC IMPACTS.....	TR-302
9.3 ENVIRONMENTAL COSTS.....	TR-303
9.4 SUMMARY.....	TR-303
10.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS.....	TR-304
10.1 PERMITS AND LICENSES REQUIRED FOR THE NICHOLS RANCH ISR PROJECT.....	TR-304
11.0 REFERENCES.....	TR-305

LIST OF ADDENDUMS

	<u>Page</u>
ADDENDUM 2A: WELL TABLES.....	Volume II
ADDENDUM 2B: CLASS III CULTURAL RESOURCE INVENTORY OF THE URANERZ ENERGY CORPORATION, HANK IN SITU URANIUM PROJECT.....	Refer to Confidential Binder
ADDENDUM 2B-2: CLASS III CULTURAL RESOURCE INVENTORY FOR URANERZ ENERGY CORPORATION'S, 80-ACRE PARCEL IN THE HANK UNIT, CAMPBELL COUNTY, WYOMING.....	Refer to Confidential Binder
ADDENDUM 2C: PALEONTOLOGICAL SURVEY HANK AND NICHOLS RANCH UNIT, PUMPKIN BUTTES, WYOMING.....	Refer to Confidential Binder

LIST OF ADDENDUMS (Continued)

	<u>Page</u>
ADDENDUM 2D: BASIC SEISMOLOGICAL CHARACTERIZATION OF CAMPBELL COUNTY, WYOMING AND BASIC SEISMOLOGICAL CHARACTERIZATION OF JOHNSON COUNTY, WYOMING.....	Volume II
ADDENDUM 3A: BLEED RATE REVERSAL PRODUCTIONS.....	Volume II
ADDENDUM 5A: URANERZ ENERGY CORPORATION OPERATIONAL GROUNDWATER SAMPLING PROCEDURE.....	Volume II
ADDENDUM 6A: LANDOWNER ROAD DESIGN CONTRUCTION LETTER ...	Volume II
ADDENDUM 6B: NICHOLS RANCH ISR PROJECT SURETY ESTIMATE.....	Volume II
ADDENDUM 6C1: RENO CREEK ISL HYDROLOGY	Volume II
ADDENDUM 6C2: RENO CREEK DEMONSTRATED RESTORATION REPORT	Volume II
ADDENDUM 6C3: HYDROLOGIC ANALYSIS OF THE RENO CREEK-PATTERN 2 PROPERTY FOR IN SITU URANIUM RECOVERY.....	Volume II
ADDENDUM 7A: DRAWDOWN PREDICATIONS	Volume II
ADDENDUM 7B: MILDOS REPORT.....	Volume II
ADDENDUM 7C: MILDOS REPORT USING ACC DATA	Volume II

LIST OF FIGURES

	<u>Page</u>
Figure 1-1 General Location Map	Map Pocket
Figure 1-2 Contour Map of Nichols Ranch Unit.....	Map Pocket
Figure 1-3 Contour Map of Hank Unit	Map Pocket
Figure 1-4 Commercial, Pilot and Proposed Areas	Map Pocket

LIST OF FIGURES (Continued)

