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Safety Evaluation Report
License Amendment for the Crow Butte Resources Marsland Expansion Area In-Situ Recovery Project Dawes County, Nebraska

Materials License No. SUA-1534

Docket No. 040-8943

Crow Butte Resources, Inc.

United States Nuclear Regulatory Commission

Protecting People and the Environment

Table of Contents

INTRODUCTION 9
REFERENCES 14
1.0 PROPOSED ACTIVITIES 15
1.1 Regulatory Requirements 15
1.2 Regulatory Acceptance Criteria 16
1.3 Staff Review and Analysis 16
1.3.1 Facility Description 16
1.3.2 General Operations 16
1.3.3 Schedule 17
1.3.4 Description of Groundwater Restoration and Decommissioning 17
1.3.5 Financial Assurance 17
1.4 Evaluation Findings 18
1.5 References 18
2.0 SITE CHARACTERIZATION 18
2.1 SITE LOCATION AND LAYOUT 18
2.1.1 Regulatory Requirements 18
2.1.2 Regulatory Acceptance Criteria 19
2.1.3 NRC Staff Review and Analysis 19
2.1.4 Evaluation Findings 20
2.1.5 References 20
2.2 METEOROLOGY 20
2.2.1 Regulatory Requirements 20
2.2.2 Regulatory Acceptance Criteria 21
2.2.3 Staff Review and Analysis 21
2.2.3.1 General Regional and Site Conditions 21
2.2.3.2 Meteorological Data Acquisition 23
2.2.3.3 Mixing Layer Heights 25
2.2.3.4 Atmospheric Dispersion Characteristics 25
2.2.4 Evaluation Findings 25
2.2.5 References 26
2.3 GEOLOGY AND SEISMOLOGY 27
2.3.1 Regulatory Requirements 27
2.3.2 Regulatory Acceptance Criteria 28
2.3.3 NRC Staff Review and Analysis 28
2.3.3.1 Regional Geology 28
2.3.3.1.1 Regional Stratigraphy 28
2.3.3.1.2 Regional Structure 28
2.3.3.2 Site Geology 29
2.3.3.2.1 Site Stratigraphy 29
2.3.3.2.2 MEA Local Structure 33
2.3.3.3 Well / Exploration Boreholes and Economically Significant Deposits 36
2.3.3.4 Seismology 37
2.3.4 Evaluation Findings 38
2.3.5 References 39
2.4 HYDOLOGY 45
2.4.1 Regulatory Requirements 45
2.4.2 Regulatory Acceptance Criteria 45
2.4.3 Review and Analysis 45
2.4.3.1 Surface Water Hydrology 45
2.4.3.2 Hydrogeology 48
2.4.3.2.1 Regional Hydrogeology 48
2.4.3.2.2 Site Hydrogeology 48

2.4.3.3 Aquifer Test 53
2.4.3.5 Water Use 54
2.4.4 Evaluation Findings 57
2.4.5 References 57
2.5 BACKGROUND SURFACE WATER AND GROUNDWATER QUALITY 59
2.5.1 Regulatory Requirements 59
2.5.2 Regulatory Acceptance Criteria 59
2.5.3 NRC Staff Review and Analysis 59
2.5.3.1 Surface Water 59
2.5.3.2 Groundwater 60
2.5.4 Evaluation Findings 62
2.5.5 References 62
2.6 BACKGROUND RADIOLOGICAL CHARACTERISTICS 63
2.6.1 Regulatory Requirements 63
2.6.2 Regulatory Acceptance Criteria 63
2.6.3 Staff Review and Analysis 63
2.6.4 Evaluation Findings 65
2.6.5 References 65
3.0 DESCRIPTION OF THE PROPOSED FACILITY 66
3.1 IN SITU RECOVERY PROCESS AND EQUIPMENT 66
3.1.1 Regulatory Requirements 66
3.1.2 Regulatory Acceptance Criteria 66
3.1.3 Staff Review and Analysis 66
3.1.3.1 Mine Unit and Mineralized Zone Description 66
3.1.3.2 Well Design, Construction and Integrity Testing 67
3.1.3.3 Excursion Monitoring Wells 68
3.1.3.4 Spills and Leaks 69
3.1.3.5 In Situ Recovery Process 69
3.1.3.5.1 Injection Pressures 69
3.1.3.5.2 Bleed 70
3.1.3.5.3 Satellite Building Material Balance and Flow Rates 71
3.1.3.5.4 Lixiviant Makeup 72
3.1.3.5.5 Drawdown 72
3.1.3.6 Schedule 73
3.1.4 Evaluation Findings 73
3.1.5 References 74
3.2 FACILITY EQUIPMENT USED AND MATERIALS PROCESSED 76
3.2.1 Regulatory Requirements 76
3.2.2 Regulatory Acceptance Criteria 76
3.2.3 NRC Staff Review and Analysis 76
3.2.4 Evaluation Findings 78
3.2.5 References 78
3.3 INSTRUMENTATION AND CONTROL 79
3.3.1 Regulatory Requirements 79
3.3.2 Regulatory Acceptance Criteria 79
3.3.3 NRC Staff Review and Analysis 79
3.3.4 Evaluation Findings 81
3.3.5 References 81
4.0 EFFLUENT CONTROL SYSTEMS 81
4.1 GASEOUS AND AIRBORNE PARICULATES 81
4.1.1 Regulatory Requirements 82
4.1.2 Regulatory Acceptance Criteria 83
4.1.3 Staff Review and Analysis 83
4.1.3.1 General 83

4.1.3.2 Ventilation and Effluent Controls 83
4.1.4 Evaluation Findings 86
4.1.5 References 86
4.2 LIQUID AND SOLID EFFLUENTS 87
4.2.1 Regulatory Requirements 87
4.2.2 Regulatory Acceptance Criteria 88
4.2.3 NRC Staff Review and Analysis 89
4.2.3.1 Liquid Wastes 89
4.2.3.1.1 Disposal Options 89
4.2.3.1.2 Liquid Byproduct Material Waste 89
4.2.3.1.3 Other Liquid Wastes 92
4.2.3.1.4 Monitoring of the Disposal Options 93
4.2.3.2 Solid Waste and Disposal 93
4.2.3.3 Spill Contingency Plans 95
4.2.4 Evaluation Findings 95
4.2.5 References 97
5.0 OPERATIONS 97
5.1 CORPORATE ORGANIZATION AND ADMINISTRATION PROCEDURES 97
5.1.1 Regulatory Requirements 97
5.1.2 Regulatory Acceptance Criteria 98
5.1.3 NRC Staff Review and Analysis 98
5.1.3.1 Corporate Organization 98
5.1.3.2 Administrative Procedures and ALARA 100
5.1.4 Evaluation Findings 101
5.1.5 References 101
5.2 MANAGEMENT CONTOL PROGRAM 102
5.2.1 Regulatory Requirements 102
5.2.2 Regulatory Acceptance Criteria 102
5.2.3 NRC staff Review and Analysis 102
5.2.3.1 Written Procedures 102
5.2.3.2 Non-Routine Work 103
5.2.3.3 Safety and Environmental Review Panel 104
5.2.3.4 Records 105
5.2.4 Evaluation Findings 106
5.2.5 References 106
5.3 Management Audit and Inspection Programs 107
5.3.1 Regulatory Requirements 107
5.3.2 Regulatory Acceptance Criteria 107
5.3.3 NRC Staff Review and Analysis 107
5.3.3.1 Radiation Safety Inspections 107
5.3.3.2 Annual ALARA Audit 108
5.3.4 Evaluation Findings 109
5.3.5 References 109
5.4 QUALIFICATIONS FOR PERSONNEL CONDUCTING THE RADIATION SAFETY PROGRAM 110
5.4.1 Regulatory Requirements 110
5.4.2 Regulatory Acceptance Criteria 110
5.4.3 Staff Review and Analysis 110
5.4.4 Evaluation Findings 111
5.4.5 References 111
5.5 RADIATION SAFETY TRAINING 112
5.5.1 Regulatory Requirements 112
5.5.2 Regulatory Acceptance Criteria 112
5.5.3 Staff Review and Analysis 112

5.5.4 Evaluation Findings 113
5.5.5 References 113
5.6 SECURITY 114
5.6.1 Regulatory Requirements 114
5.6.2 Regulatory Acceptance Criteria 114
5.6.3 NRC Staff Review and Analysis 114
5.6.3.1 Security Plan 114
5.6.3.2 Transportation Security 115
5.6.4 Evaluation Findings 116
5.6.5 References 116
5.7 RADIATION SAFETY CONTROLS AND MONITORING 116
5.7.1 Standards 116
5.7.2 Effluent Control Techniques 118
5.7.3 External Radiation Exposure Monitoring Program 118
5.7.3.1 Regulatory Requirements 118
5.7.3.2 Regulatory Acceptance Criteria 118
5.7.3.3 Staff Review and Analysis 118
5.7.3.4 Evaluation Findings 120
5.7.3.5 References 120
5.7.4 In-Plant Airborne Radiation Monitoring Program 120
5.7.4.1 Regulatory Requirements 121
5.7.4.2 Regulatory Acceptance Criteria 122
5.7.4.3 Staff Review and Analysis 122
5.7.4.4 Evaluation Findings 124
5.7.4.5 References 124
5.7.5 Exposure Calculations 124
5.7.5.1 Regulatory Requirements 124
5.7.5.2 Regulatory Acceptance Criteria 125
5.7.5.3 Staff Review and Analysis 125
5.7.5.4 Evaluation Findings 126
5.7.5.5 References 126
5.7.6 Bioassay Program 126
5.7.6.1 Regulatory Requirements 127
5.7.6.2 Regulatory Acceptance Criteria 127
5.7.6.3 Staff Review and Analysis 127
5.7.6.4 Evaluation Findings 128
5.7.6.5 References 128
5.7.7 Contamination Control Program 128
5.7.7.1 Regulatory Requirements 128
5.7.7.2 Regulatory Acceptance Criteria 129
5.7.7.3 Staff Review and Analysis 129
5.7.7.4 Evaluation Findings 131
5.7.7.5 References 131
5.7.8 Airborne Effluent and Environmental Monitoring Programs 132
5.7.8.1 Regulatory Requirements 132
5.7.8.2 Regulatory Acceptance Criteria 133
5.7.8.3 Staff Review and Analysis 133
5.7.8.3.1 Airborne Effluent and Environmental Monitoring 134
5.7.8.3.2 Reporting of Airborne Effluent and Environmental Monitoring Results 135
5.7.8.3.3 Dose to the Maximally Exposed Member of the Public 135
5.7.8.4 Evaluation Findings 136
5.7.8.5 References 136
5.7.9 Groundwater and Surface Water Monitoring Programs 137
5.7.9.1 Regulatory Requirements 137

5.7.9.2 Regulatory Acceptance Criteria ... 137
5.7.9.3 NRC Staff Review and Analysis ... 137
5.7.9.3.1 Mine Unit Operational Groundwater Monitoring ... 137
5.7.9.3.1.1 Establishment of Background Groundwater Quality ... 138
5.7.9.3.1.2 Wellfield Packages ... 139
5.7.9.3.1.3 Groundwater Excursion Monitoring and Corrective Action ... 140
5.7.9.3.2 Environmental Groundwater and Surface Water Monitoring Program ... 141
5.7.9.4 Evaluation Findings ... 142
5.7.9.5 References ... 144
5.7.10 Quality Assurance ... 144
5.7.10.1 Regulatory Requirements ... 144
5.7.10.2 Regulatory Acceptance Criteria ... 145
5.7.10.3 Staff Review and Analysis ... 145
5.7.10.4 Evaluation Findings ... 146
5.7.10.5 References ... 146
6.0 GROUNDWATER RESTORATION, RECLAMATION, AND DECOMMISSIONING ... 146
6.1 PLANS AND SCHEDULES FOR GROUNDWATER QUALITY AND RESTORATION ... 146
6.1.1 Regulatory Requirements ... 146
6.1.2 Regulatory Acceptance Criteria ... 147
6.1.3 Staff Review and Analysis ... 147
6.1.3.1 Restoration Standards ... 147
6.1.3.2 Restoration Methods ... 147
6.1.3.3 Pore Volume Estimates ... 148
6.1.3.4 Restoration Wastewater Disposal ... 149
6.1.3.5 Restoration Stability Monitoring ... 149
6.1.3.6 Well Plugging and Abandonment ... 150
6.1.3.7 Restoration Schedule ... 150
6.1.4 Evaluation Findings ... 151
6.1.5 References ... 151
6.2 PLANS FOR RECLAIMING DISTURBED LANDS ... 152
6.2.1 Regulatory Requirements ... 152
6.2.2 Regulatory Acceptance Criteria ... 152
6.2.3 NRC Staff Review and Analysis ... 152
6.2.4 Evaluation Findings ... 153
6.2.5 References ... 153
6.3 REMOVAL AND DISPOSAL OF STRUCTURES, WASTE MATERIAL, AND EQUIPMENT 154
6.3.1 Regulatory Requirements ... 154
6.3.2 Regulatory Acceptance Criteria ... 154
6.3.3 Staff Review and Analysis ... 154
6.3.4 Evaluation Findings ... 155
6.3.5 References ... 155
6.4 METHOLOGIES FOR POST RECLAMATION AND DECOMMISSIONING SURVEYS ... 156
6.4.1 Regulatory Requirements ... 156
6.4.2 Regulatory Acceptance Criteria ... 156
6.4.3 Staff Review and Analysis ... 156
6.4.3.1 Cleanup Criteria ... 157
6.4.3.2 Surface and Subsurface Soil Cleanup Verification and Sampling Plan ... 158
6.4.4 Evaluation Findings ... 158
6.4.5 References ... 158
6.5 FINANCIAL ASSURANCE ... 159
6.5.1 Regulatory Requirements ... 159
6.5.2 Regulatory Acceptance Criteria ... 159
6.5.3 Staff Review and Analysis ... 159
6.5.4 Evaluation Findings ... 161

6.5.5 References 162
7.0 ACCIDENTS 162
7.1 Regulatory Requirements 162
7.2 Regulatory Acceptance Criteria 162
7.3 NRC Staff Review and Analysis 162
7.3.1 Chemical Accidents 163
7.3.2 Radiological Release Accidents 164
7.3.3 Groundwater Contamination 165
7.3.4 Transportation Accidents 166
7.3.4.1 Chemical and Byproduct Material 166
7.3.4.2 Resin Transfer 167
7.3.5 Natural Disasters 167
7.4 Evaluation Findings 169
7.5 References 169

ABBREVIATIONS AND ACRONYMS

byproduct material Tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within this definition.

ac acre
ACL alternative concentration limit
ADAMS Agencywide Documents Access and Management System
ALARA as low as is reasonably achievable
ALI annual limit on intake
bgs below ground surface
cfm cubic feet per minute
CBR Crow Butte Resources, Inc.
CFR Code of Federal Regulations
cm centimeter
cm/s centimeters per second
CPF central processing facility
DAC derived air concentration
DOT Department of Transportation
dpm disintegrations per minute
EA environmental assessment
EPA U.S. Environmental Protection Agency
ºF degrees Fahrenheit
FEMA Federal Emergency Management Agency
FIRM Flood Insurance Rate Map
ft feet
ft msl feet above mean sea level
ft/d feet per day
ft/s feet per second
ft3/s cubic feet per second
gal gallon
gpm gallons per minute
GMS Groundwater Modeling System
GPS Global Positioning System
ha hectares
HDPE high density polyethylene
HPT health physics technician
in inches
IX ion exchange
ISR in situ recovery
kg kilograms
km kilometers
kPa/m kilopascals per meter
L liters
LC license condition
lb pound
Lpm liters per minute
LSA Low Specific Activity
m meters
m2/day square meters per day
m3 cubic meters
m3/s cubic meters per second
mg/L milligrams/liter

mi	miles
MIT	Mechanical Integrity Test
ML	maximum likelihood
m msl	meters above mean sea level
MPa	megapascals
mR	milliRoentgen
mrem	millirems
MS	management system
μCi/ml	microcurie per milliliter
NaI	sodium iodide
NDEQ	Nebraska Department of Environmental Quality
NDNR	Nebraska Department of Natural Resources
NE	Nebraska or northeast
NOGCC	Nebraska Oil and Gas Conservation Commission
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
MEA	Marsland Expansion Area
OSHA	Occupational Safety and Health Administration
Pb-210	lead-210
pCi/L	picocurie per liter
Po-210	polonium-210
psi	pounds per square inch
psi/ft	pounds per square inch per foot
PV	pore volume
QAP	Quality Assurance Program
QA/QC	Quality Assurance/Quality Control
R	Roentgen
Ra-226	radium-226
RAI	Request for Additional Information
RCRA	Resource Conservation and Recovery Act
RO	reverse osmosis
RSO	Radiation Safety Officer
RWPs	radiation work permits
SER	safety evaluation report
SERP	Safety and Environmental Review Panel
SHEQ	Safety, Health, Environment, and Quality
SOPs	standard operating procedures
SRWPs	standing radiation work permits
staff	NRC staff
TDS	Total Dissolved Solids
Th-230	thorium-230
TEDE	Total Effective Dose Equivalent
TLD	thermoluminescent detector
TR	technical report
U	uranium
U3O8	uranium oxide
UCL	upper control limit
UIC	Underground Injection Control
WL	working levels
WSSR	weighted sum of the squared residuals
yr	year

INTRODUCTION

By letter dated May 16, 2012, Crow Butte Resources, Inc. (the applicant or CBR) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to amend existing source materials license SUA-1534 to authorize construction and operation of a satellite facility, named the Marsland Expansion Area (MEA) (CBR, 2012). CBR plans to conduct in-situ uranium recovery (ISR) operations at the MEA and transport the recovered uranium to the currently licensed CBR facility for further processing.

The MEA application consists of a Technical Report (TR) and an Environmental Report (ER). The NRC staff performed an acceptance review and formally accepted the TR on October 5, 2012 (NRC, 2012). By letter dated July, 3, 2013, the NRC staff issued a request for additional information (NRC, 2013), to which the applicant responded by submitting a complete update to the TR by letter dated November 12, 2015 (CBR, 2015). By letters to the applicant dated April 21, 2016, and July 5, 2016, the staff identified open issues that required responses from the applicant to allow the staff to complete its technical review (NRC, 2016a, 2016b). The applicant responded to these open issues by submitting updated TR pages addressing the open issues by letters dated May 20, 2016 (CBR, 2016) and June 27, 2017 (CBR, 2017). Finally, the applicant submitted additional clarifications to its TR on August 31, 2017, October 26, 2017, October 31, 2017, and November 8, 2017 (CBR, 2017a, 2017b, 2017c, and 2017d).
The Atomic Energy Act of 1954, as amended by the Uranium Mill Tailings Radiation Control Act of 1978, authorizes the NRC to issue licenses for the possession and use of source material and byproduct material. The NRC must license ISR operations in accordance with NRC regulatory requirements to protect public health and safety from radiological hazards. Licenses for ISR operations are subject to safety requirements found in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, "Domestic Licensing of Source Material," and 10 CFR Part 20, "Standards for Protection Against Radiation." In accordance with 10 CFR 40.32, "General Requirements for Issuance of Specific Licenses," the NRC is required to make the following safety findings when issuing an ISR license:

> The application is for a purpose authorized by the Atomic Energy Act. The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life or property. The applicant's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property. The issuance of the license amendment will not be inimical to the common defense and security or to the health and safety of the public.

This Safety Evaluation Report (SER) documents the safety portion of the staff's review of the TR, as amended, and additional information, and includes an analysis to determine the applicant's compliance with applicable requirements in 10 CFR Part 40 and Appendix A to 10 CFR Part 40, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content," to 10 CFR Part 40. This SER also evaluates the applicant's compliance with applicable requirements in 10 CFR Part 20. In addition to the safety review documented in this SER, the staff is conducting a separate environmental review to evaluate potential environmental impacts associated with the proposed action.

Except where otherwise noted, the staff's safety review of the proposed MEA satellite facility was performed using NUREG- 1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications" (NRC, 2003). This SER is organized following the organization of NUREG-1569; however, sections of NUREG-1569 that address environmental issues are not included in the SER because they are addressed in the staff's environmental review.

The staff's review of the MEA TR identified a number of facility-specific issues that require license conditions to ensure that the operation of the facility will be adequately protective of public health and safety. Table 1 includes the license condition language as well as the section of this SER where the need for the license condition was identified. These conditions are in addition to those that currently exist in Materials License SUA-1534 (NRC, 2017). As discussed in this SER, many of the existing license conditions will also apply to the MEA. The staff concludes that the findings described in succeeding sections of this SER, including the necessary license conditions, supports the issuance of a license authorizing the construction and operation of the MEA. As such, the staff supports the issuance of the proposed license amendment authorizing the construction and operation of the MEA satellite facility, provided that the conditions identified below are included in the license. By e-mail dated XXXXXXXX, the applicant accepted all license conditions described in this SER (CBR, XXXX).

Table 1- MEA License Conditions

SER Section	License Condition
2.2.4	Prior to the commencement of construction related to NRC-licensed activities at the MEA, the licensee shall resume monitoring to collect additional meteorological data on a continuous basis at a data recovery rate of at least 90 percent until the licensee submits sufficient data and analysis to the NRC, and the NRC staff has provided written verification that the data are representative of the long-term conditions at the MEA. The data collected shall include, at a minimum, wind speed, wind direction, and an annual wind rose. When the licensee believes it has representative data, the licensee shall submit the data, a summary of the stability classification, and an analysis demonstrating that the data are representative of long-term conditions at the MEA.
2.4.4	The applicant shall minimize potential damage to infrastructure from peak flows by avoiding well installation within 100-year flood plains and areas of moderate to high risk of erosion and concentrated water flow during storm runoff. If the installation of wells in such locations cannot be avoided, adequate wellhead protection will be required to protect the wells during flood conditions. Prior to such installation, a description of wellhead protection measures that will be used to protect the wells during flood conditions shall be submitted to the NRC for review and written verification.

Table 1- MEA License Conditions	
SER Section	**License Condition**
2.5.4	Prior to the commencement of construction related to NRC-licensed activities at the MEA, the licensee shall provide the results of analysis of water samples from the Niobrara River collected quarterly at established sampling locations N-1 and N-2 for a period of one year and analyzed for the list of non-radiological constituents in Sections A, B and C of Table 2.7.3-1 of NUREG-1569. Analytical results for all samples shall be submitted to the NRC for review and written verification. Before implementing this sampling program, the licensee may submit to the NRC, for review and written approval, an alternate list of non-radiological constituents tailored to the MEA site, along with appropriate technical justification.
2.6.4	At least 90 days prior to the commencement of construction related to NRC-licensed activities at the MEA, the licensee shall collect and submit the results of preoperational soil and crop samples as described in the licensee's submittal dated June 27, 2017 (ML17193A311) to the NRC staff for review and written verification. Following NRC verification, the results of the preoperational soil samples shall be added to Appendix BB of the Marsland Technical Report, and the results of the preoperational crop samples shall be added to Appendix Q of the Marsland Technical Report, as described in the licensee's submittal dated June 27, 2017 (ML17193A311).
3.1.4	The licensee shall not construct a wellfield using either a staggered line drive or direct line drive design (i.e., one line or multiple parallel lines of production wells with a line of injections wells located on either side of and parallel to each line of production wells).
3.1.4	The licensee shall identify (1) the location, screen depth, and estimated pumping rate of any new permitted groundwater wells, and (2) any permitted change to the use of an existing groundwater well, for all groundwater wells within the MEA license area or within two kilometers of any proposed MEA production area monitoring well ring. The licensee shall evaluate the impact of ISR operations on groundwater quality for all users of groundwater wells within these areas and recommend any additional monitoring or other measures to protect groundwater users. These evaluations shall be submitted semiannually as part of the licensee's semiannual effluent and environmental monitoring program report.
4.2.4	The MEA satellite building throughput shall not exceed a maximum flow rate of 5,400 gallons per minute, excluding restoration flow.

Table 1- MEA License Conditions	
SER Section	**License Condition**
4.2.4	Prior to commencing injection of lixiviant in the first wellfield at the MEA, the licensee shall obtain and submit to the NRC a copy of the NDEQ Underground Injection Control (UIC) permit authorizing construction of a minimum of two UIC deep disposal wells. The licensee shall ensure that the deep disposal wells have enough combined capacity to handle the disposal of the total liquid effluent generation at the MEA from both production and restoration phases of operation. Prior to constructing a land application system or surge/solar evaporation ponds for liquid waste disposal at the MEA, the licensee must request and obtain a license amendment allowing the construction and use of such a system at the MEA.
4.2.4	The licensee shall dispose of solid byproduct material from the Crow Butte ISR facility and the MEA at a facility that is authorized by NRC or an NRC Agreement State to receive byproduct material. A copy of the licensee's approved solid byproduct material disposal agreement must be maintained at both the Crow Butte ISR facility and the MEA. If the agreement expires or is terminated, the licensee shall notify the NRC within seven working days after the date of expiration or termination, and shall submit a new agreement to the NRC within 90 days after expiration or termination. If the licensee does not submit a new agreement within 90 days, the licensee will be prohibited from further lixiviant injection until the licensee submits the new agreement to the NRC.
5.9.8.4	At least 60 days prior to the NRC staff's preoperational inspection for the MEA, the licensee shall submit a figure showing the air sampling locations of tank vents and general ventilation discharge points of the MEA satellite building to the NRC staff for review and written verification.
5.7.9.4	<u>Background Groundwater Quality (Replace LC 11.3C)</u> The samples shall be analyzed for ammonia, arsenic, barium, cadmium, calcium, chloride, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, pH, potassium, radium-226, selenium, sodium, sulfate, total carbonate, total dissolved solids, uranium, vanadium, zinc, and gross alpha.
5.7.9.4	At least 90 days prior to the planned start date of lixiviant injection in a new MEA wellfield, the licensee shall submit a wellfield package to the NRC for review and written verification. The licensee must receive written NRC verification of the wellfield package prior to injecting lixiviant into the mine unit.

Table 1- MEA License Conditions	
SER Section	**License Condition**
5.7.9.4	(Cont.) As part of developing its wellfield packages for new mine units at the MEA, the applicant shall perform an aquifer pumping test for each new mine unit. For mine units MU-D through MU-F, the licensee shall submit its plan for conducting the aquifer pumping test for NRC review and written verification at least 60 days prior to the planned date for performing the aquifer pumping test. For all mine units, each wellfield package, shall include (1) the information identified in Section 3.1.3 (p. 3-12) of the 2016 Response to Open Issues – Marsland Expansion Area Technical Report (ADAMS Accession No. ML16155A283), and (2) a discussion of the aquifer pumping test results and conclusions incorporating identified boundary conditions, fault-related flow effects, drawdown maps (relative to mean sea level), drawdown match curves, potentiometric surface maps (relative to mean sea level), water level graphs, and, when appropriate, directional transmissivity data and graphs, and other relevant data and data illustrations.
5.7.9.4	To ensure that the Basal Chadron Sandstone aquifer remains saturated during operations and restoration at the MEA, the licensee will monitor water levels semi-annually in dedicated, existing MEA monitoring wells 8 and 9 and in two additional monitoring wells to be installed in the Basal Chadron Sandstone aquifer. The two additional wells shall be located in NW ¼ of SW ¼ of Section 26, T30N, R51W and NW ¼ of SE ¼ of Section 26, T30N, R51W. At any time from the start of ISR operations at the MEA, if the overall average water level drawdown rate in any one of the four monitoring wells exceeds 10 ft/yr, or if the water level in any one of the four monitoring wells drops below 3539.0 ft above mean sea level, the licensee shall develop a corrective action plan addressing how compliance with these limits will be restored, and shall submit the plan to the NRC within 45 days for review and written approval. In addition, each year, as part of its semi-annual effluent and environmental monitoring program report that covers the third and fourth calendar quarters, the licensee shall document the semi-annual water level data in the four monitoring wells, present calculations of cumulative total water level drawdown and average drawdown rates for the complete period of record, and provide a written assessment of the drawdown in the Basal Chadron Sandstone aquifer at the MEA.

Table 1- MEA License Conditions	
SER Section	**License Condition**
6.5.4	At least 90 days prior to commencement of construction associated with NRC-licensed activities at the MEA, the applicant shall provide to the NRC for review and written approval an updated cost estimate that covers decommissioning and reclamation costs for the first MEA wellfield, along with a copy of the financial surety arrangement that covers those costs and that meets the requirements of Criterion 9 in 10 CFR Part 40, Appendix A. Updated cost estimates and financial assurance arrangements to cover the decommissioning and reclamation costs for subsequent wellfields at the MEA will be submitted in accordance with the update requirements in LC 9.5.

NRC finds that the applicant's technical report, provided as part of its application for a license amendment to construction and operate the MEA satellite facility, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended, and the Commission's regulations. Based on its review, as documented in this SER, the staff concludes that the MEA TR meets the applicable requirements in 10 CFR Parts 20 and 40. More specifically, in accordance with 10 CFR 40.32(b-c), the staff finds that the applicant is qualified by reason of training and experience to use source material for the purpose it requested and that the applicant's proposed equipment and procedures for use at its MEA facility are adequate to protect public health and minimize danger to life or property. In accordance with 10 CFR 40.32(d), staff finds that the amendment of the license to the applicant will not be inimical to the common defense and security or to the health and safety of the public.

References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2017a. Facsimile from W. Nelson, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, Marsland quality assurance program, November 8, 2017, ADAMS Accession No. ML17319A211.

CBR, 2017b. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to U.S. NRC, Request for Additional Clarification for Response to License Condition 11.10, October 31, 2017, ADAMS Accession No. ML17313A803.

CBR, 2017c. E-mail from L. Teahon, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, MEA Open Issues, October 26, 2017, ADAMS Accession No. ML17300A277.

CBR, 2017d. Email from L. Teahon, Crow Butte Resources, Inc., Crow Butte Operation, to T. Lancaster, U.S. NRC, MEA TR Replacement Pages, August 31, 2017, ADAMS Accession No. ML17251A260.

CBR, 2017e. Response to Open Issues – Marsland Expansion Area Technical Report, Crow Butte Resources, Inc., Crawford, Nebraska, June 27, 2017, ADAMS Accession No. ML17193A311 (Package).

CBR 2016. Response to Open Issues – Teleconference on April 6, 2016. Crow Butte Resources, Inc., Crawford, Nebraska, May 20, 2016, ADAMS Accession No. ML16155A283 (Package).

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

CBR, 2013. Volume 1 Technical Report-Response to RAI Dated July 3, 2013, Application for Amendment of USNRC Source Materials License SUA-1534, Marsland Expansion Area, Crawford, Nebraska, December 23 2013, ADAMS Accession No. ML14008A171 (Package).

CBR, 2012. Crow Butte Resources, Inc., Application for an Amendment to UNSRC Source Materials License SUA-1534 – Marsland Expansion Area, May 16, 2012, ADAMS Accession No. ML12160A512.

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc. Crawford Nebraska, SUA-1534, October 5, 2017, ADAMS Accession No. ML17062A606 (package).

NRC, 2016a. Summary of June 14, 2016, Teleconference Marsland Open Issues, July 5, 2016, ADAMS Accession No. ML16176A198

NRC, 2016b, Summary of April 6, 2016, Teleconference Regarding Marsland Open Issues, April, 21, 2016, ADAMS Accession No. ML16109A304

NRC, 2013. Request for Additional Information on the Marsland Expansion Area, July 3, 2013, ADAMS Accession No. ML13177A344

NRC, 2012. Letter to CBR, Acceptance Review, License Amendment Application for the North Trend Expansion Area, Crow Butte Resources, Inc., Crawford, Nebraska, October 5, 2012. ADAMS Accession No. ML12285A142.

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report,” June, 2003, ADAMS Accession No. ML032250177.

1.0 PROPOSED ACTIVITIES

1.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant’s summary of the proposed activities at the MEA is in compliance with the applicable requirements in 10 CFR 40.31.

1.2 Regulatory Acceptance Criteria

The MEA Technical Report (TR) was reviewed for compliance with the applicable requirements of 10 CFR 40.31 using the acceptance criteria presented in Section 1.3 of NUREG-1569 (NRC, 2003).

1.3 Staff Review and Analysis

1.3.1 Facility Description

The applicant seeks to extract uranium from an ore body located in the MEA using ISR methods (CBR, 2015). Uranium extracted from the MEA will be processed at a satellite building located within the MEA. This facility will operate at overall average production flow rate of 22,710 liters per minute (lpm) (6,000 gallons per minute (gpm)) with an expected annual production rate of 272,155 kilograms (kg) (600,000 pounds (lbs) of triuranium octoxide (U_3O_8) (CBR, 2015). Total reserves for the MEA are estimated by CBR as approximately 4,332,350 kg (9,551,197 lbs) of uranium ore as U_3O_8 (CBR, 2015).

The proposed MEA encompasses approximately 1,870.6 hectares (ha) (4,622.3 acres (ac)) (CBR, 2015). The facility will potentially consist of 11 mine units, and the total area of all mine units will occupy approximately 709 ha (1,753 ac) based on the applicant's current knowledge of available reserves. The proposed MEA is located within sections 26, 35, 36 of T30N, R51W; sections 1, 2, 11, 12, 13 of T29N R51W; and sections 7, 18, 19, 20, 29, 30 of T29N, R50W. All of the mineral resources leased within the MEA are privately owned with the exception of the SW ¼ section of section 36 of T30N, R51W, wherein the surface and mineral rights are leased by CBR from the State of Nebraska. TR Figure 1.3-1 (CBR 2015) shows the general location of the current licensed CBR facility area and the proposed MEA. TR Figure 1.3-2 (CBR, 2015) shows the land ownership in the proposed MEA.

1.3.2 General Operations

In the MEA, uranium will be recovered from the Basal Chadron Sandstone (CBR, 2015). The depth of the Basal Chadron Sandstone in the MEA ranges from 259 m to 366 m (850 ft to 1200 ft). The width varies from 305 m to 1219 m (1000 ft to 4,000 ft). The ore body ranges in grade from less than 0.11% to 0.33% U_30_8, with an average grade estimated at 0.22% U_30_8. Under the terms of the current CBR license (NRC, 2017), the applicant is currently authorized to inject lixiviant that contains either sodium carbonate or sodium bicarbonate and either oxygen or hydrogen peroxide at the currently licensed CBR facility, and the applicant has not requested a different lixiviant composition for the MEA.

Uranium extracted from the MEA will be loaded onto ion exchange (IX) resin at the satellite building (CBR, 2015). The loaded IX resin will be transported, by tanker truck, to the currently licensed CBR facility central processing facility (CPF) for elution, drying and packaging. Stripped resin will be returned to the MEA satellite building by tanker truck. (CBR, 2015). The applicant states that an anticipated barren lixiviant production bleed of 0.5 to 2.0 percent will be used to operate the wellfields (CBR, 2015). By withdrawing slightly more lixiviant than is injected, an inward hydraulic gradient would be maintained in each wellfield. This inward hydraulic gradient is used to prevent excursions (CBR, 2015).

In Section 1.8.1, the applicant states that liquid waste will be disposed of through deep disposal well (DDW) injection (see Figure 1.7-5 in CBR, 2015) without supporting surge/evaporation ponds or surge tanks. The applicant also stated in TR Section 4.2.1.9 (CBR, 2015) that at this time, CBR does not intend to apply for an NPDES permit to allow land application at the MEA. Because the current license only authorizes use of land application and evaporation ponds at the currently licensed CBR facility, the applicant would have to request and receive a separate license amendment if it decides in the future to use land application or surge/evaporation ponds at the MEA.

1.3.3 Schedule

In TR Figure 1.7-4, the applicant presented schedules for production and restoration for each proposed mine unit (CBR, 2015). The NRC staff considers groundwater restoration in wellfield part of decommissioning under 10 CFR 40.42, and therefore the timely decommissioning requirements apply. As shown on this figure, for each mine unit, production is projected to occur over a period of approximately four to six years followed by approximately three to four years of restoration. Past experience with restoration at the currently licensed CBR facility indicates that restoration requires more than three years to complete. If restoration will require more than 24 months (two years) to complete, an alternate schedule must be requested per 10 CFR 40.42.

1.3.4 Description of Groundwater Restoration and Decommissioning

As illustrated in TR Figure 1.7-4 (CBR, 2017), the groundwater restoration program at the MEA will be implemented concurrent with uranium extraction and will continue after uranium extraction is concluded. The approved CBR restoration plan consists of four steps:

Groundwater transfer
Groundwater sweep
Groundwater treatment
Wellfield recirculation

For each wellfield, once the restoration values in 10 CFR Part 40, Appendix A, Criterion 5B(5) are reached and maintained, results will be documented in a restoration report and submitted to the NRC (CBR, 2017).

After groundwater restoration has been completed and the licensee has received NRC approval of the restoration report for a wellfield, all injection and recovery wells will be plugged and the wellfield will be decommissioned (CBR, 2015). Final, site-wide decommissioning will include satellite building disassembly and disposal, and land reclamation of all disturbed areas. Appropriate NRC Regulatory Guidelines will be followed as required (CBR, 2015).

1.3.5 Financial Assurance

The applicant maintains a financial surety arrangement to cover the estimated costs of decommissioning and reclamation activities at the currently licensed CBR facility. The financial surety arrangement is an Irrevocable Standby Letter of Credit issued by the Royal Bank of Canada in favor of the State of Nebraska. At least 90 days prior to the beginning of construction related to licensed activities at the MEA, a copy of the financial arrangement that covers the estimated costs of decommissioning and reclamation of the first wellfield at the MEA, along with an updated cost estimate, will be submitted to the NRC for review and approval. Subsequently, the surety amount will be revised to reflect the estimated costs of decommissioning and reclamation activities for additional wellfields at the MEA as development activities proceed.

1.4 Evaluation Findings

The staff reviewed the proposed activities at the MEA in accordance with review procedures in Section 1.3 of the standard review plan. Information contained in the TR described the proposed activities at the MEA facility, including: (1) the corporate entities involved (discussed in Introduction), (2) the location of the facility, (3) land ownership, (4) ore-body locations, (5) the proposed recovery process, (6) operating plans and design throughput, (7) schedules for construction, startup, and duration of operations, (8) waste management and disposal plans, and (9) financial assurance.

Based upon the review conducted by the staff as indicated above, the information provided in the TR meets the applicable acceptance criteria of Section 1.3 of the standard review plan and the requirements of 10 CFR 40.31.

1.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, “Standards for Protection Against Radiation,” U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

CBR, 2017. Cameco Resources, Inc. - Response to Open Issues - Marsland Expansion Area Technical Report, Teleconference on June 14, 2016, Crow Butte Resources, Inc., Crawford, Nebraska, Crow Butte Resources, Inc., June 27, 2017, ADAMS Accession Nos. ML17193A311 (package).

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc. Crawford Nebraska, SUA-1534, October 5, 2017, ADAMS Accession No. ML17062A606 (package).

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report,” June, 2003, ADAMS Accession No. ML032250177.

2.0 SITE CHARACTERIZATION

2.1 SITE LOCATION AND LAYOUT

2.1.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has adequately identified the site location and layout in accordance with the requirements of 10 CFR 40.32(c).

2.1.2 Regulatory Acceptance Criteria

The MEA TR was reviewed for compliance with the requirements of 10 CFR 40.32(c) using the acceptance criteria presented in Section 2.1.3 of NUREG-1569 (NRC 2003).

2.1.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by the applicant in the MEA TR (CBR, 2015). The MEA is located in southwestern Dawes County, in northwestern Nebraska. TR Section 1.3 (CBR, 2015) indicated that the proposed MEA satellite building is located approximately 7.4 kilometers (km) (4.6 miles) northeast of the unincorporated community of Marsland, Nebraska, and is approximately 17.9 km (11.1 mi) south-southeast of the central processing facility (CPF) at the currently licensed CBR facility (CBR, 2015). Using Google Earth, the NRC staff determined that the northern license boundary of MEA is approximately 10.4 km (6.5 mi) south-southeast of the southern license boundary of the currently licensed CBR facility. Google Earth also indicates that the MEA is approximately 40 km (25 mi) southwest of Chadron, Nebraska, 77.2 km (48 mi) north of Scottsbluff, Nebraska, approximately 58 km (36 mi) south of the South Dakota state line, and 65 km (40 mi) east of the Wyoming state line. TR section 2.4.2.3 indicates that the topography of the MEA area consists of flat to rolling hills dissected by tributaries of the Niobrara River (CBR, 2015).

TR Figure 1.7-3 (CBR, 2015) shows the general location of the proposed MEA and the 3.2-km (2.0-mi) review area associated with the MEA. The proposed MEA is located within land survey sections 26, 35, 36 of T30N, R51W, sections 1, 2, 11, 12, 13 of T29N R51W; and 7, 18, 19, 20, 29, 30 of T29N, R50W. All of the minerals leased in the MEA are on private lands, with the exception of the southwest quarter section of section 36 of T30N, R51W. That quarter section is designated as State Trust Land and is a small part of land now held by the Board of Educational Lands and Funds. TR Figure 1.3-2 (CBR, 2015) shows the surface land ownership in the MEA.

TR Figure 1.7-5 (CBR, 2015) presents the MEA topography and layout with the proposed location of the licensed boundary, the satellite building, six deep disposal wells (two DDWs are initially proposed for MEA, refer to SER Section 4.2), and 11 proposed mine units. TR Figure 5.7-2 (CBR, 2015) shows the satellite building structure in more detail and identifies the restricted area. The elevation of the MEA ranges from 1182 to 1341 meters (m) above mean sea level (3,880 to 4,400 feet (ft) above mean sea level) with the higher elevations found to the north side of the MEA.

TR Figure 1.3-1 (CBR, 2015) presents the project location in relation to the currently licensed CBR facility along with topographical features, drainage and surface water features, nearby population centers and political boundaries, as well as principal highways, railroads, transmission lines, and waterways. Nearby major transportation links include Nebraska State Routes 2/71, and the Burlington Northern Railroad.

TR Table 2.2-7 presents the distance between the center of the site and the nearest residences for the each of the 16 cardinal directions (CBR, 2015) within a 3.62 km (2.25 mi) radius of the MEA boundary. TR Figure 2.2-2 (CBR, 2015) provides an aerial depiction of the location of rural residences within and near the 3.62 km (2.25 mile) review area. The NRC staff’s review of this table and figure indicates that the residences nearest to the site are located within the site boundary approximately 936 m (3,070 ft) east of the center of the MEA. No residences were identified in the north, north-northeast, east-northeast, east-southeast, southwest, west, and northwest directions of the review area.

TR Table 2.2-11 (CBR, 2015) provides well depths of active, inactive, and abandoned wells in the vicinity of the MEA to the extent that data was available to the applicant. Lease agreements prevent new wells from being installed within the MEA license area without CBR permission. Additionally, CBR will review the Nebraska Department of Natural Resources (NDNR) registered well database annually and will make arrangements, where appropriate, to monitor any new wells identified within the 3.62 km (2.25 mile) review area surrounding the MEA boundary.

2.1.4 Evaluation Findings

The NRC staff has reviewed the site location and layout of the MEA in accordance with the review procedures in Section 2.1.2, and the acceptance criteria in Section 2.1.3, of the standard review plan (NRC, 2003). The applicant has described the site location and layout with appropriately scaled and labeled maps showing the site layout, principal facilities and structures, boundaries, and topography.

Based upon the review conducted by NRC staff as indicated above, the NRC staff finds the information provided in the TR is sufficient and meets acceptance criteria of Section 2.1.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the license will comply with the requirements of 10 CFR 40.32(c) with respect to the location of the site and layout.

2.1.5 References

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

2.2 METEOROLOGY

This section describes the NRC staff's evaluation of the applicant's description of the meteorological conditions of the region surrounding and including the MEA. In the context of the staff's safety analysis, meteorological data are relevant to the selection of environmental monitoring locations and the performance of radiological dose assessments.

2.2.1 Regulatory Requirements

The staff determines whether the applicant has demonstrated that the meteorology program, which is part of the site monitoring programs required by Criterion 7 of Appendix A to 10 CFR Part 40, is sufficiently complete to allow for estimating doses to workers and members of the public.

2.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed to ensure that the facility will operate in a manner that protects health and safety using the acceptance criteria presented in Section 2.5.3 of NUREG-1569 (NRC, 2003).