	<u>Page</u>
Figure 2-1	Access to Nichols Ranch ISR Project..... Map Pocket
Figure 2-2	Location of Towns and Cities Within 50-Miles (~80 km) of Project Area Map Pocket
Figure 2-3	Population Density Map for Wyoming Within 50-Miles (~80 km) of Project Area Map Pocket
Figure 2-4	Campbell County Profile Map Pocket
Figure 2-5	Johnson County Profile..... Map Pocket
Figure 2-6	Natrona County Profile Map Pocket
Figure 2-7	Location of Regional Meteorological Stations TR-27
Figure 2-8	Average Monthly Temperatures for Select Meteorological Stations TR-29
Figure 2-8a	Average Monthly Minimum Temperatures for Select Meteorological Stations..... TR-30
Figure 2-8b	Average Monthly Maximum Temperatures for Select Meteorological Stations..... TR-30
Figure 2-8c	Seasonal Diurnal Temperature Variations at the Antelope Station..... TR-31
Figure 2-9	Monthly Average Precipitation (in inches) for Select Stations TR-33
Figure 2-9a	Monthly Minimum Precipitation (in inches) for Select Stations TR-33
Figure 2-9b	Monthly Maximum Precipitation (in inches) for Select Stations TR-34
Figure 2-10	Average Monthly Wind Speeds (mph) at the Antelope Station TR-38
Figure 2-10a	Annual Wind Rose 1987-2006 for Antelope Mine..... TR-40
Figure 2-10b	January through April Wind Roses..... TR-41
Figure 2-10c	May through August Wind Roses..... TR-42
Figure 2-10d	September through December Wind Roses TR-43
Figure 2-11	Fugitive Dust Calculations (1 of 3)..... TR-47
Figure 2-11	Fugitive Dust Calculations (2 of 3)..... TR-48

LIST OF FIGURES (Continued)

	<u>Page</u>
Figure 2-11 Fugitive Dust Calculations (3 of 3).....	TR-49
Figure 2-12 Structural Map of Wyoming	Map Pocket
Figure 2-13 Stratigraphic Column	Map Pocket
Figure 2-14 Seismic Zone.....	Map Pocket
Figure 2-15 Surface Drainage Areas	Map Pocket
Figure 2-15a Nichols Ranch Unit Inundated Areas for 25 Year Flood.....	Map Pocket
Figure 2-15b Hank Unit Inundated Areas for 25 Year Flood.....	Map Pocket
Figure 2-16 Typical Aquifer and Aquitard Sequence at the Nichols Ranch ISR Project	Map Pocket
Figure 2-17 Nichols Ranch Unit Water Wells.....	Map Pocket
Figure 2-18 Hank Unit Water Wells.....	Map Pocket
Figure 2-19 Water-Level Elevation for the A Sand Aquifer	Map Pocket
Figure 2-19a Regional Water-Level Elevation for the A Sand Aquifer, FT-MSL Aquifer	Map Pocket
Figure 2-20 Water-Level Elevation for the F Sand Aquifer.....	Map Pocket
Figure 2-20a Regional Water-Level Elevation for the 1 Sand Aquifer, FT-MSL Aquifer.....	Map Pocket
Figure 2-20b Hank Unit Water-Level Elevations for the F Sand Aquifer, 2008, FT-MSL Aquifer.....	Map Pocket
Figure 2-21 Water-Level Elevation for the B & C Sand Aquifers, 2007, FT-MSL.....	Map Pocket
Figure 2-21a Depth to Water in the F & G Sands and Cottonwood Alluvial at the Nichols Ranch Unit, in FT	Map Pocket
Figure 2-21b Depth to Water in the H Sand Aquifer at the Hank Unit, in FT	Map Pocket
Figure 2-22 Water-Level Elevation for the G & H Sand Aquifers, 2007, FT-MSL.....	Map Pocket

LIST OF FIGURES (Continued)

	<u>Page</u>
Figure 2-23 Nichols Ranch Unit Surface Water Rights	Map Pocket
Figure 2-24 Hank Unit Surface Water Rights	Map Pocket
Figure 3-1 Nichols Ranch Unit Site Facility Diagram	Map Pocket
Figure 3-2 Hank Unit Site Facility Diagram	Map Pocket
Figure 3-3 Nichols Ranch Unit Process Flow Diagram	Map Pocket
Figure 3-3a Process Flow Diagram Nichols Ranch Unit	Map Pocket
Figure 3-4 Hank Unit Process Flow Diagram	Map Pocket
Figure 3-4a Proposed Hank Satellite Plant Flow Diagram Details	Map Pocket
Figure 3-5 General Flow Process Schematic	Map Pocket
Figure 3-6 Plant Material Balance	Map Pocket
Figure 3-7 Typical ISR Water Balance	Map Pocket
Figure 3-8 Deep Disposal Well	Map Pocket
Figure 3-8A Nichols Ranch Unit Proposed Monitor Well Locations	Map Pocket
Figure 3-8B Hank Unit Proposed Monitor Well Locations	Map Pocket
Figure 3-9 Typical 5-Spot Well Pattern.....	Map Pocket
Figure 3-9A Header House Details	Map Pocket
Figure 3-9B Header House Ground Level	Map Pocket
Figure 3-9C Header House Piping and Instrumentation	Map Pocket
Figure 3-10 Nichols Ranch Unit Production Areas	Map Pocket
Figure 3-11 Hank Unit Production Areas	Map Pocket
Figure 3-12 Production, Restoration, and Reclamation Schedule	Map Pocket