2.2.3 Staff Review and Analysis

The following sections present the staff's review and analysis of the applicant's description of various aspects of the regional climatology and site-specific meteorology at the MEA facility. The information reviewed in this section is from information, data, and maps submitted by CBR in Section 2.5 of the MEA TR (CBR, 2015). Topics discussed in the following sections include: (1) general regional and site conditions, including wind direction analysis; (2) meteorological data acquisition, including descriptions of the instrumentation, instrumentation calibration information, and instrumentation placement; (3) mixing layer heights; and (4) atmospheric dispersion characteristics of the site. Severe weather (i.e., tornadoes) is discussed in Chapter 7 of the SER.

2.2.3.1 General Regional and Site Conditions

In Section 2.5 of the MEA TR (CBR, 2015), the applicant provided information on local and regional meteorological conditions. Because the information provided on temperature, heating/cooling/growing degree days, relative humidity, and precipitation is not relevant to the applicant's selection of environmental monitoring locations or dose assessments, the staff did not independently evaluate that information as part of its safety review. Also, because there are no evaporation ponds currently planned for the MEA, the staff did not independently evaluate the information provided on evapotranspiration. The staff's evaluation in this section focuses on the applicant's description of meteorological conditions at the MEA related to atmospheric stability class, wind speed and wind direction, and mixing heights, which was used by the applicant to identify MEA air sampling locations for environmental monitoring and to estimate radiation doses resulting from licensed activities at the MEA. The staff's reviews of the applicant's environmental monitoring program and dose estimates are provided in SER Sections 2.6, 5.7.5, and 5.7.8.

<u>Geography and Topography</u>

The applicant states in TR Section 2.5.3.1 (CBR, 2015), that the MEA and the Scottsbluff, Nebraska airport (located 48 miles south of MEA) have comparable elevation and topographic features, with the surrounding areas characterized by rolling hills and flat plains bordered by small ridges and breaks with ephemeral drainages. In TR Section 2.5.3.9 (CBR, 2015), the applicant discussed topographic and hydrologic features that could substantively affect the meteorology in the vicinity of the MEA. The applicant indicated that the nearest mountain ranges to the MEA are the Laramie Mountains, approximately 100 miles to the west, and the Black Hills, approximately 65 miles to the north (CBR, 2015). The applicant states that at such long distances, these mountain ranges have minimal impact on the meteorology of the MEA. In addition, the only significant nearby water body is the Niobrara River, which flows easterly through a point approximately 4 miles south of the MEA (CBR, 2015). The applicant states that Niobrara River (hydrological feature) is a small size stream of limited areal extent (average flow rate of 29 cfs) (CBR, 2015). The NRC staff reviewed this information, topographic maps, and the location of nearby bodies of water shown in TR Figures 2.5-1 through 2.5-3 (CBR, 2015) and agrees with the applicant's conclusion that these topographic and hydrologic features should not substantively affect the meteorology and the atmospheric transport and diffusion conditions at the MEA.

Temperature

The applicant states in TR Section 2.5.3.2 (CBR, 2015) that the annual average temperature at the MEA is similar to the regional average temperature at approximately 7.8°C (46°F). The applicant provided average, minimum and maximum monthly temperature data for the 1-year baseline monitoring period in TR Table 2.5-5 and TR Figure 2.5-19 (CBR, 2015). The applicant also provided the maximum and minimum monthly temperature data for Scottsbluff regional airport during the MEA baseline year monitoring period in TR Table 2.5-2 (CBR, 2015). However, since the temperature data are not used by the applicant to design safety-related equipment (e.g., solar evaporation ponds) and are not relevant to the applicant's safety analysis, the staff did not independently evaluate the applicant's temperature data.

Relative Humidity

The average, maximum, and minimum relative humidity over the 1-year baseline monitoring at the MEA are provided in TR Table 2.5-6 (CBR, 2015). However, since the relative humidity data are not used by the applicant to design safety-related equipment (e.g., solar evaporation ponds) and are not relevant to the applicant's safety analysis, the staff did not independently evaluate the applicant's relative humidity data.

Precipitation

In Section 2.5.3.4 of the MEA TR (CBR, 2015), the applicant states that the total precipitation for the MEA baseline monitoring year was 45.7 cm (18 inches), although 24.5 cm (10 inches) fell during an abnormally wet month of May 2011. The applicant also stated that based on long-term records from other weather stations in the region, the annual precipitation recorded during the baseline monitoring year at the MEA is probably not representative of the long-term average, and that an annual average of 38 cm (15 inches) is more likely. In TR Section 2.5.2, the applicant states that the regional precipitation totals typically range from 33 to 38 cm (13 to 16 inches) per year, and in Section 2.5.2.3, the applicant states that the Scottsbluff airport (located 77 km (48 miles) south of the MEA) receives annual average precipitation of 38.6 cm (15.2 inches) per year (CBR, 2015). Based on the data provided, the NRC staff finds that the applicant's estimate of 38 cm (15 inches) of annual average precipitation at the MEA is reasonable.

Heating, Cooling, and Growing Degree Days

The applicant states in TR Section 2.5.2.5 (CBR, 2015) that the Scottsbluff airport data for monthly heating, cooling, and growing degree days are assumed to be indicative of the MEA project area due to its proximity and comparable elevation. The applicant did not provide site-specific data for MEA, but such data are not necessary because they are not relevant to the applicant's safety analysis.

Evapotranspiration

In TR Section 2.5.3.5 (CBR, 2015), the applicant states that the daily evapotranspiration rates were calculated for the MEA using the Penman Equation and then summed for each month. Based on a review of Jensen et al. (1990) and Rosenberg et al. (1983), the staff finds the Penman equation to be a reasonable methodology for calculating evapotranspiration rates. The applicant also stated that the annual evapotranspiration rate for the MEA was computed to be approximately 152 cm (60 inches), which compares favorably with a long-term calculated average of 68 inches at the Scottsbluff airport (CBR, 2015). However, since daily, monthly, or annual evapotranspiration rates are not a consideration in the applicant's safety analysis (e.g., there are no solar evaporation ponds at the proposed MEA for which evapotranspiration would be a design parameter), the NRC staff did not perform a detailed independent evaluation of the applicant's estimates of evapotranspiration rates. However, the staff finds that the estimate of 152 cm (60 inches) per year at the MEA is rational for the reasons stated by the applicant.

Wind Speed and Wind Direction

The applicant provided monthly average, maximum, and minimum wind speeds for the Scottsbluff airport in TR Table 2.5-3 (CBR, 2015) and stated that the overall average wind speed was 14.3 km/hr (8.9 mph) for the 1996–2011 period. Mean monthly average wind speeds were lowest in the summer months and highest in the month of April. TR Figure 2.5-15 (CBR, 2015) presented a wind rose for the 15-year Scottsbluff airport National Weather Service (NWS) data indicating that predominant winds are from WNW-NW.

In TR Table 2.5-4 (CBR, 2015), the applicant provided 15-year frequency distributions of wind speed and wind direction from the Scottsbluff airport that show the dominant wind directions for that location. TR Section 2.5.3.3 (CBR, 2015) stated that during periods of fair weather, particularly in late-spring and the summer months, high pressure located over the northern plains produces moderate SE winds in the MEA; synoptic weather systems generally interrupt this pattern, producing high NNW winds. Low pressure regions develop on the lee side of the Rockies, bringing SE winds during storm development. As the low-pressure systems form and move off with the general atmospheric flow, winds switch to a NNW direction. The spring season displays the greatest variability in wind direction. During all seasons, wind speeds peak during the afternoon. Winds during the summer remain less than 19.3 km/hr (12 mph), while nighttime winds average 12.8 to 16 km/hr (8-10 mph) throughout the year.

The applicant provided annual and seasonal joint frequency distributions (JFDs) of wind speed by wind direction and atmospheric stability class in TR Tables 2.5-9 through 2.5-13 (CBR, 2015) based on one full year of on-site data with a joint frequency data recovery in excess of 90 percent. The applicant provided a wind rose for the MEA during the 1-year baseline monitoring period in TR Figure 2.5-20 and TR Table 2.5-7 (CBR, 2015), while TR Figure 2.5-21 (CBR, 2015) shows seasonal wind roses for the project area. The staff examined this information and concurs that the predominant wind direction is NNW-NW with the highest wind speeds also coming from those directions. The staff also examined TR Figure 2.5-22 (CBR, 2015), which presented a diurnal graph of wind speeds at the MEA by season, and TR Figure 2.5-23 (CBR, 2015), which shows the time distribution of wind speeds at the project site.

2.2.3.2 Meteorological Data Acquisition

The applicant established a program to collect meteorological data at the MEA and collected one year of on-site data from August 24, 2010 through August 29, 2011. TR Table 2.5-14 (CBR, 2015) identified the meteorological parameters that were measured. Parameters measured at the MEA included wind speed, wind direction, an indicator of atmospheric stability (i.e., sigma theta), ambient temperature, relative humidity, total precipitation, and solar radiation. This table also described the instrumentation employed and the measurement accuracy of the instrumentation. TR Appendix B (CBR, 2015) provided information on the instrument calibrations performed during the one year of monitoring, while TR Appendix R (CBR, 2015) discusses the siting of the meteorological tower and its instrumentation, which meet Regulatory Position (2) and (4) in

Regulatory Guide 3.6.3 (NRC, 1988). The applicant states in TR Section 2.5.3.7 (CBR, 2015) that data recovery exceeded 97 percent for the 12-month monitoring period.

With respect to siting considerations, the staff has determined that the guiding principles were met and that the tower and instruments appear to be appropriately sited. TR Table 2.5-14 (CBR, 2015) identified a free-standing self-supporting 10-meter (33-foot) aluminum tower with typical sets of instruments. The applicant provided sufficient information to establish that wind speed and wind direction were monitored at approximately the 10-meter (33-foot) level and located on appropriately-sized booms that meet the guidance in Regulatory Guide 3.63 (NRC, 1988) Section C.2. Additionally, the applicant demonstrated that although the wind sensor electrical range is limited to 356 degrees azimuth, it did not affect the accuracy of the wind direction data.

In TR Section 2.5.1 (CBR, 2015), the applicant states that in order to corroborate the conclusions drawn regarding temporal representativeness, 12 years of hourly data that had been collected from the Chadron airport, located 30 miles to the northeast of MEA, were compiled and analyzed. The Chadron airport data represented a monitoring period from January 1, 2001 through December 31, 2012. The results of the Chadron data analysis were provided in TR Appendix S (CBR, 2015), which presented regression analyses for both Scottsbluff and Chadron airports with associated p-values. With the consideration that both of these airport sites are flat or exhibit mildly rolling terrain and are similar in elevation, the applicant concluded that the consistently low p-values render the high coefficients of determination statistically significant.

In TR Sections 2.5.1 and 2.5.3.6 (CBR, 2015), the applicant analyzed the Scottsbluff airport site 2010–2011 baseline year and historical 15-year data. The applicant applied a linear regression analysis whereby the wind speed and wind direction variables of the two compared data sets were isolated and the existence of a correlation was determined based on the results of a least squares fit.

TR Figures 2.5-27 through 2.5-30 (CBR, 2015) showed wind roses, a wind direction frequency distribution, and a wind speed frequency distribution for Scottsbluff airport. The applicant states in TR Section 2.5.3.6 (CBR, 2015) that TR Figures 2.5-30 and 2.5-31 (CBR, 2015) offer conclusive evidence that the 2010–2011 baseline monitoring year adequately represents the long-term wind speed and wind direction conditions at the Scottsbluff airport. The applicant claimed that because the 1-year wind data serve as reliable predictors of the long-term wind conditions at the Scottsbluff airport, and since the MEA experiences similar regional weather patterns, the applicant proposed that the 1-year baseline monitoring data represent long-term meteorological conditions at the MEA. The NRC staff notes that although the data recovery for monitored parameters shown in TR Table 2.5-6 (CBR, 2015) satisfies the greater than 90 percent data recovery in Regulatory Guide 3.63 (NRC, 1988), the analysis used for demonstrating that 1-year baseline monitoring data represent long-term meteorological conditions (TR Appendix S in CBR, 2015) is not satisfactory. In a similar situation involving the Strata Ross ISR facility license application, the NRC staff determined that neither linear regression nor correlation analyses are appropriate statistical tests for representativeness of data sets (NRC, 2014). While linear regression and correlation analyses describe relationships between variables, a statistical test for representativeness requires an analysis of data populations (e.g., short- and long-term wind data at a given site) (NRC, 2014). Thus, the NRC staff is imposing a license condition requiring continued monitoring to substantiate that the data collected at the MEA and used for assessing radiological impacts is representative of expected long-term conditions at and near the site. This license condition is presented in SER Section 2.2.4.

The NRC staff has reviewed the baseline meteorological monitoring program conducted by the licensee, and in conjunction with the license condition that will require the applicant to continue monitoring wind speed, wind direction, and atmospheric stability at the MEA to demonstrate representativeness of long-term meteorological conditions, finds that it meets acceptance criteria (1) and (3) presented in Section 2.7.3 of NUREG-1569 (NRC, 2003). The NRC staff also finds that the MEA meteorological program discussed above is consistent with the four Regulatory Positions in RG 3.63 (NRC, 1988).

2.2.3.3 Mixing Layer Heights

In TR Section 2.5.3.8, the applicant states that it used the100-meter (328-foot) default value for mixing height in its MILDOS-AREA calculations (CBR, 2015). The applicant indicated that the nearest NWS station with available upper-air data is located in Rapid City, South Dakota, approximately 173.8 km (108 miles) north of the MEA. The applicant states that it derived mixing height values for Rapid City, shown in TR Table 2.5-15, using AERMOD calculations (CBR, 2015). The applicant also stated that because lower mixing heights lead to less pollutant dispersion, its use of the lower 100 m (328 ft) default value at the MEA (compared with the values derived for Rapid City), resulted in conservatively high dose concentration calculations using MILDOS-AREA. The staff reviewed the annual morning and afternoon mixing heights for Rapid City, South Dakota in Table B.1 of a U.S. Environmental Protection Agency (EPA) study (EPA, 1972) to validate the applicant's derived values on mixing heights presented in TR Table 2.5-15 (CBR, 2015) (i.e., 333 m (1,092.5 ft) in the morning and 1,547 m (5,075 ft) in the afternoon). In both cases, the annual mixing heights for morning and afternoon were much higher than the MILDOS-AREA default value, which makes the use of the lower default value height in this instance more conservative. The NRC staff agrees with the applicant that use of a lower mixing height is conservative for dose calculations because there is less dispersion, and therefore using the default here is conservative because it is less than the mixing height that would otherwise be considered appropriate to use. Accordingly, the staff finds the applicant's use of the default mixing height of 100 m (328 ft) in the MILDOS-AREA computations acceptable. The NRC staff also finds that the applicant's description of mixing layer heights meet acceptance criteria (1) of Section 2.5.3 in NUREG 1569 (NRC, 2003)

2.2.3.4 Atmospheric Dispersion Characteristics

The staff reviewed the detailed presentation in TR Appendix M (CBR, 2015), which provides the MEA's meteorological input parameters used in the applicant's MILDOS-AREA calculations. The applicant presented the JFDs for wind speed, wind direction, and atmospheric stability in TR Table 2.5-9 (CBR, 2015).

The staff also reviewed the description of the regional climatology (Section 2.5.3 of CBR, 2015), and agrees with applicant's conclusion that the MEA was relatively windy, with a high frequency of D stability class conditions which would be conducive to generally good atmospheric dispersion conditions. The staff concludes that the applicant has provided an adequate description of atmospheric dispersion parameters for the baseline year at the MEA.

2.2.4 Evaluation Findings

NRC staff reviewed the meteorological data submitted by the applicant for the proposed MEA facility in accordance with Sections 2.5.2 and 2.5.3 of NUREG-1569 (NRC 2003).

The applicant has acceptably described the MEA meteorology by providing data on: (1) temperature, (2) relative humidity, (3) precipitation, (4) heating, (5) cooling, and growing degree days, (6) wind direction, wind speed and an indicator of atmospheric stability class, (7) period of record, (8) height of the meteorological tower and associated instrumentation, and (9) average mixing height.

Based on the NRC staff review documented in the SER, the NRC staff finds that the applicant properly collected one year of meteorological data, but did not substantiate that the data collected at the MEA and used for assessing radiological impacts was representative of expected long-term conditions at and near the site. Therefore, the NRC staff is including the following license condition:

> Prior to the commencement of construction related to NRC-licensed activities at the MEA, the licensee shall resume monitoring to collect additional meteorological data on a continuous basis at a data recovery rate of at least 90 percent until the licensee submits sufficient data and analysis to the NRC, and the NRC staff has provided written verification that the data are representative of the long-term conditions at the MEA. The data collected shall include, at a minimum, wind speed, wind direction, and an annual wind rose. When the licensee believes it has representative data, the licensee shall submit the data, a summary of the stability classification, and an analysis demonstrating that the data are representative of long-term conditions at the MEA.

The applicant has provided acceptable descriptions for adequate siting of instruments on the meteorological tower, instrument accuracy, and the construction of JFDs. The JFD information presented is for a period of one year, with a joint data recovery exceeding 90 percent.

The applicant noted that there are no effects of nearby water bodies or terrain on meteorological measurements, and staff concurs with this conclusion based on the distance of major topographic features from the site and the minimal presence of bodies of water which could impact the local meteorology.

Based on the information provided in the TR and the detailed review conducted by the staff of the applicant’s description of meteorology at the MEA, and in conjunction with the license condition that will require the applicant to continue monitoring wind speed, wind direction, and atmospheric stability at the MEA to demonstrate representativeness of long-term meteorological conditions, the NRC staff concludes that the applicant has provided a description of the MEA meteorology that is consistent with the acceptance criteria presented in Section 2.5.3 of NUREG-1569 (NRC, 2003) and that meets the requirements of Criterion 7 of Appendix A to 10 CFR Part 40.

2.2.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

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Jensen, M.E., R.D. Burman, and R.G. Allen 1990, "Evapotranspiration and Irrigation Water Requirements," ASCE Manuals and Reports on Engineering Practice No. 70, American Society of Civil Engineers, NY, 322 pp.

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2.3 GEOLOGY AND SEISMOLOGY

2.3.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has provided sufficient characterization of geology and seismology at the MEA for the NRC staff to be able to assess the applicant's ability to control production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

Section 2.6.4 of NUREG-1569 (NRC, 2003) identifies or describes the following regulatory requirements applicable to the NRC staff's review of geology and seismology at ISR facilities: 10 CFR 40.31(f) and 10 CFR Part 40, Appendix A, Criteria 4(e) and 5G(2).

The requirement in 10 CFR 40.31(f) pertains to the NRC staff's environmental review and is not applicable to this safety review. Criterion 4(e) of 10 CFR Part 40, Appendix A requires that a surface impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. Because there are no surface impoundments proposed for the MEA, and because there is no evidence of capable faults in the vicinity of the MEA, this requirement is not applicable to this review. Criterion 5G(2) of 10 CFR Part 40, Appendix A applies to tailings disposal systems, which are not used at ISR facilities such as the MEA. Therefore, Criterion 5G(2) is also not applicable to the technical review of the proposed MEA.

Therefore, because the above requirements do not apply, the NRC staff's review in this section addresses the applicant's ability to control production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

2.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, the NRC staff reviewed the applicant's characterization of geology and seismology at the MEA for compliance with 10 CFR 40.41(c) using acceptance criteria 1 through 11 presented in Section 2.6.3 of NUREG-1569 (NRC, 2003).

2.3.3 NRC Staff Review and Analysis

The following sections present the NRC staff's review and analysis of the following aspects of the geology and seismology of the MEA: regional geology, site geology, soils, mineralogy, exploration boreholes, and seismology. The NRC staff's review in this section is based on information, data, and maps submitted by CBR in the MEA TR (CBR, 2015) and as updated (CBR, 2016 and CBR, 2017).

2.3.3.1 Regional Geology

2.3.3.1.1 Regional Stratigraphy

The applicant presented the regional bedrock geologic map and generalized stratigraphic column, respectively, of northwestern Nebraska in TR Figure 2.6-1 and TR Table 2.6-1 (CBR, 2015 and CBR, 2017). In TR Section 2.6.1 (CBR, 2015), the applicant describes the geological units found in northwestern Nebraska. These consist of sedimentary deposits comprising, from oldest to youngest, the Pierre Shale, the White River and Arikaree Groups, and the overlying alluvium deposits. The White River Group includes, from oldest to youngest, the Basal, Middle and Upper units of the Chadron Formation, and the overlying Brule Formation. The Arikaree Group includes, from oldest to youngest, the Gering Formation, the Harrison-Monroe Creek Formation and the Upper Harrison Beds. The applicant reported that, on a regional scale, the geologic units underlying the Pierre Shale include the Niobrara, Carlile Shale, Greenhorn Limestone and Graneros Shale Formations.

The NRC staff reviewed the description of the regional geologic units provided by the applicant (CBR, 2015 and CBR, 2017) and compared this information with independent published sources. The NRC staff confirmed that the applicant's description is consistent with the regional stratigraphic descriptions presented by Collings and Knode (1984), Miller and Appel (1997), Hoganson et al. (1998), and Swinehart et al. (1985). The regional information provided gives clear context to the site-specific material presented in the TR. The NRC staff finds that the TR (CBR, 2015) documents the regional stratigraphic information and thus meets acceptance criteria (1), (2), (8) and (9) in Section 2.6.3 of the NUREG-1569 (NRC, 2003).

2.3.3.1.2 Regional Structure

The NRC staff reviewed the description of the regional geologic structure provided by the applicant in TR Section 2.6 1 (CBR, 2015). The applicant describes the Black Hill uplift, Chadron Arch, the White River fault, Pine Ridge fault, Bordeaux fault, Toadstool Park fault, and Cochran Arch as the prominent regional-scale structural features reported in the published literature (CBR, 2017). The MEA is located within a structural feature known as the Crawford Basin, which is a triangular shaped basin bounded by the reported Toadstool Park fault to the northwest, the

Chadron Arch and Bordeaux fault to the east, and the Cochran Arch and Pine Ridge fault to the south (CBR, 2015; DeGraw, 1969).

The NRC staff compared the descriptions of the regional geologic structure provided by the applicant (CBR, 2017) with published sources. The NRC staff confirmed that the applicant's descriptions are consistent with the regional structural geology descriptions provided by DeGraw (1971), Swinehart et al. (1985), and Collings and Knode (1984). The regional information provided is gives clear context to the site-specific material presented in the TR. The NRC staff finds that the TR (CBR, 2015) documents the regional structural geology and thus meets acceptance criteria (6), (9) and (10) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

2.3.3.2 Site Geology

2.3.3.2.1 Site Stratigraphy

The applicant provided a detailed description of the stratigraphy at the MEA in TR Section 2.6 (CBR, 2015) and accompanying tables and figures. TR Table 2.6-2 and the cross sections presented in TR Figures 2.6-3a through 2.6-3n for locations shown in TR Figure 2.6-2 characterize the geologic units at the MEA (CBR, 2015; 2017). Based on data presented in TR Sections 2.6 and 2.7 (CBR, 2015; 2017), the NRC staff notes the following approximate thicknesses and hydrogeological function of the various geologic units (see SER Section 2.4):

Alluvium	<9 m (< 30 ft)	
Arikaree Group	12 to 49+ m (40 to 160+ ft)	Upper Aquifer
Brule	107 to 168 m (350 to 550 ft),	Upper Aquifer
Upper and Middle Chadron	110 to 137 m (360 to 450 ft),	Upper Confining Unit
Basal Chadron Sandstone[1]	6 to 27 m (20 to 90 ft),	Production Zone Aquifer
Pierre Shale	229 to 305+ m (750 to 1,000+ ft)	Lower Confining Unit

These geologic units are consistent with the regional units discussed in SER section 2.3.3.1.1.

The NRC staff reviewed the applicant's supporting geologic data consisting of borehole logs, X-ray diffraction, particle grain size analyses, isopach maps, and cross sections and found the information to be comprehensive. The NRC staff finds that the TR (CBR, 2015) documents the

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[1] In the MEA TR (CBR, 2015), the applicant refers to this unit as the "basal sandstone of the Chadron formation." In its most recent NRC license renewal application, the applicant referred to this unit as the "Basal Chadron Sandstone" (CBR, 2007). Different authors have proposed revisions to the stratigraphic boundaries and nomenclature of the White River Group in Nebraska, including designating the Basal Chadron Sandstone as the Chamberlain Pass Formation (Terry, 1998; Terry and LaGarry, 1998; LaGarry, 1998). After reviewing information from the U. S. Geological Survey (USGS) (derived from State geologic maps), the NRC staff determined that the USGS has not adopted the stratigraphic modifications proposed by those authors for the White River Group in Nebraska (USGS, 2015). Furthermore, the NDEQ retained the traditional stratigraphic terms in the Class III Underground Injection Control (UIC) permit issued to CBR for the North Trend Expansion Area (NDEQ, 2011). Stratigraphic nomenclature aside, nothing in the naming conventions for the geologic units in Nebraska, or at the MEA, changes the interpretation of the physical or hydraulic features of the rock units. Therefore, for consistency with its prior review documents, the NRC staff will continue to refer to this unit as the Basal Chadron Sandstone in this SER.

site stratigraphy and thus meets acceptance criteria (1) through (4), (8) and (9) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

Further detail of the NRC staff's evaluation of the applicant's stratigraphic information is provided below for each geologic unit.

Pierre Shale - Lower Confinement

The applicant indicated that the Pierre Shale is a regional marine shale. The depth to the Pierre Shale shown in the applicant's cross sections ranges from approximately 282 to 366 m (925 to 1,200 ft) bgs (CBR, 2015; 2017).

In TR Section 2.7.2.2 (CBR, 2015), the applicant reported that the Pierre Shale is the lower confining layer beneath the production zone (the Basal Chadron Sandstone) and is regionally continuous and sufficiently thick throughout the MEA (CBR, 2015). The applicant's borehole geophysical logs, as illustrated in the applicant's cross sections and structure contour map, show that the Pierre Shale is laterally continuous throughout the MEA (TR Figures 2.6-3a through 2.6-3n in CBR, 2017). The geophysical log of an oil and gas exploratory well (Hollibaugh No. 1; CBR, 2015, Appendix C) within the MEA (T29N, R51W, section 12) indicates that the Pierre Shale locally attains a thickness of about 270 m (890 ft). Thus, the NRC staff finds that the applicant provided information to demonstrate that the Pierre Shale is an underlying confining layer that is sufficiently thick and laterally continuous throughout the MEA.

Oil and gas well geophysical logs provided by the applicant (CBR, 2015) are consistent with the observation made by the applicant that there is a lack of permeable water-bearing zones within the Pierre Shale in the region of the MEA. The applicant reported that X-ray diffraction analyses of Pierre Shale samples indicate the unit is comprised primarily of mixed layered illite/smectite and quartz (CBR, 2015). The results of the applicant's particle grain size distribution analyses of Pierre Shale samples show a composition consisting of 60 to 51 percent silt-size and 39 to 48 percent clay-size particles. The NRC staff considers these results to demonstrate the impermeable nature of the Pierre Shale. Additionally, the applicant indicated that measured vertical hydraulic conductivity of this regional unit at the nearby currently licensed CBR facility is less than 1×10^{-10} cm/s (5.47×10^{-14} ft/s) (CBR, 2015).

The NRC staff finds that the applicant has documented that the Pierre Shale is a lower confining layer based on its extensive thickness, lateral continuity and low permeability throughout the MEA. Accordingly, the NRC staff finds that the TR (CBR, 2015) describes the Pierre Shale at the MEA and thus meets acceptance criteria (1) through (4), (8), and (9) in Section 2.6.3 of the NUREG-1569 (NRC, 2003).

Basal Chadron Formation - Production Zone

The applicant's proposed production zone at the MEA is the Basal Chadron Sandstone. The applicant states that the Basal Chadron, which lies unconformably over the thick Pierre Shale, is a coarse-grained arkosic sandstone interbedded thin clay beds (CBR, 2015). The applicant's cross sections and isopach contour map of the Basal Chadron Sandstone (TR Figures 2.6-3a through 2.6-3n in CBR, 2015), and 2.6-9 (CBR, 2017), respectively) show the Basal Chadron Sandstone is laterally continuous throughout the MEA and has a thickness that ranges from approximately 6 to 27 m (20 to 90 ft).

The TR stated that MEA ore deposits are roll front deposits with coffinite being the predominant uranium mineral species present (CBR, 2015). The applicant describes a detailed geochemical analysis of the Crow Butte uranium ore based on data reported in a USGS study (Hansley et al., 1989) as follows: (1) the heavy mineral portion of samples included garnet, magnetite, marcasite, and ilmenite; (2) vanadium was detected in the samples primarily as an amorphous species rather than as discrete mineral phases; (3) uranium has remained in a reduced state, as evidenced by unoxidized minerals (e.g., coffinite and uraninite) comprising the bulk of the ore. The applicant states that the Basal Chadron Sandstone at the currently licensed CBR facility is composed of 50 percent monocrystalline quartz, 30 to 40 percent undifferentiated feldspar, plagioclase feldspar and microcline feldspar (CBR, 2015). The remainder includes polycrystalline quartz, chert, chalcedonic quartz, various heavy minerals and pyrite. X-ray diffraction analyses of samples from the currently licensed CBR facility indicated that the Basal Chadron Sandstone is 75 percent quartz with the remainder K-feldspar and plagioclase (CBR, 2015). The applicant states that the ore ranges from 0.11 percent to 0.33 U_30_8, with an average ore grade of 0.17 percent. Based on the similar regional deposition of the currently licensed CBR facility and the MEA, whereby the ore bodies in the two areas are within the same geologic unit (Basal Chadron Sandstone) and have the same mineralization source, the MEA ore body is expected to be similar mineralogically and geochemically to that of the ore body at the currently licensed CBR facility.

The NRC staff finds that the TR (CBR, 2015) documents the lithologic and geochemical characteristics of the Basal Chadron Sandstone production zone at the MEA and has therefore met acceptance criteria (1) through (4), (8), and (9) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

<u>Upper and Middle Chadron Formations – Upper Confinement</u>

As described in TR Section 2.6.1.1 (CBR, 2015), the Basal Chadron sandstone is separated from the overlying Brule Formation by the Middle and Upper Chadron confining units. The Middle Chadron is described by the applicant as clay-rich with interbedded bentonitic clay and sand and the Upper Chadron as a bentonitic clay grading downward to green and red clay, with some interbedded sandstone intervals. The applicant reports that at the MEA the contact between the Upper and Middle Chadron is difficult to ascertain due to similarities in grain size and geophysical log responses.

The combined thickness of the Upper and Middle Chadron units as shown in the applicant's isopach map (TR Figure 2.6-8 in CBR, 2015) ranges from approximately 110 to 137 m (360 to 450 ft) and generally thins toward the south across the MEA. The Middle and Upper Chadron units are laterally continuous throughout the MEA in the cross sections provided by the applicant (TR Figures 2.6-3a through 2.6-3n in CBR, 2017).

The applicant reported that X-ray diffraction analyses of Upper Chadron core samples from the MEA indicated that they consisted primarily composed of mixed layered illite/smectite, calcite and quartz (CBR, 2015). On the basis of grain size analysis, these Upper Chadron samples were classified by the applicant as siltstone, with more than 50 percent of the sample grain sizes reported to fall in the silt-clay fraction range (CBR, 2015). The applicant also reported that X-ray diffraction analyses of Middle Chadron core samples from the MEA indicated that they are primarily composed of mixed layered illite/smectite (CBR, 2015). The applicant further indicated that, on the basis of particle grain size analyses, the Middle Chadron samples are classified as a siltstone (CBR, 2015). Middle Chadron particle grain size sample results provided in the TR (CBR, 2015) show a composition consisting of silt- (35 to 46 percent), sand- (33 to 48 percent), and clay- (17 to 21 percent) size particles. Coupled with the electric log characteristics as shown in the applicant's cross sections (CBR, 2015), the applicant's sample analysis results demonstrate the low-permeability nature of the Middle and Upper Chadron units. The low-permeability nature of these units is further supported by the results of pump testing discussed in SER Section 2.4.3.3.

The NRC staff finds that the applicant has provided lithologic and mineralogical information to indicate that groundwater within the Basal Chadron Sandstone aquifer (production zone) is separated from the overlying water-bearing Brule Formation by the confining unit consisting of the Middle and Upper Chadron Formation. Accordingly, the NRC staff finds that the TR (CBR, 2015) documents the characteristics of the Middle and Upper Chadron confining unit at the MEA and thus meets acceptance criteria (1) through (4), (8), and (9) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

Brule Formation

In TR Section 2.6.1.1, the applicant indicated that the Brule Formation lies conformably on top of the Chadron Formation and is overlain by sandstones of the Arikaree Group (CBR, 2015). The applicant also stated that the Brule Formation consists of an uppermost Brown Siltstone member underlain by siltstones with rare interbeds of sandstone and volcanic ash belonging to the Whitney member (CBR, 2015). The Whitney member is underlain by clayey siltstones, claystones, sandstones and volcanic ashes of the Orella member. The applicant has determined through geologic and geophysical investigation that at the MEA the Brule Formation is predominated by the Brown Siltstone and Whitney members while the presence of the Orella member is minimal (CBR, 2017).

The overall thickness of the undifferentiated Brule Formation in the MEA cross sections (TR Figures 2.6-3a through 2.6-3n in CBR, 2015) and isopach map (TR Figure 2.6.7 in CBR, 2017) provided by the applicant ranges from approximately 107 to 168 m (350 to 550 ft), generally thinning from north to south across the MEA.

The applicant states that the thick, fine to medium grained sandstones near the base of the Brown Siltstone member of the Brule Formation are present across the entire MEA and constitute the first overlying aquifer above the production zone (CBR, 2015).

The NRC staff finds that the TR (CBR, 2015) documents the lithologic and stratigraphic characteristics of the Brule Formation at the MEA and thus meets acceptance criteria (1) through (3), (8) and (9) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

Arikaree Group

The applicant states that the Arikaree Group contains numerous interbedded channel and floodplain deposits along with eolian volcanoclastics (CBR, 2015). Based on grain size analysis of core samples, the applicant reports that the interbedded lithologies within the unit include illite/smectite mudstones, siltstones and fine-grained sandstones. The Arikaree Group uncomformably overlies the Brule Formation and is subdivided, from youngest to oldest, into the Upper Harrison Beds, Harrison-Monroe Creek and Gering Formations, respectively. The isopach map provided by the applicant (TR Figure 2.6.6 in CBR, 2015) shows that the thickness of the undifferentiated Arikaree Group over the MEA generally ranges between 12 to over 49 m (40 to over 160 ft), with increasing thickness from south to north.

The applicant states that fine sand units within the Upper Harrison beds, fine-grained sandstones within the Harrison-Monroe Creek Formation, and coarse- to fine-grained sandstones of the Gering Formation represent locally water-bearing units (CBR, 2015). The water-bearing units are reported to be interbedded with low-permeability mudstone units and to be highly variable, ranging between three to several tens of meters (10 to several hundred feet) wide and up to 20 m (50 ft) thick (CBR, 2015).

The NRC staff finds that the TR (CBR, 2015) documents the lithologic and stratigraphic characteristics of the Arikaree Group at the MEA and thus meets acceptance criteria (1) through (3), (8) and (9) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

Alluvium

The applicant reports that surficial alluvium within the MEA consists of locally outcropping sedimentary rocks, sand, gravel, and sandy soil horizons and may include weathered portions of the Arikaree Group (CBR, 2015). The thickness of the alluvial deposits shown on the cross sections provided by the applicant (TR Figures 2.6-3a through 2.6-3n in CBR, 2015) ranges from less than one meter (<3 ft) to approximately 9 m (30 ft).

The NRC staff finds that the TR (CBR, 2015) documents the lithologic and stratigraphic characteristics of the surface alluvium at the MEA and thus meets acceptance criteria (1) through (3), (8) and (9) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

2.3.3.2.2 MEA Local Structure

The applicant provided a description of the local structure at the MEA in Section 2.6.1 of the TR (CBR, 2015). The applicant also presented cross sections extending down to the top of the Pierre Shale (TR Figures 2.6-3a through 2.6-3n in CBR, 2017), which illustrate the orientation of formation bedding across the MEA.

With regard to potential faulting within the MEA license area, the NRC staff has not encountered any evidence that faults have created preferential pathways connecting the overlying aquifers with the Basal Chadron Sandstone aquifer. CBR constructed 14 geologic cross sections across the MEA based on geologic and geophysical borings (TR Figure 2.6-2, and 2.6.3 in CBR, 2015). The NRC staff observed no vertical offsets in any of the cross sections of the MEA that would indicate faulting. Faults are discussed in greater detail in SER Section 2.4.

As observed by the applicant, the regionally-mapped Pine Ridge and Niobrara River faults are reported by some investigators (e.g. DeGraw, 1971; Swinehart, 1985) as passing approximately 8 km (5 mi) north of the northern limit of the MEA and adjacent to the southern margin of the MEA, respectively (TR Figure 2.6-16 in CBR, 2015). The mapping of these faults is based on regional lines of evidence but no detailed study of them has been published. DeGraw (1971) has also reported the existence of east-west trending faulting more than 6 km (4 mi) south of the MEA.

To evaluate the existence of the reported Pine Ridge and Niobrara River faults, the applicant provided three regional north-south cross sections based on geophysical logs. As shown in TR Figure 2.6-21 (CBR, 2015), these cross-sections (TR Figures 2.6-22 through 2.6-24 in CBR, 2015) extend from south of the Niobrara River (south of the MEA) northward though the MEA, across the area of the currently licensed CBR facility and the proposed North Trend Expansion Area. Each of the three sections intersects the reported traces of the Niobrara River and Pine Ridge faults. Cross section R1-R1' extends through the middle of the MEA whereas R0-R0' and R2-R2' are located approximately 2 km (1 mi) to the east and west of R1-R1', respectively. The cross sections are vertically exaggerated by a factor of 10. The top of the Pierre Shale, the top of the Basal Chadron Sandstone, and a pair of persistent marker beds discernable on the geophysical logs were used for stratigraphic correlation.

<u>Pine Ridge Fault</u>

The existence of the Pine Ridge fault (or structural feature) was initially reported by DeGraw (1969) based on a structure contour map of the pre-Tertiary surface of western Nebraska derived from oil and gas well data. The DeGraw (1969) structure contour map indicates that the fault exhibits a north-side down displacement of about 90 m (300 ft) immediately north of the MEA and a similar displacement of about 200 m (500 ft) further to the east. Souders (1981) inferred the presence of an unnamed fault with north-side down displacement where his cross sections A-A' and B-B' cross the trace of the Pine Ridge fault as delineated by DeGraw (1969). These cross sections are located approximately 3 and 19 km (2 and 12 mi), respectively, east of CBR's easternmost cross section R0-R0' (CBR, 2015). The Souders cross sections are based on limited test well data south of the fault and extrapolated outcrop dip measurements of the top of the Pierre Shale from several kilometers to the north. In contrast to the greater fault displacement indicated by DeGraw (1969), the Souders (1981) cross sections only indicate about 37 m (120 ft) of displacement on the fault extending down to the Pierre Shale. A cross section (B-B') presented by Swinehart et al. (1985) also shows the presence of a fault where it crosses the trace of the Pine Ridge fault indicated by DeGraw (1969). This cross section is located approximately 18 km (11 mi) east of CBR cross-section R0-R0' (CBR, 2015) and indicates about 23 m (75 ft) of north-side down displacement on the fault extending down to the Pierre Shale.

The NRC staff has reviewed the regional cross-sections prepared by the applicant. Cross section R0-R0' intersects the reported Pine Ridge fault at a point about 3 km (2 mi) west of where Souders' (1981) cross section A-A' crosses the fault trace. The applicant notes (Section, 2.6.1 of CBR, 2015) that the surface of the Pierre Shale at this point vertically drops 6.7 m (22 ft) over a distance of 3.7 km (2.3 mi). On sections R1-R1' and R2-R2', the Pierre Shale rises 7.3 m (24 ft) and 8.8 m (29 ft), respectively, from south to north as the location of the reported fault is crossed. The applicant considers that these topographic changes in the Pierre Shale surface are likely erosional rather than structural. The applicant notes that, contrary to the information presented by DeGraw (1969), at no point on the CBR-generated cross-sections is an offset of about 90 m (300 ft) observed at the reported location of the Pine Ridge fault. The applicant further observes that, in contrast to the information presented by Souders (1981), no offset of about 37 m (120 ft) that impacts all overlying strata, as would be expected by fault movement that post-dates deposition of the overlying strata.

The applicant states in the MEA TR (Section 2.6.1 of CBR, 2015) that the Three Crow Expansion Area (TCEA) Technical Report also addressed concerns about the presence of the Pine Ridge fault. The applicant further states (Section 2.6.1 in CBR, 2015) that TCEA cross-sections presented in Appendix Z of the MEA TR (CBR, 2015) do not substantiate a reported north side down vertical displacement of some 90 m (300 ft), contrary to the information presented by DeGraw (1969). In addition, the applicant observes that, in two of those cross-sections, the elevation of the top of the Pierre Shale decreases southward, which is contradictory to a north side down vertical displacement. While not ruling out the presence of a short-offset fault, the applicant concludes that the increases in elevation recorded for the top of the Pierre Shale are most likely a result of erosional topographic lows or structural dips due to flexing associated with the formation of the Crawford Basin. CBR further concludes that the exclusion of the existence of a large-offset fault eliminates the potential for such a feature to act as a boundary for ground water flow and movement that could impact production operations at MEA (TR Section 2.6.1.3 in CBR, 2015).

Niobrara River Fault

In TR Section 2.6.1.3 (CBR, 2015), the applicant discusses its evaluation of the possible presence of the Niobrara River fault (strucutual or paleotopographic feature) near the southern boundary of the MEA (CBR, 2015). The applicant notes that DeGraw (1971; cited as Stout et al. 1971) indicates the presence of the Niobrara River fault parallel to the Niobrara River (Figure 2.6-16). As the applicant observes, DeGraw (1971; cited as Stout et al. 1971) reports that the Niobrara River fault and an unnamed fault (Figure 2.6-16) to the south form a graben which contains the Niobrara River valley. The applicant notes that the basis for inferring the presence of these faults is not presented in DeGraw (1971) and the pre-Tertiary surface structure contour map presented in DeGraw (1969) does not indicate the presence of any feature or displacement corresponding to the fault locations indicated in DeGraw (1971). The applicant has reviewed Cameco geophysical and geologic sample logging and generated structure contour maps of the top of the Pierre Shale (TR Figure 2.6-14 in CBR, 2015). Based on this review, the TR indicates the presence of what appears to be a minor trough with a relatively small amount of elevational relief outside of the MEA boundary and generally parallel to but slightly to the north of the reported Niobrara River Fault trace. The applicant indicates that this apparent trough may represent a paleotopographic feature, a synclinal feature related to the Cochran Arch, or a graben.

The NRC staff has further found that Figure 22 in Swinehart et al. (1985) also indicates the presence of the Niobrara River fault across southern Dawes County. However, the NRC staff notes that the accompanying structure contour maps for the base of Cenozoic and younger horizons (Figures 8, 11 and 15 in Swinehart, 1985) do not indicate any corresponding structural offset along the reported fault trace (nor any indication of a fault further south). Moreover, no fault is shown in cross section B-B' (Figure 5) in Swinehart et al. some 12 km (7.5 mi) east of the southern limit of the MEA where it crosses the trace of the reported fault. The NRC staff has also evaluated cross sections presented in Souders (1981) that cross the trace of the Niobrara River fault as reported by DeGraw (1971) and Swinehart et al. (1985). Cross sections A-A', B-B' and C-C' in Souders (1981) intersect the reported Niobrara River fault trace at approximately 8 km (5 mi) west, 12 km (7.5 mi) east, and 28.2 km (17.5 mi) east, respectively, from the southern limit of the MEA of. None of these cross sections indicate the presence of a fault at or near the reported location of the Niobrara River fault.

The NRC staff finds that the applicant has adequately demonstrated, through cross sections derived from site-specific borehole geophysical and geologic sample logging data north of the MEA, that there are not significant offsets of the Pine Ridge fault (or structural feature) as reported in published information and there is no direct evidence of the existence of the reported Niobrara River fault at or near MEA. In addition, even if these faults did exist, , the MEA could be operated safely for the following reasons: (1) ambient ground-water flow in the Basal Chadron Sandstone aquifer is to the northwest and away from any potential Niobrara River structural feature or fault; (2) License Condition 10.7 (NRC, 2017) requires the applicant to maintain an overall inward hydraulic gradient within the perimeter monitor well ring starting when lixiviant is first injected into the production zone and continuing until the initiation of the stabilization period, whereby ground-water flow will be toward the mine unit production and injection wells and away from both of the reported faults; (3) the ambient hydraulic gradients are strongly downward from the overlying aquifer of the Brule Formation and Arikaree Group to the Basal Chadron Sandstone aquifer (Section 2.9.3.2 in CBR, 2016); therefore, mining fluids would not be able to migrate upward through any preferential pathways; and (4) and the license condition presented in SER Section 5.7.9.4 (NRC, 2017) requires the applicant to conduct a preoperational aquifer pumping test for each wellfield to verify the validity of the hydrogeological conceptual model of the MEA and the absence of fault-related flow effects at the proposed MEA.

The NRC staff finds that the TR (CBR, 2015) documents the characterization of local geologic structures at the MEA and thus meets acceptance criterion (6) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

2.3.3.3 Well / Exploration Boreholes and Economically Significant Deposits

In TR Section 2.6 (CBR, 2015), the applicant refers to previous exploratory drilling that was performed at the MEA to explore the uranium deposit and characterize the geology. In TR Section 6.2.3.1 (CBR, 2015), the applicant describes the procedures used to plug and abandon the exploratory holes that were drilled at the MEA. The NRC staff has verified with the Nebraska Department of Environmental Quality (NDEQ) that all MEA exploratory test holes were properly plugged and abandoned in accordance with the requirements of the State of Nebraska (NDEQ, 2014). No evidence of a vertical conduit through the upper confining unit from improperly abandoned exploration drill holes was seen in data collected during the pumping test performed by the applicant at the MEA (refer to SER Section 2.4 for the analysis of the pumping test).

Crude oil or gas production did not occur in Dawes County between 1984 and 2013 (NEO, 2013; NOGCC, 2013) and coal has not been produced anywhere in Nebraska (U.S. Energy Information Administration, 2012). Within the townships that encompass the MEA (T29N, R50W; T29N, R51W, and T30N, R51W), the Nebraska Oil and Gas Conservation Commission (NOGCC) lists oil wells Chicoine 1-A (1981) and Aschwege 11-1 (1981) as plugged and abandoned. Twelve dry holes (drilled between 1952 and 1981) within these townships are listed as properly abandoned. According to NOGCC regulations, all oil and gas test holes must be properly plugged and abandoned in accordance with the requirements of the State of Nebraska. TR Section 2.6.1.5 (CBR, 2015) indicates that two oil and gas wells are currently producing in Sioux County, but are located at a significant distance southwest of the MEA in section 8, T 25 N, R 55 W and section 11, T 25 N, R 56 W (CBR, 2015).

The applicant states that sand and gravel are the only non-fuel minerals produced in Dawes County (CBR, 2015). During a site visit in 2014, the NRC staff did not see any oil and gas or other activities related to the extraction of geologic resources at the MEA. The only significant land disturbance activity seen by the NRC at that time was cultivation for farming.

The NRC staff finds that CBR's exploratory test holes and other exploratory oil and gas holes have been properly plugged and abandoned in accordance with state requirements, and therefore will not act as vertical conduits for fluid migration from the Basal Chadron Sandstone through either the upper or lower confining units.

The NRC staff finds that the TR (CBR, 2015) documents the absence of non-uranium geologic resources at the MEA. In conjunction with the verification from NDEQ of the plugging of all exploratory test holes at the MEA, the NRC staff finds that corresponding acceptance criteria (5) and (9) in Section 2.6.3 of NUREG-1569 (NRC, 2003) have been met.

2.3.3.4 Seismology

In TR Section 2.6.1.4 (CBR, 2015), the applicant presented information on the seismic history and seismic hazards in the vicinity of the MEA, including (1) catalogs of earthquakes that have occurred in Nebraska in the vicinity of the Chadron and Cambridge Arches from 1884 to 2009 and earthquakes that have occurred from 1992 through 2007 within 125 miles (201.2 km) of the city of Crawford in Wyoming and South Dakota; (2) intensities, based on the Modified Mercalli Index (MMI), for most of the significant historical earthquakes in the region, including those that occurred in the Wyoming and South Dakota; and (3) 2008 USGS National Seismic Hazard Maps (USGS, 2008) . Each of these seismic data sets is analyzed below.

<u>Regional Historical Earthquake Catalogs</u>

In TR Tables 2.6-5 and 2.6-6 (CBR, 2015), the applicant presented two catalogs of earthquakes: one identifying earthquakes that have occurred in Nebraska, in the vicinity of the Chadron and Cambridge Arches, from 1884 to 2009; and the other identifying earthquakes that have occurred within 125 miles (201.2 km) of the City of Crawford, Nebraska (including parts of Wyoming and South Dakota) from 1992 through 2007. Using the most updated earthquake catalogs available (NRC, 2012b, USGS, 2017a), the NRC staff compiled a catalog of historical earthquakes of magnitude 2.5 or greater within a 100-mile (161 km) radius of the MEA. The results of the staff's search, shown in Table 2.3-1 below, include a few more events than those identified by the applicant in the TR. Only two of the events in Table 2.3-1 exceeded a magnitude of 3.5: a magnitude 3.7 event on May 25, 1941, and a magnitude 3.8 event on August, 22, 1964.

The historical earthquakes identified by the applicant and the staff directly reflect the seismic activity level in the region surrounding the MEA. Table 2.3-1 shows that most of the earthquakes fall within a magnitude range of 2.5 to 3.5, with only three events at or above magnitude 4.0. In general, earthquakes below 4.0 on the Richter scale do not cause damage, and earthquakes around 3.0 are the smallest can be felt. Table 2.3-1 also indicates that there was not a single event recorded within 15 miles of the MEA in the 120 years of recording history. Based on these historical data, the staff concludes that MEA is located in an aseismic region.

Intensities of the Historical Significant Earthquakes

The MMI is a scale used to rate the intensity of an earthquake (earthquake intensity is a measure of the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures). Intensity is usually the highest in the epicentral region of an earthquake and decreases with increasing distance from the epicenter. The MMI is distinct from earthquake magnitude (i.e., Richter scale), which is a measure of the energy released from an earthquake.

Section 2.6.1.4 of the MEA TR presents historical observations of the MMI intensities for those significant earthquakes listed in the catalogs provided by the applicant. Earthquakes in the region had an MMI intensity ranging from I to VI, with the majority between I and III. According to the MMI scale (USGS, 2017b), earthquakes with MMIs of VI may have slight damage to chimneys, while those with lower MMIs may be felt but will not result in damage. The only earthquake with an MMI of VI recorded in the region occurred on July 30, 1934. It was centered in Dawes County (near Chadron), and resulted in damaged chimneys, plaster, and china. The NRC staff finds that the intensity data presented in the MEA TR further confirm the conclusion that the MEA is located in an aseismic region with low seismicity and low seismic intensity.

USGS Seismic Hazard Maps

Figures 2.6-17 and 2.6-18 in the MEA TR (CBR, 2015) present 2008 seismic hazard maps for the United States and Nebraska that show expected ground accelerations during earthquakes based on a 10 percent probability of exceedance in 50 years (equivalent to an occurrence rate of once every 475 years). Figure 2.3-1 shows the most recent version of the USGS National Seismic Hazard map (USGS, 2014), which is essentially the same as Figure 2.6-17 for the region around the MEA. Figure 2.3-1 shows that the MEA is located in a region with peak acceleration about 2-5% g, where g is the acceleration due to gravity (equal to 9.8 m/s^2 or 32.2 ft/s^2). This range of peak accelerations is considered very low in the United States. Therefore, the information in the seismic hazard maps supports the conclusion that the MEA is located in an area with low seismic hazard.

Summary

Based on the seismic information discussed above for the region surrounding the MEA, the staff finds that the applicant's assessment of seismology is supported by published seismic data, studies, and USGS hazard maps. Therefore, the staff finds that the discussion of seismology and seismic hazards meets the acceptance criteria (7) in Section 2.6.3 of NUREG-1569 (NRC, 2003).

2.3.4 Evaluation Findings

The NRC staff evaluated the licensee's site characterization information addressing geology and seismology at the MEA in accordance with the review procedures in SRP Section 2.6.2 and the acceptance criteria in SRP Section 2.6.3.

The applicant has described the geology and seismology by providing: (1) a description of the local and regional stratigraphy; (2) geologic, topographic, and isopach maps at acceptable scales showing surface and subsurface features and locations of all wells and site explorations used in defining stratigraphy; (3) a geologic and geochemical description of the mineralized zone and the geologic units adjacent to the mineralized zone; (4) a description of the local and regional geologic structure; (5) a discussion of the seismicity and seismic history of the region; and (6) a generalized stratigraphic column that includes the thickness of rock units, a representation of lithologies, and a definition of mineralized horizon.

The NRC staff finds the site characterization of the MEA geology and seismology presented in the TR to meet accordance criteria with Section 2.6.3 of NUREG-1569 (NRC, 2003). The characterization of the MEA geology and seismology presented in the TR is sufficient to document the licensee's ability to maintain control over production fluids containing source and byproduct materials and thus, meets 10 CFR 40.41(c).

2.3.5 References

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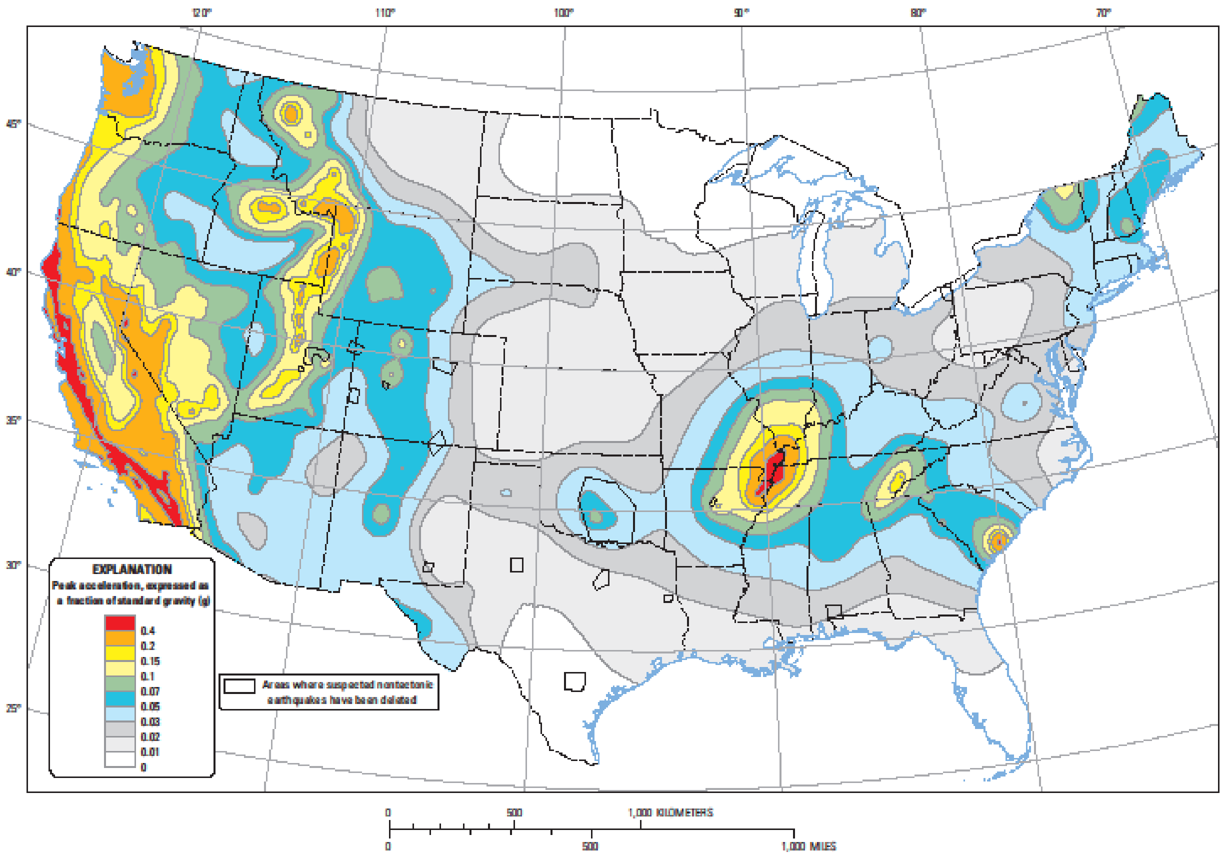
Table 2.3-1 Historical earthquakes within 100 miles of proposed MEA

year	month	day	hr	min	sec	Latitude	Longitude	Depth (mi)	M	Dist.(mi)	Dist.(km)
1895	10	11	23	55	0	43.9	-103.3	NR	3.36	97	156
1895	10	12	1	25	0	43.9	-103.3	NR	3.38	97	156
1920	7	14	23	0	0	43.2	-103.2	NR	3.16	48	78
1924	12	30	22	10	0	43.5	-103.5	NR	3.59	70	113
1924	12	30	22	15	0	43.5	-103.5	NR	2.65	70	113
1924	12	30	22	20	0	43.5	-103.5	NR	2.65	70	113
1924	12	30	22	30	0	43.5	-103.5	NR	2.65	70	113
1933	8	8	0	0	0	41.9	-103.7	NR	2.98	47	76
1934	7	30	7	20	0	42.7	-103	NR	4.1	19	30
1936	10	30	10	30	0	43.5	-103.5	NR	2.65	70	113
1938	3	24	13	11	0	42.7	-103.4	NR	3.31	16	25
1941	5	25	6	25	0	43.5	-103.5	NR	3.7	70	113
1942	2	25	14	3	0	42.5	-104.4	NR	2.65	59	94
1942	2	25	14	15	0	42.5	-104.4	NR	3.31	59	94
1942	2	25	14	30	0	42.5	-104.4	NR	2.65	59	94
1943	5	16	19	40	0	43.5	-103.5	NR	2.65	70	113
1964	3	24	6	12	0	43.5	-103.5	NR	3.38	70	113
1964	3	28	3	0	0	42.7	-104.1	NR	3.31	45	73
1964	3	28	10	8	46.5	43	-101.8	30	4.84	81	131
1964	3	28	10	24	50	42.8	-101.7	NR	3.28	81	131
1964	8	22	3	28	11	42.9	-104.7	NR	3.84	79	127
1975	5	16	5	57	1	43.2	-103.7	NR	2.65	53	86
1975	8	25	10	0	34.7	42.57	-101.55	29	2.58	87	140
1978	5	7	16	6	23	42.26	-101.95	38	3.72	68	110
1981	9	13	22	16	29.7	43.04	-101.85	5	3.23	80	129
1983	5	6	6	14	46.9	42.955	-102.198	5	2.98	62	100
1987	1	1	8	2	24	42.788	-103.482	5	3.08	23	37
1989	2	9	5	15	45.8	42.685	-101.898	5	3.49	70	113
1990	1	28	4	59	59.1	43.313	-102.504	5	3.72	68	109
1990	3	2	4	15	27	43.3	-102.5	5	2.94	67	108
1992	11	2	6	54	10.3	42.74	-104.389	5	2.9	60	97
1993	2	20	13	8	10.1	42.83	-101.461	5	3.19	94	151
1994	3	18	22	51	43.1	43.4	-103.5	5	2.48	63	102
1996	4	9	2	48	8.1	43.069	-104.102	5	3.24	58	94
1996	5	3	7	47	51.5	43.045	-104.022	5	2.78	54	87
1998	6	18	16	26	38.32	42.622	-103.003	5	3.08	15	24
2003	5	25	7	32	33.3	43.087	-101.794	5	3.91	84	136
2004	1	5	2	53	16.5	43.598	-103.995	5	2.48	85	136
2006	9	7	6	23	20	42.977	-102.236	5	2.28	61	98
2007	4	24	9	35	1.26	42.58	-102.94	5	2.38	17	27
2008	8	22	23	1	31.81	43.075	-104.289	5	2.78	66	106
2011	3	10	1	38	13.68	42.861	-104.087	5	2.9	49	79

year	month	day	hr	min	sec	Latitude	Longitude	Depth (mi)	M	Dist.(mi)	Dist.(km)
2011	11	14	6	51	38.38	43.043	-103.415	5	4	38	62
2011	11	15	9	31	46.13	43.05	-103.504	5	3.3	40	65
2011	11	19	8	28	4.43	42.911	-103.082	5	2.8	30	48
2012	1	16	13	41	10.18	43.487	-102.996	5	3	69	112
2012	10	18	5	21	11.11	42.212	-101.952	5	3.6	69	112
2013	12	12	9	43	20.41	43.818	-103.318	5	3.5	91	147
2016	7	17	23	41	5.65	43.31	-103.161	5	2.8	56	90

NR = not reported.
Sources: NUREG-2115, Vol. 4, Appendix B (Earthquake Catalog) (1895 through 2008), USGS Advanced National Seismic System (ANSS) Catalog (2009 to present).



Ten-percent probability of exceedance in 50 years map of peak ground acceleration

Figure 2.3-1 2014 Seismic Hazard Map of the United States showing peak ground acceleration for ten-percent probability of exceedance in 50 years (USGS, 2014).

2.4 HYDOLOGY

2.4.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the characterization of surface and groundwater hydrology at the MEA is sufficient to support an analysis of the applicant's ability to maintain control over production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

2.4.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria presented in Section 2.7.3 of NUREG-1569 (NRC, 2003).

2.4.3 Review and Analysis

The following sections present the NRC staff's review and analysis of various aspects of the surface water and groundwater hydrology of the MEA. Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by Crow Butte Resources, Inc. (CBR) in the MEA TR (CBR, 2015) and as updated (CBR, 2016 and CBR, 2017).

2.4.3.1 Surface Water Hydrology

Surface water hydrology is discussed in TR Section 2.7 (CBR, 2015). The MEA is located within the Niobrara River Basin, which occupies approximately 30,740 sq km (11,870 sq mi) and extends across several counties in Nebraska, including Dawes County (CBR, 2015). Within this watershed, the MEA is located within Niobrara River sub-basin N-14 (NAC, 2012; CBR, 2015). TR Figure 2.7-6 (CBR, 2015) provides an illustration of the topography and surface water features at the MEA.

The applicant describes the Niobrara River in TR Section 2.7.1.1 (CBR, 2015). The Niobrara River originates in eastern Wyoming near Manville, in Niobrara County, and flows in an east-southeast direction into western Nebraska (see TR Figures 2.7-2 and 2.7-3 in CBR, 2015). The river flows across Sioux County in Nebraska, east through the Agate Fossil Beds National Monument, past the town of Marsland to the south of the proposed MEA, and through Box Butte Reservoir. From the reservoir, the river flows east across northern Nebraska, and joins the Snake River approximately 20.9 km (13 miles) southwest of Valentine. The Niobrara River joins the Keya Paha River approximately 9.6 km (6 miles) west of Butte, Nebraska. The river eventually joins the Missouri River northwest of Niobrara, Nebraska, in northern Knox County.

The applicant indicated that natural surface impoundments, ponds, and lakes are absent in the MEA. The Box Butte Reservoir, which occupies 6.5 sq km (1,000 acres), is located approximately 4.8 km (3 mi) from the southeast corner of the MEA license boundary (CBR, 2015). There are no direct drainages from the MEA to the reservoir (CBR, 2015).

The NRC staff used the Nebraska Floodplain Interactive Map (NDNR, 2014) and Nebraska Administrative Code (NAC, 2012) to verify the characterization of MEA surface water features and topography, as well as the Flood Insurance Rate Map (FIRM) flood zones subsequently discussed. The NRC staff finds that the applicant's description of the surface water drainages is sufficient and meets acceptance criteria (1) presented in Section 2.7.3 of NUREG-1569 (NRC, 2003).

The applicant performed two studies to assess the potential for erosion or flooding that could impact the proposed MEA, which are presented in Appendices K-1 and K-2 to the TR (CBR, 2015). The studies relied on rainfall, soil, land use, floodplain, and digital elevation data for the area.

The analysis presented in Appendix K-1 of the TR (CBR, 2015) identified proposed wells and facilities in areas of moderate to high risk of erosion that may require mitigation measures. The applicant used a GIS-based erosion model (Revised Universal Soil Loss Equation [RUSLE]) to investigate potential erosion in the project area. The model provides a fine spatial resolution of the model results and was selected due to its wide acceptance, including for construction site management at the federal level in NPDES Phase II permitting (CBR, 2015). The output of the RUSLE model is an annual rate of erosion and sedimentation in tons per acre per year, as opposed to erosion resulting from specific storm events. A detailed description of RUSLE is presented in Appendix K-1 (CBR, 2015). Mine units and other MEA facility locations were compared to the RUSLE map to evaluate erosion risk potential for each location. Proposed mine units, the satellite building, and the areas adjacent to the satellite building for potential placement of the access road and DDW were all evaluated. TR Table 3.1-2 in CBR (2015) lists the risk of erosion for each mine unit (MU). According to this table, MU-A and MU-I have low or very low erosion risk throughout the unit, while MU-C, MU-D, MU-E, and MU-F have very low erosion risk throughout the unit. MU-5 has multiple locations of moderate erosion risk. MU-2, MU-3, MU-4, and MU-B have locations of moderate and high erosion risk. The applicant proposes that if wells cannot be placed outside of areas deemed to have moderate to high erosion risk, mitigation measures, such as berms, can be implemented to minimize the potential for flooding and erosion. Model results indicate that the risk of erosion is low or very low at the satellite building, satellite building access road, and the two proposed DDWs.

Because the RUSLE model is unable to accurately define erosion rates in areas of concentrated flow during flood events (CBR, 2015), the applicant compared drainage lines (i.e., channels, gulleys, or areas of concentrated flow) and Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Map (DFIRM) floodplain extents to MU locations. Figures 22 through 27 of TR Appendix K-1 (CBR, 2015) display the drainage lines and floodplain extents relative to the MUs and the location of the satellite building. Drainage line 21, which contains some areas of 100-year floodplain, crosses mine units MU-2, MU-3, MU-4, and MU-5. The applicant has stated that well locations in these mine units will be positioned outside of the floodplain associated with drainage line 21 or will include flood protection measures (e.g., berms). Drainage line 24 crosses the proposed access road to the satellite building. Although the proposed access road and satellite building are not within the 100-year floodplain, the applicant has stated that the access road will be constructed considering the potential for concentrated runoff and erosion to occur.

The analysis presented in Appendix K-2 of the TR (CBR, 2015) provides estimates of storm related discharge rates and velocities within the MEA based on application of the HEC-GeoHMS and HEC-GeoRAS software developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center. For the analysis, the MEA was divided into two study areas based on drainage characteristics: Hydrologic Project South and Hydrologic Project East. Hydrologic Project

South contains the majority of sub-basins and drainages where the wellfields and satellite building would be located (i.e., the areas where licensed activities would occur). Peak discharge rates and flood velocities were calculated for storms with return intervals of 10, 25, 50, and 100 years.

Peak discharge rates for the main drainages where they exit the MEA license boundary are summarized in TR Tables 3.1-3 and 3.1-4 (CBR, 2015). The peak discharge for Hydrologic Project South during a 100-year storm is estimated to be 41.20 m^3/s (1,455 cfs), whereas the peak discharge for Hydrologic Project East during the same storm is estimated to be 75.29 m^3/s (2,659 cfs). The associated flood water maximum velocities within MEA drainages were 1.7 to 2.0 m/s (5.8 to 6.5 ft/s) for Hydrologic Project South and 2.7 m/s (8.9 ft/s) for Hydrologic Project East.

The applicant has stated that CBR will use the results of the two hydrologic and erosion studies to assess the potential for erosion and flooding that may require implementation of special design features or mitigation measures, including:

- constructing facilities outside of flood-prone boundaries in order to avoid potential impacts to facilities from flooding and potential impacts to major ephemeral drainages and the Niobrara River in the event of any potential spills or leaks;
- locating surface structures/wells outside of the 100-year flood zone boundaries whenever possible. Any facilities that will have to be built within the 100-year flood zone boundaries will be protected from flood damage by the use of control measures such as diversion/collection ditches, channels, storm drains, slope drains, and/or berms;
- burying pipelines below the frost line, and locating pipeline valve stations outside of the 100-year flood zone in order to avoid damage due to potential surface flooding;
- avoiding placement of production, injection and monitor wells in potential flood prone areas and, where necessary to place such wells in these areas, instituting surface water control measures (e.g., diversion or erosion control structures);
- building wellheads in flood-prone areas such that the casing extends above grade and is mounted on a concrete pad;
- providing an above ground, anchored protective housing to protect the well casing in the event of flooding; and
- sealing wellheads as applicable to withstand brief periods of submergence.

To ensure that adequate erosion and flooding protection measures are implemented, the NRC staff is imposing a license condition to minimize potential damage to infrastructure from peak flows by avoiding well installation within 100-year flood plains and areas of moderate to high risk of erosion and concentrated water flow during storm runoff. The license condition is provided in SER Section 2.4.4, and states that if the installation of wells in such locations cannot be avoided, adequate wellhead protection will be required to protect the wells during flood conditions. This license condition will ensure that wellfield infrastructure will be sufficiently protected from potential erosion and flooding risk in peak flow areas and from objects (e.g., trees and limbs) carried by flooding currents.

The NRC staff has reviewed the flooding and erosion studies conducted by the licensee and the applicant's provisions for wellfield protection from flooding and finds that the analysis meets acceptance criterion (2) presented in Section 2.7.3 of NUREG-1569 (NRC, 2003).

2.4.3.2 Hydrogeology

The applicant conducted a site investigation at the MEA to develop an understanding of the hydrogeology. The investigation included drilling of exploration borings, installation of monitoring wells, and measurement of hydrogeological properties within the different aquifers.

2.4.3.2.1 Regional Hydrogeology

The applicant describes the regional hydrostratigraphic units underlying the MEA and the region. These units are horizontal strata that include aquifers and confining units. Aquifers are geological formations with sufficient permeability and porosity to significantly transmit and store groundwater. Confining units are strata with insufficient permeability (e.g., shale units) that hydraulically separate aquifers. Referring to SER Table 2.4-1, the regional aquifers relevant to this safety evaluation are the Arikaree Group and Brule Formation, which are unconfined, surficial aquifers, and the deeper, confined Basal Chadron Sandstone (CBR, 2015). Separating these aquifers are the remaining members of the Brule and Chadron Formations, which collectively are identified as the upper confining unit to the Basal Chadron Sandstone aquifer. The lower confining unit beneath the Basal Chadron Sandstone aquifer is the Pierre Shale. SER Section 2.3 contains geological descriptions of all of the hydrostratigraphic units shown in SER Table 2.4-1. In SER Section 2.3, the NRC staff found that this information is consistent with the general regional-scale descriptions provided by Collings and Knode (1984), Miller and Appel (1997), Hoganson, et al. (1998), and Swinehart et al. (1985).

Table 2.4-1: MEA Hydrostratigraphic Column
(adapted from Information in TR Section 2.7.2 (CBR, 2015; CBR, 2017))

STRATA		HYDROGEOLOGICAL FUNCTION
Alluvium		Discontinuous/low aquifer potential
Arikaree Group		Uppermost (unconfined) aquifer
White River Group	Brule	Unconfined aquifer
	Upper Chadron Formation	Upper confining layer
	Middle Chadron Formation	Upper confining layer
	Basal Chadron Sandstone	production zone – confined aquifer
Pierre Shale		Lower confining layer

2.4.3.2.2 Site Hydrogeology

<u>Arikaree Group</u>

The applicant reports that within the MEA the Arikaree Group is locally used for domestic and livestock purposes (TR Section 2.7.2.1 in CBR, 2015).

TR Figure 2.7-8 (CBR, 2015) shows the locations of 10 Arikaree monitoring wells installed by the applicant in 2013 across the MEA. In Section 2.7.2.1 of the TR, the applicant states that the greatest saturated thickness, 24 m (78 feet), was observed on the north end of the MEA in well AOW-8, with considerably thinner saturated intervals of 0 to 10.7 m (0 to 35 ft) observed near the central portion of the project area (CBR, 2015). Saturated thickness increases to approximately 9.1 to 10.7 m (30 to 35 ft) from the central portion of the MEA southward toward the Niobrara River. One well (AOW-7) located in the west-central portion of the MEA did not contain measurable water during well development or monitoring.

The applicant conducted Arikaree groundwater-level measurements within Arikaree monitoring wells at the MEA in 2013 and 2014 (refer to TR Table 2.9-7 and TR Figures 2.9-4a through 2.9-4d in CBR, 2015). The measurements were conducted in four consecutive quarters for a period of one year. The NRC staff's examination of the data as illustrated in TR Figures 2.9-4a through 2.9-4d (CBR, 2015) did not reveal significant seasonal water lever fluctuations over the one-year period. The NRC staff agrees with the applicant that the water level data illustrated in potentiometric maps (TR Figures 2.9-4a through 2.9-4d in CBR, 2015) indicate that local groundwater flow direction in the Arikaree Formation within the MEA is generally toward the south-southeast (see Section 2.9.3.2 of CBR, 2015).

The applicant conducted grain size analysis and falling head permeameter testing of 10 core samples obtained from the Arikaree Group (CBR, 2015) where the visual observed textural composition ranged from siltstones to sandstones. Grain size analysis indicated a predominance of silt-sized particles. Hydraulic conductivity values ranged from 1.0 x 10^{-4} cm/sec (3.3 x 10^{-6} ft/sec) to 2.9 x 10^{-3} cm/sec (9.5 x 10^{-5} ft/sec) (based on grain-size analysis using the Kozeny-Carmen equation) for four samples that had the highest percentage of sand, and hydraulic conductivity values ranged from 2.3 x 10^{-5} cm/sec (7.5 x 10^{-7} ft/sec) to 9.2 x 10^{-5} cm/sec (1.0 x 10^{-6} ft/sec) for the remaining samples.

Brule Formation

The applicant reports that the Brule Formation produces widely variable amounts of water at MEA, ranging from 0.5 gpm to in excess of 800 gpm for a local agricultural well (well #732) (TR Section 2.7.2.1 in CBR, 2015).

The applicant states in Section 2.7.2.1 of the TR that the first overlying aquifer unit above the production zone is a 3 to 10.7 m (10- to 35-ft) thick water-bearing sandstone at the base of the Brown Siltstone Member of the Brule Formation (CBR, 2015; CBR, 2017). This aquifer unit is present across the entire MEA. Other sand-rich horizons that may produce water within the Brule Formation have been reported above this lower sandstone, but are limited in lateral extent and do not extend across the entire MEA (CBR, 2015; CBR, 2017). The applicant recently (post-2015) performed geophysical and geologic sample logging in the lower Brule Formation, which corroborated the lack of deeper aquifers within the formation at the MEA (CBR, 2017). The applicant attempted to develop wells in the lower Brule Formation, but the wells went dry and took longer than a week to recover (CBR, 2017). The NRC staff agrees with the applicant that the inability to develop wells further substantiates the lack of deeper aquifers in the Brule Formation.

As discussed in Section 2.9.3.2 of the TR, the applicant monitored groundwater levels in 11 upper Brule aquifer monitoring wells during 2013 and 2014 (refer to TR Table 2.9-7 and TR Figures 2.9-5a to 2.9-5d in CBR, 2015). The measurements were conducted in four consecutive quarters for a period of one year. The NRC staff's examination of the data in TR Figures 2.9-5a through 2.9-5d (CBR, 2015) did not reveal significant seasonal water lever fluctuations over the one-year period. The NRC staff agrees with the applicant that the water level data illustrated in potentiometric maps (TR Figures 2.9-5a to 2.9-5d in CBR, 2015) indicate that local groundwater flow direction in the Brule aquifer within the MEA is generally to the southeast toward the Niobrara River with a horizontal hydraulic gradient of 0.011 (CBR, 2015).

The applicant states that comparison of the groundwater level data for the Arikaree aquifer and Brule aquifer indicates potentiometric surfaces that are nearly equal in elevation, with nearby pairs of monitoring wells screened in the two units showing groundwater elevation differences of approximately 1.5 m (5 ft) or less (CBR, 2015). Based on the NRC staff's examination of water level data in TR Table 2.9-7 (CBR, 2015) and associated potentiometric maps (TR Figures 2.9-4a through 4d and 2.9-5a through 2.9-5d in CBR, 2015), the NRC staff agrees with the applicant's conclusion that this similarity in groundwater elevations and shared south-southeast groundwater flow direction indicate that groundwater within the Brule Formation is not confined by overlying units, and that the Arikaree Group and Brule Formation function as a single hydrogeological unit (CBR, 2015).

A strong downward hydraulic gradient exists between the Brule aquifer and the Basal Chadron Sandstone aquifer at all locations within the MEA (CBR, 2015). Head differences observed during October 2013 between six monitoring well pairs in the Brule aquifer and Basal Chadron Sandstone aquifer (BOW-2010-1 and Monitor-3, BOW-2010-2 and Monitor-4A, BOW-2010-3 and Monitor-8, BOW-2010-4 and Monitor-10, BOW-201-5 and Monitor-11, BOW-2010-6 and Monitor-1) ranged from approximately 105 to 158 m (346 to 518 ft) (CBR, 2015).

The applicant conducted grain size analysis and falling head permeameter testing of 13 core samples obtained from the Brule Formation (CBR -2015) where the visual observed textural composition was observed by the applicant to range from mudstones to sandstones. Grain size analysis indicated a predominance of silt-sized particles. Hydraulic conductivity values for two samples that had the highest percentage of sand were 1.4×10^{-4} cm/sec (4.5×10^{-6} ft/sec) and 2.3×10^{-4} (7.5×10^{-6} ft/sec) (based on grain-size analysis using the Kozeny-Carmen equation), and the average hydraulic conductivity based on all samples tested was 8.9×10^{-5} cm/sec (7.5×10^{-7} ft/sec). A falling head permeameter test of one of the core samples indicated a vertical hydraulic conductivity value of 1.31×10^{-7} cm/s (4.30×10^{-9} ft/s) (CBR, 2015), which may reflect sampling from a localized area containing layers of lower conductivity material.

Middle and Upper Chadron Formation

The applicant states in TR Section 2.7.2.1 that, based on geologic sample logs and geophysical drill-hole logs (TR Figures 2.6-3a through 2.6-3n and 2.6-8 in CBR, 2015, and TR Figures 7, 2.6-3a through 2.6n and TR Appendix HH in CBR, 2017), X-ray diffraction analysis (TR Appendix G-1 and G-2), and particle grain size analyses of five core samples (TR Appendix G-1), , the upper confinement for the production zone within the MEA is 110 to 137 m (360 to 450 ft) thick and composed of smectite-rich mudstone and siltstones of the upper Chadron and middle Chadron (CBR, 2015). X-ray diffraction analysis of core samples from the middle Chadron indicated a predominant mixed-layered illite/smectite or montmorillonite with quartz (TR Appendix G-1 in CBR, 2015). X-ray diffraction of the core samples from the upper Chadron were primarily composed of montmorillonite, calcite, and quartz (CBR, 2017).

Estimated hydraulic conductivities for the upper confining unit were developed using particle grain size distribution data, based on the Kozeny-Carmen method, from five core samples collected from the upper and middle Chadron (CBR, 2015). Results of the particle size distribution analyses indicate sediments dominated by silts and clays. Estimated hydraulic conductivities of three core samples collected within the upper Chadron ranged from 4.3×10^{-5} to 5.9×10^{-5} cm/s (1.4×10^{-6} to 1.9×10^{-6} ft/s). Estimated hydraulic conductivities for two core samples collected within the middle Chadron ranged from 1.7×10^{-5} to 2.9×10^{-5} cm/s (5.6×10^{-7} to 9.5×10^{-7} ft/s). Observing that results of X-ray diffraction analysis indicated the predominance of a mixed-layer of high plasticity clayey sediments, the applicant noted that the use of the Kozeny-Carmen method is acceptable for developing hydraulic conductivity estimates for sands and silts, but not for cohesive clayey sediments with a high degree of plasticity (CBR, 2015). Thus, the NRC staff views the results of the particle grain size analysis using Kozeny-Carmen method as more qualitative due to the upper and middle Chadron being predominantly composed of high plasticity clayey sediments.

The applicant reports that falling head permeameter testing (ASTM D5084) of a core sample (M-1635c, Run 3, Sample 1) from the upper Chadron Formation returned an average measured vertical hydraulic conductivity value of 1.32×10^{-7} cm/s (4.3×10^{-9} ft/s). As a point of reference, EPA requires that clay liners at hazardous waste landfills be built so that the permeability is equal to or less than 10^{-7} cm/s (EPA, 1989). Application of the Kozeny-Carmen equation to calculate hydraulic conductivity for the same core (M-1635c, Run 3, Sample 1) based on particle grain size distribution resulted in an estimated value of 4.3×10^{-5} cm/s (1.4×10^{-6} ft/s) (CBR, 2015). The difference between the two results is attributed to the qualitative nature of the Kozeny-Carmen method for high plasticity clayey sediments (as discussed in the previous paragraph) and the likely presence of heterogeneous and anisotropic conditions across the confining layers, as indicated by the results of the falling head permeameter test. The falling head permeameter test, which is a direct test of the vertical hydraulic conductivity, resulted in a lower value of hydraulic conductivity than the hydraulic conductivity as determined by the grain size distribution.

<u>Basal Chadron Sandstone</u>

The applicant states that groundwater from the underlying Basal Chadron Sandstone aquifer is not used as a domestic supply within the MEA because of the greater depth (259 to 366 m [850 to 1200 ft] bgs) and inferior water quality (CBR, 2015). Potentiometric maps and cross-sections of the Basal Chadron Sandstone aquifer indicate confined groundwater flow (refer to TR Figures 2.9-6a through 2.9-6d in CBR, 2015 and TR 2.6-3a through 2.6-3n in CBR, 2017). In the vicinity of the MEA, groundwater flow in the Basal Chadron Sandstone aquifer is predominantly to the northwest, toward the White River drainage basin, with a horizontal hydraulic gradient of 0.0004 (CBR, 2015).

The applicant provided hydrographs of water level data obtained from the 13 Basal Chadron Sandstone aquifer monitoring wells (TR Appendix GG in CBR, 2016). These hydrographs present water level data for the period from October 2013 to April 2016. The hydrographs of the 13 wells show a drop in water levels in the Basal Chadron Formation ranging from 3 to 4.9 m (10 to 16 ft) with an average drop of approximately 18.5 km (11.5 feet). One possible source for this observed drop in water levels in the Basal Chadron Sandstone aquifer is the consumptive use of groundwater in the Basal Chadron Sandstone aquifer at the currently licensed CBR facility (TR Appendix GG in CBR, 2016). Another possible source contributing to the drop, although unlikely, is the large seasonal agricultural groundwater withdrawals from a tributary arm of the Basal Chadron Sandstone aquifer approximately 56 to 80 km (35 to 50 miles) southwest of MEA in the North Platte drainage. The Basal Chadron Sandstone is not continuous directly between the MEA and the North Platte drainage (see, e.g. Sibray, 2010), but there do appear to be indirect flow paths approximately 96.5 to 161 km (60 to 100 miles) in length that may hydraulically connect the MEA and the North Platte basin.

The applicant estimated the expected drawdown of the potentiometric surface of the Basal Chadron Sandstone aquifer over the period of MEA operations and a 10-year aquifer recovery period in a model that uses the Theis solution for confined aquifers (Theis, 1935). The modeling was done using AquiferWin32® analytical modeling software (TR Appendix GG in CBR, 2016). Results of the computed model indicated a maximum cumulative drawdown at the MEA of less than 179 m (111 feet) over the period of combined ISR operations from the MEA, TCEA, and the currently licensed CBR facility. The minimum available head at the MEA (after accounting for the drawdown of 179 m (111 feet) is projected to be greater than 515 m (320 feet) within MEA ISR wellfields, and greater than 270 feet within the entire MEA license area, for the duration of combined ISR operations. CBR, 2016.

To provide additional assurance that the Basal Chadron Sandstone aquifer will remain saturated throughout the proposed operations and restoration of the MEA, the NRC staff is imposing a license condition that will require monitoring of water levels in existing MEA Basal Chadron Sandstone aquifer monitoring wells 8 and 9 and two additional two monitoring wells to be installed in the Basal Chadron Sandstone aquifer within the MEA. The license condition requires a corrective action plan to be developed and submitted to the NRC within 30 days for review and approval if the cumulative total drawdown in these wells at any time during MEA operations and restoration exceeds 274 m (170 feet). The license condition is presented in SER Section 5.7.9.4.

<u>Pierre Shale (lower confining unit to the Basal Chadron Sandstone)</u>

Lower confinement for the Basal Chadron Sandstone aquifer in the vicinity of the MEA is provided by approximately 229 m (750 ft) to more than 305 m (1,000 ft) of black marine shale deposits of the Pierre Shale, considered a regional aquiclude of very low permeability (CBR, 2015).

According to the applicant (see TR Section 2.7.2.3 of CBR, 2015), the lack of major folding across the axis of the Cochran Arch north of the MEA, as shown in cross-section A-A' of TR Figure 2.6-3 (CBR, 2015) and cross-section AA-AA' (Figure 7 in CBR, 2017), indicates that the deformation associated with the Cochran Arch did not produce significant vertical fractures within the Pierre Shale. The applicant reports that particle grain-size analyses of two Pierre Shale core samples from the MEA were characterized by low permeability silty clay and that X-ray diffraction of seven core samples from the MEA indicated the prevalence of illite and smectite clays (CBR, 2015). The applicant asserts that the swelling nature of these clays in the presence of water makes it unlikely that any fractures or penetrations that could exist within the Pierre Shale would provide a pathway for loss of confinement through the thick unit.

The applicant notes that the Pierre Shale has a measured vertical hydraulic conductivity at the currently licensed CBR facility of less than 1×10^{-10} cm/s (3.3×10^{-12} ft/s) (CBR, 2015) and cites references (Neuzil and Bredehoeft, 1980; Neuzil et al., 1982; Neuzil, 1993) that estimate the regional hydraulic conductivity of the unit as ranging from 10^{-7} to 10^{-12} cm/s (3.3×10^{-9} to 3.3×10^{-12} ft/s). The NRC staff notes that the higher hydraulic conductivity value in this range corresponds to a regional estimate obtained from numerical analysis and is hypothesized to be the result of flow in transmissive fractures within the Pierre Shale (Neuzil et al., 1982). The NRC staff further notes that even this higher value is considered to represent a low degree of permeability for engineering geology applications (Reeves et al, 2006, pg. 95). The applicant also remarks that the sub-Pierre low permeability units including the Niobrara Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale further hydraulically isolate the Basal Chadron Sandstone aquifer from the underlying “D”, “G”, and “J” sandstones of the Dakota Group by more than 305 m (1,000 ft) vertically (refer to TR Table 2.6-1 in CBR, 2015).

The NRC staff finds that the applicant’s hydrogeological characterization of the hydrostratigraphic units discussed above is sufficient and meets acceptance criteria (3) and (5) presented in Section 2.7.3 of NUREG-1569 (NRC, 2003).

2.4.3.3 Aquifer Test

Appendix F of the TR provides details of a large-scale aquifer pumping test performed in 2011 at the MEA to confirm the hydraulic properties and degree of isolation of the Basal Chadron Sandstone (CBR, 2015). The aquifer pumping test was performed in accordance with aquifer pumping test procedures in an NDEQ-approved regional pumping test plan dated September 27, 2010 with subsequent approved changes dated March 16, 2011 (CBR, 2015). The NRC reviewed the procedures used for conducting the aquifer pumping test and finds they are consistent with industry practices and thus sufficient. The test included recovery of water levels in the Basal Chadron Sandstone aquifer observation wells, which were monitored for 12 days after cessation of pumping. A total of eight production zone (Basal Chadron Sandstone aquifer) monitoring wells were installed for the test. The applicant monitored those wells, along with three Brule aquifer wells (BOW wells), during the test. A summary of well completion data is included in TR Table 2.7-2 and TR Appendix F (CBR, 2015), with well locations shown in TR Figure 2.7-7 (CBR, 2015).

The applicant conducted the 2011 aquifer pumping test in the Basal Chadron Sandstone aquifer with the following stated objectives (CBR, 2015):

- evaluate the degree of hydraulic communication between the production zone pumping well and the surrounding production zone observation wells;
- evaluate the presence or absence of the production zone aquifer within the test area;
- assess the hydrologic characteristics of the production zone aquifer within the test area including the presence or absence of hydraulic boundaries;
- demonstrate sufficient confinement (hydraulic isolation) between the production zone and the overlying aquifer for the purpose of ISR operations.