LIST OF FIGURES (Continued)

	<u>Page</u>
Figure 3-13	Typical (Injection/Recovery) Well Construction Diagram..... Map Pocket
Figure 3-14	Typical Monitor Well Construction Diagram..... Map Pocket
Figure 3-15	Results of Simulation of Gradient Reversal for Nichols Ranch Unit Map Pocket
Figure 3-16	Results of Simulation of Gradient Reversal for Hank Unit Map Pocket
Figure 5-1	Uranerz Organization..... Map Pocket
Figure 5-1a	Dryer Process Flow Diagram..... Map Pocket
Figure 5-2a	Central Process Plant Survey Locations Map Pocket
Figure 5-2b	Process Satellite Process Plant Survey Locations..... Map Pocket
Figure 7-1	Nichols Ranch Unit Predicated Drawdown in the A Sand at the End of Three Years of ISR, in FT Map Pocket
Figure 7-2	Hank Unit Predicated Drawdown at the End of Three Years of ISR for the F Sand, in FT Map Pocket
Figure 7-3	Location of Nichols Ranch, Hank Sites and Nearest Residents to Nichols Ranch Central Processing Plant Map Pocket
Figure 7-3a	Exposure Pathways Diagram Map Pocket
Figure 7-4	Location of Cities Within 80 km of Nichols Ranch Central Processing Plant Map Pocket

LIST OF TABLES

	<u>Page</u>
Table 2-1	Nearest Residents..... TR-7
Table 2-2	Cities Within a 50-mi Radius of the Nichols Ranch ISR Project Area TR-12
Table 2-3	Wyoming Population Data Campbell, Johnson, and Natrona Counties TR-13

LIST OF TABLES (Continued)

	<u>Page</u>
Table 2-4	Population By Place, By Minority: 1990 and 2000 TR-16
Table 2-5	Previous Cultural Resource Inventories Within or near Uranerz Energy Corporation's Nichols Ranch ISR Project Permit Area..... TR-18
Table 2-6	Previously Recorded Sites Within or near Uranerz Energy Corporation's Nichols Ranch ISR Project Permit Area..... TR-18
Table 2-7	Meteorological Stations Included in Climate Analysis TR-26
Table 2-8	Annual Average Temperature for Select Stations TR-29
Table 2-9	Annual Average Precipitation for Select Stations TR-32
Table 2-10	Emissions Inventory..... TR-50
Table 2-11	Maximum Expected Earthquakes Intensities and Ground Accelerations at the Nichols Ranch ISR Project Site TR-56
Table 2-12	Surface Drainage Properties, Estimated Peak Flows, and Velocities..... TR-59
Table 2-12a	Outfalls Inside and Within a One-mile Radius of the Hank Unit License Boundary..... TR-64
Table 2-12b	Outfalls Inside and Within a One-mile Radius of the Nichols Ranch Unit License Boundary TR-65
Table 2-12c	WYPDES Effluent Limitations for Permits Within a One Mile of the Hank Unit Project..... TR-66
Table 2-12d	WYPDES Effluent Limitations for Permits in or near the Nichols Ranch Project..... TR-67
Table 2-13	Basic Well Data for the Nichols Ranch Unit Wells..... TR-72
Table 2-14	Basic Well Data for the Hank Unit..... TR-73
Table 2-15	Summary of Aquifer Properties for the Nichols Ranch Unit..... TR-75
Table 2-16	Summary of Aquifer Properties for the Hank Unit..... TR-76
Table 2-17	Summary of Groundwater Quality..... TR-92
Table 2-18	Outfalls Located within Nichols Ranch Unit License Boundary..... TR-99