Based on the information presented in TR Appendix F (CBR, 2015), the distances of the monitoring wells from the pumping well (CPW-2010-1A) ranged from 20 to 2,682 m (67 to 8,800 ft) for the Basal Chadron Sandstone aquifer wells and from 41 to 2,093 m (133 to 6,867 ft) for the overlying Brule aquifer wells. Well CPW-2010-1A was pumped at an average discharge rate of 102.5 liters/min (27.08 gpm) for 103 hours. The radius of influence (ROI) within the Basal Chadron Sandstone aquifer during the test was estimated to be in excess of 2,682 m (8,800 ft). All of the Basal Chadron Sandstone aquifer observation wells and pumping well showed significant and predictable drawdown during the aquifer pumping test, which supports the presence of hydraulic continuity of this regional unit throughout the test area. A maximum drawdown of 7.13 m (23.40 ft) was observed in the pumping well during the test. The lack of a discernable drawdown in Brule aquifer observation wells during the aquifer pumping test indicates that adequate confinement exists between the overlying Brule aquifer and the Basal Chadron Sandstone production zone.

The applicant analyzed the aquifer pumping test data using the Theis (1935) drawdown and recovery methods and the Jacob Straight-Line Distance-Drawdown method (Cooper and Jacob 1946) to calculate transmissivity, storativity, and hydraulic conductivity of the Basal Chadron

Sandstone aquifer (CBR, 2015). Estimated hydraulic parameters for individual well locations for the 2011 aquifer pumping test are summarized in TR Table 2.7-3 (CBR, 2015). The mean hydraulic conductivity of the units is calculated as 7.8 m/d (25 ft/d) (ranging from 2.1 to 18.9 m/d [7 to 62 ft/day]) based on an average net unit thickness of 12 m (40 ft) and a mean transmissivity of 94 m^2/d (1,012 ft^2/d); ranging from 21 to 229 m^2/d (230 to 2,469 ft^2/day). Based on both the drawdown and recovery analyses, hydraulic conductivities of the aquifer materials within 30.5 m (100 ft) of the pumping well were approximately three to nine times greater than hydraulic conductivities estimated for other observation wells in the aquifer pumping test area based on both the drawdown and recovery analyses, as indicated by an apparent higher conductivity boundary condition effect (flattening of drawdown and recovery curves using curve fitting techniques) in these wells. The mean storativity (the volume of water released from aquifer storage per unit of surface area per unit of change in head) is calculated as 2.56×10^{-4} (ranging from1.7×10^{-3} to 8.32×10^{-5}).

After reviewing the applicant's aquifer pumping test procedures and results, the NRC staff finds that the results of the aquifer pumping test sufficiently defined aquifer properties (hydraulic conductivity, transmissivity, and storativity) of the Basal Chadron Sandstone aquifer (a regional unit) and demonstrated that there is adequate confinement between the overlying Brule aquifer and the Basal Chadron Sandstone aquifer. The NRC staff finds that the applicant's aquifer pumping test methods and results are sufficient and meets acceptance criterion (3) presented in Section 2.7.3 of NUREG-1569 (NRC, 2003).

2.4.3.5 Water Use

In TR Sections 2.2 and 2.7.1, the applicant describes water usage in the region of the MEA (CBR, 2015). Plausible municipal or domestic surface water resources in the form of ponds, lakes and surface water impoundments are not present within the MEA (CBR, 2015). Water from the Niobrara River, located south of the MEA license area boundary, is diverted into the Box Butte Reservoir, which is situated approximately three miles (4.8 km) east of the southeastern corner of the MEA license area boundary (see TR Figure 2.7-6 in CBR, 2015). According to the applicant, the primary purpose of the reservoir is irrigation, with secondary benefits for recreation, fish, and wildlife (CBR, 2015).

The applicant states that there is no public water supply system in the vicinity of the MEA and that the residential homes scattered throughout the MEA are supplied with domestic water from private wells (CBR, 2015). CBR conducted water user surveys in 2010 and 2011 to identify and locate all private water supply wells within a 2.25-mile (3.62-km) area of review (AOR) for the proposed MEA (CBR, 2015). The water user survey targeted the location, depth, casing size, depth to water, and flow rate of all wells within the area that were (or potentially could be) used as domestic, agricultural, or livestock water supplies. TR Table 2.2-11 and TR Appendix A (CBR, 2015) list the active, inactive, seasonal and abandoned water supply wells within the MEA and AOR. The locations of all active, inactive, seasonal and abandoned water supply wells are depicted on TR Figures 2.7-6 and 2.9-3 (CBR, 2015). Available NDNR registration and abandonment records for wells within the AOR are presented in TR Appendices E-1 and D-2 (CBR, 2015).

The water user survey identified a total of 134 private water supply wells within the proposed MEA license boundary and associated AOR (CBR, 2015). The applicant reported that, based on available information, all of these wells draw water from the Arikaree Group and/or Brule aquifers

(CBR, 2015). Within the MEA a total of 10 active private water supply wells were found (see TR Table 2.2-11 in CBR, 2015). Eight of these were classified for livestock use, and two were classified as “other use” (identified as driller water supply) wells. Outside the proposed MEA license boundary, but within the AOR, 87 active private wells were found. These were classified by use as livestock (61), domestic/livestock (12), agricultural (5), domestic (4), domestic/garden (2), domestic/agricultural (1), domestic/livestock/agricultural (1), and livestock/garden (1) wells.

The presence of high-capacity irrigation wells within and near the MEA screened in the Arikaree Group and Brule aquifers is expected to have a seasonal impact on those aquifers. In July 2013, the NRC staff issued a request for additional information (RAI) to CBR requesting “an analysis of the hydraulic effects that nearby agricultural wells may have on the migration potential of MEA regulated material releases in the overlying groundwater zone toward these wells” (NRC, 2013). In response to this RAI, CBR provided an analysis performed in December 2013 of the potential hydrologic impacts to local irrigation wells resulting from a hypothetical shallow casing leak in the overlying aquifer at the MEA ISR wellfields (included as TR Appendix AA-1). The focus of this assessment was well 732, which is a high capacity irrigation well located in the shallow Arikaree/Brule aquifer approximately 762 m (2500 ft) east of the nearest MEA ISR wellfield pattern area. To accomplish this task, an analytical groundwater flow model was used to simulate groundwater flow in the shallow Arikaree/Brule aquifer at the MEA. Particle-tracking techniques were used to illustrate the 30-year capture zone of irrigation well 732 to assess whether a hypothetical shallow casing leak from the MEA wellfields could potentially impact the irrigation well. The results of this analysis indicated that MEA wellfields would not be located within the capture zone of irrigation well 732 and that a shallow casing leak in the wellfield would not impact the irrigation well. However, because the analysis relied on limited information concerning the water levels in Arikaree/Brule aquifer, CBR undertook continuous monitoring of groundwater elevations in shallow Arikaree/Brule aquifer monitoring wells during the 2014 irrigation season to better quantify the hydrologic influence (e.g. drawdown) of agricultural well pumping near the MEA.

CBR collected daily water level elevation data using dedicated Troll® dataloggers from eight shallow monitoring wells (AOW-4, AOW-5, AOW-9, AOW-10, BOW-2010-4A, BOW-2010-5, BOW-9, and BOW-10) at the MEA from December 11, 2013 to October 9, 2014 (CBR, 2015). Results of water level monitoring reported in TR Section 2.9.3.2 (CBR, 2015) indicate that the operation of irrigation well 732 caused a maximum of 0.67 m (2.2 ft) of drawdown in the nearest monitoring well cluster (AOW-9/BOW-9) over a 100-day (3.3 month) irrigation well pumping period. The applicant emphasizes that the similar drawdown measured in AOW-9 and BOW-9 is indicative of the hydraulic interconnection between the Arikaree and Brule aquifers in the MEA. Drawdown observed in other shallow monitoring wells was less than 0.15 m (0.5 feet).

The applicant reports that irrigation well 732 pumped 218,580,969 liters (57,742,980 gallons) of groundwater over an approximate 100-day (3.3 month) period during the 2014 irrigation season (late April to early August 2014) (CBR, 2015). This well pumped approximately 3,028 liters/min (800 gpm) for 12 hours each day, equating to an average continuous pumping rate of 1,518 liters/min (401 gpm) each day over the 100-day operating period. The applicant notes that these irrigation operating conditions differed somewhat from the estimated operating conditions used in the December 2013 impact analysis (i.e., well 732 operating 11 hours per day for 5 months, or an average continuous pumping rate of 1,412 liters/min [373 gpm]). The applicant recalibrated the groundwater flow model used for the December 2013 analysis using the 2014 irrigation season water level data for monitoring wells AOW-9/BOW-9 and the updated information for irrigation well

732. The documentation for this revised analysis, completed in November 2014, is included as Appendix AA-2 of the TR (CBR, 2015). Calibrated flow model parameters and irrigation well operating conditions are summarized below:

Hydraulic conductivity: 2.5 m/d (8.2 ft/d)
Transmissivity: 153.8 m^2/d (1,656 ft^2/d) (aquifer thickness 61.6 m [202 ft])
The hydraulic gradient: 0.004
Porosity: 0.15
Specific Yield: 0.048 (adjusted downward from 0.1 to calibrate the model)
Pumping rate: 1,518 liters/m (401 gpm) for 3.3 months (100 days).

Based on Figure 2 in TR Appendix AA-2 (CBR, 2015), the differences between observed and simulated drawdowns in wells AOW-9/BOW-9 are generally in the range of ± 0.15 m (0.5 ft). The applicant reported that the difference between simulated and observed drawdown in other surficial aquifer monitoring wells was less than 0.15 m (0.5 ft). The NRC staff agrees with the applicant's conclusions that the model is adequately calibrated and can be used to make predictions with a reasonable degree of accuracy (CBR, 2015).

To assess whether a hypothetical shallow casing leak from the MEA wellfields could potentially impact irrigation well 732, CBR applied the calibrated groundwater flow model in conjunction with particle-tracking to calculate and illustrate the 30-year capture zone around the well (CBR, 2015, Appendix AA-2). For purposes of this analysis, a conservative ("worst-case") scenario was simulated: a hypothetical shallow casing leak occurring along the downgradient portion of the adjacent MEA wellfields while irrigation well 732 pumps the maximum allowable amount of groundwater (251 acre-ft/year, 373 gpm for 5 months). These are the same operating conditions assumed in the original December 2013 impact analysis.

The revised 30-year capture zone of irrigation well 732 is illustrated in Figure 3 of TR Appendix AA-2 (CBR, 2015). This figure indicates that no MEA wellfields fall within the capture zone of irrigation well 732. These results support the applicant's conclusion (CBR, 2015) that a casing leak within the MEA wellfields will not impact irrigation well 732 nor other nearby agricultural wells given their location in relation to the "worse-case" capture zone.

The applicant states that based on population projections, future water use within the MEA and its vicinity are anticipated to be a continuation of present use (CBR, 2015). The applicant further stated that irrigation development within the MEA AOR is anticipated to be consistent with the past and that the limited water supplies, topography, and semi-arid climate are likely to restrain any irrigation development (CBR, 2015). The applicant reported that one irrigation center pivot extends into the license boundary (SE ¼ section of Section 18, T29N R50W; TR Figure 7.3-2 in CBR, 2015) and may continue to be operated by the land owner, but the pivot will not be operated inside any MEA monitor well ring. Other than this, there are no other lands within the license boundary that are irrigated, and no additional irrigation within the license boundary will occur during MEA operations (CBR, 2015). In addition, under the terms of the applicant's leases, no new irrigation wells will be installed within the license area without CBR permission. It is anticipated by the applicant that the residents of Marsland and the surrounding area will continue to use water supplied exclusively by private wells.

The NRC staff finds that the applicant's description and analysis of the water use at MEA and the surrounding area is sufficient and meets acceptance criterion (6) presented in Section 2.7.3 of NUREG-1569 (NRC, 2003).

2.4.4 Evaluation Findings

The NRC staff has completed its review of the hydrologic site characterization information for the proposed MEA, and concludes that the applicant has acceptably described the surface water hydrology by providing the location, data, and description of the drainages in and around the license area as well as erosion and flood potential analyses for the facility. To ensure that adequate erosion and flooding protection measures are enacted, the NRC staff is imposing the following license condition:

> The applicant shall minimize potential damage to infrastructure from peak flows by avoiding well installation within 100-year flood plains and areas of moderate to high risk of erosion and concentrated water flow during storm runoff. If the installation of wells in such locations cannot be avoided, adequate wellhead protection will be required to protect the wells during flood conditions. Prior to such installation, a description of wellhead protection measures that will be used to protect the wells during flood conditions shall be submitted to the NRC for review and written verification.

The applicant has acceptably described the regional groundwater hydrology and characterized the overlying aquifer and the production zone aquifer with an aquifer pumping test, site data on hydraulic parameters and the integrity of confining layers, and potentiometric surface maps with acceptable contour intervals based on an appropriate number of monitoring wells.

The applicant also provided information regarding the water use within and in the vicinity of the MEA. A recalibrated groundwater flow model, based on continuous water level data from Arikaree/Brule aquifer monitoring wells, was provided by the applicant to demonstrate that a hypothetical casing leak within MEA wellfields would not impact nearby agricultural wells.

Based upon its review of the MEA hydrologic characterization presented in the TR, the NRC staff concludes that the information provided by the applicant, as supplemented by the requirements of the erosion control and drawdown license conditions discussed above and in Section 5.7.9, meets the applicable acceptance criteria of Section 2.7.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's operation of the MEA will comply with the requirements of 10 CFR 40.41(c).

2.4.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

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CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

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2.5 BACKGROUND SURFACE WATER AND GROUNDWATER QUALITY

2.5.1 Regulatory Requirements

The purpose of this review is to determine whether the applicant has demonstrated that it has performed the characterization of background preoperational surface and groundwater quality at the MEA according to the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7 using acceptance criterion (4) in Section 2.7.3 and acceptance criterion (1) in Section 2.9.3 of NUREG-1569 (NRC, 2003).

2.5.3 NRC Staff Review and Analysis

The following sections present the NRC staff's review and analysis of preoperational background surface water and groundwater quality of the MEA. Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by Crow Butte Resources (CBR) in their MEA TR (CBR, 2015) and as updated (CBR, 2017).

2.5.3.1 Surface Water

Regulatory Guide 4.14 (NRC, 1980) recommends surface water sampling for several types of areas. The locations can include large permanent onsite water impoundments, such as a pond or lake, offsite impoundments that may be subject to direct surface drainage from potentially contaminated areas, surface waters or drainage systems crossing the site boundary, and surface waters that may be subject to drainage from potentially contaminated areas.

Surface water/sediment sampling locations for the MEA are shown in TR Figure 2.7.4 (CBR, 2015). The applicant initially identified six sediment and surface runoff sampling locations in ephemeral stream channels but, in response to inquiries from NRC staff in July, 2014, added an additional sampling point (MED-7) along the eastern side of the site boundary. The applicant states (CBR, 2017) that no background water samples were collected from the ephemeral drainage system as no water was present in these drainages between the fourth quarter of 2013 and the second quarter of 2015. The applicant has committed to collecting background water samples from MED-1 through MED-7 if water flow becomes available at any time prior to mining (2017). CBR conducted sediment sampling at MED-1 through MED-6 on October 25, 2013 and May 2, 2014; sampling at MED-7 was conducted on October 17, 2014 and April 30, 2015. The analytical results for these samples are presented in TR Table 2.9-39 (CBR, 2015).

Two surface water sampling locations, N-1 and N-2, are in the Niobrara River (upstream and downstream of potential discharge location MED-3). Monthly background water quality results for N-1 and N-2 (refer to TR Figure 2.7-4 in CBR, 2015) are presented in TR Tables 2.9-29 and 2.9-30 (CBR, 2015), respectively, for radiological constituents (suspended and dissolved) in samples collected between September 2013 and August 2014. A summary of the background radiological analysis results is presented in TR Table 2.9-31 (CBR, 2015).

The applicant presents non-radiological water quality data acquired by the NDEQ for stations on the Niobrara River (CBR, 2015). One of these stations (SNI4NIOBR402-NIOBRARA RIVER ABOVE BOX BUTTE RESERVOIR) is located near sampling point N-2 (see Figure 2.7-4 in CBR, 2015). Data from 2003 through 2011 for this station are presented in TR Tables 2.9-15 through 2.9-25 and summarized in TR Table 2.9-26 (CBR, 2015). The applicant reports that the segment of the Niobrara River located south of the MEA is classified by NDEQ as “Supported Beneficial Use” for aquatic life, agricultural water supply and aesthetics but as “Impaired” for recreational use due to the presence of *E. coli* (CBR, 2015). The applicant also presents the data obtained by NDEQ in 2008 for a station on the east side of the Box Butte Reservoir (SNI4NIOBRA20-NIOBRARA RIVER BELOW BOX BUTTE RESERVOIR) (see Tables 2.9-27 and 2.9-28 in CBR, 2015). Notwithstanding this data, the NRC staff notes that the applicant did not provide non-radiological background water quality data for all the constituents listed in the table acceptance criterion (4) in section 2.7.3 of NUREG-1569 (NRC, 2003) for both the N-1 and N-2 sampling locations to meet acceptance criterion (4) in section 2.7.3 of NUREG-1569, nor did the applicant provide an alternate list of constituents tailored to the site with appropriate justification. Therefore, the NRC staff is imposing a license condition in Section 2.5.4 to obtain satisfactory non-radiological background surface water quality data for the Niobrara River Stations N-1 and N-2.

TR section 2.7.1 states that no surface water impoundments, lakes, or ponds have been identified within the MEA (CBR, 2015). Based on a site visit in 2014 and review of Google Earth aerial imagery (dating from 9/25/2013), the NRC staff has not been able to identify any impoundments onsite. The Box Butte Reservoir is located offsite, southeast of the project area. The applicant reports that Box Butte Reservoir is classified by NDEQ as “Supported Beneficial Use” for recreation, agricultural water supply and aesthetics but as “Impaired” for aquatic life due to elevated mercury levels in fish tissues (CBR, 2015).

Based on the information provided by the applicant and the provisions of the above-referenced license condition in this SER section, the NRC staff finds that the background surface water quality characterization is sufficient and meets acceptance criterion (4) in Section 2.7.3 and acceptance criterion (1) in Section 2.9.3 of NUREG-1569 (NRC, 2003).

2.5.3.2 Groundwater

TR Section 2.9.3 (CBR, 2015) presents data for radiological and non-radiological analyses for private water supply wells within the 2.25 miles (3.62 km) AOR and monitoring wells within the MEA completed in the Arikaree, Brule, and Basal Chadron Sandstone aquifers. Quarterly preoperational radiological and non-radiological water quality samples were collected on all active private wells within the AOR during 2014 and 2015.

The location of private water supply wells is shown in TR Figure 2.9-3, and their characteristics are detailed in Table 2.2-11 (CBR, 2015). Private wells were sampled over a cumulative time span extending from March 2011 to March 2013. The applicant states that 43 wells were sampled for four quarters and 12 others were sampled for less than four quarters (7 were seasonal wells that did not operate year-round, and 5 became inoperable during the sampling period) (CBR, 2015). An additional 17 water supply wells were not sampled at all because they were not operational. The samples collected were analyzed for radiological and non-radiological constituents. The results of these analyses are summarized in TR Table 2.9-4 (CBR, 2015), with well-by-well results presented in TR Tables 2.9-5 (radiological) and 2.9-6 (non-radiological), respectively. The data in TR Table 2.9-5 indicates that dissolved natural uranium concentrations were consistently below the corresponding Environmental Protection Agency (EPA) Drinking Water Maximum Contaminant Level (MCL) of 0.03 mg/L. For radium-226, results were also below the corresponding EPA MCL (5 pCi/L) with the exception of the sample obtained on September 22, 2011 from well 741 which yielded a radium-226 value of 9.5 pCi/L. The total dissolve solids (TDS) results (standard methods) for the private wells ranged from 202-400 mg/l, and are thus below the corresponding EPA Secondary Drinking Water Maximum Contaminant Level (SMCL) of 500 mg/L.

For the monitoring wells in the Arikaree Group and Brule Formation, four quarterly sampling events were conducted, beginning the fourth quarter of 2013 and ending in the third quarter of 2014. This monitoring included 10 Arikaree Group monitoring wells (AOW-1, AOW-3, AOW-4, AOW-5, AOW-6, AOW-7, AOW-8, AOW-9, AOW-10, AOW-11) and 11 Brule Formation monitoring wells (BOW-2010-1, BOW-2010-2, BOW-2010-3, BOW-2010-4A, BOW-2010-5, BOW-2010-6, BOW-2010-7, and BOW-2010-8, BOW-9, BOW-10, and BOW-11. The location of these wells is shown on TR Figure 2.7-8. The corresponding well completion records are included in TR Appendix E-2 (CBR, 2015). Analytical results for the Arikaree monitoring wells are presented in TR Tables 2.9-42 (radiological) and 2.9-43 (non-radiological) (CBR, 2015). Analytical results for the Brule monitoring wells are presented in Table 2.9-8 (non-radiological) and 2.9-9 (radiological) (CBR, 2015). The analytical results obtained for these wells are similar to those obtained for the public water supply wells. Dissolved natural uranium and radium results were consistently below the corresponding EPA MCLs (0.03 mg/L and 5 pCi/L, respectively). With regard to total dissolved solids (TDS) results (standard methods), the values measured for Arikaree wells ranged from 220 to 300 mg/l, and are thus below the corresponding EPA SMCL of 500 mg/L. For Brule wells, TDS values exceeded the EPA SMCL in monitoring wells BOW 2010-1 (1030 – 1280 mg/L), BOW 2010-2 (620 – 970 mg/L), and BOW 2010-4A (610 – 730 mg/L).

The applicant also provided radiological and non-radiological analytical results for 11 Basal Chadron Sandstone monitoring wells sampled quarterly for a one-year period starting in the fourth quarter of 2011. The locations of these wells are shown on TR Figure 2.7-6 (CBR, 2015), and the analytical results are presented in TR Tables 2.9-4 (summary), 2.9-10 and 2.9-11 (CBR, 2015). By comparing TR Figures 1.4-1 (estimated MEA ore body extent) and 2.7-6 (monitoring well locations map) (CBR, 2015), the NRC staff determined that seven of the Basal Chadron Sandstone monitoring wells (1, 2, 4A, 5, 6, 11, and CPW-2010-1) are located within the estimated ore body. The NRC staff also determined, by further comparison of earlier-cited TR Figures 1.4-1 and 2.7-6 with TR Figures 2.9-6a through 2.9-6d (Basal Chadron Sandstone potentiometric surface maps), that the Basal Chadron Sandstone monitoring wells are located along-gradient, cross-gradient, or down-gradient as a function of time relative to the areal extent of the ore zone. The applicant's data indicate that dissolved natural uranium concentrations in Basal Chadron Sandstone monitoring wells are above the corresponding EPA MCL (0.03 mg/L) occur in well MW-4A (>0.03-0.077 mg/L). Dissolved radium-226 values above the corresponding MCL (5 pCi/L) occur in MW-1 (12.3 – 15 pCi/L), MW4A (262 - 390 pCi/L), MW-6 (9.0 pCi/L), MW10 (6.6 pCi/L), and CPW-2010-1 (14.3 – 27.5 pCi/L). The analytical results for the Basal Chadron Sandstone samples indicated levels of TDS ranging from 770 to 1450 mg/L. The TDS results for the Basal Chadron samples were significantly above corresponding EPA Secondary Drinking Water Maximum Contaminant Level (SMCL) of 500 mg/L.

Based on the information provided, the NRC staff finds that the background groundwater quality data presented by the applicant for the Arikaree, Brule and Basal Chadron Sandstone provides complete background groundwater quality data for the MEA and thus meets acceptance criterion

(4) in Section 2.7.3 and acceptance criterion (1) in Section 2.9.3 of NUREG-1569 (NRC, 2003) and the preoperational requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.4 Evaluation Findings

The NRC staff reviewed the preoperational groundwater and surface water quality of the proposed MEA facility in accordance with Section 2.7.3 of NUREG-1569. The applicant describes the preoperational background groundwater quality by providing appropriate chemical and radiochemical analyses of water samples from the production aquifer and overlying aquifers. The applicant has also provided appropriate radiological background water quality data for drainages within the MEA. However, the NRC staff has determined that the applicant has not provided non-radiological analysis of surface water samples from the Niobrara River sufficient to meet acceptance criteria (4) in Section 2.7.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff is imposing the following license condition (discussed in SER Section 2.5.3.1):

> Prior to the commencement of construction related to NRC-licensed activities at the MEA, the licensee shall provide the results of analysis of water samples from the Niobrara River collected quarterly at established sampling locations N-1 and N-2 for a period of one year and analyzed for the list of non-radiological constituents in Sections A, B and C of Table 2.7.3-1 of NUREG-1569. Analytical results for all samples shall be submitted to the NRC for review and written verification. Before implementing this sampling program, the licensee may submit to the NRC, for review and written approval, an alternate list of non-radiological constituents tailored to the MEA site, along with appropriate technical justification.

Based on the review conducted by the NRC staff as indicated above, the information provided in the TR, as supplemented by the information to be provided in accordance with the license condition, represents complete background groundwater quality data for the MEA, and thus meet the preoperational requirements of 10 CFR Part 40, Appendix A, Criterion 7 using acceptance criteria (4) of Section 2.7.3 and acceptance criteria (1) in Section 2.9.3 of NUREG-1569 (NRC, 2003).

2.5.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

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NRC 1980. Regulatory Guide 4.14, Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills", April, 1980.

2.6 BACKGROUND RADIOLOGICAL CHARACTERISTICS

This section discusses the background radiological characteristics of the surrounding environment. The background radiological characteristics are used to evaluate the potential radiological impact of operations on the environment. This includes spills, routine discharges from operations, and other potential releases to the environment. In addition, the data collected is used to identify a radiological baseline for decommissioning, restoration, and reclamation.

During the course of the review, the NRC staff determined that the background radiological characteristics associated with groundwater and surface water is better addressed in the broader discussion of groundwater and surface water characterization programs in Section 2.5 of this SER.

2.6.1 Regulatory Requirements

Section 2.9.4 of NUREG-1569 (NRC, 2003) identifies 10 CFR 51.45 as the regulatory requirement applicable to the NRC staff's review of preoperational monitoring programs at ISR facilities.

10 CFR 51.45 pertains to the adequacy of the applicant's environmental report for the NRC staff's environmental review under the National Environmental Policy Act. As such, the requirement found in 10 CFR 51.45 is not applicable to this safety review.

Therefore, for the purpose of this review, the applicant must demonstrate that the proposed preoperational monitoring program for the MEA is in compliance with 10 CFR Part 40, Appendix A, Criterion 7.

2.6.2 Regulatory Acceptance Criteria

The NRC staff determines whether the applicant has demonstrated that its proposed preoperational monitoring program for the MEA will comply with 10 CFR Part 40, Appendix A, Criterion 7. The proposed preoperational monitoring program for the MEA was reviewed for compliance with this requirement by comparing it to the acceptance criteria in Section 2.9.3 of NUREG-1569 (NRC, 2003).

2.6.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015) and as updated (CBR, 20017). This section discusses the applicant's proposed preoperational monitoring program for the MEA to determine the radiological characteristics of the sampled environmental media.

The applicant's preoperational monitoring program is described in TR Section 2.9 and summarized in TR Table 2.9-41 (CBR, 2017). The applicant has proposed taking air particulate, radon gas, soil, vegetation, food (including crops, livestock, and fish), direct radiation, and sediment samples following the guidance in RG 4.14 (NRC, 1980) (CBR, 2017).

The applicant indicated in TR Section 2.9.8.1 (CBR, 2017) that it will have no tailings impoundment on site (CBR, 2015). In addition, the applicant states that no evaporation ponds are planned for the MEA (refer to TR Section 6.2.1.2 of CBR, 2015).

Based on the applicant's proposed operations and cleanup activities, the NRC staff has determined that radon flux monitoring is not necessary for preoperational monitoring because radon flux measurements are only needed if the applicant is required to demonstrate compliance with the regulations specified in 40 CFR 192.02 related to the control of mill tailings and wastes left on site. Radon flux measurements measure radon emitted per unit area per time, such as radon emitted from a tailings impoundment or waste disposal area. Therefore, the staff concludes the applicant is not required to collect radon flux measurements to comply with Criterion 7 of Appendix A to 10 CFR Part 40.

The applicant states that there are no onsite surface impoundments subject to drainages from the satellite operations, and therefore sediment samples will not be collected from surface impoundments (refer to TR Section 2.9.7.1 of CBR, 2017). During a staff inspection of the main facility, the staff toured the MEA and did not identify any natural surface impoundments (NRC, 2014). Therefore, no sampling of impoundments is required to comply with Criterion 7 of Appendix A to 10 CFR Part 40.

The applicant identified seven private gardens within approximately 3 km (1.86 mi) of the MEA site (refer to TR Section 2.9.5.2 and TR Figure 2.7-4 of CBR, 2017). According to the applicant, consent by the private landowners was not granted due to the large amount of garden crops required to meet the detection limits specified in RG 4.14 (NRC, 1980) (CBR, 2017). Because the sampling of the recommended garden crops is outside the control of the applicant, and the fact that other local food crops will be sampled, the NRC staff concludes the applicant is not required to collect garden crops to comply with Criterion 7 of Appendix A to 10 CFR Part 40.

The applicant identified game animals in and around the MEA (CBR, 2017). The applicant attempted to obtain samples of elk and pronghorn from the Nebraska Game and Parks Commission but was unsuccessful (CBR, 2017). Because the sampling of game animals is outside the control of the applicant, and the fact that other local meat (beef) will be sampled, the NRC staff concludes the applicant is not required to collect game animals to comply with Criterion 7 of Appendix A to 10 CFR Part 40.

The applicant's initial surface soil sampling program did not include soil samples at a depth of 15 cm (6 in.) as recommended in acceptance criteria 2.9.3(2) of NUREG-1569 (NRC, 2003) (CBR, 2015). The applicant committed to collecting preoperational soil samples (for sample locations, refer to Figure 3 of TR Appendix BB of CBR, 2015) at a depth of 15 cm (6 in.) and adding the results to TR Appendix BB (CBR, 2017). This commitment is captured in a preoperational license condition presented in SER Section 2.6.4.

The applicant's initial food sampling program did not include local cultivated crops as recommended in RG 4.14 (NRC, 1980) (CBR, 2015). The applicant committed to collecting preoperational crop samples and adding the results to TR Appendix Q (CBR, 2017). This commitment is captured in a preoperational license condition presented in SER Section 2.6.4.

Air monitoring stations are shown on TR Figure 7.3-2 (CBR, 2015). The locations for the air monitoring stations are based on the criteria from Section 1.1 of RG 4.14 (NRC, 1980) using the results of onsite wind data as discussed in TR Section 2.9 (CBR, 2017).

The applicant used the recommendations in RG 4.14 for types of samples, sampling methods, sample locations, frequency of sampling, and specific types of analyses for its preoperational monitoring program (CBR, 2017). In addition, the applicant used the detection limits recommended in RG 4.14 (NRC, 1980) for each type of analysis (CBR, 2017).

The NRC staff finds that the applicant's preoperational monitoring program has identified and has, or will, measure all relevant environmental samples consistent with acceptance criteria 2.9.3(1) and 2.9.3(2) of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed preoperational monitoring program will comply with Criterion 7 of Appendix A to 10 CFR Part 40.

2.6.4 Evaluation Findings

The applicant has established an acceptable preoperational monitoring program for the MEA. The NRC staff concludes that the applicant's program, as described in its MEA TR, complies with 10 CFR Part 40, Appendix A, Criterion 7.
The NRC staff is imposing the following preoperational license condition to obtain information on the applicant's preoperational monitoring program for the MEA consistent with the applicant's commitment (CBR, 2017) to provide this information.

> At least 90 days prior to the commencement of construction related to NRC-licensed activities at the MEA, the licensee shall collect and submit the results of preoperational soil and crop samples as described in the licensee's submittal dated June 27, 2017 (ML17193A311) to the NRC staff for review and written verification. Following NRC verification, the results of the preoperational soil samples shall be added to Appendix BB of the Marsland Technical Report, and the results of the preoperational crop samples shall be added to Appendix Q of the Marsland Technical Report, as described in the licensee's submittal dated June 27, 2017 (ML17193A311).

2.6.5 References

10 CFR 40, Part 40, "Domestic Licensing of Source Material," Appendix A, Criterion 7

CBR, 2017. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, Response to Open Issues – Marsland Expansion Area Technical Report, Teleconference on June 14, 2016, June 27, 2017, ADAMS Accession No. ML17193A311 (Package).

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2014. NRC Inspection Report 040-08943/14-001, Arlington, TX, July 18, 2014, ADAMS Accession No. ML14199A537.

NRC, 2003. NUREG-1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications-Final Report,” June, 2003, ADAMS Accession No. ML032250177.

NRC, 1980. Regulatory Guide 4.14, Revision 1, “Radiological Effluent and Environmental Monitoring at Uranium Mills,” April 1980.

3.0 DESCRIPTION OF THE PROPOSED FACILITY

3.1 IN SITU RECOVERY PROCESS AND EQUIPMENT

3.1.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the equipment and processes used in the wellfields during operation at the MEA will meet the requirements of 10 CFR 40.32(c) and (d) and 40.41(c).

3.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria outlined in Section 3.1.3 of NUREG-1569 (NRC, 2003a).

3.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by the applicant in the MEA TR (CBR, 2015). As part of its review of the information supplied by the applicant, the NRC staff also examined past inspection reports of processes and equipment at the currently licensed CBR facility similar to those proposed for MEA.

The following subsections present the NRC staff’s review and analysis of various aspects of the ISR processes and equipment proposed for the MEA. Review areas addressed in this section include the uranium extraction and restoration operations, wellfield infrastructure, and the proposed schedule for operations.

3.1.3.1 Mine Unit and Mineralized Zone Description

The applicant describes the ISR process and equipment to be used at the MEA in section 3.1 of the TR (CBR, 2015). The MEA license area is approximately 1,871 hectares (4,622.3 ac), of which 709.4 hectares (1,753 ac) will be wellfields and construction disturbed areas. Within the MEA, the satellite building will be located within a fenced area. (CBR, 2015)

For wellfield infrastructure, the applicant states that the ore zones at the MEA will be divided into separate production areas (wellfields) where the injection and extraction wells will be installed. Consistent with the currently licensed CBR facility, wells will be arranged in 7-spot patterns with injection wells spaced between 19.8 and 45.7 m (65 and 150 ft) (CBR, 2015). The NRC staff previously found the applicant’s injection and production well arrangement at its currently licensed CBR facility to be acceptable (NRC, 2014a). The NRC staff finds that the applicant’s injection and production well arrangement in a similar formational hydrogeology at the MEA (refer to TR Section 2.7.2 of CBR, 2015) will be equivalent to the injection and production well arrangement used at the currently licensed facility (refer to TR Sections 2.7.2.1 and 2.7.2.2 of CBR, 2007a) and that, therefore, the findings and conclusions from the prior staff review apply to the MEA as well. The NRC staff also finds that there are no safety concerns associated with the proposed injection and production well arrangement at the MEA that were not previously reviewed.

TR Section 3.1.3 (CBR, 2015) states, "Other wellfield designs include alternating single line drives" (staggered and direct line drives are illustrated in Shao-Chih Way, 2008).[2] The NRC staff does not approve the use of staggered or direct line drives for the MEA because the TR does not sufficiently demonstrate the containment of injected fluids and a monitoring program for a line drive at the MEA. Therefore, the NRC staff will impose a license condition requiring that CBR not construct a wellfield using a design containing line drives. This license condition is presented in SER Section 3.1.4.

The applicant states that uranium at the MEA will be extracted from an ore body in the Basal Chadron Sandstone at depths of 259 m to 366 m (850 ft to 1,200 ft) below ground surface. In plan-view, the ore zone is a 305 m to 1,219 m (1,000 ft to 4,000 ft) wide strip trending generally North to South (CBR, 2015). The thickness of ore-bearing Basal Chadron Sandstone ranges between 8 m and 27 m (25 ft and 90 ft), and the average uranium grade is 0.22% U_3O_8. (CBR, 2015). The NRC staff finds this description of the MEA mineralized zone is sufficient and meets acceptance criterion (1) presented in Section 3.1.3 of NUREG-1569 (NRC, 2003a).

3.1.3.2 Well Design, Construction and Integrity Testing

The applicant describes in detail the well installation and cementing procedures to protect overlying and underling aquifers and prevent cross contamination. The applicant provides a description of three well construction methods in section 3.1.2 of the TR (CBR, 2015). Typical well completion schematics for each of these methods are provided in TR Figures 3.1-1, 3.1-2 and 3.1-3. Connections between factory-constructed well casing sections will be joined using an O-ring and spline locking system. The NRC staff reviewed TR Section 3.1.2.1 (CBR, 2015) and found that the applicant's description of the polyvinyl chloride (PVC) and metal well construction materials that will be used at the MEA are inert to lixiviants and will be designed, sized, and constructed to withstand injection pressures. The screen interval is determined by the applicant's geologic staff review of geophysical logs. The screened interval of an injection and production well is selected by identifying ore-bearing sand zone to be mined. As discussed in SER Section 3.1.3.3, the screen interval of monitoring wells at the perimeter of the wellfield (perimeter monitoring wells) will include sand horizons that could be impacted by the nearby mining wells (injection and production well) through permeable sands that hydraulically connect the mining wells to the surrounding perimeter monitoring wells. The applicant committed to maintaining well completion reports associated data (geophysical logs) on-site for review (CBR, 2015). The NRC staff finds that the applicant's description of the proposed well construction meets acceptance criteria (2a) and (3) presented in Section 3.1.3 of NUREG-1569 (NRC, 2003a).

The applicant states in section 3.1.2.7 of the TR that after the completion of well installation, the wells will be developed by airlifting and pumping (CBR, 2015). Airlift well development entails the injection of air to break down the mud-cake left on the borehole wall and to remove fine grained sediments. In accordance with License Condition 10.5 (CBR, 2017), mechanical integrity tests

[2] "Line drive" refers to a wellfield configuration that includes one line or multiple parallel lines of production wells with a line of injection wells located on either side of and parallel to each line of production wells.

(MITs) will be performed when wells are brought into service initially and every five years thereafter. Wells will also be tested after any repair or work is done on the well and whenever there is any question of casing integrity. MITs will be performed at a pressure which is 125 percent of the maximum operating wellhead casing pressure. A well passes the MIT if a pressure-drop of less than 10 percent occurs over a minimum 20-minute period. All MITs will be documented and the records will be maintained on site for NRC review (CBR, 2015). The NRC staff finds that the applicant's description of the proposed MIT procedures meets acceptance criteria (2b) presented in Section 3.1.3 of NUREG-1569 (NRC, 2003a)

Based on the NRC staff's review of information provided in the TR, the applicant's past experience with the above-referenced MIT procedures described in TR Section 3.1.2.7 (CBR, 2015), and the requirements of the standard License Condition 10.5 (CBR, 2017), the NRC staff finds that the applicant's MIT procedures for the MEA (CBR, 2015) are consistent with those used at its currently licensed CBR facility. The NRC staff previously found the applicant's MIT procedures at its currently licensed CBR facility to be acceptable (NRC, 2014a). The NRC staff finds that the applicant's MIT procedures at the MEA will be equivalent to the MIT procedures used at the currently licensed facility and that, therefore, the findings and conclusions from the prior staff review apply to the MEA as well. The NRC staff also finds that there are no safety concerns associated with the proposed MIT procedures at the MEA that were not previously reviewed.

3.1.3.3 Excursion Monitoring Wells

The applicant's proposed configuration and density for MEA groundwater monitoring wells in the overlying Brule aquifer and wellfield perimeter monitoring wells in Basal Chadron aquifer (production aquifer) are similar to that of the currently licensed CBR facility (CBR, 2007a). Based on annual inspection of facility records by the NRC (NRC, 2011, 2012, 2013, and 2014b), the monitoring well pattern at the currently licensed CBR facility has been demonstrated to be effective in detecting excursions. Based on the staff's review of information provided in the TR, the NRC staff finds that the applicant's MEA monitoring well pattern is the same monitoring well pattern used at its currently licensed CBR facility. The NRC staff previously found the applicant's monitoring well pattern at its currently licensed CBR facility to be acceptable (NRC, 2014a). The NRC staff finds that the applicant's monitoring well pattern in a similar formational hydrogeology at the MEA will be equivalent to the monitoring well pattern used at the currently licensed facility and that, therefore, the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the proposed monitoring well pattern at the MEA that were not previously reviewed.

Screened intervals of the MEA wellfield perimeter monitor wells will cover the production zone in sand horizons that could be impacted by nearby mining wells (TR Section 3.1.2.2 in CBR, 2015). The screened interval will be determined by CBR geology staff using borehole geophysical logs and formation samples. The NRC staff finds that the proposed excursion monitoring well network for the MEA is sufficient and meets acceptance criterion (3) presented in Section 3.1.3 of NUREG-1569 (NRC, 2003a). The applicant's monitoring program and procedures for control excursions at the MEA are further discussed in SER section 5.7.9 and a discussion of the flare factor that may result in excursions is further discussed in SER section 6.1.

3.1.3.4 Spills and Leaks

The applicant states in section 3.1.3 of the TR that wellfield piping will be constructed of polyvinyl chloride (PVC) or high-density polyethylene (HDPE) (CBR, 2015). The applicant states that individual well lines and trunk lines will be buried to prevent freezing. Individual pipelines and trunk lines are pressure tested at operating pressures prior to their final burial below the frost line prior to operations and following maintenance activities that may affect the integrity of the system (CBR, 2015). As the applicant is committed to piping installation procedures that will prevent piping failures and that are consistent with typical programs used in the industry, the NRC staff finds the procedures are sufficient and meet acceptance criterion (9) presented in Section 3.1.3 of NUREG-1569 (NRC, 2003a).

The applicant provides a description of the header houses that will be used to distribute injection fluid to injection wells and collect production solution (CBR, 2015). The applicant states that pressure and flow of injection and production wells will be continuously monitored for pressure and flow at each header house using an electronic monitoring system. This system will allow these monitoring parameters to be observed at the control room of the MEA satellite building. The control system will be equipped with high and low alarms for pressure and flow, which will alert control room personnel to certain ranges of pressure and flow that signal a potential pipe leak and trigger automatic shutoffs and shutdowns. Additionally, the header houses will be equipped with an alarm for the presence of liquids in the header house sump (CBR, 2015).

Based on the NRC staff's review of information provided in the TR, the staff finds that the proposed instrumentation and operation of wellfield piping, header houses, and associated control systems are consistent with those used at the currently licensed CBR facility. The NRC staff previously found the applicant's instrumentation and operation of wellfield piping, header houses, and associated control systems at its currently licensed CBR facility to be acceptable (NRC, 2014a). The NRC staff is not aware of any safety-related reason why instrumentation and operation of wellfield piping, header houses, and associated control systems implemented and used at the currently licensed facility would not be similarly effective for the MEA. Therefore, the NRC staff finds that the applicant's instrumentation and operation of wellfield piping, header houses, and associated control systems will be protective of public health and safety at the MEA.

The applicant states in section 7.5.4 of the TR that a program of continuous wellfield inspections will be implemented by wellfield operators. Various process components within process, storage, and wellfield areas will be inspected to ensure proper operation and to detect leaks (CBR, 2015). The inspection program is consistent with the program at the currently licensed CBR facility, which was previously found to be acceptable by the NRC staff (NRC, 2011, 2012, 2013, and 2014b). The NRC staff also finds that there are no unreviewed safety concerns with respect to the wellfield inspection program. Based on the above, the NRC staff finds that the wellfield inspection program to be used at the MEA is acceptable.

3.1.3.5 In Situ Recovery Process

3.1.3.5.1 Injection Pressures

The applicant states in TR Section 3.1.3 (CBR, 2015) that based on regional information, prior CBR permit submittals, and historical operational practices, the formation fracture gradient (i.e., pressure required to induce fractures in rock at a given depth) for operations at the currently-licensed CBR facility has been calculated to be 14.25 kPa/m (0.63 psi/ft). The formation fracture gradient for the MEA has been calculated to be 11.99 kPa/m (0.53 psi/ft) (CBR, 2015), which is commensurate with that previously calculated for the currently licensed CBR facility (NRC, 1998).

Using the formation fracture gradient, the NRC staff estimated the maximum bottom-hole injection pressure that could be maintained without fracturing at the MEA. The staff estimated the formation fracture pressure for the maximum well depth of 366 m (1,200 ft) to be 4.38 MPa (636 psi). Considering that the minimum static water level depth in Basal Chadron Sandstone monitoring wells at the MEA is 121.6 m (399 feet) below the ground surface (TR section 2.9.3.2 in CBR, 2015) and using a hydrostatic pressure gradient of 9.79 kPa/m (0.433 psi /ft), the NRC staff estimated the bottom hole hydrostatic pressure at a depth of 244 m (801 ft) deep to be 2.39 MPa (347 psi). Therefore, the bottom-hole formation fracture pressure constraint is 1.99 MPa (289 psi or 636 psi – 347 psi). License Condition 10.14 (NRC, 2017), which will also apply to MEA as a standard license condition, states that the injection pressures during wellfield operations shall not exceed 0.69 MPa (100 psi) at the injection well heads (refer to SER Section 3.3.3). Because the design operating wellhead pressure of 0.69 MPa (100 psi) is less than the bottom hole formation fracture pressure constraint of 1.99 MPa (289 psi), the staff finds that the operating pressures are acceptable and will not cause the well to exceed the estimated bottom-hole formation fracture pressures at the MEA.

3.1.3.5.2 Bleed

Although the applicant states that the MEA will be operated at an overall average production flow rate of 6,000 gpm, excluding restoration flows (TR Section 1.4 of CBR, 2015), the water balance projections (Appendix T of CBR, 2015) indicate that the maximum production flow will amount to 5,400 gpm. The applicant estimates that an anticipated bleed rate of 0.5 to 2.0 percent of the total mining flow will be maintained (CBR, 2015). The bleed ensures that more fluid is recovered than injected, thus creating an inward hydraulic gradient to prevent excursions. As required by standard License Condition 10.7 (NRC, 2017), the applicant must maintain an overall inward hydraulic gradient during operations and restoration at the perimeter ore zone monitoring wells for each wellfield. This license condition will also apply to the MEA. The NRC staff evaluated the ability of the applicant to maintain an overall inward hydraulic gradient at the MEA during production to prevent excursions at perimeter ore zone monitoring wells. Due to similarities between the proposed MEA project and the currently licensed Crow Butte project, this evaluation centered on a review of records for the current Crow Butte license area. Some of the relevant similarities considered in the NRC staff's evaluation included:

- design and operational schedule of wellfields;
- groundwater treatment capacity;
- production wellfield bleed at MEA will be 0.5 to 2 percent of the production flow. A production bleed of 0.5 percent to 1.5 percent has been successfully applied at the currently licensed CBR facility (CBR, 2007a);
- Published information (see SER Section 2.3) indicates that the ISR related regional stratigraphic units in this portion of the State of Nebraska are present beneath both of the above-referenced projects;
- Hydrogeological characterization of the MEA (refer to SER Section 2.4) indicates that the ISR hydrogeology and Basal Chadron Sandstone aquifer properties are similar to those at the currently licensed CBR facility (CBR, 2015).

The NRC staff's review of the currently licensed CBR facility's records included inspection reports (NRC 1999 - 2002, 2003b, 2004-2006, 2007b, 2008, 2009, 2010, 2011, 2021, 2013, 2014b) and numerous excursion monitoring reports. From 2000 to 2014, NRC records indicate 16 perimeter monitoring wells were placed on excursion status. The corrective actions for the perimeter ring wells on excursions have consisted primarily of adjusting flow in the nearest mine units to capture any outward flow. These corrective actions have proved adequate in controlling the excursions in a timely manner for ten perimeter wells (See Section 5.7.9.3.2 of NRC, 2014a). The NRC staff finds that the record of historical excursions demonstrates the applicant's ability to maintain the containment of ISR fluids within the wellfield. Based on the above-referenced similarities between the MEA and the currently licensed CBR facility and the applicant's demonstrated ability to maintain an overall inward gradient at their currently licensed facility, the NRC staff has reasonable assurance that the applicant will be able to maintain an overall inward gradient at the MEA.

The applicant states that the eluant bleed stream at the central processing facility (CPF) at the currently licensed CBR facility is currently 5 – 10 gpm (CBR, 2015). This is anticipated to likely increase by a maximum of 10 percent due to processing of loaded ion exchange resin from the MEA (CBR, 2015). The applicant states that the eluant bleed waste stream will be managed by reuse in the CPF or by deep disposal well (DDW) injection at the currently licensed CBR facility (CBR, 2015). The total wastewater flow at the CPF amounts to 92 gpm, some of which is diverted into evaporation ponds (Figure 3.1-6, CBR, 2007a). The NRC staff finds that, allowing for an estimated maximum increase of 1 gpm in the eluent bleed stream due to processing of additional IX resin brought in from the MEA, the total wastewater flow at the CPF would remain sufficiently below the estimated injection rate capacity of 1,136 Lpm to 1,514 Lpm (300 gpm to 400 gpm) reported by the applicant for the existing DDW (CBR, 2000). Therefore, the NRC staff has determined that adequate disposal capacity is available at the currently licensed CBR facility for the additional eluant liquid waste generated from the CPF processing of MEA loaded ion exchange resin.

3.1.3.5.3 Satellite Building Material Balance and Flow Rates

The applicant provides a water balance schematic for the proposed MEA production in TR Figure 3.1-8 and a restoration process flow schematic in TR Figure 6.1-1 (CBR, 2015). The TR indicates that the byproduct material liquid waste generated from MEA operation will be composed primarily of the combination of production bleed and restoration liquid waste flow. The production bleed is estimated to be 95 Lpm to 246 Lpm (25 gpm to 65 gpm), which represents 0.4 to 1.2 percent of the reported MEA satellite building production capacity of 20,441 Lpm (5,400 gpm). Coupled with other liquid waste contributions such as restoration liquid waste, the applicant projects that the maximum expected net consumption for the entire operation will be 1,158 Lpm (306 gpm) (CBR, 2015).

In section 3.1.6 of the TR, the applicant describes the plan to handle and dispose of these liquid wastes at the MEA through DDWs. The maximum disposal rate for DDW No. 1 at the currently licensed CBR facility is estimated to be 757 to 1,514 Lpm (200 to 400 gpm) (NRC, 2014a). Adequate disposal capacity is critical for ISR operations and restoration. The applicant has made a commitment that, depending on the capacity of the two planned DDWs, up to four additional DDWs, or surge/evaporation ponds, or land application will be installed or employed to satisfy the wastewater capacity requirements (CBR, 2015). A license amendment application would need to be submitted to and granted by the NRC prior to any surge/evaporation pond construction or the use of land application at the MEA. Disposal of liquid byproduct material in DDWs is further discussed in SER Section 4.2.

The applicant has submitted an application to NDEQ for an Area Permit to install and operate Class I Nonhazardous Waste Injection Wells on private lands within the MEA license boundary (CBR, 2015). The current permit application is for two Class I Nonhazardous Waste Injection Wells to be installed under the Area Permit and permit modifications would be required for any wells added to the Area Permit at a later date (TR Section 4.2.1.8 in CBR, 2015). TR Figure 1.7-5 shows the proposed locations of the two DDWs and four other additional contingent DDWs. If the applicant does not receive the Area Permit, it would have to submit a license amendment request to the NRC to authorize another disposal option.

The current license authorizes CBR to use land application of treated wastewater in two areas at the existing Crow Butte facility, and CBR has a National Pollutant Discharge Elimination System (NPDES) permit from the NDEQ for that activity. CBR indicated that it has not used land application at the existing Crow Butte facility and does not intend to apply for an NPDES permit to allow land application at the MEA at this time (CBR, 2015). The current NRC license does not authorize land application at the MEA. Therefore, the NRC staff is imposing a license condition that states that the applicant must obtain a license amendment prior to constructing surge/evaporation ponds or land application at the MEA. This license condition is presented in SER Section 4.2.4.

3.1.3.5.4 Lixiviant Makeup

The NRC staff previously found the applicant's lixiviant composition at its currently licensed CBR facility to be acceptable (NRC, 2014a). Under standard License Condition 10.1 (NRC, 2017), the lixiviant injected into the production aquifer consists of native groundwater, with added sodium carbonate/bicarbonate, carbon dioxide, oxygen and/or hydrogen peroxide (Section 3.1.3.5.7 of NRC, 2014a). This license condition will also apply to the MEA. Because the applicant's lixiviant composition at the MEA (CBR, 2015) will be equivalent to the lixiviant composition used at the currently licensed facility (refer to Section 3.1.3.5.5 of CBR 2014a), the findings and conclusions from the prior staff review (NRC, 2014a) apply to the MEA as well. The staff also finds that there are no safety concerns associated with the proposed lixiviant composition at the MEA that were not previously reviewed.

3.1.3.5.5 Drawdown

In TR Section 2.2.4 (CBR, 2015), the applicant states that groundwater from the production water-bearing zone (basal sandstone of the Chadron Formation) is not used as a domestic supply within the MEA because of the greater depth (244 to 351 m [800 to 1150 ft] bgs) and inferior water quality. According to the applicant, groundwater is locally obtained from the Arikaree and Brule Formations, with the latter, typically encountered at depths from approximately 15 to 107 m (50 to 350 ft) bgs, being the primary source. TR Figure 2.9-3 shows the location of the private wells that are within one and two kilometers of the MEA license boundary. Active private wells are used for livestock, agricultural or domestic purposes (CBR, 2015).

New private groundwater wells may potentially impact or be impacted by MEA operations. Therefore, the NRC staff is imposing a license condition to require the applicant to: (1) identify the location, screen depth, and estimated pumping rate of any new groundwater wells, or new use of an existing well within the licensed area, (2) evaluate the impact of ISR operations to potential groundwater users, and (3) recommend any additional monitoring or other measures to protect groundwater users. This license condition is presented in SER Section 3.1.4.

3.1.3.6 Schedule

As shown in the wellfield schedule provided in TR Figure 1.7.4, the applicant plans to initiate wellfield production in succession, and restore wellfield groundwater sequentially (CBR, 2015). The MEA will be divided into eleven adjacent wellfield areas as shown in the well field map provided in TR Figure 1.7.5 (CBR, 2015). Operations will start at wellfield MU-1, followed by startup of MU-2 approximately six months after operations begin at MU-1. The initiation of operations in wellfield MU-3 will occur approximately one year from the startup of MU-2 and the startup of the remaining wellfields will be staggered through time. As the uranium yield for a wellfield drops below the economic benefit of the production operations, wellfield restoration will begin with the cessation of lixiviant injection (NRC, 2015). Restoration is the first step in decommissioning of a wellfield, which is considered a separate outdoor area under 10 CFR 40.42. Once restoration begins, it must be completed within two years (24 months) under 10 CFR 40.42(h). If restoration time will exceed two years, 10 CFR 40.42(i) allows a licensee to request NRC approval of an alternate decommissioning (groundwater restoration) schedule. The NRC staff finds the description of the schedule for the MEA operation is sufficient and meets acceptance criterion (6) presented in Section 3.1.3 of NUREG-1569 (NRC, 2003a) and 10 CFR 40.42.

3.1.4 Evaluation Findings

The staff reviewed the ISR process and equipment proposed for use at the MEA in accordance with Section 3.1.3 of NUREG-1569 (NRC, 2003a). The applicant describes the wellfield infrastructure, equipment, and ISR operations and used the results from field testing to support the safe application of ISR. The applicant addressed the mineralized zone and demonstrated protection against the vertical and horizontal migration of water, proposed acceptable well designs and tests for well integrity, and demonstrated that the ISR process will meet the following criteria:

- Down-hole injection pressures are less than formation fracture pressures, and overall production rates are higher than injection rates to create and maintain a cone of depression.
- MEA satellite building material balances and flow rates are appropriate.
- Reasonable estimates of gaseous, liquid, and byproduct material and effluents are provided (used in evaluation of effluent monitoring and control measures in Section 4.0 of NUREG-1569 (NRC, 2003a).
- Disposal operations and capacity are sufficient (see SER Section 4.2.4 for the staff's findings on disposal operations).

Section 3.1.3 of the TR (CBR, 2015) states, "Other wellfield designs include alternating single line drives." The NRC staff does not approve of the use of line drives for the MEA because the TR does not sufficiently demonstrate the containment of injected fluids and a monitoring program for a line drive at the MEA. Therefore, the staff is imposing the following license condition:

> The licensee shall not construct a wellfield using either a staggered line drive or direct line drive design (i.e., one line or multiple parallel lines of production wells

with a line of injections wells located on either side of and parallel to each line of production wells).

New groundwater wells or new use of an existing well may potentially impact or be impacted by MEA operations. Therefore, the staff is imposing the following license condition:

> The licensee shall identify (1) the location, screen depth, and estimated pumping rate of any new permitted groundwater wells, and (2) any permitted change to the use of an existing groundwater well, for all groundwater wells within the MEA license area or within two kilometers of any proposed MEA production area monitoring well ring. The licensee shall evaluate the impact of ISR operations on groundwater quality for all users of groundwater wells within these areas and recommend any additional monitoring or other measures to protect groundwater users. These evaluations shall be submitted semiannually as part of the licensee's semiannual effluent and environmental monitoring program report.

Based upon the above review, the NRC staff finds that the information provided in the TR, as supplemented by information to be collected in accordance with the license conditions during operations, is sufficient and meets the acceptance criteria of Section 3.1.3 (NRC, 2003a) and the requirements of 10 CFR 40.32(c) and (d) and 10 CFR 40.41(c).

3.1.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

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NRC, 2014a. Safety Evaluation Report (Revised), Cameco Resources, Inc., Crow Butte Operation License Renewal, August 14, 2014, ADAMS Accession No. ML14149A433.

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NRC, 2008. NRC Inspection Report 040-08943/08-001, Arlington, TX, August 28, 2008, ADAMS Accession No. ML082410870.

CBR, 2007a. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264.

NRC, 2007b. NRC Inspection Report 040-8943/07-001, Arlington, TX, October 16, 2007, Accession No. ML072890610.

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NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

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NRC, 2003a. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, Accession No. ML032650623.

NRC, 2002. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 (Package).

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3.2 FACILITY EQUIPMENT USED AND MATERIALS PROCESSED

3.2.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has sufficiently demonstrated that the equipment and processes to be used during operations in the facility at the MEA will meet the requirements of 10 CFR 40.32(c) and (d) and 40.41(c).

3.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.2.3 of NUREG-1569 (NRC, 2003).

3.2.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and drawings submitted by CBR in its MEA TR (CBR, 2015).

The MEA will consist of wellfields in the ore zone area, a MEA satellite building to extract uranium from the lixiviant by ion exchange (IX), DDWs, and chemical storage areas (Chapter 1 and Section 3.2.1 in CBR, 2015). Major equipment inside the 39.6 m (130 ft) long by 30.5 m (100 ft) wide MEA satellite building will be the IX system and the lixiviant make-up circuit. Loaded IX resin generated at the MEA satellite building will be transported to the central processing facility (CPF) at the currently licensed CBR facility for elution, precipitation, drying, and packaging using equipment and processes covered under the existing Crow Butte license. The eluted resin will be transported back to the MEA satellite building and reused in ion exchange columns. (CBR, 2015)

The MEA satellite building will consist of an extraction circuit. The extraction circuit includes the flow of lixiviant from the wellfield to the eight fixed-bed ion exchange columns and back to the wellfield. The exchange columns will be operated as three sets of two columns in series with two columns available for restoration. Bleed will constitute 0.5 to 2.0 percent of the barren lixiviant stream. Bleed waste fluids will be routed to and disposed of in DDWs (CBR, 2015). The NRC staff has determined that the applicant's description of facilities and equipment meets acceptance criterion (1) in Section 3.2.3 of NUREG-1569 (NRC, 2003) and is therefore acceptable.

The primary radiological emission from the facility will be radon-222 gas and its decay products. Processing at the MEA satellite building will produce water-based solutions and loaded resin (no yellowcake processing or drying); therefore, airborne uranium concentrations are expected to be at or near background levels. There is a small chance that small quantities of airborne uranium particulates could occur from any spills during the transfer of loaded IX resin to a truck for transport to the CPF; however, the applicant has committed to cleaning up such spills as soon as possible to prevent the wet materials from drying out and creating the potential for airborne particles. Small amounts of radon-222 may be released in the MEA satellite building during solution spills, filter changes, IX resin transfer operations, and maintenance activities. In TR Section 5.7.1.1 (CBR, 2015), the applicant committed to equip the satellite facility with exhaust fans to remove any radon that may be released in the MEA satellite building. Local ventilation piping will also be provided for process vessels where significant concentrations of radon may be expected. The ventilation system at the MEA satellite facility will be similar to that used at the CPF (CBR, 2015). In TR Section 4.1.1 (CBR, 2015), the applicant states that other emissions to the air are limited to exhaust and dust from internal combustion engines and fugitive dust (CBR, 2015). The NRC staff finds that the applicant's identification of potential effluents and sources of radiological emissions, as well as proposed ventilation, is sufficient and meets acceptance criteria (2), (3), and (7) in Section 3.1.3 of NUREG-1569 (NRC, 2003).

The applicant states that the MEA will be equipped with ion exchange and reverse osmosis equipment capable of processing up to 22,712 Lpm (6,000 gpm) of production flow and 5,678 Lpm (1,500 gpm) of restoration flow. The applicant plans to handle and dispose of liquid wastes generated by well development, production, and aquifer restoration through disposal in deep disposal well injection at the MEA. CBR initially plans to use 2 DDWs. The applicant states in TR Section 1.8.1 (CBR, 2015) that the wastewater management program will be reevaluated after about 5 to 6 years of operation. Additional wastewater management systems to be evaluated will include up to four additional DDWs, surge/evaporation ponds, and land application. The applicant commits to submit an evaluation for any proposed changes to the waste management system for NRC written verification and will submit a license amendment request if necessary (CBR, 2015). As discussed in Section 3.1.3.5.3 (CBR, 2015), CBR has not requested authorization to use disposal methods other than DDWs at the MEA, and therefore use of alternate methods, such as surge/evaporation ponds or land application, would require a license amendment.

The applicant includes a list of bulk chemicals that may be used in the uranium recovery process. These include carbon dioxide, oxygen, hydrogen peroxide, and sodium sulfide. The applicant states that none of the hazardous chemicals used at the MEA are covered under EPA's Risk Management Program regulations. The chemicals proposed for use are similar to those discussed in Chapter 4 of NUREG/CR-6733 (NRC, 2001). Table 4-1 of this NUREG presents a list of chemicals used at ISR facilities and pertinent regulations for those chemicals. Consistent with NUREG/CR-6733, the applicant has listed the specific regulations that apply to the chemicals that will be used. The applicant's identification of applicable industry standards to ensure proper handling of hazardous chemicals meets acceptance criteria (5) and (7) presented in Section 3.2.3 of NUREG-1569 (NRC, 2003).

Since oxygen readily supports combustion, fire and explosion, oxygen is a primary ignition source for the MEA. If the oxygen storage tank explodes, damage to the MEA satellite building and subsequent radiological releases could occur. However, the applicant states that the oxygen storage facility would be located a safe distance from the MEA satellite building to minimize potential damage and designed to meet industry standards. In TR Section 3.2.2.1 (CBR, 2015), the applicant states that it will use sodium sulfide as a reductant during the restoration process. To prevent accidents, the applicant states that it will store sodium sulfide bags or sacks in a cool, dry, and clean area to prevent contact with acids, oxidizers, or other potentially reactive materials. The applicant also states that it may use hydrogen sulfide as a reductant, if necessary, and that proper safety precautions will be taken to minimize impacts of hydrogen sulfide on radiological safety.

Based on representations made by the applicant, the NRC staff considers sodium sulfide to be the primary reductant for the MEA. The NRC staff does not approve of the use of hydrogen sulfide at the MEA or any facilities under the applicant's license SUA-1534 because the applicant did not sufficiently discuss, relevant to the use of this chemical, storage and handling procedures. The licensee has stated that hydrogen sulfide gas has never been used at the CPF. Based on License Condition 10.10 of the current license (NRC, 2017), CBR would be required to obtain a license amendment prior to using hydrogen sulfide at the existing Crow Butte facility or the MEA.

Gasoline, diesel and propane will also be used, but not in the uranium recovery process. Since these materials are flammable, bulk quantities will be stored outside process areas at the satellite MEA satellite building. The storage tanks will be located above ground and within secondary containment basins in compliance with regulatory requirements. Based on a risk assessment for chemical storage, the applicant identified hydrochloric acid as the most significant hazard with respect to chemical and radiological safety. Hydrochloric acid is only used and stored at the CPF and will neither be used nor stored at the MEA (CBR, 2015).

Based on the NRC staff's review of information provided in the TR and the applicant's past experience with the above-referenced flammable materials storage and hazardous chemical controls, equipment, and procedures, the NRC staff finds that the applicant's MEA flammable materials storage and hazardous chemical controls, equipment, and procedures are consistent with those used at its currently licensed CBR facility. The NRC staff previously found the applicant's flammable materials storage and hazardous chemical controls, equipment, and procedures at its currently licensed CBR facility to be acceptable (NRC, 2014). The NRC staff finds nothing to invalidate the previous findings on the flammable materials storage and hazardous chemical controls, equipment, and procedures, and previous NRC staff conclusions remain valid. Therefore, the NRC staff has reasonable assurance that the applicant's flammable materials storage and hazardous chemical controls, equipment, and procedures at the MEA will be protective of public health and safety. In addition, the NRC staff has not identified any unreviewed safety-related concerns pertinent to the flammable materials storage and hazardous chemical controls, equipment, and procedures at the MEA.

3.2.4 Evaluation Findings

The NRC staff reviewed the proposed equipment to be used and materials to be processed in the MEA satellite building and chemical storage facilities at the MEA in accordance with Section 3.2.3 of NUREG-1569 (NRC, 2003). The applicant describes the equipment, facilities, and procedures that will be used to protect health and minimize danger to life or property.

Based upon the review conducted by the NRC staff as indicated above, the NRC staff finds that the information provided in the TR is sufficient and meets the acceptance criteria in Section 3.2.3 of NUREG-1569 (NRC, 2003). The NRC staff concludes that the applicant adequately described the equipment, facilities, and procedures that will be used during operations to protect health and minimize danger to life or property. Therefore, the staff has reasonable assurance that the applicant will comply with 10 CFR 40.32(c) and (d) and 10 CFR 40.41(c).

3.2.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report - License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534., Docket No. 40-8943, August 14, 2014, ADAMS Accession No. ML14149A433.

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3.3 INSTRUMENTATION AND CONTROL

3.3.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has adequately demonstrated that the instrumentation and control proposed for the MEA facility meet the requirements of 10 CFR 40.32(c) and (d) and 40.41(c).

3.3.2 Regulatory Acceptance Criteria

If not specifically stated otherwise, changes to the licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.3.3 of NUREG-1569 (NRC, 2003). Since yellowcake dryers are not proposed at MEA, acceptance criteria (5) in NUREG-1569 was not used in the review of the applicant's proposed instrument and controls.

3.3.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and drawings submitted in the MEA TR (CBR, 2015).

The applicant states in section 3.3 of the TR that instrumentation would be provided for the MEA to monitor and control the ISR process. The instrumentation and controls at the MEA will be configured similarly to those used at the currently licensed CBR facility but use newer equipment (CBR, 2015). The descriptions of the ISR systems and variables that will be monitored and controlled include the liquid levels of chemical storage and process tanks, flow and pressure within production and injection well pipelines, trunk lines, and pipelines at the MEA satellite building including all waste flow leaving the MEA satellite building. The control system will contain continuous monitoring and alarms that are activated when operating parameters are outside of the specified operating ranges.

Pipeline flow instrumentation will be provided to monitor and control flow and will include a variety of flow meters. These include turbine meters, ultrasonic meters, variable area meters, electromagnetic flow meters, differential pressure meters, positive displacement meters, piezoelectric and vortex flow meters. These meters will allow for the monitoring and controlling of pipeline flow to and from each of the proposed production and injection wells, total production and injection flow at trunk lines, and total flow to and from the proposed MEA satellite building including total waste flow leaving the MEA satellite building.

At the currently licensed CBR facility, the operating pressures at the injection well heads are required to be maintained at or below 0.69 MPa (100 psi) (refer to Section 3.1.3.5.7 of NRC, 2014) by means of facility-specific License Condition 10.14 (CBR, 2017). Since the proposed MEA ISR infrastructure and operations associated with this requirement are similar to that of the currently licensed CBR facility, the NRC staff is imposing the same requirement for the MEA by revising this facility-specific license condition to a standard license condition. The applicant indicates that this requirement will be met by setting alarms for the injection manifold at each wellhouse at 0.62 to 0.66 MPa (90 to 95 psi). The actual pressure at the wellhead should be lower than the pressure monitored at the wellhouse manifold due to line losses (CBR, 2015).

Instrumentation provided to monitor and control the trunk line pressures will include pressure gauges, pressure shutdown switches, and pressure transducers. The injection system will be equipped with instrumentation to record an alarm and operators are notified in the event of any pressure loss, which might indicate a leak or rupture. Wet alarms will be installed in header houses to monitor the presence of liquids within the header house sumps. The applicant has committed to providing final designs, including installation and use of devices to monitor injection pressure, flow rate, and volume, to the NRC for approval prior to construction at the MEA. (CBR, 2015).

The applicant describes the automated control system for MEA as a Sequential Control and Data Acquisition (SCDA) network with programmable logic controllers. In addition, a processor will be installed in each wellfield house that is separate from the main control system. A local area network (LAN) will be used to interconnect the control system throughout the facility to many computer screens. This system will allow for continuous monitoring and control of critical processes, pressures, all waste flows, wellfield flows, and MEA satellite building operations. The system will have alarm set points that will alert operators when any parameters are outside of satisfactory levels. An uninterruptible power supply system will be equipped to all critical systems in the event of a power failure. A similar system is being used at the currently licensed CBR facility (CBR, 2007). The NRC staff finds the applicant's instrument and controls meets acceptance criteria (1) through (4) presented in Section 3.3.3 of NUREG-1569 (NRC, 2003).

Based on the staff's review of information provided in the TR and the applicant's past experience with the above-referenced instrument and controls, the NRC staff finds that the applicant's planned MEA instrument and controls is consistent with that used at its currently licensed CBR facility. The NRC staff previously found the applicant's instrument and controls at its currently licensed CBR facility to be acceptable (NRC, 2014). The NRC staff finds nothing to invalidate the previous findings on the instrument and controls and previous NRC staff conclusions remain valid. Therefore, the NRC staff has reasonable assurance that the applicant's instrument and controls is at the MEA would be protective of public health and safety. In addition, the NRC staff has not identified any unreviewed safety-related concerns pertinent to the instrument and controls at the MEA.

3.3.4 Evaluation Findings

The NRC staff reviewed the proposed instrumentation and controls for the MEA facility in accordance with Section 3.3.3 of NUREG-1569 (NRC, 2003). Since yellowcake dryers are not proposed at MEA, acceptance criteria (5) in NUREG-1569 was not used in the review of the applicant's proposed instrument and controls. The applicant adequately described the instrumentation and controls that will be used at the MEA facility. Based on the NRC staff's review of information presented in this section, the information provided in the TR is sufficient and meets the applicable acceptance criteria in Section 3.3.3 of NUREG-1569 (NRC, 2003) and meets the requirements of 10 CFR 40.32(c) and(d) and 40.41(c)

3.3.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

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4.0 EFFLUENT CONTROL SYSTEMS

4.1 GASEOUS AND AIRBORNE PARICULATES

This section discusses the basic design of the gaseous and airborne particulate radioactive material effluent control systems for the MEA as proposed by the applicant in the MEA TR (CBR, 2015), as updated. The purposes of the effluent control systems are to prevent and minimize the spread of gaseous and airborne particulate contamination to the atmosphere by the use of emission controls and to achieve radiation doses to workers and members of the public that are as low as reasonably achievable (ALARA).

During the course of the review, the NRC staff determined that the areas of review presented in Section 5.7.1 of NUREG-1569, which address effluent control techniques, are similar to the areas of review for effluent control systems in Section 4.1 (NRC, 2003). Therefore, the NRC staff's review of the applicant's proposed effluent control techniques is included in this section and is not discussed in Section 5.7.2 of this SER.

4.1.1 Regulatory Requirements

Sections 4.1.4 and 5.7.1.4 of NUREG-1569 (NRC, 2003) identify or describe the following regulatory requirements applicable to the NRC staff's review of gaseous and airborne particulate radioactive material effluent control systems and effluent control techniques (hereafter collectively referred to as effluent control systems) at ISR facilities: 10 CFR 20.1101, 20.1201, 20.1301, 20.1302, 20.1501(a), 20.1701, and 40.32(b); 10 CFR Part 20 Subpart L, Subpart M; and 10 CFR Part 40, Appendix A, Criteria 5G(1) and 8. In this section, the staff determines whether the applicant has demonstrated it will comply with these requirements, with the exceptions noted below.

The applicant states that there will be no yellowcake dryer (refer to Sections 3.2 and 4.1.2 of CBR, 2015) and no tailings impoundment (refer to Section 2.9.9 of CBR, 2015) at the MEA. Therefore, the requirements in 10 CFR Part 40, Appendix A, Criterion 8 pertaining to yellowcake dryers and tailings impoundments are not applicable to this review.

Because 10 CFR Part 40, Appendix A, Criterion 5(G)(1), addresses requirements for waste solutions associated with a tailings disposal system, this requirement is not applicable to the applicant's proposed airborne effluent control systems. In addition, because 40 CFR Part 440, Subpart C (mentioned in Criterion 8) covers wastewater discharges from ore mines and processing operations, this requirement is also not applicable to the applicant's proposed airborne effluent control systems.

The requirement in 10 CFR 20.1301(c) applies to the medical use of byproduct material (10 CFR Part 35) and thus is not applicable to this review. In addition, the conditions specified in 10 CFR 20.1301(d) and (f) have not been encountered with this applicant and are therefore not being reviewed at this time.

This review focuses on the design of the effluent control systems for the MEA and its potential impact on maintaining doses ALARA for workers and the public. Therefore, issues related to the training and experience qualification requirements specified in 10 CFR 40.32(b) are addressed in staff's review of the applicant's corporate programs in SER Section 5.1, and are not discussed here. Likewise, the records and reporting requirements in 10 CFR 20, Subparts L and M, respectively, are addressed in the applicant's management control program in SER section 5.2. In addition, the radiation protection program elements specified in 10 CFR 20.1101(a) and (c) are addressed in the NRC staff's review of the applicant's management audit and inspection program, qualifications for personnel conducting the radiation safety program, and radiation safety training program, in SER sections 5.3, 5.4, and 5.5.

Because this review focuses on maintaining doses ALARA for workers and the public, specific dose requirements for workers and the public are not applicable to the design of the effluent control systems for the MEA. However, a detailed discussion on the applicant's programs to demonstrate compliance with the occupational dose limits specified in 10 CFR 20.1201 is provided in SER sections 5.7.3 and 5.7.4. The applicant's program for demonstrating compliance with radiation dose limits for individual members of the public specified in 10 CFR 20.1301(a) and (b) and 20.1302 is evaluated in SER section 5.7.8.

Therefore, for the purposes of this review, the applicant must demonstrate that the proposed effluent control systems for gaseous and airborne particulate radioactive material are in compliance with 10 CFR 20.1101(b) and (d), 20.1301(e), 20.1501(a), 20.1701, and 10 CFR Part 40, Appendix A, Criterion 8, requirements stating that milling operations must be conducted so airborne effluents are reduced to ALARA levels, and the primary means of accomplishing this must be by means of emissions controls.

4.1.2 Regulatory Acceptance Criteria

For gaseous and airborne particulate radioactive material generated at the MEA, the NRC staff determines whether the applicant has demonstrated that operations at the MEA will comply with 10 CFR 20.1101(b) and (d), 20.1501(a), 20.1701, and applicable portions of 10 CFR Part 40, Appendix A, Criterion 8 (exceptions noted in SER Section 4.1.1). The proposed gaseous and airborne particulate radioactive material effluent control systems for the MEA was reviewed for compliance with these requirements by comparing it to applicable acceptance criteria in NUREG-1569, Sections 4.1.3 and 5.7.1.3 (NRC, 2003) as well as the gaseous and airborne particulate radioactive material effluent control systems in place at the currently licensed CBR facility.

4.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in the TR (CBR, 2015). The following sections present the NRC staff's review and analysis of the applicant's release of gaseous and airborne particulate radioactive material that will be generated at the MEA as well as the applicant's proposed control measures for those materials.

4.1.3.1 General

As discussed in TR Sections 3.2 and 4.1.2, the only processing of uranium that will be carried out at the MEA will be processing uranium onto ion exchange resin (CBR, 2015). The remainder of the processes, including elution, precipitation, drying, and packaging of the yellowcake product, will be performed using equipment and processes at the currently licensed CBR facility (CBR, 2015).

The applicant will provide both general work area ventilation and hard piped ventilation systems for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected at the MEA (e.g., ion exchange columns and bicarbonate mix tanks) (CBR, 2015).

4.1.3.2 Ventilation and Effluent Controls

The applicant states in TR Section 4.1.2.3 that the ventilation system at the proposed MEA would be similar to the ventilation system used at the currently licensed CBR facility (CBR, 2015). In TR Section 4.1.2.3, the applicant describes the operation of the ventilation system at that facility, stating that the system maintains a negative pressure in the building in order to limit employee exposure. Also, in TR Section 4.1.2.3, the applicant indicated that the exhaust fans at the MEA will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere, and that exhaust fans will be designed such that the system will be capable of limiting employee exposure with the failure of a single fan. In addition, airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system controlling any releases that occur inside the vessel, and exhaust fans will create negative pressure, ensuring that air will not enter the process areas from vessels and systems within the satellite building. (CBR, 2015)

As discussed in NUREG/CR-6733 (NRC, 2001), the primary source of airborne uranium particulates during normal operations at an ISR facility is from yellowcake drying and packaging operations. As indicated in SER Section 4.1.3.1, the applicant will not be performing any drying or packaging operations at the MEA. Because of this, the applicant indicated in TR Section 4.1.2 that the in-plant (satellite building) air particulate concentrations at the MEA would be expected to be at or near background levels (CBR, 2015). Based on the proposed operations at the MEA, the NRC staff concludes that air particulate concentrations at the MEA should be lower than those at the currently licensed CBR facility, as this is consistent with radioactive particulate source terms analyzed in NUREG/CR-6733 (NRC, 2001). Because there are no drying or packaging operations authorized at the MEA, there are no ventilation or effluent controls needed to limit potential uranium particulate releases from these operations.

Prior to November 30, 2007, the applicant was only licensed to use unpressurized upflow type ion exchangers at the currently licensed CBR facility (NRC, 2007). The applicant estimated that these upflow ion exchangers release 100 percent of the contained radon found in the water processed by these ion exchange columns (18,930 Lpm (5000 gpm)) to the environment. Since that time, the applicant added six pressurized downflow ion exchange columns to process an additional 15,140 Lpm (4000 gpm) at the currently licensed CBR facility (refer to Section 7.12.3 of CBR, 2007 and NRC, 2009).

The applicant indicated in TR Section 3.2.1 (CBR, 2015) that the ion exchange system at the MEA will consist of eight fixed-bed ion exchange columns. The applicant describes the MEA ion exchange columns as the pressurized downflow type where there is no overflow of water, oxygen stays in solution, and radon emissions are contained. Radon releases only occur when the columns are disconnected from the circuit and opened to remove the resin for elution. The applicant estimated that less than 1 percent of the contained radon found in the water that will be processed by the MEA ion exchange columns (22,700 Lpm (6000 gpm)) will be vented to the atmosphere (refer to TR Section 7.3.1 of CBR, 2015).

Therefore, because the pressurized downflow ion exchange columns release only a small fraction of radon to the atmosphere, and the MEA will not process as much water as the currently licensed CBR facility, the NRC staff concludes that the amount of radon released from ion exchange operations at the MEA within the satellite building and to the environment should be less than at the currently licensed CBR facility.

The applicant states in TR Section 4.1.2.3 (CBR, 2015) that a separate ventilation system will be installed at the MEA for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected during resin transfer. The system will consist of an air duct or piping system connected to the top of each of the process tanks. Exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere by forced ventilation. The applicant indicated that the design of the fans will be such that the system will be capable of limiting employee exposure with the failure of any single fan. In addition, the applicant will perform radon daughter monitoring during operation to verify that radon daughters are maintained below the applicant's 25 percent derived air concentration action level. Lastly, the applicant states that discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility, as recommended in Regulatory Guide 8.31 (NRC, 2002). (CBR, 2015)

The applicant indicated that the MEA ventilation system will be designed to achieve 4 to 5 air exchanges per hour (CBR, 2015). This air exchange rate is similar to that of the currently licensed CBR facility (refer to TR Appendix Y of CBR, 2015), which has been adequate to ensure occupational exposure to radon progeny at the currently licensed CBR facility is ALARA (refer to Section 5.7.4 of NRC, 2014). Because the expected average production flow rate at the MEA is less than that of the currently licensed CBR facility (refer to TR Section 1.6 of CBR, 2015), the process of extracting uranium to the ion exchange columns is similar to that used at the currently licensed CBR facility, and the ventilation system is similar to the ventilation system currently used at the currently licensed CBR facility, the NRC staff finds the air exchange rate at the MEA will be acceptable.

To ensure that the effluent control systems will operate correctly prior to, and during, operations, the applicant proposed conducting a preoperational test to verify the air exchange rate (CBR, 2015). In addition, the applicant committed to an inspection and maintenance program for the effluent control system in accordance with RG 3.56 (NRC, 1986) and with their standard operating procedures. (CBR, 2015)

The NRC staff evaluated the applicant's proposed airborne effluent control techniques for radon gas, as described above, for compliance with 10 CFR 20.1101(b), 20.1701, and 10 CFR Part 40, Appendix A, Criterion 8, requirements addressing ALARA considerations. Acceptance criteria (1) and (4) in Section 5.7.1.3 of NUREG-1569 (NRC, 2003) state that effective control of radon gas can be achieved by using a pressurized tank system or by using appropriate ventilation systems in buildings where radon gas venting is expected, and refer to RG 3.56 for acceptable testing, maintenance, and inspection methods for effluent control techniques. As described above, the applicant's proposed pressurized tank and ventilation systems to control radon gas meet acceptance criterion (1) in Section 5.7.1.3 of NUREG-1569 (NRC, 2003). In addition, the applicant's proposed inspection and maintenance program for the effluent control system meets acceptance criterion (4) in Section 5.7.1.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed airborne effluent control techniques for radon gas comply with 10 CFR 20.1101(b), 20.1701, and 10 CFR Part 40, Appendix A, Criterion 8, requirements addressing ALARA considerations.

Section 190.12 of 40 CFR Part 190 establishes dose limits for members of the public from exposures to planned discharges of radioactive materials, other than radon and its daughters, from uranium fuel cycle operations. Under 10 CFR 20.1301(e), the applicant must comply with the requirements in 40 CFR Part 190 at the MEA. Because there will be no yellowcake dryer at the MEA, and thus no applicable emissions (NRC, 1981), the staff concludes that the applicant's operations at the MEA will comply with 40 CFR Part 190 (and the identical requirements in Criterion 8 of 10 CFR Part 40, Appendix A), and therefore with 20.1301(e).

The applicant calculated the dose to the individual likely to receive the highest dose from licensed operations at the currently licensed CBR facility (CBR, 2016, 2017). The calculated dose due to air emissions, excluding Radon-222 and its daughters, was 0.22 mrem in 2015 (CBR, 2016) and 0.01 mrem in 2016 (CBR, 2017). These values are well below the 10 mrem ALARA constraint on air emissions described in 10 CFR 20.1101(d). As described above, because there will be no yellowcake dryer at the MEA, there are no expected emissions of radioactive material other than Radon-222 and its daughters. Therefore, the NRC staff has reasonable assurance that the applicant's proposed operations will comply with 10 CFR 20.1101(d).

In TR Section 4.1 (CBR, 2015), the applicant describes the types of effluents released during operations as well as general discharge points. In TR Sections 5.7.3 (CBR, 2015) and 5.7.7 (CBR, 2017), the applicant provided a description of specific sampling locations and methodologies to determine concentrations and quantities of discharges of radioactive material. In Section 5.7.8 of this SER, the NRC staff concluded that the acceptance criteria in NUREG-1569, Section 5.7.7.3, have been met. Based on this conclusion, the NRC staff finds that the applicant's monitoring of the proposed effluent control system meets acceptance criterion (2) in Section 4.1.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed operations will comply with 10 CFR 20.1501(a).

4.1.4 Evaluation Findings

The NRC staff reviewed the proposed effluent control systems for gaseous and airborne particulates for the MEA by comparing its proposed design with the design of the currently licensed CBR facility.

The applicant acceptably described the release points and sources of both uranium and radon at MEA. The proposed facility will not include a yellowcake drying system. The applicant has discussed emissions associated with activities for routine operations, maintenance activities, and spill cleanups. The applicant has committed to meeting 10 CFR Part 20 occupational dose limits and public dose limits and to maintaining these doses ALARA.

Based upon the review conducted by the NRC staff as indicated above, the information provided in the technical report meets the requirements of 10 CFR 20.1101(b) and (d), 20.1301(e), 20.1501(a), 20.1701, and applicable portions of 10 CFR Part 40, Appendix A, Criterion 8 (see exceptions noted in SER Section 4.1.1).

4.1.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2017. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to NRC, 2016 Annual ALARA Report, August 1, 2017, ADAMS Accession No. ML17220A070.

CBR, 2016. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to NRC, 2015 Annual ALARA Report, March 14, 2016, ADAMS Accession No. ML16097A560 (package).

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264.

NRC, 2014. Safety Evaluation Report (Revised), License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534, August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2009. NRC Inspection Report 040-8943/09-001, Arlington, TX, September 28, 2009, ADAMS Accession No. ML092670138.

NRC, 2007. License Amendment No. 22, Central Processing Plant Upgrade, Crow Butte Resources, Inc. Crawford Nebraska, SUA-1534, November 30, 2007, ADAMS Accession No. ML072700204.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1. Washington, DC: May.

NRC, 2001. "A Baseline Risk-Informed Performance-Based Approach for In-Situ Leach Uranium Extraction Licensees," NUREG/CR–6733, September 2001.

NRC, 1986. "General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills," Regulatory Guide 3.56, Washington, DC: May.

NRC, 1981. "40 CFR 190 Compliance Assessment for NRC Licensed Uranium Recovery Facilities as of December 1, 1980," February 1981, ADAMS Accession # ML103000028.

4.2 LIQUID AND SOLID EFFLUENTS

4.2.1 Regulatory Requirements

Section 4.2.4 of NUREG-1569 (NRC, 2003) identifies or describes the following regulatory requirements applicable to the NRC staff's review of liquid and solid effluents at ISR facilities: 10 CFR 20.1101, 20.1201, 20.1301, 20.1302, 20.2007, and 10 CFR Part 40, Appendix A, Criteria 2, 5A(1) through 5A(5), 5E, 5F, 5G(1), 6(6) and 8. In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

The applicant states that there will be no surface impoundments (refer to TR Sections 2.9 and 4.2 of CBR, 2015) at the MEA. Therefore, the requirements in 10 CFR Part 40, Appendix A, Criteria 5A(1) through 5A(5) pertaining to design provisions for surface impoundments are not applicable to this review. Because 10 CFR Part 40, Appendix A, Criteria 5F and 5G(1) address requirements for waste solutions associated with a tailings disposal system, this requirement is not applicable to the applicant's proposed effluent control systems for liquid and solid radioactive material. The requirement in 10 CFR 20.1301(c) applies to the medical use of byproduct material (10 CFR Part 35) and thus is not applicable to this review. 10 CFR 20.1301(e) is related to effluents that travel off site and thus is not applicable to this review. 10 CFR Part 40, Appendix A, Criterion 5E is related to the containment of tailings impoundments and thus is not applicable to this review. In addition, the conditions specified in 10 CFR 20.1301(d) and (f) have not been encountered with this applicant and are therefore not being reviewed at this time.

This review focuses on the design of the effluent control systems for the MEA and its potential impact on maintaining doses ALARA for workers and the public. The radiation protection program elements specified in 10 CFR 20.1101(a) and (c) are addressed in the NRC staff's review of the applicant's management audit and inspection program, qualifications for personnel conducting the radiation safety program, and radiation safety training program, in SER sections 5.3, 5.4, and 5.5.