LIST OF TABLES (Continued)

	<u>Page</u>
Table 2-19 Williams Production RMT Company (WY0051161 and WY0054411-10) Average Water Quality and Discharge Rates	TR-99
Table 2-20 Yates Petroleum Corporation (WY0056502) Estimated Water Quality and Discharge Rate	TR-100
Table 2-21 Vegetation/Habitat Types, Number of Acres, and Sampling Intensity, Nichols Ranch ISR Project, 2006	TR-108
Table 2-22 Radiological Background in Surface and Subsurface Soil - Nichols Ranch Unit	TR-116
Table 2-23 Radiological Background in Sediment - Nichols Ranch Unit	TR-118
Table 2-24 Radiological Background in Surface and Subsurface Soil - Hank Unit ...	TR-120
Table 2-25 Radiological Background in Sediment - Hank Unit	TR-122
Table 2-26 Nichols Ranch Unit Gamma/Soil and Sediment Sample Locations.....	TR-124
Table 2-27 Hank Unit Gamma/Soil and Sediment Sample Locations	TR-127
Table 2-28 Ambient Radon-222 Levels - Nichols Ranch Unit	TR-132
Table 2-29 Background Gamma Exposure Rate - Nichols Ranch Unit.....	TR-133
Table 2-30 Ambient Radon-222 Levels - Hank Unit	TR-134
Table 2-31 Background Gamma Exposure Rate - Hank Unit.....	TR-134
Table 2-32 Radiological and Nonradiological Background Levels in Vegetation Nichols Ranch Unit.....	TR-137
Table 2-33 Radiological and Nonradiological Background Levels in Vegetation Hank Unit.....	TR-139
Table 2-34 Groundwater Baseline Water Quality Parameters	TR-142
Table 5-1 Restoration Target Values Parameters	TR-219
Table 6-1 Uranerz Reclamation Seed Mixture.....	TR-245
Table 7-1 Emissions Inventory.....	TR-259

LIST OF TABLES (Continued)

	<u>Page</u>
Table 7-2	Population Distribution Within 80 km of Nichols Ranch Central Processing Plant TR-268
Table 7-3	Nearest Residents to Nichols Ranch Central Processing Plant..... TR-269
Table 7-4	Center of Site Boundary from Nichols Ranch Central Processing Plant TR-269
Table 7-5	Development, Production, and Restoration Schedule..... TR-271
Table 7-6	MILDOS Input Parameters - Nichols Ranch Unit..... TR-273
Table 7-7	MILDOS Input Parameters – Hank Unit TR-274
Table 7-8	Summary of Total Effective Dose Equivalent to Individual Receptors, mrem/year TR-275
Table 7-9	Summary of Total Effective Dose Equivalent Site Boundary, mrem/year TR-276
Table 7-10	Summary of Total Effective Dose Equivalent to Populations, person-rem/year TR-276
Table 7-11	Bulk Chemicals Required at the Nichols Ranch ISR Project TR-286
Table 10-1	Permit and Licenses for the Nichols Ranch ISR Project TR-304

LIST OF EHXIBITS

	<u>Page</u>
Exhibit 2-1	Previously Recorded Cultural Resource Sites Map Pocket
Exhibit 2-2	Hank Unit WYPDES Outfalls and Associated Impoundments Map Pocket
Exhibit 2-3	Nichols Ranch Unit WYPDES Outfalls and Associated Impoundments Map Pocket
Exhibit 5-1	Environmental Monitoring Locations..... Map Pocket