Because this review focuses on maintaining doses ALARA for workers and the public, specific dose requirements for workers and the public are not applicable to the design of the effluent control systems for the MEA. However, a detailed discussion on the applicant's programs to demonstrate compliance with the occupational dose limits specified in 10 CFR 20.1201 is provided in SER sections 5.7.3 and 5.7.4. The applicant's program for demonstrating compliance with radiation dose limits for individual members of the public specified in 10 CFR 20.1301(a) and (b) and 20.1302 is evaluated in SER section 5.7.8. 10 CFR Part 40, Appendix A, Criterion 6(6) for demonstrating methodologies for conducting post-reclamation and decommissioning radiological surveys is evaluated in SER section 6.4.

Therefore, for the purposes of this review, the applicant must demonstrate that the proposed effluent control systems for liquid and solid radioactive material are in compliance with 10 CFR 20.1101(b) and (d), as well as the 10 CFR Part 40, Appendix A, Criterion 8 requirement that milling operations must be conducted so liquid and solid effluents are reduced to ALARA levels and the primary means of this reduction must be emissions controls. The applicant's liquid disposal by injection in deep wells must also meet any other applicable federal, state, and local government regulations pertaining to deep well injection in compliance with 10 CFR 20.2007. The applicant must also provide objective evidence of an agreement for disposal of these materials either in a licensed waste disposal site or at a licensed mill tailings facility to demonstrate nonproliferation of waste disposal sites in compliance with 10 CFR Part 40, Appendix A, Criterion 2.

4.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 and 40, as specified above. For liquid and solid effluents generated at the MEA, the NRC staff determines whether the applicant has demonstrated that operations at the MEA will comply with 10 CFR 20.1101(b) and (d), 20.1501(a), 20.1701, and applicable portions of 10 CFR Part 40, Appendix A, Criterion 8 (exceptions noted in SER Section 4.2.1). The proposed effluent control systems for liquid and solid radioactive material for the MEA was reviewed for compliance with these requirements by comparing it to acceptance criteria in NUREG-1569, Section 4.2.3 (NRC, 2003) as well as the liquid and solid effluent control systems in place at the currently licensed CBR facility.

4.2.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015). The following sections present the NRC staff's review and analysis of various aspects of the liquid and solid waste that will be generated at the MEA facility, including the control and disposal of such wastes.

4.2.3.1 Liquid Wastes

In TR Section 4.2.1 (CBR, 2015), the applicant discusses the different liquid waste streams that will be generated at the MEA facility, which are categorized as 11e.(2) byproduct or non-byproduct. The applicant further categorizes liquid waste based on the type of waste, its source, and chemical constituents. Liquid wastes generated from the uranium recovery process are considered liquid byproduct material. Development water and domestic sewage are considered liquid non-byproduct material (CBR, 2015).

4.2.3.1.1 Disposal Options

For liquid byproduct material, the disposal method proposed by the applicant consists of two deep disposal wells (DDWs) to be approved through a Nebraska UIC permit (CBR, 2015). A tank on line with surge capacity for the DDW well system will be used as needed. Additionally, at the discretion of the applicant, the solar evaporation ponds at the currently licensed CBR facility can receive well fluids transported from the MEA. The applicant has made a commitment that, depending on the capacity of the two planned DDWs, additional DDWs or surge/evaporation ponds will be installed at the MEA to satisfy the wastewater capacity requirements (CBR, 2015). Under the current license, land application may only be used as a disposal option in two locations at the currently licensed CBR facility. The NRC staff is imposing a license condition, described in section 4.2.4 of the SER, below, to clarify that a license amendment would be required prior to constructing surge/evaporation ponds or using land application at the MEA. The applicant states that it does not intend to apply for a permit at this time to authorize land application disposal at the MEA (CBR, 2015). The disposal options are evaluated below.

4.2.3.1.2 Liquid Byproduct Material Waste

In TR Section 4.2.1, the applicant identifies the following sources of liquid byproduct waste: ISR process eluent and production/restoration bleed (CBR, 2015). ISR process waste water is fluid generated from the eluent or production/restoration bleed. It is characterized as byproduct material.

The applicant indicates that even though it does have a National Pollutant Discharge Elimination System (NPDES) permit from the NDEQ for land application of treated wastewater at the currently licensed CBR facility, the applicant has not used land application there and does not intend to apply for an NPDES permit to allow land application at the MEA at this time (CBR, 2015), although it may do so in the future. Under the current license, land application is allowed only at two locations at the currently licensed CBR facility, and a license amendment would be required for CBR to conduct land application at the MEA. Prior to the commencement of any land application, the NRC must have reasonable assurance that the land application will be protective of health and safety in accordance with regulatory requirements and guidance. The NRC staff is imposing a license condition to clarify that the applicant must request and obtain a license amendment prior to using land application at the MEA. This license condition is presented in SER Section 4.2.4.

As indicated in TR Section 4.2.1.10 (CBR, 2015), liquid wastes also may occur due to accidental releases. The applicant states that if a spill occurs in the MEA satellite building (e.g., via a piping failure or a process storage tank failure), the spill or leak would be contained within the MEA satellite building structure and limited by the immediate shut down of the pump system in the event of a piping failure (CBR, 2015). Liquid waste released inside the MEA satellite building from a spill or the associated wash down water will be drained through a sump and sent to the MEA liquid waste disposal system. The MEA satellite building will have a building pad and concrete curb built around the entire MEA satellite building, which will be designed to contain the contents of the largest tank within the building in the event of a rupture. The applicant also states that wellfield buildings will have wet alarms for early detection of leaks and the DDW pump house and wellhead will be designed to contain any release of liquids within the building or surrounding bermed containment area. (CBR, 2015). The information provided indicates that potential liquid waste release scenarios at the MEA, and the design features, equipment and procedures for preventing, monitoring and responding to such releases, are consistent with those at the currently licensed CBR facility. In its prior safety review for the currently licensed facility, the NRC staff found the applicant's analysis of liquid waste release accidents and procedures for addressing them to be acceptable (NRC, 2014). The NRC staff finds that the potential liquid waste release accident scenarios at the MEA, and the design features, equipment, and procedures for addressing them, are sufficiently similar to those at the currently licensed facility such that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with liquid waste release accidents at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed equipment, facilities and procedures will be adequate to protect health and minimize danger to life or property with respect to liquid waste release accidents.

The applicant plans to discharge byproduct liquid wastes to DDWs as the proposed disposal method at the MEA facility (CBR, 2015). As a backup to this disposal system, well fluids would be transported to the existing evaporation ponds at the currently licensed CBR facility (CBR, 2015). The MEA TR does not propose constructing surge/evaporation ponds as a disposal option at the MEA. TR Section 3.1.7 states that the need for new surge/evaporation ponds at the MEA will be evaluated pending the performance of the two DDWs planned for the MEA (CBR, 2015). The NRC staff is imposing a license condition to clarify that a license amendment would be necessary prior to any surge/evaporation pond construction at the MEA. This license condition is presented in SER Section 4.2.4.

Under 10 CFR 20.2007, compliance with 10 CFR Part 20, Subpart K does not relieve a licensee from complying with other applicable Federal, State, and local regulations governing any other toxic or hazardous properties of materials that may be disposed of. The applicant currently operates two Class I UIC permitted DDWs at the currently licensed CBR facility for disposal of wastewater and has committed to securing a Class I UIC permit for the proposed DDWs at the MEA (CBR, 2015). The State of Nebraska is an EPA-authorized state for primary enforcement responsibility (primacy) of the UIC Program. CBR is required to satisfy regulatory provisions in 40 CFR Part 146 for obtaining UIC Class I disposal well permits for the proposed MEA DDWs from the NDEQ. Consistent with Acceptance Criterion 13 in Section 6.1.3 of NUREG-1569 (NRC, 2003), the proposed MEA DDWs must satisfy both EPA regulations under the UIC Program and applicable provisions of 10 CFR Part 20. The applicant will be required by license condition to submit a copy of the NDEQ approved permit to the NRC prior to commencing injection of lixiviant in the first wellfield at the MEA. This license condition is presented in SER Section 4.2.4.

SER Section 3.1 provides the NRC staff's evaluation of the applicant's plans, mine unit timetables, and water balance for the operation. Based on the water balance in Appendix T of the MEA TR (CBR, 2015), the projected maximum operational throughput of 20,440 Lpm (5,400 gpm) will generate a waste stream (bleed) that is 0.5 to 2.0 percent of the throughput. Given the importance of having adequate DDW disposal capacity for the concomitant liquid waste stream, the applicant has committed to installing a minimum of two DDWs at the MEA and making efforts to maximize the cumulative DDW injection rate for wastewater generated during production and restoration. To ensure adequate liquid byproduct disposal capacity for the MEA, the staff will include a corresponding condition in the license. This license condition is presented in SER Section 4.2.4. The NRC staff finds with provisions of the license condition meet acceptance criteria (7) in Section 4.2.3 of NUREG 1569 (NRC, 2003)

Class I UIC DDWs are used to inject wastes into deep, isolated aquifers. Typically, DDWs are constructed with several layers of materials that provide redundant layers of protection to minimize the possibility of liquids contaminating underground sources of drinking water. In addition, operators are required by the NDEQ to demonstrate that no significant leaks exist by performing a MIT of the deep disposal well prior to operation and every five years after for the life of the well. Operators are required to monitor several parameters, such as injection pressure, that would indicate potential failure of a deep injection well. This operational data will be available in reports that are available for NRC review during inspections of the MEA facility.

The NRC staff previously evaluated the operation of the DDWs at the currently operating main facility (refer to Section 4.2.3.1.2 of NRC, 2014) and found it acceptable. The staff has determined that the operation of the proposed DDWs at the MEA is bounded by these previous findings for the following reasons:

- the DDWs proposed for the MEA and the two DDWs in operation at the currently licensed CBR facility will use the same aquifer unit to inject process wastes (refer to TR Sections 3.1.7 and 4.2.1.8 of CBR, 2015 and NRC, 2014);
- each MEA DDW is projected to inject process wastes at a depth of 1,200 to 1,500 m (4,000 to 5,000 ft) bgs (TR Section 7.3.2 of CBR, 2015) compared to approximately 1,042 m to 1,139 m (3,420 ft to 3,738 ft) bgs for DDW #2 at the currently licensed CBR facility (CBR, 2015, NRC, 2014, and NRC, 2012);
- the stratigraphy of sediment and rock layers are similar for the MEA and the currently licensed CBR facility (CBR, 2015; NRC, 2014);
- the applicant describes the expected composition of the liquid byproduct material to be discharged into the MEA DDWs as chemically and radiologically similar to the waste stream currently discarded into the current DDWs at the current CBR licensed facility (CBR, 2015 and NRC, 2014).

The information provided indicates that the applicant's operation of the DDW's at the MEA will be consistent with the operation of the DDWs at the currently licensed CBR facility. In its prior safety review for the currently licensed facility (NRC, 2014), the NRC staff found the applicant's disposal of licensed material in deep wells will meet the requirements of 10 CFR 20.2001(a)(3). This regulation requires disposal of licensed material by release in effluents to be within the dose limits specified for individual members of the public in 10 CFR 20.1301. The NRC staff finds that the total expected curie content of the effluent to be injected into the proposed MEA, and the operation, design and characteristics of the DDW's at the proposed MEA are sufficiently similar to those at the currently licensed facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with DDWs at the MEA that were not previously reviewed. Therefore, the staff has reasonable assurance that the disposal of licensed material in the DDWs at the MEA will meet the requirements of 10 CFR 20.2001(a)(3). The NRC staff finds the applicant's description of byproduct liquid waste disposal system meets acceptance criteria (1) and (8) in Section 4.2.3 of NUREG 1569 (NRC, 2003).

4.2.3.1.3 Other Liquid Wastes

TR Section 4.2.1 (CBR, 2015) indicates that the sources of liquid waste that are not byproduct material will consist of water generated during well completion and development, storm water runoff, and domestic liquid waste (CBR, 2015). Well development water is groundwater recovered from a well generally after its initial installation, but before the aquifer had been exposed to the ISR process. For some wells, particularly those screened in the mineralized zone, the development water may contain naturally occurring radionuclides. The applicant states that well development water will be collected using a dedicated vacuum truck and delivered to the well work-over fluid tank located in the satellite building prior to disposal.

Storm water runoff will be managed and controlled under permits issued by the NDEQ that require that procedural and engineering controls be implemented so that runoff will not pose a potential source of pollution. Per the applicant, the design and engineering controls for the proposed MEA facilities will be such that any potentially contaminated storm water runoff or snowmelt (e.g., any tankage diking or curbing outside of the satellite building) will be collected and disposed of in the DDWs (CBR, 2015). Domestic liquid waste water (sanitary waste generated from restrooms and the lunchroom) must meet the requirements of the State of Nebraska and the discharge is limited to nonhazardous materials (CBR, 2015).

The design and operation of the proposed non-byproduct waste disposal system at the MEA is consistent with that of the system in place at the currently licensed CBR facility, which incorporates identical elements as follows (CBR, 2009):

- Well development water containing naturally occurring radionuclides is treated with filtration and/or reverse osmosis for its use make-up water, disposed in the deep disposal well or evaporated into the atmosphere from the pond;
- Storm water runoff is managed and controlled under permits issued by the NDEQ and non-hazardous domestic liquid waste water generated from restrooms and the lunchroom is disposed of in on-site septic system(s) under a permit issued by the NDEQ.

The NRC staff previously found the applicant's non-byproduct waste disposal system at the currently licensed CBR facility to be acceptable (NRC, 2014). The NRC staff finds that the operation, design, and characteristics of the applicant's non-byproduct waste disposal system at the MEA will be equivalent to the system at the currently licensed facility and that, therefore, the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the proposed non-byproduct waste disposal system at the MEA that were not previously reviewed.

4.2.3.1.4 Monitoring of the Disposal Options

Deep Disposal Well

Monitoring of the DDWs will be required by the Nebraska UIC permit to ensure the health and safety of workers and the public. The monitoring will consist of daily measurements of flow rates and pressures, and performing MIT every five years for the life of the well.

The proposed operation and monitoring of deep well disposal at the MEA is consistent with that in place at the currently licensed facility, which incorporates identical elements as follows (CBR, 2007):

- Monitoring of the deep disposal well is required by the Nebraska UIC permit program to ensure the health and safety of worker and the public. The monitoring consists of daily measurements of flow rates and pressures, and performing MIT every five years for the life of the well;
- The applicant committed to continue to retain deep disposal well operational monitoring data required by the Nebraska UIC program and make the data available to NRC staff during on-site inspections.

The staff previously found the applicant's operation and monitoring of DDWs at its main facility to be acceptable (NRC, 2014). The NRC staff finds that the operation and monitoring of the DDWs at the MEA will be equivalent to those operation and monitoring used at the currently licensed facility and that, therefore, the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the proposed non-byproduct waste disposal system at the MEA that were not previously reviewed.

On-site Ponds

Initially, there will be no surge/evaporation ponds constructed at the MEA. The applicant states in TR Section 3.1.7 that the future need for surge/evaporation ponds at the MEA will be determined depending on the performance of the DDWs planned for the MEA (CBR, 2015). A license amendment would be required prior to any surge/evaporation pond construction at the MEA. A license amendment application requesting authority to construct surge/evaporation ponds would have to include plans for pond design, monitoring, inspections, and a pond leak corrective action program.

4.2.3.2 Solid Waste and Disposal

In TR Section 4.3.2, the applicant states that solid waste can be generated from maintenance or non-routine activities, routine operations, and general housekeeping (CBR, 2015). The types of waste can include, but not be limited to, spent resin, resin fines, empty reagent containers, miscellaneous piping and fittings, and domestic trash. The applicant classified the solid waste into four types (CBR, 2015):

1. Non-contaminated solid waste – Waste which is not contaminated with byproduct material or that can be decontaminated to remove any radioactivity to levels that are protective of human health and the environment. This type of waste may include, but not be limited to, piping, valves, instrumentation, equipment and any other item which is not contaminated

or may be successfully decontaminated. The applicant estimated that approximately 535 cubic meters (700 cubic yards) will be generated each year, and stated that this waste will be disposed of at the nearest permitted sanitary landfill.

2. Byproduct material – Tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Byproduct material can include, but not be limited to, filters, personal protective clothing, spent resin, piping, etc. The applicant estimated that approximately 45.9 cubic meters (60 cubic yards) of 11(e).2 byproduct material waste will be generated each year. These materials will be stored on site until a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility.

3. Domestic solid waste – Waste generated during normal operations of the restrooms and/or lunchrooms. The domestic solid waste is collected in the septic tanks of the septic system approved by the State of Nebraska. The domestic solid waste is extracted from the tank and hauled off-site for further processing by licensed haulers.

4. Hazardous Waste – Solid waste that meets the definition of hazardous waste under the Resource Conservation and Recovery Act (RCRA). The applicant states that the site only generates universal hazardous wastes, such as used waste oil and batteries. The facility is classified as a Conditionally Exempt Small Quantity Generator under the RCRA hazardous waste program. To maintain this classification, the amount of hazardous waste generated or handled at this facility must be less than 100 kg (220 pounds) for any one month. CBR has management procedures in place to control and manage these types of wastes and the disposal of waste oil is handled by a licensed waste oil recycler.

Based on industry standards, NRC staff finds the classification of solid waste sources described by the applicant for the MEA (CBR, 2015), as summarized above, is satisfactory.

Non-contaminated solid waste and domestic solid waste must be disposed of off-site at a facility permitted by the State to accept those materials (e.g., solid waste landfill). Hazardous waste must be disposed of offsite at a facility permitted to accept hazardous waste (e.g., a treatment, storage and disposal facility permitted by the approved RCRA program). Byproduct material must be disposed of at a NRC-licensed facility.

Solid waste other than byproduct material is not regulated by the NRC. In TR Section 4.3.2, the applicant states that solid byproduct material will be stored in appropriate containers within a restricted access area before being shipped to a licensed disposal facility (CBR, 2015). The applicant is required by an existing license condition to maintain an agreement for disposal of byproduct material with a licensed byproduct disposal facility or cease operations (refer to License Condition 9.9 of NRC, 2017). To ensure that the byproduct material disposal agreement is applicable to both the currently licensed Crow Butte facility and the MEA in accordance with 10 CFR Part 40, Appendix A, Criterion 2, the staff is modifying the existing license condition. The modified license condition is presented in SER Section 4.2.4.

The current byproduct material disposal agreement is with the operator of the White Mesa Mill, near Blanding, Utah. The NRC staff previously reviewed the applicant's byproduct disposal agreement and found it acceptable (NRC, 2014). For this agreement, the maximum annual volume for disposal is 3,823 cubic meters (5,000 cubic yards) of byproduct material; this maximum volume is common to many agreements. This volume will cover the projected amount of solid byproduct material from both the currently licensed CBR facility and the MEA. The NRC staff finds the applicant's description of solid material waste disposal meets acceptance criteria (6) in Section 4.2.3 of NUREG 1569 (NRC, 2003).

4.2.3.3 Spill Contingency Plans

The applicant indicates that the spill contingency plan for unplanned spills or releases to the environment at the MEA (TR Section 4.3.1.2 and TR Section 5.7.1.3 in CBR, 2015) is the same as the plan for the currently licensed CBR facility (CBR, 2007) and incorporates identical elements as follows:

- The applicant commits to maintaining a spill contingency plan for unplanned spills or releases to the environment. The RSO has the responsibilities to update the plan and to ensure enforcement of the plan;
- Requirements for spills reportable to NRC are listed in 10 CFR Part 20;
- The applicant maintains a list of spills reportable to Nebraska DEQ which is made available to NRC staff during on-site inspections;
- During decommissioning the applicant is required to perform a final survey of an area subjected to a spill during operations.

The NRC staff previously found the applicant's spill contingency plan at its main facility to be acceptable (NRC, 2014). The NRC staff finds that spill contingency plan at the MEA is equivalent to that for the currently licensed facility and that, therefore, the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with spill contingency plan at the MEA that were not previously reviewed. The NRC staff finds the applicant's description of plans and procedures for addressing reasonably expected system failures meets acceptance criteria (5) in Section 4.2.3 of NUREG 1569 (NRC, 2003)

4.2.4 Evaluation Findings

The NRC staff reviewed the type, disposal, and monitoring of liquid and solid effluents at the MEA in accordance with Section 4.2.3 of NUREG-1569 (NRC, 2003). Since surge/evaporation ponds are not proposed at the MEA, acceptance criteria 2 through 4 do not apply. Additionally, acceptance criteria 9 applies to the environmental review and does not apply to this safety review. The applicant describes the solid and liquid effluents that are generated at the facility. An acceptable disposal method was identified for liquid byproduct material consisting of two DDWs to be approved through a Nebraska UIC permit. The applicant has made a commitment that, depending on the capacity of the two planned DDWs, additional DDWs or surge/evaporation ponds will be installed to satisfy the wastewater capacity requirements (CBR, 2015). Additionally, the solar evaporation ponds at the currently-licensed facility will be used for disposal of well fluids at the discretion of the applicant. The applicant would need to request and obtain a license amendment to construct and use surge/evaporation ponds at the MEA. The applicant has provided acceptable methods of disposal and acceptable methods of monitoring disposal of liquid and solid waste.

The applicant has projected a maximum operational throughput for MEA of 20,440 Lpm (5,400 gpm) (CBR, 2015). To ensure adequate liquid byproduct disposal capacity for the operation at the MEA, the NRC staff will include the following condition in the license:

> The MEA satellite building throughput shall not exceed a maximum flow rate of 5,400 gallons per minute, excluding restoration flow.

The applicant has identified an acceptable disposal method (i.e., DDWs) for liquid byproduct material, pending approval through a NDEQ permit for the DDWs, and the disposal method will be of sufficient capacity to handle liquids from production and restoration efforts. As the safe disposal of liquid byproduct material is an important component of operations at the facility, the NRC staff will include the following condition in the license issued to the applicant:

> Prior to commencing injection of lixiviant in the first wellfield at the MEA, the licensee shall obtain and submit to the NRC a copy of the NDEQ Underground Injection Control (UIC) permit authorizing construction of a minimum of two UIC deep disposal wells. The licensee shall ensure that the deep disposal wells have enough combined capacity to handle the disposal of the total liquid effluent generation at the MEA from both production and restoration phases of operation. Prior to constructing a land application system or surge/solar evaporation ponds for liquid waste disposal at the MEA, the licensee must request and obtain a license amendment allowing the construction and use of such a system at the MEA.

The applicant is required by an existing license condition to maintain an agreement for disposal of byproduct material with a licensed byproduct disposal facility or cease operations (refer to License Condition 9.9 in NRC, 2017). To ensure that the byproduct material disposal agreement is applicable to both the currently licensed Crow Butte facility and the MEA in accordance with 10 CFR Part 40, Appendix A, Criterion 2, the NRC staff will include the following modification to the license condition in the license:

> The licensee shall dispose of solid byproduct material from the Crow Butte ISR facility and the MEA at a facility that is authorized by NRC or an NRC Agreement State to receive byproduct material. A copy of the licensee's approved solid byproduct material disposal agreement must be maintained at both the Crow Butte ISR facility and the MEA. If the agreement expires or is terminated, the licensee shall notify the NRC within seven working days after the date of expiration or termination, and shall submit a new agreement to the NRC within 90 days after expiration or termination. If the licensee does not submit a new agreement within 90 days, the licensee will be prohibited from further lixiviant injection until the licensee submits the new agreement to the NRC.

The applicant has shown that effluent control systems, procedures, and required training will limit radiation exposures under both normal and accident conditions by providing information on the health and safety impacts of system failures and identifying preventive measures and mitigation for such occurrences.

Based upon the NRC staff's review of the information provided in the TR as described above, the staff has reasonable assurance that the applicant will comply with the requirements listed in section 4.2.1 above.

4.2.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

40 CFR Part 146. Code of Federal Regulations, Title 40, Protection of Environment, Part 146, Underground Injection Control Program, U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

CBR, 2009. Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264.

CBR, 2000. Request to Amend License Condition 10.7, September 12, 2000, ADAMS Accession No. ML003753427.

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report, Cameco Resources, Inc., Crow Butte Operation License Renewal (Revision 1), August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2012. NRC Inspection Report 040-08943/12-001, July 13, 2012, ADAMS Accession No. ML12195A073.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

5.0 OPERATIONS

5.1 CORPORATE ORGANIZATION AND ADMINISTRATION PROCEDURES

5.1.1 Regulatory Requirements

The NRC staff determines whether the applicant has demonstrated that the proposed corporate organization relevant to the operations at the MEA is in accordance with 10 CFR 20.1101 and 10 CFR 40.32(b), (c), and (d), which require that the applicant to be qualified through training and experience to use source materials as they relate to the proposed corporate organization and Safety and Environmental Review Panel functions.

5.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40, using the acceptance criteria presented in Section 5.1.3 of NUREG-1569 (NRC, 2003).

5.1.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and drawings submitted in the MEA TR (CBR, 2015) and as updated (CBR, 2017b).

5.1.3.1 Corporate Organization

TR Figure 5.1-1 (CBR, 2017b) presents the corporate organization for CBR. The applicant indicates that the organization chart (TR Figure 5.1-1 in CBR, 2017b) for CBR illustrates the organization for the entire Crow Butte operation (currently licensed CBR facility and CBR's proposed MEA) that play a key part in the Safety, Health, Environment and Quality Management System (SHEQ MS). The Board of Directors for CBR is ultimately responsible for setting health and safety policy which gets directed and implemented down the chain of command through the President of CBR, the General Manager of US Operations, Restoration Manager, Manager of Safety, Health, Environment, and Quality (SHEQ), Radiation Safety Officer (RSO) and the Plant (MEA Satellite Building) Supervisor (TR Section 5.1 in CBR, 2017b).

The President of CBR is responsible for interpreting and acting upon the CBR Board of Directors' policy and procedural directions. The CBR President is empowered by the CBR Board of Directors with the responsibility and authority for the radiation safety and environmental programs at the currently licensed CBR facility and any satellite facilities (including the MEA) that may be licensed in the future. The President directly supervises the CBR General Manager. Both the CBR General Manager and the Director of SHEQ report directly to the President.

The General Manager of US Operations is responsible for ensuring that Crow Butte personnel comply with Industrial Safety, Radiation Safety, and Environmental Protection Programs, and all relevant state and federal regulations. The General Manager of US Operations has the responsibility and the authority to suspend, postpone, or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The General Manager of US Operations reports directly to the President.

The Restoration Manager is responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations and restoration. The Restoration Manager is authorized to immediately implement any action to correct or prevent hazards. The Restoration Manager has the responsibility and the authority to suspend, postpone, or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The Restoration Manager cannot unilaterally override a decision for suspension, postponement, or modification if that decision is made by the Manager of Safety, Health, Environment and Quality, or the RSO. The Restoration Manager reports directly to the General Manager of US Operations.

The SHEQ Manager is responsible for health and safety and environmental programs as stated in the SHEQ Management System (SHEQ MS) and for ensuring that the applicant complies with all applicable regulatory requirements. The SHEQ Manager reports directly to the Restoration Manager and assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The SHEQ manager may suspend, postpone, or modify any activity that is determined to be a threat to employees, public health, the environment or potentially a violation of state or federal regulations.

The RSO is responsible for the development, administration, and enforcement of all radiation safety programs. The RSO reports directly to the Restoration Manager and has a secondary reporting requirement to the General Manager of US Operations. The RSO is provided sufficient authority to maintain facility safety. For example, the RSO is authorized to review and approve process or procedural changes that may affect radiological safety and may also conduct inspections and immediately order changes necessary to preclude radiation safety hazards or to maintain regulatory compliance.

The Plant (MEA Satellite Building) Supervisor supervises plant operations, including the safe and efficient recovery and processing of uranium oxide while staying within regulatory and technical constraints. The Plant Supervisor is responsible for carrying out any procedures or actions implemented by the Restoration Manager, Manager of SHEO, or the RSO to correct or prevent radiation safety hazards in the plant. The RSO and the Plant Supervisor or the RSO and the Restoration Manager are responsible for conducting weekly inspections of all facility areas to observe general radiation control practices and review required changes in procedures and equipment. The Plant Supervisor reports directly to the Restoration Manager.

The applicant will be using the same management organizational structure as that used at the currently licensed CBR facility (NRC, 2014 and CBR, 2015). The applicant will employ subcontractors to accomplish a variety of tasks at the MEA including both construction activities and continuing operations. The NRC Staff finds that the applicant's description of the contractor management program ensures a consistent approach to managing to activities that are governed by the SHEQ MS (e.g., the development of a scope of work that identifies and addresses Safety, Radiation, Environmental, and Quality objectives, training, establishment and control of site access, and emergency preparedness and response). Thus, the NRC Staff finds the applicant's subcontractor management as described in TR Section 5.1.10 (CBR, 2015) is acceptably governed by the SHEQ MS.

License Condition 9.7 of CBR's current license (NRC, 2017) requires CBR to follow the recommendations in Regulatory Guide 8.31 (NRC, 2002a), with stated exceptions. This license condition will also apply to the MEA. The NRC staff finds that the applicant's management organizational structure and responsibilities as described in TR Section 5.1 (CBR, 2017b) are consistent with the recommendations in Regulatory Guide 8.31 (NRC, 2002a). Based on the above review, the NRC staff finds that the applicant's description of the MEA proposed management structure and responsibilities is sufficient and meets acceptance criteria (1), (2), and (5) in Section 5.1.3 of NUREG-1569 (NRC, 2003).

TR Section 5.2.3 describes the composition of the applicant's Safety and Environmental Review Panel (SERP). The SERP will consist of a minimum of three individuals. One member of the SERP will have expertise in management and shall be responsible for managerial and financial approval for changes; one member shall have expertise in operations and/or construction and will have responsibility for implementing any operational changes; and one member will be the radiation safety officer (RSO) or equivalent, with the responsibility of assuring changes conform to radiation safety and environmental requirements. Additional members may be included in the SERP, as appropriate, to address technical aspects such as groundwater or surface water hydrology, specific earth sciences, and other technical disciplines. Temporary members or permanent members, other than the three above-specified individuals, may be consultants. The NRC staff finds that the applicant's description of the MEA proposed composition of the SERP is sufficient and meets acceptance criteria (3) in Section 5.1.3 of NUREG-1569 (NRC, 2003).

5.1.3.2 Administrative Procedures and ALARA

In TR Sections 5.1.8 and 5.1.9 (CBR, 2015), the applicant states that it attempts to keep exposures to all radioactive materials and other hazardous material as low as possible and to as few personnel as possible, taking into account certain conditions, such current technology and cost/safety benefit of improvements. In its discussion of the ALARA program, the applicant also provides the responsibilities of all pertinent personnel in complying with the ALARA policy. Personnel involved in the ALARA program include senior managers, the RSO, facility supervisors, and facility employees. The applicant listed the responsibilities of these employees in its TR.

In particular, ALARA responsibilities of the RSO are as follows:

1. Develop and administer the ALARA program;
2. Ensure compliance with regulations and administrative policies that affect any radiological aspect of the SHEQ MS;
3. Assist with the review and approval of new equipment, process changes or operating procedures to ensure that the plans do not adversely affect the radiological aspects of the SHEQ MS;
4. Maintain equipment and surveillance programs to assure continued implementation of the ALARA program;
5. Assist with conducting an annual ALARA audit to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy;
6. Review annually all existing operating procedures involving or potentially involving any handling, processing, or storing of radioactive materials to ensure the procedures are ALARA and do not violate any newly established or instituted radiation protection practices; and
7. Conduct (or designate a qualified individual to conduct) daily inspections of pertinent facility areas to observe that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle. (CBR, 2015)

The NRC staff finds that the applicant's description of ALARA commitments and administrative procedures meets acceptance criteria (4) in Section 5.1.3 of NUREG-1569 (NRC, 2003). This determination is based on the applicant's delineation of ALARA responsibilities, as presented in the TR, which are consistent with Regulatory Guide 8.31 (NRC, 2002a) and Regulatory Guide 4.15 (NRC, 2011). Furthermore, License Condition 9.7 of the current license (NRC, 2017) requires that the applicant maintain an ALARA program consistent with Regulatory Guide 8.31 (NRC, 2002a). This license condition will apply to the MEA.

5.1.4 Evaluation Findings

The NRC staff has completed its review of the corporate organization and administrative procedures proposed for use at the MEA. This review was performed using the acceptance criteria in Section 5.1.3 of NUREG-1569 (NRC, 2003). The NRC staff determined that the applicant's corporate organization is acceptable for managing the health and safety aspects of the proposed ISR facility. The NRC staff also determined that the applicant has established an acceptable Safety and Environmental Review Panel. The applicant demonstrated that it will maintain system of procedures to ensure radiological health and safety and environmental protection (*i.e.*, the SHEQ MS). The NRC staff has reviewed pertinent procedures contained in the SHEQ MS and finds that the applicant's procedures address the necessary health and safety and environmental protection aspects of the proposed operation. The applicant's description of its ALARA program is acceptable because it contains the necessary management and worker responsibilities for maintaining radiological exposures ALARA. The applicant is required to meet standards set forth in Regulatory Guides 8.22 (NRC, 1988), 8.30 (NRC, 2002b), and 8.31 (NRC, 2002a) in accordance with the current license (refer to License Condition 9.7 of NRC, 2017). This license condition will not change with this license amendment and will be applicable to operations at the MEA.

Based on the information provided in the TR and the detailed review conducted by the staff of the applicant's description of the proposed corporate organization relevant to the operations at the MEA, the NRC staff concludes that the applicant has provided a description of the MEA proposed corporate organization and administrative procedures that meets the acceptance criteria presented in Section 5.1.3 of NUREG-1569 (NRC, 2003). Therefore, the staff has reasonable assurance that the applicant's organization and SERP functions will comply with requirements of 10 CFR 20.1101 and 10 CFR 40.32(b), (c), and (d).

5.1.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2017. Response to Open Issues – Marsland Expansion Area Technical Report, Teleconference on June 14, 2016. Crow Butte Resources, Inc., Crawford, Nebraska June 14, 2017, ADAMS Accession No. ML17193A311 (Package).

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report - License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534., Docket No. 40-8943, August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2011. Regulatory Guide 4.15, "Administrative Practices in Radiation Surveys and Monitoring," May 2011.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002a. Regulatory Guide 8.31, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities will be As Low As Is Reasonably Achievable," May 2002.

NRC, 2002b. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities," May 2002.

NRC, 1988. Regulatory Guide 8.22, "Bioassays at Uranium Mills," August 1988.

5.2 MANAGEMENT CONTOL PROGRAM

5.2.1 Regulatory Requirements

The NRC staff determines whether the applicant has demonstrated that the proposed management control program for the MEA is consistent with the requirements of 10 CFR Part 20, Subparts L and M; 10 CFR 20.1101; and 10 CFR 40.61(d) and (e).

The applicant states that there will be no yellowcake dryer (refer to Sections 3.2 and 4.1.2 of CBR, 2015) and no tailings impoundment (refer to Section 2.9.9 of CBR, 2015) at the MEA. Therefore, the requirements in 10 CFR Part 40, Appendix A, Criterion 8 pertaining to yellowcake dryers and tailings impoundments are not applicable to this review.

5.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40, using the acceptance criteria presented in Section 5.2.3 of NUREG-1569 (NRC, 2003).

5.2.3 NRC staff Review and Analysis

5.2.3.1 Written Procedures

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015). NRC staff visited the site on several occasions during the course of this review to confirm information presented in the TR.

In TR Section 5.2 (CBR, 2015), the applicant presents a discussion of its written procedures and the process for developing them. This process centers on the following aspects: Safety, Health, Environment and Quality Management System (SHEQ MS), Performance-Based License Condition, and the Safety and Environmental Review Panel (SERP). Regarding the SHEQ MS, this document contains eight volumes of standards and procedures, including the following (TR Section 5.2.1.1 in CBR, 2015):

Volume 1 - Standards
Volume 2 - Management Procedures
Volume 3 - Operating Manual (SOPs)

Volume 4 - Health Physics Manual
Volume 5 - Industrial Safety Manual
Volume 6 - Environmental Manual
Volume 7 - Training Manual
Volume 8 - Emergency Manual

The applicant has developed written operating procedures for all process activities, including those activities involving radioactive materials for the currently licensed CBR facility. Where radioactive material handling is involved, pertinent radiation safety practices are incorporated into the operating procedure. Additionally, written operating procedures have been developed for non-process activities including: environmental monitoring, health physics procedures, emergency procedures, and general safety. The applicant maintains these procedures at the currently licensed CBR facility and a copy is kept in the area where it will be used. The SHEQ Manager, with assistance from the RSO and the Safety Supervisor, is responsible for drafting, approving, and updating the SHEQ MS manuals for the entire CBR operation including the proposed MEA. The applicant states that the SHEQ MS manual is certified to meet the ISO 14001 Environmental Management System Standard. (CBR, 2015)

As part of routine inspections, the NRC staff reviews the applicant's written operating procedures, as well as the process for drafting, approving and updating those procedures. The same written operating procedures and the process for drafting, approving and updating those procedures will be used for the MEA. The NRC staff finds the applicant's description of the written operating procedures and the process for drafting, approving and updating those procedures is sufficient and meet acceptance criteria (1) and (2) in Section 5.2.3 of NUREG-1569 (NRC, 2003).

5.2.3.2 Non-Routine Work

According to TR Section 5.2.1.2 (CBR, 2015), Radiation Work Permits (RWPs) are required for non-routine work where a potential exists for significant exposure to radioactive materials and for which no operating procedure exists. RWPs describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. RWPs are reviewed and approved in writing by the RSO prior to initiation of the work. (CBR, 2015)

The applicant may also utilize Standing Radiation Work Permits (SRWPs) for periodic tasks that require similar radiological protection measures (*e.g.*, maintenance work on a specified system) (CBR, 2015). The SRWPs describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The SRWPs are reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work. As part of routine inspections, the NRC staff reviews RWPs and SRWPs to ensure that the radiation protection procedures are being implemented properly.

The information provided in TR Section 5.2 (CBR, 2015) indicates that the RWPs and SRWPs for non-routine work at the MEA is consistent with the RWPs and SRWPs for non-routine work in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's RWPs and SRWPs for non-routine work acceptable (NRC, 2014). The NRC staff finds that the proposed RWPs and SRWPs for non-routine work at the MEA is sufficiently similar to the RWPs and SRWPs for non-routine work in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the RWPs and SRWPs for non-routine work at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the proposed RWPs and SRWPs for non-routine work as described the applicant will meet acceptance criteria (3) presented in Section 5.2.3 of NUREG-1569 (NRC, 2003).

5.2.3.3 Safety and Environmental Review Panel

The applicant discussed the Safety and Environmental Review Panel (SERP) in TR Section 5.2.3 (CBR, 2015). The composition of the panel was previously discussed in Section 5.1.3.1 of this SER. The purpose of the SERP is to review various facility changes or tests that are allowed without a license amendment per the current performance-based license condition discussed below. The applicant identified satisfactory procedures for using the SERP, the areas of review undertaken for a particular SERP review, and the reporting requirements.

The applicant states that it will implement the following review procedures for the evaluation of all appropriate changes to the facility operations as outlined in SHEQ MS, Volume II, *Management Procedures* (CBR, 2015). Per the procedures, the SERP will consider the following:

1. Current NRC License Requirements
2. Ability to Meet NRC Regulations
3. Licensing Basis
4. Financial Surety
5. Essential Safety and Environmental Commitments

According to the applicant, reports of SERP review results will be published in a written report format and will document the findings, recommendations, and conclusions (CBR, 2015). SERP reports will include the following:

1. A description of the proposed change, test, or experiment (proposed action)
2. A listing of all SERP members conducting the review and their qualifications (if a consultant or other member not previously qualified)
3. The technical evaluation of the proposed action, including all aspects of the SERP review procedures listed above
4. Conclusions and recommendations
5. Signatory approvals of the SERP members
6. Any attachments, such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

The applicant commits to maintaining all SERP reports and associated records of any changes through termination of the NRC license. The applicant also commits to submitting an annual report to the NRC that describes all changes, tests, or experiments, which will include a summary of the SERP evaluation of each change. Any page changes resulting from any SERP decisions will also be submitted to the NRC annually as part of updates to the license TR pages. (CBR, 2015)

The SERP procedures and documentation described by the applicant (CBR, 2015) for the MEA are consistent with the requirements in License Condition 9.4 for the currently licensed CBR facility (NRC, 2017). License Condition 9.4 will not change with this license amendment and will be applicable to the MEA. The NRC staff will continue to evaluate the applicant's annual reports submitted pursuant to this license condition, as well as assess the SERP records through onsite inspections. The NRC staff finds that the applicant's description of its SERP program, along with provisions in License Condition 9.4, meet acceptance criterion (4) in Section 5.2.3 of NUREG-1569 (NRC, 2003).

5.2.3.4 Records

The SHEQ MS Volume 2*, Management Procedures,* provides specific instructions for the proper maintenance, control, and retention of records associated with implementation of the program (CBR, 2015). According to the applicant (TR Section 5.2.1.3 in CBR, 2015), the following records will be maintained:

Survey records
Calibrations
Personnel monitoring
Bioassays
Transfers or disposal of source or byproduct material
Transportation Accidents
Decommissioning and reclamation
Site characterization
Background radiation levels

These records will be maintained onsite until license termination. The NRC Staff routinely reviews these records at the currently licensed CBR facility during inspections to determine compliance with the license and regulations. The NRC will also do the same reviews at the MEA after its operations begin. The following license conditions (CBR, 2017), which will also apply to the MEA, discuss various aspects of the applicant's recordkeeping commitments:

License Condition 9.10 – sampling, analysis, surveys, calibration, audits/inspections, training, reviews, investigations, corrective actions.
License Condition 9.11 - all entrances to the facility are conspicuously posted with the words, "Caution: any area within this facility may contain radioactive material."
License Condition 11.1 – injection and production flow rates, manifold injection pressure, monitoring data, corrective actions, effluent and environmental monitoring program
License Condition 11.6 – spills, leaks, excursions, incidents/events

The information provided in TR Section 5.2 (CBR, 2015) and provisions of license conditions indicates that the records program at the MEA is consistent with the records program in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's records program acceptable (NRC, 2014). The NRC staff finds that the proposed records program at the MEA is sufficiently similar to the records program in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the records program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the proposed records program along with provisions in license conditions will meet acceptance criteria (5), (7) through (9), and (11) through (13) presented in Section 5.2.3 of NUREG-1569 (NRC, 2003).

5.2.4 Evaluation Findings

The NRC staff reviewed the management control program of the proposed MEA in accordance with Section 5.2.3 in NUREG-1569 (NRC, 2003) with some exceptions. Acceptance criterion (8) concerning cultural resources is an environmental issue addressed in the MEA Environmental Assessment. Acceptance Criterion (10) is applicable to new licensees and is therefore not applicable to the applicant, which is an existing licensee that is applying for a license amendment for the MEA. The applicant has described the actions that will be considered by the SERP. The applicant describes the process that will be used to develop standard operating procedures. Spills and contamination events will be documented by the applicant as required by 10 CFR Parts 20 and 40, or as required by license conditions addressing events that may not otherwise require reporting under 10 CFR Parts 20 or 40.

Based upon the review conducted by the NRC staff described above, the information provided in the TR meets the applicable acceptance criteria of Section 5.2.3 in NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant will comply with the requirements of 10 CFR Part 20, Subparts L and M; 10 CFR 20.1101; and 10 CFR 40.61(d) and (e).

5.2.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, “Standards for Protection Against Radiation,” U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report (Revised), Cameco Resources, Inc., Crow Butte Operation License Renewal, August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report,” June, 2003, ADAMS Accession No. ML032250177.

5.3 Management Audit and Inspection Programs

5.3.1 Regulatory Requirements

The NRC staff determines whether the applicant has demonstrated that the proposed management audit and inspection program for the MEA meets the requirements of 10 CFR 20.1702, 10 CFR 20.1101, and 10 CFR 40.32(b), (c), and (d).

The applicant states that there will be no yellowcake dryer (refer to Sections 3.2 and 4.1.2 of CBR, 2015) and no tailings impoundment (refer to Section 2.9.9 of CBR, 2015) at the MEA. Therefore, the requirements in 10 CFR Part 40, Appendix A, Criterion 8 pertaining to yellowcake dryers and tailings impoundments are not applicable to this review.

5.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40, using the acceptance criterion presented in Section 5.3.3 of NUREG-1569 (NRC, 2003).

5.3.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their MEA TR (CBR, 2015).

5.3.3.1 Radiation Safety Inspections

In TR Section 5.3.1 (CBR, 2015), the applicant proposes to perform various inspections as part of its radiation safety program. License Condition 9.7 requires the applicant to follow the guidance set forth in Regulatory Guide 8.31, which specifies the scope of radiation safety inspection program and associated management. However, in accordance with the exception to Regulatory Guide 8.31 provided in License Condition 9.7 (NRC, 2017), the applicant also proposes allowing the RSO to delegate inspections to properly trained, experienced MEA satellite building personnel. Specifically, TR Section 5.3.1 (CBR, 2015) states that daily inspections will be conducted by the radiation safety officer (RSO), designated health physics technician (HPT), or trained designated operator, which the NRC staff finds is consistent with License Condition 9.7. This license condition will apply to the MEA.

The information provided in TR Section 5.3 (CBR, 2015) and provisions of License Condition 9.7 indicates that the proposed radiation safety inspection program at the MEA is consistent with the radiation safety inspection program in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's radiation safety inspection program acceptable (NRC, 2014). The NRC staff finds that the proposed radiation safety inspection program at the MEA is sufficiently similar to the radiation safety inspection program in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the radiation safety inspection program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the radiation safety inspection program at the MEA meets acceptance criterion (1) presented in Section 5.3.3 of NUREG-1569 (NRC, 2003).

5.3.3.2 Annual ALARA Audit

In TR Section 5.3.2 (CBR, 2015), the applicant proposes conducting audits of the radiation safety and ALARA programs. These audits will be conducted by the SHEQ Manager, qualified personnel from other uranium recovery facilities, or outside radiation protection auditors. The ALARA audit includes a review of the following areas:

- Employee exposure records
- Bioassay results
- Inspection log entries and summary reports of daily, weekly, and monthly inspections
- Documented training program activities
- Radiation safety meeting reports
- Radiological survey and sampling data
- Reports on any overexposure of workers
- Operating procedures that were reviewed during this time period

The ALARA report summarizes the following information:

- Trends in personnel exposures
- Proper use, maintenance and inspection of equipment used for exposure control
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters

The NRC staff reviews the ALARA audit reports during routine inspections. Furthermore, the current license requires the applicant to describe the corrective actions taken when urinary uranium action levels have been exceeded (refer to License Conditions 11.7 and 11.8 of NRC, 2017). The procedures identified by the applicant and contained in the current license have been proven effective during operations at the currently licensed CBR facility.

Under License Condition 9.7 (NRC 2017), the applicant is required to follow the guidance in Regulatory Guide 8.31 (NRC, 2002) for the currently licensed CBR facility. This regulatory guide provides recommendations for inspections of worker health protection practices and radiation protection and As Low As is Reasonably Achievable (ALARA) program audits. The NRC staff has reviewed the applicant's implementation of these aspects of its management audit and inspection program through onsite inspections and a review of inspection reports and has determined that the applicant's implementation of its audit and inspection program has been consistent with the license condition. License Condition 11.2 (NRC, 2017) requires the applicant to submit the results of the annual audit of the radiation safety and ALARA programs and a land use survey to the NRC. Both of these license conditions will apply to the MEA.

The information provided in TR Section 5.3 (CBR, 2015) and provisions of License Condition 9.7 and 11.2 indicates that the proposed ALARA audit program at the MEA is consistent with the ALARA audit program in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's ALARA audit program acceptable (NRC, 2014). The NRC staff finds that the proposed ALARA audit program at the MEA is sufficiently similar to the ALARA audit program in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the ALARA audit program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the ALARA audit program at the MEA meets acceptance criterion (1) presented in Section 5.3.3 of NUREG-1569 (NRC, 2003).

5.3.4 Evaluation Findings

Based on the information provided in the TR, current license conditions, and the detailed review conducted by the staff of the applicant's description of the proposed management audit and inspection program for the MEA, the NRC staff concludes that the applicant has provided a description of the MEA management audit and inspection program that meets the acceptance criterion presented in Section 5.3.3 of NUREG-1569 (NRC, 2003). Therefore, the staff has reasonable assurance that the applicant's management audit and inspection program for the MEA will comply with 10 CFR 20.1702, 10 CFR 20.1101, and 10 CFR 40.32 (b), (c), and (d).

5.3.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report - License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534., Docket No. 40-8943, August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2012. NRC Inspection Report 040-08943/12-001, July 13, 2012, ADAMS Accession No. ML12195A073.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1. Washington, DC: May 2002.

5.4 QUALIFICATIONS FOR PERSONNEL CONDUCTING THE RADIATION SAFETY PROGRAM

This section discusses the proposed minimum qualifications and experience levels required for personnel who will be assigned the responsibility for developing, conducting, and administering the radiation safety program (i.e., the radiation safety staff) at the MEA.

5.4.1 Regulatory Requirements

Section 5.4.4 of NUREG-1569 (NRC, 2003) identifies the following regulatory requirements applicable to the NRC staff's review of the minimum qualifications and experience levels required for the radiation safety staff at ISR facilities: 10 CFR 20.1101 and 10 CFR 40.32(b). In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

This review focuses on the proposed minimum qualifications and experience levels required for the radiation safety staff at the MEA. Therefore, issues related to the radiation protection program elements specified in 10 CFR 20.1101(b) and (d) relating to ALARA are addressed in the NRC staff's review of the applicant's effluent control systems and external radiation exposure monitoring programs for workers in SER sections 4.1, 4.2, and 5.7.3 and are not discussed here. In addition, the radiation protection program element specified in 10 CFR 20.1101(c) is addressed in the NRC staff's review of the applicant's management audit and inspection program in SER section 5.3.

Therefore, for the purpose of this review, the applicant must demonstrate that the proposed minimum qualifications and experience levels required for the radiation safety staff is in compliance with 10 CFR 20.1101(a) and 10 CFR 40.32(b).

5.4.2 Regulatory Acceptance Criteria

The proposed minimum qualifications and experience levels required for the radiation safety staff for the MEA was reviewed for compliance with these requirements by comparing it to the acceptance criterion in NUREG-1569, Section 5.4.3 (NRC, 2003).

5.4.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015).

In TR Section 5.4.1 (CBR, 2015), the applicant identifies the requirements for a radiation safety officer (RSO). The proposed educational requirements for an RSO include a bachelor's degree in physical science, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in radiation protection related to uranium recovery (CBR, 2015). The proposed qualifications are consistent with RG 8.31, Section 2.4 (NRC, 2002).

Other minimum qualifications for the RSO identified by the applicant include health physics experience (CBR, 2015). This experience includes at least 1 year of work experience relevant to uranium recovery operations in applied health physics, radiation protection, industrial hygiene, or similar work (CBR, 2015). The applicant also identifies specialized training for the RSO that will include at least 4 weeks of specialized classroom training in health physics specifically applicable to uranium recovery (CBR, 2015). The proposed qualifications are consistent with RG 8.31, Section 2.4 (NRC, 2002).

In TR Section 5.4.2 (CBR, 2015) the applicant identifies two alternative combinations of education, training, and experience that would satisfy the minimum qualifications for a health physic technician (HPT). The first set of qualifications includes an associate degree or 2 or more years of study in the physical sciences, engineering, or a health-related field; at least a total of 4 weeks of generalized training in radiation protection applicable to uranium recovery facilities; and 1 year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium recovery facility. The proposed qualifications are consistent with RG 8.31, Section 2.4 (NRC, 2002).

The second set of qualifications for an HPT includes a high school diploma, a total of at least 3 months of specialized training in radiation protection relevant to uranium recovery facilities (up to one month may be on-the-job training), and 2 years of relevant work experience in applied radiation protection. The proposed qualifications are consistent with RG 8.31, Section 2.4 (NRC, 2002).

The NRC staff finds that the applicant will require minimum qualifications and experience levels for its radiation safety staff consistent with acceptance criterion 5.4.3(1) of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed minimum qualifications and experience levels for its radiation safety staff comply with 10 CFR 20.1101(a) and 10 CFR 40.32(b).

5.4.4 Evaluation Findings

The applicant has established acceptable minimum qualifications and experience levels required for the radiation safety staff at the MEA. The NRC staff concludes that the applicant's program, as described in its MEA TR, complies with 10 CFR 20.1101(a) and 10 CFR 40.32(b).

5.4.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002. “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” Regulatory Guide 8.31, Revision 1. Washington, DC: May, 2002.

5.5 RADIATION SAFETY TRAINING

This section discusses the proposed radiation safety training program at the MEA.

5.5.1 Regulatory Requirements

Section 5.5.4 of NUREG-1569 (NRC, 2003) identifies and describes the following regulatory requirements applicable to the NRC staff’s review of radiation safety training programs at ISR facilities: 10 CFR 19.12, 10 CFR 20.1101, and 10 CFR 40.32(b). In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

This review focuses on the proposed radiation safety training program at the MEA. Therefore, issues related to the radiation protection program elements specified in 10 CFR 20.1101(b) and (d) relating to ALARA are addressed in the NRC staff’s review of the applicant’s effluent control systems and external radiation exposure monitoring programs for workers in SER sections 4.1, 4.2 and 5.7.3 and are not discussed here. In addition, the radiation protection program element specified in 10 CFR 20.1101(c) is addressed in the NRC staff’s review of the applicant’s management audit and inspection program in SER section 5.3. Therefore, for the purpose of this review, the applicant must demonstrate that the proposed radiation safety training program is in compliance with 10 CFR 19.12, 10 CFR 20.1101(a), and 10 CFR 40.32(b).

5.5.2 Regulatory Acceptance Criteria

The proposed radiation safety training program at the MEA was reviewed for compliance with these requirements by comparing it to the radiation safety training program in place at the currently licensed CBR facility.

5.5.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015).

The applicant’s radiation safety program is contained in its SHEQ MS Volume VII, Training Manual (CBR, 2015). In TR Section 5.5 (CBR, 2015), the applicant states that it will administer the training program consistent with NRC Regulatory Guide 8.13 (NRC, 1999), NRC Regulatory Guide 8.29 (NRC, 1996), and NRC Regulatory Guide 8.31 (NRC, 2002).

The applicant states (CBR, 2015) that all new workers, including supervisors, will be given instruction on the health and safety aspects of the specific jobs they will perform. The RSO or a HPT will conduct all radiation safety training. Training topics will include fundamentals of health protection, personal hygiene (using respirators correctly, wearing protective clothing, etc.), facility-provided protection, health protection measurements, radiation protection regulations, and emergency procedures. Each worker will be given a written test, including annual refresher training, and training records will be kept until license termination. HPTs will also receive on-the-job training. (CBR, 2015)

The applicant states (CBR, 2015) that visitors not receiving training will be escorted by site personnel properly trained and knowledgeable about the hazards of the facility. Contractors having work assignments at the facility will be given appropriate radiation safety training. Contractors performing work on heavily contaminated equipment will receive the same training normally required of site workers. (CBR, 2015)

The applicant states (CBR, 2015) that it will provide training to new female hires and their supervisors on prenatal exposure risks, including the content in Regulatory Guide 8.13, and provide an opportunity of the employee or supervisor to ask questions or discuss the possible effects on job status. In addition, after an employee provides written declaration of pregnancy, prenatal instructions and Regulatory Guide 8.13 will be provided to that employee again, worker specific exposure monitoring will be conducted, and work duties will be adjusted as necessary (CBR, 2015).

The information provided in TR Section 5.5 (CBR, 2015) indicates that the proposed radiation safety training program at the MEA is consistent with the radiation safety training program in place at the currently licensed facility. In its prior safety review for the currently licensed facility, the NRC staff found the applicant's radiation safety training program acceptable (NRC, 2014). The NRC staff finds that the proposed radiation safety training program at the MEA is sufficiently similar to the radiation safety training program in place at the currently licensed facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the radiation safety training program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed radiation safety training program will meet the regulatory requirements related to the applicant's radiation protection program and qualifications through training.

5.5.4 Evaluation Findings

The NRC staff concludes that the applicant has established an acceptable radiation safety training program at the MEA, and that the applicant's program, as described in its MEA TR, complies with 10 CFR 19.12, 10 CFR 20.1101(a), and 10 CFR 40.32(b).

5.5.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, “Standards for Protection Against Radiation,” U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2014. Safety Evaluation Report (Revised), License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534, August 14, 2014, ADAMS Accession NO. ML14149A433.

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report,” June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002. “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” Regulatory Guide 8.31, Revision 1. Washington, DC: May, 2002.

NRC, 1999. “Instruction Concerning Prenatal Radiation Exposure,” Regulatory Guide 8.13, Revision 3. Washington, DC: June, 1999.

NRC, 1996. “Instruction Concerning Risks from Occupational Radiation Exposure,” Regulatory Guide 8.29, Revision 1. Washington, DC: February, 1996.

5.6 SECURITY

5.6.1 Regulatory Requirements

The NRC staff determines whether the applicant has demonstrated that the proposed security measures for the MEA meet the requirements of 10 CFR 20, Subpart I.

5.6.2 Regulatory Acceptance Criteria

The staff reviewed the TR for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criterion in Section 5.6.3 of NUREG-1569 (NRC, 2003).

5.6.3 NRC Staff Review and Analysis

5.6.3.1 Security Plan

Unless otherwise stated, the information reviewed in this section is from information, data, and drawings submitted in the MEA TR (CBR, 2015).

According to TR Sections 5.6 and 5.6.1.1 (CBR, 2015), the applicant’s security measures are specified in the Security Plan and Security Threat chapter in Volume VIII, Emergency Manual, of the Safety, Health, Environment, and Quality Management System (SHEQ MS). The security at the MEA site will be consistent with the policies and procedures already approved and used at the currently licensed CBR facility. Subpart I of 10 CFR Part 20 requires licensees to maintain control over licensed material, which includes both source material (*i.e.*, natural uranium) and byproduct material, as defined in 10 CFR 40.4. At the MEA, licensed material will include loaded ion exchange resin contained in IX columns and byproduct material awaiting disposal. The following structures will contain pregnant and barren lixiviant: production pipelines in the wellfields and header houses, production trunklines to the MEA Satellite Building, and piping in the satellite building. Loaded ion exchange resin will be placed in a transport truck and temporarily stored in the vehicle until the truck is filled and ready for delivery to the currently licensed CBR facility.

In TR Section 5.6.1.1 (CBR, 2015), the applicant has proposed different security measures for restricted and controlled areas of the facility. The applicant has identified proposed restricted areas of the MEA in TR Figure 5.7-2. The restricted areas consist of the MEA satellite building area where access is controlled for the protection of individuals from the exposure to radiation and radioactive materials. The controlled areas are areas outside the restricted area but within the site boundary where the applicant may limit access for any reason. Security measures for these areas include fences, locking gates, and signs identifying these areas as radiation areas. Satellite building doors can be locked to prevent unauthorized access. The MEA satellite building will routinely operate 24 hours per day, 7 days per week; therefore, the applicant's employees will normally be onsite except for occasional shutdowns. Areas of stored and non-stored licensed material will be controlled by fences and locked access gates. In addition to the aforementioned security features, the applicant will install a locking gate on the main access road.

The applicant indicated in TR Section 5.6.1.1 (CBR, 2015) that it will address visitors and trespassers in the following manners: (1) the applicant's employees are instructed to report any unauthorized persons to satellite building supervisors, who will escort such persons off the premises; (2) visitors must register at the satellite building office, and those who visit infrequently will be escorted around the site; and (3) frequent visitors will be properly trained by the applicant and allowed to enter controlled areas unescorted. The applicant proposed the following wellfield security measures: (1) all wellfields will be fenced and posted with signs; (2) header houses will be locked at all times to prevent unauthorized access to non-stored licensed source material; and (3) only authorized personnel will have keys to wellhouses, all of which are equipped with a lock.

The NRC staff has reviewed the applicant's satellite building and facility security measures and determined that these measures meet the acceptance criterion in Section 5.6.3 of NUREG-1569 (NRC, 2003). The applicant has demonstrated that it will maintain control of licensed source and byproduct material contained within restricted areas using fences, gates, signs, security cameras, and satellite building personnel. The applicant will also maintain control of licensed source material in unrestricted areas by locking header houses and enclosing wellfields with gates and fences.

5.6.3.2 Transportation Security

In TR Section 6.5.1.2 (CBR, 2015), the applicant states that transportation of licensed materials will be generally restricted to transferring ion exchange resin between the MEA and the currently licensed CBR facility, as well as transferring contaminated equipment between the MEA and company facilities. The applicant states that it routinely receives, stores, uses, and ships hazardous materials as defined by the U.S. DOT from its currently licensed CBR facility (CBR, 2015).

Under 10 CFR 71.5, the applicant's transport of licensed material must comply with applicable Department of Transportation (DOT) regulations, including DOT Hazardous Materials Regulations under 49 CFR Part 172, Subpart I ("Security Plans"). In addition to the packaging and shipping requirements contained in these DOT regulations, 49 CFR 172, Subpart I requires persons who transport certain hazardous materials to develop a Security Plan. This security plan contains point-to-point security procedures and guidelines protecting drivers, vehicles, and cargo. The applicant's transport of licensed material occurs over short distances through remote areas. To ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination, security measures for the driver, cargo, and equipment security measures include securing access to all openings of the transport vehicle with locks and/or tamper indicators and maintaining constant surveillance outside restricted areas.

Based on the NRC staff's review of the applicant's description of their transportation security plan as required by 49 CFR 172, Subpart I, the staff has reasonable assurance that the applicant will safely transport licensed source and byproduct materials between the MEA and the currently licensed CBR facility.

5.6.4 Evaluation Findings

The NRC staff has completed its review of the security measures at the MEA. This review included an evaluation using the acceptance criterion in Section 5.6.3 of NUREG-1569 (NRC, 2003).

Based on the information provided by the licensee and the detailed review conducted of the applicant's description of the proposed security measures for the MEA, the staff concludes that the proposed security measures meet the acceptance criterion in Section 5.6.3 of NUREG-1569 (NRC, 2003). Therefore, the staff has reasonable assurance that the applicant's organization and SERP functions will comply with 10 CFR Part 20, Subpart I.

5.6.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

5.7 RADIATION SAFETY CONTROLS AND MONITORING

The purpose of this section is to evaluate the techniques the applicant proposes to use to monitor and minimize radiation exposures at the MEA facility.

5.7.1 Standards

As part of its assessment, the NRC staff will present certain standards with which the applicant must comply either because they are regulatory requirements, or through license conditions, or both. These and other standards used as guidance are listed below and referenced throughout the remaining portion of Section 5.7. These standards are as follows:

<u>Guidance</u>

- Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills", Revision 1, Issued April 1980
- Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs

(Inception through Normal Operations to License Termination) - Effluent Streams and the Environment," Revision 2, issued July 2007

- Regulatory Guide 8.7, "Instructions for Recording and Reporting Occupational Radiation Exposure Data," Revision 2, issued November 2005
- Regulatory Guide 8.15, Acceptable Programs for Respiratory Protection, Revision 1, issued October 1999
- Regulatory Guide 8.22, "Bioassay at Uranium Mills," Revision 2, issued May 2014
- Regulatory Guide 8.25, Air Sampling in the Workplace, Revision 1, issued June 1992
- Regulatory Guide 8.30, Health Physics Surveys in Uranium Recovery Facilities, Revision 1, issued May 2002
- Regulatory Guide 8.31, Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable, May 2002.
- Regulatory Guide 8.34, "Monitoring Criteria and Methods To Calculate Occupational Radiation Doses," Revision 0, issued July 1992
- Regulatory Guide 8.36, "Radiation Dose to the Embryo/Fetus," Revision 0, issued July 1992
- Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities", July 1993.

<u>Regulations</u>

- 10 CFR 20, Subpart B - Radiation Protection Programs, § 20.1101
- 10 CFR 20, Subpart C – Occupational Dose Limits: 20.1201 – 1208
- 10 CFR 20, Subpart F – Surveys and Monitoring: 20.1501 and 20.1502
- 10 CFR 20, Subpart L – Records: 20.2101 – 20.2110
- 10 CFR 20, Subpart M – Reports: 20.2201 – 20.2207

<u>Numerical Standards</u>

- 10 CFR 20, Appendix B, Table 1 - Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage DAC, Natural Uranium Class W: 3.0 E-10 microcuries per milliliter (µCi/mL) DAC Natural Uranium Class D: 5E -10 µCi/mL
- 10 CFR 20.1201 – Total Effective Dose Equivalent (TEDE): 5 rem, or the sum of the DDE and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem
- 10 CFR 20.1201 - Annual Limit to the Eye Lens: 15 rem
- 10 CFR 20.1201 - Annual Limits to the Skin of the Whole Body and Extremity 50 rem
- 10 CFR 20.1201(e) – 10 mg per week limit on intake of soluble uranium

5.7.2 Effluent Control Techniques

The NRC staff's review of the applicant's proposed effluent control techniques can be found in Section 4.1 of this SER.

5.7.3 External Radiation Exposure Monitoring Program

This section discusses the external radiation exposure monitoring program. The purpose of this section is to describe the devices and methods the applicant will use to detect measure, calculate, and/or monitor external radiation exposures to workers.

5.7.3.1 Regulatory Requirements

Section 5.7.2.4 of NUREG-1569 (NRC, 2003) identifies and describes the following regulatory requirements applicable to the NRC staff's review of external radiation exposure monitoring programs for workers at ISR facilities: 10 CFR 20.1101, 20.1201(a), 20.1501, 20.1502; and 10 CFR Part 20 Subpart L and Subpart M. In this section, the staff determines whether the applicant has demonstrated it will comply with these requirements, with the exceptions noted below.

This review focuses on the design and implementation of the external radiation exposure monitoring program at the MEA and its potential impact on maintaining doses ALARA for workers. Radiation protection program elements specified in 10 CFR 20.1101(a) and (c) are addressed in the NRC staff's reviews of the applicant's management audit and inspection program (section 5.3 of the SER), qualifications for personnel conducting the radiation safety program (section 5.4 of the SER), and radiation safety training program (section 5.5 of the SER). Likewise, the records and reporting requirements in 10 CFR 20, Subparts L and M, respectively, and 10 CFR 20.1501(b) are addressed in the staff's review of the applicant's management control program in SER section 5.2. Finally, 10 CFR 20.1502(b) addresses internal dosimetry.

Additionally, the requirement in 10 CFR 20.1101(d), which applies to air emissions, is addressed in SER section 4.1.

Therefore, for the purposes of this review, the applicant must demonstrate that the proposed external radiation exposure monitoring program will comply with 10 CFR 20.1101(b), as it relates to occupational dose, 20.1201(a), 20.1501(a), (c) and (d), and 20.1502(a).

5.7.3.2 Regulatory Acceptance Criteria

The NRC staff determines whether the applicant has demonstrated that its proposed external radiation exposure monitoring program for the MEA meets the requirements of 10 CFR 20.1101(b), as it relates to occupational dose; 20.1201(a); 20.1501(a), (c), and (d); and 20.1502(a). The proposed external radiation exposure monitoring program for the MEA was reviewed for compliance with these requirements by comparing it to the external radiation exposure monitoring program in place at the currently licensed CBR facility.

5.7.3.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015).

The applicant describes its proposed external radiation exposure monitoring program for the MEA in TR Section 5.7.2 (CBR, 2015). The applicant proposed to conduct gamma surveys at the MEA Satellite Building locations as shown in TR Figure 5.7-2 TR (CBR, 2015).

The applicant plans to conduct external radiation surveys quarterly in designated radiation areas and semiannually in all other areas of the MEA Satellite Building (CBR, 2015). The applicant will establish a designated "Radiation Area" if the gamma survey exceeds the action level of 5 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates (CBR, 2015).

The applicant indicated that the minimum specifications for survey equipment will include the lowest range, which is 100 microRoentgens per hour (µR/hr), and the highest range to read at least 5 millroentgens per hour (mR/hr) full scale (CBR, 2015). In addition, the applicant proposed external radiation survey equipment, including a Ludlum Model 3 meter with a Ludlum Model 44-38 GM detector, or equivalent (CBR, 2015). This equipment is capable of measuring between 0 and 200 mR/hr (Ludlum 2006, 2011). The applicant indicated that the gamma exposure rate surveys will be performed in accordance with the guidance in NRC Regulatory Guide 8.30 (NRC, 2002) and the instructions contained in its SHEQ MS, Volume IV, Health Physics Manual (CBR, 2015).

The applicant states that beta surveys of specific operations that involve direct handling of large quantities of aged yellowcake are performed in accordance with the instructions currently contained in SHEQ MS Volume IV, Health Physics Manual (CBR, 2015). The applicant is required by license condition (refer to License Condition 9.7 of NRC, 2017) to follow the guidance in Regulatory Guide 8.30 (NRC, 2002). Regulatory Guide 8.30 (NRC, 2002) contains recommendations on performing surveys for beta exposure. In addition, under License Condition 11.10 (NRC, 2017), which was imposed during the staff's review of the most recent license renewal (refer to Section 5.7.7.3.1 in NRC, 2014), the applicant is required to account for beta-gamma contamination that could lead to internal and external exposure. These license conditions will not change with this license amendment and will be applicable to operations at the MEA.

The applicant indicated that personnel dosimetry will be issued to all process employees and exchanged on a quarterly basis (CBR, 2015). This will include satellite building and wellfield operators. The applicant states that the personnel dosimeters are provided by a vendor that is accredited by the National Voluntary Laboratory Accreditation Program. The applicant states that the personnel dosimeters can range from 1 mR to 1000 R. According to the applicant, the results from the personnel dosimetry will be used to determine individual Deep Dose Equivalent for use in determining Total Effective Dose Equivalent. (CBR, 2015)

The information provided in TR Section 5.7.2 (CBR, 2015) indicates that the proposed external radiation exposure monitoring program at the MEA is consistent with the external radiation exposure monitoring program in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's external radiation exposure monitoring program acceptable (Refer to Section 5.7.3 of NRC, 2014). The NRC staff finds that the proposed external radiation exposure monitoring program at the MEA is sufficiently similar to the external radiation exposure monitoring program in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the external radiation exposure monitoring program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed external radiation exposure monitoring program will comply with the applicable regulatory requirements related to occupational dose and surveying and monitoring.

5.7.3.4 Evaluation Findings

The NRC staff concludes that the applicant has established an acceptable external radiation exposure monitoring program at the MEA. Therefore, the NRC staff has reasonable assurance that the applicant's program, as described in its MEA TR, will comply with 10 CFR 20.1101(b), as it relates to occupational dose; 20.1201(a); 20.1501(a), (c), and (d); and 20.1502(a).

5.7.3.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

Ludlum, 2011. Ludlum Model 44-38 Beta-Gamma Detector Manual, Ludlum Measurements, Inc., June 2011 ADAMS Accession No. ML13086A183

Ludlum, 2006. Excerpts from Ludlum Model 3 Survey Meter Manual, Ludlum Measurements, Inc., January 2006 ADAMS Accession No. ML13086A176

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report (Revised), License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534, August 14, 2014, ADAMS Accession NO. ML14149A433.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities, Revision 1," May 2002.

5.7.4 In-Plant Airborne Radiation Monitoring Program

This section evaluates the in-plant airborne radiation monitoring program used by the applicant to characterize the airborne uranium and radon daughter levels at various locations in the MEA Satellite Building to ensure that workers are adequately monitored for internal radiation exposures.

5.7.4.1 Regulatory Requirements

Section 5.7.3.4 of NUREG-1569 (NRC, 2003) identifies the following regulatory requirements applicable to the NRC staff's review of in-plant airborne radiation monitoring programs at ISR facilities: 10 CFR 20.1101, 20.1201(a), 20.1201(e), 20.1202, 20.1203, 20.1204(a), 20.1208, 20.1301, 20.1702; 10 CFR Part 20, Subparts L and M; and 10 CFR Part 40, Appendix A, Criterion 8. In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

This review focuses on the in-plant airborne radiation monitoring program used by the applicant to characterize the airborne uranium and radon daughter levels at the MEA. Radiation protection program elements specified in 10 CFR 20.1101(a) and (c) are addressed in the NRC staff's reviews of the applicant's management audit and inspection program (section 5.3 of the SER), qualifications for personnel conducting the radiation safety program (section 5.4 of the SER), and radiation safety training program (section 5.5 of the SER). Likewise, issues related to the radiation protection program elements specified in 10 CFR 20.1101(b) and (d) relating to ALARA are addressed in the NRC staff's review of the applicant's effluent control systems and external radiation exposure monitoring programs for workers in SER sections 4.1, 4.2 and 5.7.3 and are not discussed here.

Because this review focuses on the applicant's in-plant airborne radiation monitoring program for workers, specific dose requirements for the public are not applicable to this review. However, a detailed discussion on the applicant's programs to demonstrate compliance with the radiation dose limits for individual members of the public specified in 10 CFR 20.1301(a), (b), and (e) is presented in SER section 5.7.8.

The requirement in 10 CFR 20.1301(c) applies to the medical use of byproduct material (10 CFR Part 35) and thus is not applicable to this review. In addition, the conditions specified in 10 CFR 20.1301(d) and (f) have not been encountered with this applicant and are therefore not being reviewed at this time.

The applicant states that there will be no yellowcake dryer (refer to Sections 3.2, 4.1.2 and 5.7.3.1 of CBR, 2015) and no tailings impoundment (refer to Section 2.9.9 of CBR, 2015) at the MEA. Therefore, the requirements in 10 CFR Part 40, Appendix A, Criterion 8 pertaining to yellowcake dryers and tailings impoundments are not applicable to this review. In addition, because 40 CFR Part 440, Subpart C (mentioned in Criterion 8) covers wastewater discharges from ore mines and processing operations, this requirement is also not applicable to the applicant's proposed in-plant airborne radiation monitoring program. Lastly, the ALARA requirements in 10 CFR Part 40, Appendix A, Criterion 8, relate to controlling emissions at the source, not monitoring those emissions, and are also not applicable to this review. The NRC staff's evaluation of ALARA aspects of controlling emissions is addressed in SER section 4.1.

The records and reporting requirements in 10 CFR 20, Subparts L and M, respectively, are addressed in the applicant's management control program in SER section 5.2.

Therefore, for the purpose of this review, the applicant must demonstrate that the proposed in-plant airborne radiation monitoring program is in compliance with 20.1201(a), 20.1201(e), 20.1202, 20.1203, 20.1204(a), 20.1208, and 20.1702.

5.7.4.2 Regulatory Acceptance Criteria

The proposed in-plant (within the MEA satellite building) airborne radiation monitoring program at the MEA was reviewed for compliance with these requirements by comparing it to the in-plant airborne radiation monitoring program in place at the currently licensed CBR facility.

5.7.4.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015).

The following sections describe and evaluate the in-plant (within the MEA Satellite Building) airborne radiation monitoring program proposed by the applicant. The program consists of airborne uranium particulate monitoring, radon daughter concentration monitoring, and the respiratory protection program.

The applicant describes its proposed in-plant (within the MEA Satellite Building) airborne radiation monitoring program for the MEA in TR Section 5.7.3 (CBR, 2015). Monitoring locations and planned surveys will be consistent with RG 8.30 (NRC, 2002a) and RG 8.25 (NRC, 1992). The applicant plans to conduct in-plant airborne radiation monitoring at the locations identified in MEA TR Figure 5.7-2 for airborne uranium and radon daughters. (CBR, 2015)

The applicant states that locations of sample points are based, in part, on a determination of airflow patterns in areas where monitoring is needed (CBR, 2015). The applicant proposed that once the ventilation system is installed and operational, and prior to process operations, a portable anemometer would be used to assess the ventilation patterns (i.e., direction and velocity) in the work areas. Once the facility is constructed and operational, another assessment will be made of the sampling points and results, and a determination made as to the need for any changes to the monitoring points and frequency. (CBR, 2015)

The applicant states that the measurement of airborne uranium is performed by gross alpha counting of the air filters using an alpha scaler, such as a Ludlum 2000 or equivalent, and that the approach used is consistent with the guidance in RG 8.25 (NRC, 1992) (CBR, 2015). During its review of the in-plant airborne radiation monitoring program for the 2014 license renewal of the currently licensed Crow Butte facility, the NRC staff determined that the applicant did not demonstrate that gross alpha counting will differentiate all airborne radioactivity in air samples, including radionuclides that are not uranium, some which may not emit alpha particles and thus will not be detected (refer to Section 5.7.4.3.1 of NRC, 2014). To address this deficiency, the NRC staff imposed License Condition 10.8 (NRC, 2017) which requires the applicant to measure and identify all potential radionuclides in airborne samples. This license condition will not change with this license amendment and will be applicable to operations at the MEA.

The applicant proposed using inhalation class D for natural uranium at the MEA (CBR, 2015). This inhalation class is based on the applicant's analysis of yellowcake produced at the currently licensed CBR facility (CBR, 2015). Although yellowcake will not be produced at the MEA (CBR, 2015), an appropriate inhalation classification is required for other chemical forms of natural uranium compounds encountered at the MEA (e.g., carbonates). During its review for the 2014 license renewal of the currently licensed CBR facility, the NRC staff imposed license condition 10.9, (NRC, 2017), which requires the licensee to use inhalation class W for all uranium products encountered during operations that are neither assigned an inhalation classification (i.e., 10 CFR 20, Appendix B) nor have site-specific data available (refer to Section 5.7.4.3.1 of NRC, 2014) for radiation protection purposes (i.e., determining occupational dose). This license condition will not change with this license amendment and will be applicable to operations at the MEA.

According to NRC Regulatory Guide 8.30, an action level is a level where the applicant should take action to identify the cause of a predetermined survey result and take corrective action if appropriate (NRC, 2002a). The applicant considers the chemical toxicity of uranium and limits individual intakes of soluble uranium to 10 mg in a week (CBR, 2015). The applicant states that when exposures lead to an individual exceeding 25 percent of the weekly limit, the RSO will conduct an investigation and initiate corrective actions, as appropriate, to reduce future exposures (CBR, 2015).

The radon daughter airborne samples are collected monthly at each sample location (refer to Figure 5.7-2 of CBR, 2015) and analyzed using the modified Kusnetz method (refer to TR Section 5.7.3.3 of CBR, 2015). The Kusnetz method is described in Section 2.3 of NRC, 2002a.

The applicant established an action level of 25 percent of the derived air concentration (DAC) given in Table 1 of Appendix B to 10 CFR Part 20 for radon and daughters (CBR, 2015). The applicant indicated that if the results are greater than 0.08 Working Levels, which represents 25 percent of the DAC for radon and daughters, then the monitoring frequency will increase to weekly until the levels are below the action level for four consecutive weeks. (CBR, 2015).

The applicant states (CBR, 2015) that the respirator program is designed to implement the guidance contained in Regulatory Guide 8.15 (NRC, 1999) and Regulatory Guide 8.31 (NRC 2002b). In TR Section 5.7.3.1, the applicant states that precipitation, drying, and packaging operations will not be performed at the MEA (CBR, 2015). Therefore, the applicant indicated that typical operations at the MEA are not expected to exceed action levels and thus, it is not expected that respirator use will be required for such “normal” operation of the satellite facility. However, the applicant indicated that anytime that the potential exists for elevated exposures to employees, respirators could be required. These conditions could be certain maintenance activities such as tank entry, disassembly of potentially contaminated piping and equipment, welding/grinding on contaminated piping/equipment, or the failure of the process building ventilation system.

The information provided in TR Section 5.7.3 (CBR, 2015) indicates that the proposed in-plant airborne radiation monitoring program at the MEA is consistent with the in-plant airborne radiation monitoring program in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant’s in-plant airborne radiation monitoring program acceptable (Refer to Section 5.7.4 of NRC, 2014). The NRC staff finds that the proposed in-plant airborne radiation monitoring program at the MEA is sufficiently similar to the in-plant airborne radiation monitoring program in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The NRC staff also finds that there are no safety concerns associated with the proposed in-plant airborne radiation monitoring program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant’s proposed in-plant airborne radiation monitoring program will comply with the applicable regulatory requirements related to occupational dose limits and limiting intakes of radioactive material.

5.7.4.4 Evaluation Findings

The NRC staff concludes that the applicant has established an acceptable in-plant (within the MEA Satellite Building) airborne radiation monitoring program at the MEA. Therefore, the NRC staff has reasonable assurance that the applicant's program, as described in its MEA TR, will comply with 20.1201(a), 20.1201(e), 20.1202, 20.1203, 20.1204(a), 20.1208, and 20.1702.

5.7.4.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report, Cameco Resources, Inc., Crow Butte Operation License Renewal (Revision 1), August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002a. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities, Revision 1", May, 2002.

NRC, 2002b. Regulatory Guide 8.31, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will be As Low As Reasonable Achievable", Revision 1, May 2002.

NRC, 1999. Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection, Revision 1," October, 1999.

NRC, 1992. Regulatory Guide 8.25, "Air Sampling in the Workplace," Revision 1, June, 1992.

5.7.5 Exposure Calculations

This section discusses the methodologies proposed by the applicant to calculate the exposures to radioactive materials by personnel in work areas where airborne radioactive materials could exist.

5.7.5.1 Regulatory Requirements

Section 5.7.4.4 of NUREG-1569 (NRC, 2003) identifies the following regulatory requirements applicable to the NRC staff's review of exposure calculations at ISR facilities: 10 CFR 20.1101, 20.1201(a), 20.1201(e), 20.1202, 20.1203, 20.1204, and 20.1208. In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

This review focuses on the methodologies proposed by the applicant to calculate the exposures to workers to radioactive materials at the MEA. Therefore, issues related to the radiation protection program elements specified in 10 CFR 20.1101(a) and (c) are addressed in the NRC staff's review of the applicant's management audit and inspection program (Section 5.3 of the SER), qualifications for personnel conducting the radiation safety program (Section 5.4 of the SER), and radiation safety training program (Section 5.5 of the SER). Likewise, issues related to the radiation protection program elements specified in 10 CFR 20.1101(b) and (d) relating to ALARA are addressed in the NRC staff's review of the applicant's effluent control systems (Section 4.0 of the SER) and external radiation exposure monitoring programs for workers (Section 5.7.3 of the SER) .

Therefore, for the purpose of this review, the applicant must demonstrate that the methodologies proposed to calculate the exposures of workers to radioactive materials are in compliance with 10 CFR 20.1201(a), 20.1201(e), 20.1202, 20.1203, 20.1204, and 20.1208.

5.7.5.2 Regulatory Acceptance Criteria

The proposed methodologies to calculate the exposures of workers to radioactive materials at the MEA was reviewed for compliance with these requirements by comparing it to the methodologies to calculate the exposures of workers to radioactive materials in place at the currently licensed CBR facility.

5.7.5.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in the MEA TR (CBR, 2015).

The applicant describes its methodologies for calculating worker exposures in TR Section 5.7.4 (CBR, 2015). The applicant states that its exposure calculations are based upon the recommendations in NRC Regulatory Guide 8.30 (NRC, 2002) for natural uranium and radon daughters and provided example intake and dose calculations for each type of exposure (CBR, 2015).

Routine worker exposures to both natural uranium and radon daughters will be based on actual hours worked (CBR, 2015). This is considered to be 100 percent occupancy. For exposures during non- routine work, exposures are based on actual time. (CBR, 2015)

The applicant states that it will use the appropriate equations in Regulatory Guide 8.30 (NRC 2002) to estimate occupational worker internal dose (CBR, 2015).

The applicant describes its program for monitoring the exposure of a declared pregnant woman (refer to TR Section 5.7.4.3 of CBR, 2015). The applicant explained that dosimeters for declared pregnant women are exchanged monthly until the end of gestation. If personal monitoring was not performed prior to notification of the pregnancy, the applicant will estimate the exposure using available information, such as surveys and area monitoring results. The applicant indicated that the exposure calculations for the embryo/fetus will be performed in accordance with NRC Regulatory Guide 8.36 (NRC, 1992). (CBR, 2015)

The information provided in TR Section 5.7.4 (CBR, 2015) indicates that the proposed methodologies to calculate the exposures of workers to radioactive materials at the MEA are consistent with the methodologies to calculate the exposures of workers to radioactive materials in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's methodologies to calculate the exposures of workers to radioactive materials acceptable (refer to Section 5.7.5 of NRC, 2014). The NRC staff finds that the proposed methodologies to calculate the exposures of workers to radioactive materials at the MEA is sufficiently similar to the methodologies to calculate the exposures of workers to radioactive materials in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the proposed methodologies to calculate the exposures of workers to radioactive materials at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed methodologies to calculate the exposures of workers to radioactive materials will comply with the applicable regulatory requirements related to occupational dose limits.

5.7.5.4 Evaluation Findings

The NRC staff concludes that the applicant has established acceptable methodologies to calculate the exposures of workers to radioactive materials at the MEA. Therefore, the NRC staff has reasonable assurance that the applicant's program, as described in its MEA TR, will comply with 10 CFR 20.1201(a), 20.1201(e), 20.1202, 20.1203, 20.1204, and 20.1208.

5.7.5.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2014. Safety Evaluation Report (Revised), License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534, August 14, 2014, ADAMS Accession NO. ML14149A433.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities, Revision 1," May, 2002.

NRC, 1992. Regulatory Guide 8.36, "Radiation Dose to the Embryo/Fetus," July, 2002.

5.7.6 Bioassay Program

This section discusses the applicant's proposed bioassay program. The bioassay program monitors potential internal uptakes and radiation exposures, and confirms the results of the airborne uranium particulate monitoring program.

5.7.6.1 Regulatory Requirements

Section 5.7.5.4 of NUREG-1569 (NRC, 2003) identifies 10 CFR 20.1204 and 10 CFR Part 20, Subpart L, as the regulatory requirements applicable to the NRC staff's review of bioassay programs at ISR facilities. In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exception noted below.

This review focuses on the applicant's proposed bioassay program to confirm the results of its airborne radiation monitoring program and exposure calculations at the MEA. Therefore, issues related to the records requirements in 10 CFR Part 20, Subpart L, are addressed in the applicant's management control program in SER section 5.2.

Therefore, for the purpose of this review, the applicant must demonstrate that the proposed bioassay program is in compliance with 10 CFR 20.1204.

5.7.6.2 Regulatory Acceptance Criteria

The proposed bioassay program at the MEA was reviewed for compliance with these requirements by comparing it to the bioassay program in place at the currently licensed CBR facility.

5.7.6.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in the MEA TR (CBR, 2015) and as updated (CBR, 2017).

The applicant states that it will continue to implement a bioassay program as described in NRC Regulatory Guide 8.22, Bioassay at Uranium Mills (NRC, 2014a) for operations at the MEA (refer to TR Section 5.7.5 of CBR, 2017). Regulatory Guide 8.22 (NRC, 2014a) identifies the working conditions under which bioassays should be performed, the types of bioassay, frequency, actions based on bioassay results, time of specimen collection and availability of results, prevention of specimen contamination, and quality control. The applicant's proposed bioassay program consists of the following:

- Requires all new employees to submit a baseline urinalysis prior to the start of employment at the facility.
- During operations, urine sample are collected from workers (including facility and wellfield operators) on a quarterly basis.
- During operations, urine samples are collected monthly from workers who have the potential to be exposed to dried yellowcake, or more frequently as determined by the RSO.
- The action levels for urinalysis are based on Table A-1 in Regulatory Guide 8.22.
- Upon termination, an exit bioassay is required from all employees (CBR, 2017).

The information provided in TR Section 5.7.5 (CBR, 2017) indicates that the proposed bioassay program at the MEA is consistent with the bioassay program in place at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's bioassay program acceptable (refer to Section 5.7.5 of NRC, 2014b). The NRC staff finds that the proposed bioassay program at the MEA is sufficiently similar to the bioassay program in place at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the proposed bioassay program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed bioassay program will comply with the applicable regulatory requirements related to occupational dose limits.

5.7.6.4 Evaluation Findings

The NRC staff concludes that the applicant has established an acceptable bioassay program at the MEA. Therefore, the NRC staff has reasonable assurance that the applicant's program, as described in the MEA TR, will comply with 10 CFR 20.1204.

5.7.6.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

CBR, 2017. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to U.S. NRC, Response to Open Issues – Marsland Expansion Area Technical Report, Teleconference on June 14, 2016, June 27, 2017, ADAMS Accession No. ML17193A311 (Package).

NRC, 2014a. Regulatory Guide 8.22, "Bioassay at Uranium Mills," Revision 2, Washington, DC.

NRC, 2014b. Safety Evaluation Report (Revised), License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534, August 14, 2014, ADAMS Accession NO. ML14149A433.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

5.7.7 Contamination Control Program

This section evaluates the contamination control program used by the applicant to prevent employees from leaving the site while contaminated. The contamination control program is also used to ensure that materials and equipment are below acceptable limits before releasing them for unrestricted use.

5.7.7.1 Regulatory Requirements

Section 5.7.6.4 of NUREG-1569 (NRC, 2003) identifies and describes the following regulatory requirements applicable to the NRC staff's review of contamination control programs at ISR facilities: 10 CFR 20.1101, 20.1501 and 20.1702. In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

This review focuses on the design and implementation of the contamination control program at the MEA. Therefore, issues related to the radiation protection program elements specified in 10 CFR 20.1101(a) and (c) are addressed in the NRC staff's review of the applicant's management audit and inspection program (Section 5.3 of the SER), qualifications for personnel conducting the radiation safety program (Section 5.4 of the SER), and radiation safety training program (Section 5.5 of the SER). Likewise, the requirements specified in 10 CFR 20.1702 addressing airborne radioactivity and the use of respirators are evaluated in SER Section 5.7.4.

The requirement in 10 CFR 20.1101(d) applies to air emissions and is therefore not applicable to this review.

The requirement in 10 CFR 10 CFR 20.1501(b) applies to subsurface residual radioactivity and is therefore not applicable to this review.

The requirement in 10 CFR 20.1501(d) applies to personnel dosimeters and is therefore not applicable to this review.

Therefore, for the purposes of this review, the applicant must demonstrate that the proposed contamination control program is in compliance with 10 CFR 20.1101(b), and 20.1501(a) and (c).

5.7.7.2 Regulatory Acceptance Criteria

The NRC staff determines if the applicant has demonstrated that its contamination control program for the MEA meets the requirements of 10 CFR 20.1101(b), and 20.1501(a) and (c). The proposed contamination control program for the MEA was reviewed for compliance with these requirements by comparing it to the acceptance criteria in NUREG-1569 (NRC, 2003), Section 5.7.6.3 with the exceptions noted below.

Acceptance Criterion 5.7.6.3(5) addresses the requirements in 10 CFR Part 20, Subpart L and Subpart M. The requirements in these subparts do not directly support the NRC staff's findings for the regulatory requirements specified above. Therefore, the NRC staff did not apply Acceptance Criterion 5.7.6.3(5) to the review of the applicant's contamination control program. However, the records and reporting requirements in 10 CFR Part 20, Subparts L and M, respectively, are addressed in the applicant's management control program in SER section 5.2.

Acceptance Criterion 5.7.6.3(8) specifies, in part, that radiation surveys are performed in conformance with Section 1 of RG 8.30 (NRC, 2002) for releasing equipment or scrap for unrestricted use. However, Section 2 of RG 8.30 (NRC, 2002) contains recommendations for contamination surveys, not Section 1. Therefore, the NRC staff applied the recommendations in Section 2 of RG 8.30 (NRC, 2002) in its evaluation of Acceptance Criterion 5.7.6.3(8).

5.7.7.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015) and as updated (CBR, 2017a, b, and c).

The applicant describes its proposed contamination control program for the MEA in TR Sections 3.3 (CBR, 2015), 5.7.6 (CBR, 2017a), and 6.3 (CBR, 2015), TR Section 5 of its Quality Assurance

Program (CBR, 2017b), and in its proposed contamination control program submitted in accordance with License Condition 11.10 (NRC, 2017) (CBR, 2017c).

In addition to the applicant's proposed contamination control program, License Condition 9.6 (NRC, 2017) requires the applicant to release items for unrestricted use in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) (NRC, 1993). In addition to specific release limits, the Guidelines provide recommendations for minimizing contamination levels on equipment and scrap. Furthermore, License Condition 9.7 (NRC, 2017) requires the applicant to follow the guidance in RG 8.30 (NRC, 2002). RG 8.30 provides recommendations on surveys for surface contamination for areas, items, and personnel as well as the calibration of survey instruments. These license conditions will also apply to the MEA.

Personnel and Area Surveys

The applicant describes its plans for personnel and area contamination surveys in TR Sections 5.7.6.1 and 5.7.6.2 (CBR, 2017a). The applicant will perform alpha and beta surveys in clean areas (e.g., change rooms, lunchrooms, offices) on a weekly basis. The applicant established a target level of nothing detectable above background levels. If contamination levels in clean areas exceed 25 percent of the removable contamination limits, the area will be cleaned and resurveyed. (CBR, 2017a)

The applicant states that all personnel will be required to perform and document alpha and beta contamination monitoring (CBR, 2017a). In addition, the applicant will conduct quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel surveys. All contamination on skin and clothing is considered to be removable so the limits for removable contamination will be applied to personnel monitoring. (CBR, 2017a)

Based on the applicant's commitments and the requirement specified in License Condition 9.7 (NRC, 2017), the NRC staff finds the applicant's proposed plan for personnel and area surveys meets acceptance criteria (1) through (3) in Section 5.7.6.3 of NUREG-1569 (NRC, 2003).

Survey Equipment

The applicant provided a description the proposed types of contamination monitoring equipment for use at the MEA (refer to TR Section 3.3 of CBR, 2015; TR Section 5.7.6 of CBR, 2017a; TR Section 5 of CBR, 2017b; and CBR, 2017c). The applicant describes the equipment by type of radiation detected and provided a description of calibration methods and frequency (refer to TR Section 3.3 of CBR, 2015; TR Section 5.7.6 of CBR, 2017a; TR Section 5 of CBR, 2017b; and CBR, 2017c). In addition, the applicant provided a demonstration that the monitoring equipment is sufficiently sensitive for the radiation expected at the MEA (CBR, 2017a).

Based on the applicant's commitments and the requirement specified in License Condition 9.7 (NRC, 2017), the NRC staff finds the applicant's description of the proposed types of contamination monitoring equipment for use at the MEA, in addition to the planned use and calibration of these instruments, meets the acceptance criterion (4) in Section 5.7.6.3 of NUREG-1569 (NRC, 2003).

Release of Items for Unrestricted Use

The applicant describes its procedures for removing and disposing of equipment and scrap in TR Section 6.3 (CBR, 2015). These procedures will address:

- contamination levels on internal surfaces of pipes, drain lines and duct work
- contamination levels prior to applying a covering material (paint, etc.)
- equipment or scrap with an existing covering material (paint, etc.)

Based on the applicant's commitments and the requirement specified in License Condition 9.6 (NRC, 2017), the NRC staff finds the applicant's proposed plan for evaluating equipment and scrap for residual radioactivity meets acceptance criteria (6) through (8) in Section 5.7.6.3 of NUREG-1569 (NRC, 2003).

The applicant states that equipment and scrap with surface contamination in excess of the limits in Table 5.7.6.3-1 in NUREG-1569 (NRC, 2003) will not be released for unrestricted use and will be disposed of at an appropriate disposal site (refer to TR Section 6.3 of CBR, 2015). The NRC staff observes that the limits specified in Table 5.7.6.3-1 in NUREG-1569 (NRC, 2003) are identical to the limits specified in the Guidelines (NRC, 1993). The NRC staff finds the applicant's proposed plan for controlling equipment and scrap with residual contamination that exceeds the limits in Table 5.7.6.3-1 in NUREG-1569 (NRC, 2003) meets acceptance criterion (9) in Section 5.7.6.3 of NUREG-1569 (NRC, 2003).

5.7.7.4 Evaluation Findings

The NRC staff concludes that the applicant has established an acceptable contamination control program at the MEA. Therefore, the NRC staff has reasonable assurance that the applicant's program, as described in its MEA TR, will comply with 10 CFR 20.1101(b), and 20.1501(a) and (c).

5.7.7.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2017a. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to U.S. NRC, Response to Open Issues – Marsland Expansion Area Technical Report, Teleconference on June 14, 2016, June 27, 2017, ADAMS Accession No. ML17193A311 (Package).

CBR, 2017b. E-mail from L. Teahon, Cameco Resources, Crow Butte Operation, to R. Burrows, NRC, Quality Assurance Program, March 20, 2017, ADAMS Accession No. ML17080A486.

CBR, 2017c. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to U.S. NRC, Request for Additional Clarification for Response to License Condition 11.10, October 31, 2017, ADAMS Accession No. ML17313A803.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2002. Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities, Revision 1," May 2002.

NRC, 1993. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," U.S. Nuclear Regulatory Commission, April 1993, ADAMS Accession No. ML003745526.

5.7.8 Airborne Effluent and Environmental Monitoring Programs

The following sections discuss and evaluate the applicant's proposed airborne effluent and environmental monitoring programs during operations. The NRC staff evaluated the preoperational environmental monitoring program in SER Section 2.6. These programs include radiation monitoring outside of the MEA Satellite Building area during operations and environmental monitoring around the facility.

During the course of the review, the NRC staff determined that environmental monitoring associated with groundwater and surface water is better addressed in the broader discussion of groundwater and surface water monitoring programs. Therefore, the environmental monitoring program for groundwater and surface water is presented in Section 5.7.9 of this SER.

5.7.8.1 Regulatory Requirements

Section 5.7.7.4 of NUREG-1569 (NRC, 2003) identifies the following regulatory requirements applicable to the NRC staff's review of airborne effluent and environmental monitoring programs at ISR facilities: 10 CFR 20.1302(a), 20.1501(a), 10 CFR Part 20, Subpart L, and 10 CFR 40.65. In addition, in this section the NRC staff is evaluating the applicant's analysis of the estimated maximum dose to a member of the public for compliance with 10 CFR 20.1301 and 20.1302(b), using Section 7.3 of NUREG-1569 (NRC, 2003). Specifically, the NRC staff is evaluating the dose to a member of the public from air pathways and direct radiation from operations at the MEA. As discussed in SER Section 4.2, there are no receiving water exposure pathways and thus, in accordance with Section 7.3.1.1.1 of NUREG-1569 (NRC, 2003), an analysis of water pathways is not needed. Sections 7.3.1.2.4, 7.3.1.3.4, and 7.3.1.4.4 of NUREG-1569 (NRC, 2003) identify the following regulatory requirements applicable to the NRC staff's review of the estimated maximum public dose: 10 CFR 20.1301, 20.1302(b), and 20.1101(d). Other acceptance criteria in Section 7.3 of NUREG-1569 (NRC, 2003) relate to the staff's environmental review under the National Environmental Policy Act (NEPA) and are not applicable to this review.

In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

This review focuses on the design, conduct, and reporting of the applicant's proposed airborne effluent and environmental monitoring programs for the MEA during operations. Therefore, issues related to the records requirements in 10 CFR Part 20, Subpart L, are addressed in the applicant's management control program in SER section 5.2.

The applicant's program for demonstrating compliance with the ALARA requirements for individual members of the public specified in 10 CFR 20.1101(d) is evaluated in SER section 4.1 and is therefore not evaluated in this section.

Therefore, for the purpose of this review, the applicant must demonstrate that the proposed airborne effluent and environmental monitoring programs for the MEA are in compliance with 10 CFR 20.1302(a), 20.1501(a), and 10 CFR 40.65. In addition, the applicant must demonstrate that the dose to the maximally exposed member of the public from air pathways and direct radiation from MEA operations complies with 10 CFR 20.1301 and 20.1302(b).

5.7.8.2 Regulatory Acceptance Criteria

The NRC staff determines whether the applicant has demonstrated that its proposed airborne effluent and environmental monitoring programs at the MEA will comply with 10 CFR 20.1302(a), 20.1501(a), and 10 CFR 40.65. The proposed airborne effluent and environmental monitoring program for the MEA was reviewed for compliance with these requirements by comparing it to the acceptance criteria in NUREG-1569 (NRC, 2003), Section 5.7.7.3.

The NRC staff also determines whether the applicant has demonstrated that the dose to the maximally exposed member of the public complies with 10 CFR 20.1301 and 20.1302(b). The applicant's analysis of the maximally exposed member of the public was reviewed for compliance with these requirements by comparing it to the acceptance criteria in NUREG-1569 (NRC, 2003), Sections 7.3.1.2.3, 7.3.1.3.3 and 7.3.1.4.3.

The NRC staff observes that the acceptance criteria in NUREG-1569 (NRC, 2003), Sections 7.3.1.2.3, 7.3.1.3.3 and 7.3.1.4.3, refer to compliance with public dose limits and determination of radionuclide concentrations at the facility boundary. This is not generally correct for uranium in situ recovery facilities. According to 10 CFR 20.1302(b), an applicant may meet the public dose requirements by either calculating a dose to a member of the public from the licensed operation regardless of where the dose is received (§ 20.1302(b)(1)), or by determining radionuclide concentrations at the boundary of the unrestricted area (§ 20.1302(b)(2)(i)) (NRC, 2001). The unrestricted area boundary at most uranium in situ recovery facilities, including the MEA, does not extend to the facility boundary. This distinction is not relevant to this review as the applicant proposed the methodology for calculating dose to a member of the public as required in § 20.1302(b)(1) and as described below.

5.7.8.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015) and as updated (CBR, 2017a and b). This section discusses the applicant's proposed airborne effluent and environmental monitoring programs that focus on radiation monitoring outside of the MEA satellite building area during operations.

5.7.8.3.1 Airborne Effluent and Environmental Monitoring

As discussed in Sections 3.2 and 4.1.2 of the TR, the only processing of uranium that will be carried out at the MEA will be processing uranium onto ion exchange resin (CBR, 2015). The remainder of the processes, including elution, precipitation, drying, and packaging of the yellowcake product, will be performed using equipment and processes at the currently licensed CBR facility (CBR, 2015). Therefore, during normal operations, the major radioactive effluent for MEA operations would be radon (CBR, 2015).

The applicant's operational airborne effluent monitoring program is described in TR Section 5.7.7 (CBR, 2017a). The source of air emissions (radon), and how these emissions will be monitored, is described in TR Section 5.7.7.2 (CBR, 2017a). These sources include specific release points from the satellite building, general ventilation releases, and the wellhouses and wellfield (CBR, 2017a). For spills of process fluid, the applicant will estimate (i.e., calculate) the radon releases based on the volume of fluid released and the radon concentration in the fluid (CBR, 2017a). Radon from the building tanks and vents from other similar ISR satellite facilities represent the majority (greater than 90 percent) of the total effluents released (See, for example, Uranerz, 2017). Therefore, the NRC staff has reasonable assurance that unmonitored effluents will represent less than 30 percent of the total estimated effluent releases as recommended in RG 8.37 (NRC, 1993). Monitoring locations within the general work areas of the facility are shown in TR Figure 5.7-2 (CBR, 2015). The applicant committed to providing the NRC staff with a figure showing the sampling locations of the tanks and general ventilation discharge points for review prior to operation (refer to TR Section 5.7.7.2 of CBR, 2017). This commitment is captured in a preoperational license condition presented in SER Section 5.7.8.4. Measurements of radon emissions will be made with alpha track etch detectors (general areas of satellite facility, wellhouses) and Lucas cells (tank vents, wellheads) (CBR, 2017a). The typical flow rates for the tank vent lines and general building ventilation systems are described in TR Appendix Y (CBR, 2015). Flow rate calculations will be based on information provided by the manufacturer of the individual fans (CBR, 2017a).

The applicant's environmental monitoring program is described in TR Section 5.7.7 (CBR, 2017a) and summarized in TR Table 5.7-1 (CBR, 2017b). Air monitoring stations are shown on TR Figure 7.3-2 (CBR, 2015). The locations for the air monitoring stations are the same locations used for the preoperational sampling program and are based on the criteria from Section 1.1 of RG 4.14 (NRC, 1980) as discussed in TR Section 2.9 (CBR, 2017a). The applicant has proposed taking soil, vegetation, food (including crops, livestock, and fish), direct radiation, and sediment samples during operations (CBR, 2017a).

The applicant used the recommendations in RG 4.14 for types of samples, sample locations, frequency of sampling, and specific types of analyses for its airborne effluent and environmental monitoring programs (CBR, 2017a). In addition, the applicant used the lower limit of detection recommended in RG 4.14 (NRC, 1980) for each type of analysis (CBR, 2017a). The applicant has a quality assurance program that addresses sample collection, instrument calibration, and other aspects of airborne effluent and environmental monitoring that was approved by the NRC staff (NRC, 2017).

The NRC staff finds that the applicant's operational airborne effluent and environmental monitoring programs have identified, and will monitor, all airborne effluent discharge locations as well as environmental monitoring locations consistent with acceptance criteria 5.7.7.3(1) through (4) of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed operational airborne effluent and environmental monitoring programs will comply with 10 CFR 20.1302(a) and 20.1501(a).

5.7.8.3.2 Reporting of Airborne Effluent and Environmental Monitoring Results

The reporting requirements in 10 CFR 40.65 specify, in part, that licensees must specify the quantity of each of the principal radionuclides released to unrestricted areas in gaseous effluents during the previous six months of operations. The applicant states that the quantity of radon released from all sources will be summarized in the semiannual report in accordance with 10 CFR 40.65 (CBR, 2017a). In addition, License Condition 11.1(D) (NRC, 2017) requires the applicant to submit a semiannual report that summarizes the results of the operational effluent and environmental monitoring program, consistent with the terms of RG 4.14. This standard license condition will also apply to operations at the MEA. Based on the NRC staff's evaluation of the applicant's proposed airborne effluent and environmental monitoring programs above and the requirements of License Condition 11.1(D) (NRC, 2017), the NRC staff finds that the applicant's proposed airborne effluent and environmental monitoring programs meets acceptance criterion 5.7.7.3(6) of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed airborne effluent and environmental monitoring programs will comply with 10 CFR 40.65.

5.7.8.3.3 Dose to the Maximally Exposed Member of the Public

The applicant provided a discussion on public exposure from the MEA operations in TR Section 7.3 (CBR, 2015). The applicant provided a human exposure pathway diagram in Figure 7.3-1 that includes relevant airborne and external exposure pathways (CBR, 2015).

For calculating an estimated maximum dose from the MEA to a member of the public prior to beginning operation, the applicant estimated individual exposures using an updated version of the MILDOS-AREA code (Yuan, et al., 1989). Inputs into the code reflect conditions at the site, including thickness of the ore, radium concentration, and onsite wind data (refer to SER Section 2.2 for a discussion of the collection of wind data), and agricultural pathway parameters (refer to TR Appendix M of CBR, 2015). Material deposited on the ground from effluents is assumed to contribute to external radiation and ingestion exposure from intake of contaminated food products (Yuan, et al., 1989).

The applicant identified various members of the public that may spend up to 10 hours on site such as delivery personnel and visitors, as well as nearby residences (refer to TR Figure 7.3-2 in CBR, 2015). The highest dose calculated was at Residence #2 (habitable, but not occupied) with an estimated dose of 27 mrem per year (refer to TR Table 7.3-1 of CBR, 2015). The applicant reported that the dose excluding radon and its progeny was zero (0) mrem per year.

Based on the NRC staff's evaluation of the applicant's methodology for determining the maximum public radiation exposure from the MEA operations, the NRC staff finds that the applicant's determination of the estimated maximum public exposure meets the acceptance criteria in NUREG-1569 (NRC, 2003), Sections 7.3.1.2.3, 7.3.1.3.3, and 7.3.1.4.3,. Therefore, the NRC staff has reasonable assurance that the maximum public radiation exposure from the MEA operations will comply with 10 CFR 20.1301 and the applicant's methodology for determining the maximum public radiation exposure will comply with 20.1302(b).

5.7.8.4 Evaluation Findings

The NRC staff concludes that the applicant has established acceptable airborne effluent and environmental monitoring programs at the MEA. Therefore, the NRC staff has reasonable assurance that the applicant's program, as described in its MEA TR, complies with 10 CFR 20.1302(a), 20.1501(a), and 10 CFR 40.65.

The NRC staff is imposing the following preoperational license condition to obtain information on the applicant's effluent monitoring program consistent with the applicant's commitment (CBR, 2017a) to provide this information.

> At least 60 days prior to the NRC staff's preoperational inspection for the MEA, the licensee shall submit a figure showing the air sampling locations of tank vents and general ventilation discharge points of the MEA satellite building to the NRC staff for review and written verification.

In addition, the NRC staff concludes that the dose to a maximally exposed member of the public from operations at the MEA is acceptable and in compliance with 10 CFR 20.1301 and 20.1302(b).

5.7.8.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2017a. E-mail from L. Teahon, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, MEA Open Issues, October 26, 2017, ADAMS Accession No. ML17300A277.

CBR, 2017b. Facsimile from W. Nelson, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, Marsland quality assurance program, November 8, 2017, ADAMS Accession No. ML17319A211.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc. Crawford Nebraska, SUA-1534, October 5, 2017, ADAMS Accession No. ML17062A606 (package).

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2001. NUREG-1736, "Consolidated Guidance: 10 CFR 20 – Standards for Protection Against Radiation, Final Report," October, 2001, ADAMS Accession No. ML013330179.

NRC 1993. Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities", July 1993.

NRC, 1980. Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills", Revision 1, Washington, DC, April, 1980.

Uranerz, 2017. Letter from B. Bonifas, Uranerz Energy Corporation, to U.S. NRC, Semi-Annual Report Uranerz Energy Corporation Nichols Ranch ISR Project, August 30, 2017, ADAMS Accession No. ML17251B125.

Yuan, Y.C., J.H.C. Wang, and A. Zielen, 1989. "MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources." Report ANL/ES-161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division, http://mildos.evs.anl.gov/documents/ANL_ES_161.pdf (accessed 10/25/2017).

5.7.9 Groundwater and Surface Water Monitoring Programs

5.7.9.1 Regulatory Requirements

In this section, the NRC staff determines whether the applicant has demonstrated that the groundwater and surface water monitoring program for the proposed MEA facility meets the requirements of 10 CFR 40.32(c), 10 CFR 40.41(c), and 10 CFR Part 40, Appendix A, Criteria 5B(5), 5D, and 7.

5.7.9.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria for groundwater and surface water monitoring in Section 5.7.8.3 of NUREG-1569 (NRC, 2003).

5.7.9.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and drawings submitted by Crow Butte Resources in its MEA TR (CBR, 2015).
TR Section 5.7.8 (CBR, 2015) described groundwater and surface water monitoring programs to be implemented at the MEA facility during operations. Preoperational monitoring, which was conducted as part of the site characterization or mine unit baseline data acquisition, is discussed in Section 2.5 and 2.6 of this SER. Restoration monitoring, which is conducted during groundwater restoration of a mine unit, is discussed in Section 6.1 of this SER. The following sections address mine unit operational groundwater monitoring, new mine unit hydrologic packages, and license area groundwater and surface water environmental monitoring programs.

5.7.9.3.1 Mine Unit Operational Groundwater Monitoring

TR Section 5.7.8 states that the operational monitoring program for all mine units will consist of excursion monitoring at designated wells in the surrounding perimeter monitoring well ring and in the overlying aquifer (CBR, 2015). The purpose of the perimeter monitoring well ring is to provide early detection of the movement of production fluids (horizontal excursion) from the production zone (i.e., Basal Chadron Sandstone) in the wellfield. The purpose of the monitoring wells in the overlying aquifers is the early detection of movement of production fluids (vertical excursion) from the mineralized zone. The applicant has designated the hydraulically-interconnected Brule and Arikaree Formations as the overlying aquifer (CBR, 2015).

Consistent with its practice at the currently licensed CBR facility, the applicant does not plan to install monitoring wells in the "D", "G", and "J" sandstones of the Dakota Group (the aquifer underlying the production zone)) at the MEA due to the presence of a thick and effective confining layer (Pierre Shale) immediately beneath the production zone (CBR, 2015). In addition, as noted by the applicant (CBR, 2015), the units underlying the Pierre Shale are not considered to be underground sources of drinking water due to their high concentrations of total dissolved solids.

The applicant's operational monitoring program at the MEA will be the same as the one used at the currently licensed CBR facility (CBR, 2015). In accordance with License Condition 10.4 (NRC, 2017), the proposed operational monitoring program includes the installation of Basal Chadron Sandstone perimeter monitoring wells spaced no further than 122 meters (400 feet) apart and no further than 91 meters (300 feet) from the wellfield boundary for early detection of potential horizontal excursions of lixiviant. As required by License Condition 11.3 (NRC, 2014), the applicant will also install one monitoring well per every 0.4 hectares (5 ac) at the MEA in the overlying aquifer (Brule and Arikaree) for the detection of potential vertical excursions.

TR Section 5.7.9.1 (CBR, 2015) indicates that well development and groundwater and surface water sampling activities will be performed in accordance with detailed instructions contained in the latest CBR SHEQ MS, Volume VI, Environmental Manual. These instructions are used by the applicant at the currently licensed CBR facility.

The NRC staff previously found this operational groundwater monitoring design acceptable for the main facility based on the stratigraphy and hydrogeology at the currently licensed CBR facility (Sections 2.3, 2.4, 5.7.9 in NRC, 2014). Given the equivalency of the proposed MEA monitoring program to that at the currently licensed CBR facility and the similar stratigraphy and hydrogeology present at the MEA (see SER Sections 2.3 and 2.4), the staff finds the proposed operational groundwater monitoring design acceptable for the MEA. In addition, the NRC staff has not identified any unreviewed safety-related concerns pertinent to the operational groundwater monitoring design at the MEA.

5.7.9.3.1.1 Establishment of Background Groundwater Quality

Acceptance criteria (1) in Section 5.7.8.3 of NUREG-1569 (NRC, 2003) recommends that the NRC staff evaluate the approach to establishing background groundwater quality of the production zone, overlying aquifer, underlying aquifer and perimeter monitoring well ring. The production zone background groundwater quality is used to establish the standards to which the groundwater in the mine unit production zone must be restored under Criterion 5B(5) of 10 CFR Part 40, Appendix A. The overlying aquifer and perimeter monitoring well ring background water quality is used to establish the groundwater quality standards that must also be met under Criterion 5B(5) if the groundwater in these aquifers (overlying and production-zone aquifers) is impacted by ISR operations and restored.

To establish the mine unit background water quality, wells are developed and sampled in accordance with the instructions contained in SHEQ MS Volume VI, Environmental Manual (Section 5.7.9 in CBR 2015). License Condition 11.3(A)-(D) (NRC, 2017), which specifies the approach to establishing background groundwater quality, requires the minimum sampling well density to be: one production zone well per four acres, one upper aquifer monitoring well per five acres of mine unit area, and all perimeter monitoring wells. Four samples will be collected at least 14 days apart from each well. Representative background concentrations are established on a parameter-by-parameter basis using either the mine unit or well-specific mean value or other NRC-approved statistically valid analysis.

Under License Condition 11.3(A)-(D) (NRC, 2017), which will apply to the MEA, CBR will be required to establish background water quality standards for constituents listed in the license condition. The constituents to be monitored to establish background groundwater quality concentrations at the MEA will also require the measurement of gross alpha in accordance with 10 CFR Part 40, Appendix A, Criteria 5 and 13. Thus, the NRC staff is updating License Condition 11.3(C) to add gross alpha to the listed constituents. The updated portion of the standard license condition is provided in SER Section 6.1.4.

The NRC staff finds that the applicant's plan for establishing background groundwater quality at the MEA along with the provisions of License Condition 11.3 (NRC, 2017) meets acceptance criterion (1) in Section 5.7.8.3 of the NUREG-1569 (NRC, 2003) and 10 CFR Part 40, Appendix A, Criteria 5 and 13, and is therefore acceptable.

5.7.9.3.1.2 Wellfield Packages

In TR Section 3.1.3 (CBR, 2016), the applicant commits to submitting a wellfield package prior to the startup of each mine unit operations at the MEA. The applicant also commits to performing aquifer pumping test at each mine unit. The applicant's wellfield pumping test approach is to demonstrate hydraulic containment above the production zone, demonstrate communication between production and injections wells and perimeter horizontal excursion monitor wells, and to further evaluate the hydrologic properties of the Basal Chadron Sandstone aquifer. The applicant is committed to providing the following in each wellfield package: (1) hydrologic test data, (2) completion reports for the monitoring wells; (3) water quality data used to determine excursion control parameters, (4) background groundwater quality data; (5) well density, (6) sampling frequency, and (7) determination of groundwater restoration goals, and (8) aquifer pumping test to establish that the production and injections wells are hydraulically connected to the perimeter horizontal excursion monitor wells and are hydraulically isolated from the vertical excursion monitor wells (TR Section 3.1.3 in CBR, 2016).

The NRC staff is memorializing the applicant's commitments related to aquifer pumping tests and wellfield packages in a license condition. Current License Condition 11.3E requires that hydrologic test packages (wellfield packages) be submitted to the NRC for review. The NRC staff is deleting License Condition 11.3E and replacing it with a new MEA-specific license condition for wellfield packages. The new the license condition will require the applicant to perform an aquifer pumping test for each mine unit prior to submitting the wellfield package, and to provide the data from the aquifer pumping test in the wellfield packages. Also, although the NRC staff found no direct evidence of the reported Niobrara River fault (or structure) near the southern MEA license boundary (see SER Section 2.3.3.2), to ensure that the aquifer pumping tests are designed to identify any potential fault-related flow effects, the NRC staff is requiring the applicant to submit its plans for conducting aquifer pumping tests in MU-D through MU-F (TR Figure 1.7-5, CBR, 2015) to the NRC for review and written verification. Finally, the NRC staff is requiring that the all wellfield packages for MEA mine units be submitted to the NRC for review and written verification. The new license condition is presented in SER Section 5.7.9.4.

With the commitments for aquifer pumping tests and wellfield packages discussed above, the NRC staff finds the applicant's approach for establishing background groundwater quality and verifying the hydrogeological conceptual model for the MEA meets criterion (4) of Section 5.7.8.3 of NUREG-1569 (NRC, 2003).

5.7.9.3.1.3 Groundwater Excursion Monitoring and Corrective Action

Per License Condition 11.4 (NRC, 2017), the upper control limits (UCLs) for the excursion monitoring program will be established by collecting four samples from each designated monitoring well at a minimum density of: 1) one upper aquifer monitoring well per 0.4 hectares (5 ac) of mine unit area, and 2) all perimeter monitoring wells. These samples will be collected at least 14 days apart. The samples will be analyzed for the indicator parameters: chloride, conductivity, and total alkalinity. The UCLs will be calculated for each indicator parameter, in each monitoring well, as equal to 20 percent above the maximum concentration measured for that parameter among the background samples. For those indicator parameters with background concentrations that average 50 mg/L or less, the UCL for that parameter may be calculated as equal to 20 percent above the maximum background concentration, the background average plus five standard deviations, or the background average plus 15 mg/L. This license condition will not change with the MEA license amendment and will also apply at the MEA.

TR Section 5.7.9.3 (CBR, 2015) indicates that excursion monitoring will be conducted using chloride, conductivity, and total alkalinity as excursion indicators. The applicant also states that monitoring wells will be sampled for these excursion indicators on a biweekly basis during operations. If two UCLs are exceeded in a well, or if a single UCL is exceeded by 20 percent, a confirming water sample will be taken within 48 hours after the results of the first analyses are received and the applicant will analyze the sample for the indicator parameters. If the second sample does not indicate an exceedance of the UCLs, a third sample will be taken and analyzed in a similar manner within 48 hours after the second set of samples was acquired. If neither the second nor the third sample indicates an exceedance of the UCLs, the first sample will be considered in error (refer to License Condition 11.5 in NRC, 2014). In accordance with License Condition 11.5 (NRC, 2017), if the resampling verifies UCL exceedance, the well will be placed on excursion status and the NRC Project Manager will be contacted by e-mail or telephone within 24 hours and in writing within 7 days. Once the monitoring well does not exceed excursion criteria for three consecutive weeks, the monitoring well is taken off excursion status.

TR Section 5.7.9.3 (CBR, 2015) states that upon verification of an excursion, the applicant will take corrective actions appropriate to the specific circumstances using the following approach (though not necessarily in this order) (CBR, 2015):

- Preliminary investigation of the probable cause;
- Adjustments as needed to increase the recovery in the vicinity of the monitoring well and hydraulic gradient toward the production zone; and
- Enhancement of recovery through extraction at individual wells.

The applicant states that injection adjacent to the monitoring well may be suspended and the monitor well will be sampled weekly while on excursion status (CBR, 2015). In accordance with License Condition 11.5 (NRC, 2017), a written report describing the excursion event, corrective actions taken, and the corrective action results will be submitted to the NRC within 60 days of the excursion confirmation.

In accordance with License Condition 11.5 (NRC, 2017), if an excursion is not corrected within 60 days of confirmation, the applicant will either: (a) terminate injection of lixiviant within the production area until the excursion is corrected; or (b) increase the surety in an amount to cover the full third-party cost of correcting and cleaning up the excursion. The surety increase will remain in force until the NRC has verified that the excursion has been corrected and cleaned up. For all wells that remain on excursion after 60 days, the applicant will provide further status updates in quarterly reports required by license condition.

Given the provisions of License Conditions 11.4 and 11.5 (NRC, 2017), the NRC staff finds that the above-referenced excursion reporting requirements and required actions meet acceptance criteria (2), (3), and (5) in Section 5.7.8.3 of NUREG-1569 (NRC, 2003).

5.7.9.3.2 Environmental Groundwater and Surface Water Monitoring Program

As discussed in SER section 2.4.3.2.2, the NRC staff is imposing a license condition to provide additional assurance that the Basal Chadron Sandstone aquifer (production zone) remains saturated throughout the proposed operations and restoration of the MEA. The license condition will require the applicant to monitor water levels semi-annually in the dedicated, existing MEA Basal Chadron Sandstone monitoring wells 8 and 9 and two additional monitoring wells to be installed in the Basal Chadron Sandstone aquifer within the MEA. Results of the groundwater level monitoring program will be used to validate the applicant's AquiferWin32® analytical modeling projections provided in TR appendix GG (CBR, 2016). Based on the applicant's modeling (discussed in 2.4.3.2.2), the applicant predicted a maximum drawdown of 33.8 m (111 ft) at the MEA. If the drawdown reaches that value, there would still be over 300 ft of head in the BCS at the MEA.

The license condition contains two triggers that will require further actions by the applicant. These triggers are (1) the water level in the Basal Chadron Sandstone aquifer falls below 3,539.0 feet above mean sea level, and (2) the overall average rate of cumulative drawdown exceeds 10 ft/yr. The staff calculated the first trigger value by adding a buffer of 60 feet to the maximum cumulative drawdown of 111 feet predicted by the applicant, rounding that sum to 170 feet, and subtracting that from the February 22, 2011 water level elevation of 3709.0 ft above mean sea level (Appendix GG (CBR, 2016), which was used as a baseline water elevation. The staff calculated the second trigger value by starting with the overall average rate of cumulative maximum drawdown of 6.5 ft/yr reflected in TR Appendix GG Figure 19 (CBR, 2016) and adding a buffer of 3.5 ft/yr, which results a maximum allowable overall average rate of the cumulative drawdown of 10 ft/yr. If either of these triggers occur at the MEA, the applicant will be required to develop a corrective action plan and submit it to the NRC within 30 days for review and approval. The license condition is presented in SER section 5.7.9.4.

TR Section 5.7.9 (CBR, 2015) and TR Table 5.7.1 (CBR, 2017) indicated that in addition to wellfield monitoring, all private water wells within 2 km (1.2 mi) of the wellfield area boundaries will be sampled on a quarterly basis for dissolved and suspended natural uranium, Ra-226, Th-230, PB-210, and Po-210. The proposed private water well sample analyses and sampling frequency are consistent with Table 2 of Regulatory Guide 4.14 (NRC, 1980). The private water wells will be only be sampled with the landowner's consent. The NRC staff finds the proposed private water well sampling plan for the MEA to be acceptable because it is identical to the one in effect at the currently licensed CBR facility which has been shown by operational experience and NRC facility inspections to be protective of public health and safety.

The applicant also proposes collecting surface water samples quarterly from the sampling points identified in TR Figure 2.7-4 and analyzing for dissolved and suspended natural uranium, Ra-226, Th-230, Pb-210, and Po-210 (TR Section 5.7.9.3 in CBR, 2015 and TR Table 5.7.1 in CBR, 2017). The proposed surface water sample analyses and sampling frequency are consistent with Regulatory Guide 4.14 (NRC, 1980).

As discussed in SER Section 2.5.3.1, the applicant will not have private surface water impoundments at or within the license boundary, nor are there any offsite surface impoundments subject to direct drainage from potentially contaminated areas consistent with Regulatory Guide 4.14 (NRC, 1980). Therefore, no operational surface water samples from impoundments are required.

5.7.9.4 Evaluation Findings

The NRC staff reviewed the groundwater and surface water monitoring programs of the proposed MEA in accordance with Section 5.7.8.3 of NUREG-1569 (NRC, 2003). The applicant has defined a sampling program that addresses the following areas:

- Surface water bodies that lie within the facility boundary, including downstream sampling locations;
- Wellfield background water quality sampling, including the number and sampling interval, constituents sampled, and statistical methods;
- Operational groundwater monitoring including identification of: appropriate well spacing for monitoring, excursion parameters, UCL computational methods, excursion notification requirements, and corrective actions for excursions.

As discussed in SER section 5.7.9.3.1.1, the NRC staff is updating License Condition 11.3(C), which relates to establishment of background water quality, to include the background groundwater quality measurement of gross alpha. Updated License Condition 11.3(C) will read as follows:

> The samples shall be analyzed for ammonia, arsenic, barium, cadmium, calcium, chloride, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, pH, potassium, radium-226, selenium, sodium, sulfate, total carbonate, total dissolved solids, uranium, vanadium, zinc, and gross alpha.

As discussed in SER section 5.7.9.3.1.1, the NRC staff is deleting the current License Condition 11.3E and imposing the following a license condition for MEA wellfield packages:

> At least 90 days prior to the planned start date of lixiviant injection in a new MEA wellfield, the licensee shall submit a wellfield package to the NRC for review and written verification.

The licensee must receive written NRC verification of the wellfield package prior to injecting lixiviant into the mine unit.

As part of developing its wellfield packages for new mine units at the MEA, the applicant shall perform an aquifer pumping test for each new mine unit. For mine units MU-D through MU-F, the licensee shall submit its plan for conducting the aquifer pumping test for NRC review and written verification at least 60 days prior to the planned date for performing the aquifer pumping test.

For all mine units, each wellfield package shall include (1) the information identified in Section 3.1.3 (p. 3-12) of the 2016 Response to Open Issues – Marsland Expansion Area Technical Report (ADAMS Accession No. ML16155A283), and (2) a discussion of the aquifer pumping test results and conclusions incorporating identified boundary conditions, fault-related flow effects, drawdown maps (relative to mean sea level), drawdown match curves, potentiometric surface maps (relative to mean sea level), water level graphs, and, when appropriate, directional transmissivity data and graphs, and other relevant data and data illustrations.

As discussed in SER section 5.7.9.3.2, the NRC staff is imposing the following license condition to ensure that the Basal Chadron Sandstone aquifer (production zone) at the MEA remains saturated during MEA operations and restoration.

To ensure that the Basal Chadron Sandstone aquifer remains saturated during operations and restoration at the MEA, the licensee will monitor water levels semi-annually in dedicated, existing MEA monitoring wells 8 and 9 and in two additional monitoring wells to be installed in the Basal Chadron Sandstone aquifer. The two additional wells shall be located in NW ¼ of SW ¼ of Section 26, T30N, R51W and NW ¼ of SE ¼ of Section 26, T30N, R51W. At any time from the start of ISR operations at the MEA, if the overall average water level drawdown rate in any one of the four monitoring wells exceeds 10 ft/yr, or if the water level in any one of the four monitoring wells drops below 3539.0 ft above mean sea level, the licensee shall develop a corrective action plan addressing how compliance with these limits will be restored, and shall submit the plan to the NRC within 45 days for review and written approval. In addition, each year, as part of its semi-annual effluent and environmental monitoring program report that covers the third and fourth calendar quarters, the licensee shall document the semi-annual water level data in the four monitoring wells, present calculations of cumulative total water level drawdown and average drawdown rates for the complete period of record, and provide a written assessment of the drawdown in the Basal Chadron Sandstone aquifer at the MEA.

Based upon the review conducted by the NRC staff and the information provided in the TR (CBR, 2015), the NRC staff concludes that the groundwater and surface water monitoring programs meet the applicable acceptance criteria of Section 5.7.8.3 of NUREG-1569 (NRC, 2003). Therefore, the staff has reasonable assurance that the applicant's groundwater and surface water monitoring programs will comply with the following regulations:

- 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life and property;

- 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license;
- 10 CFR Part 40, Appendix A, Criterion 5B(5), which provide concentration limits for hazardous constituents;
- 10 CFR Part 40, Appendix A, Criterion 5D, which requires a groundwater corrective action program; and
- 10 CFR Part 40, Appendix A, Criterion 7, which requires a detection monitoring program.

5.7.9.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

CBR, 2017. E-mail from L. Teahon, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, MEA Open Issues, October 26, 2017, ADAMS Accession No. ML17300A227 (package).

CBR 2016. Response to Open Issues - Teleconference on April 6, 2016. Crow Butte Resources, Inc., Crawford, Nebraska, May 20, 2016, ADAMS Accession No. ML16155A283 (Package).

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2014. Safety Evaluation Report (Revised), Cameco Resources, Inc., Crow Butte Operation License Renewal, August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report,” June, 2003, ADAMS Accession No. ML032250177.

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 1980. Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills”, Revision 1, Washington, DC, April, 1980.

5.7.10 Quality Assurance

A quality assurance program is necessary to ensure that all radiological and non-radiological measurements that support the radiological and non-radiological monitoring programs are reasonably valid and of a defined quality.

5.7.10.1 Regulatory Requirements

Section 5.7.9.4 of NUREG-1569 (NRC, 2003) identifies the following regulatory requirements applicable to the NRC staff’s review of quality assurance programs at ISR facilities: 10 CFR 20.1101 and 10 CFR Part 20, Subparts L and M. In addition, for the currently licensed CBR facility, License Condition 11.1(D) (NRC, 2017) requires the applicant to submit a semiannual report summarizing the results of the operational effluent and environmental monitoring program consistent with the terms of RG 4.14 (NRC, 1980). RG 4.14 (NRC, 1980) contains recommendations regarding the quality of the samples collected and the reporting of the sample measurement results that the applicant must comply with under License Condition 11.1(D). In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements, with the exceptions noted below.

This review focuses on the quality assurance program used by the applicant to ensure the quality of results related to the effluent and environmental monitoring program at the MEA. Therefore, issues related to the radiation protection program elements specified in 10 CFR 20.1101(a) and (c) are addressed in the NRC staff's review of the applicant's management audit and inspection program (Section 5.3 of the SER), qualifications for personnel conducting the radiation safety program (Section 5.4 of the SER), and radiation safety training program (Section 5.5 of the SER). Likewise, issues related to the radiation protection program elements specified in 10 CFR 20.1101(b) and (d) relating to ALARA are addressed in the NRC staff's review of the applicant's effluent control systems (Section 4.0 of the SER) and external radiation exposure monitoring programs for workers (Section 5.7.3 of the SER).

The records and reporting requirements in 10 CFR 20, Subparts L and M, respectively, are addressed in the applicant's management control program in SER section 5.2.

Therefore, for the purpose of this review, the applicant must demonstrate that the proposed quality assurance program is in compliance with License Condition 11.1(D) (NRC, 2017).

5.7.10.2 Regulatory Acceptance Criteria

The quality assurance program proposed for the MEA was reviewed for compliance with License Condition 11.1(D) (NRC, 2017) by comparing the quality assurance program proposed for the MEA to the quality assurance program in place at the currently licensed CBR facility.

5.7.10.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015) and as updated (CBR, 2017a and b).

To satisfy License Condition 9.12 of its renewed license (NRC, 2014), the applicant submitted (CBR, 2017a) a quality assurance program (QAP) that addressed the recommendations in RG 4.15 (NRC, 2007). The NRC staff approved the applicant's QAP by a license amendment (NRC, 2017) after finding the QAP consistent with RG 4.15 (NRC, 2007).

The applicant states (CBR, 2017b) that the QAP approved as part of its renewed license (CBR, 2017a) also applies to operations at the MEA.

The information provided by the applicant (CBR, 2017b) indicates that the proposed quality assurance program at the MEA is the same as the quality assurance program in place at the currently licensed CBR facility. In its prior technical review of the quality assurance program at the currently licensed CBR facility, the NRC staff found the applicant's quality assurance program acceptable (NRC, 2017). Because the applicant will use the same program at the MEA, the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with the proposed quality assurance program at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed quality assurance program will meet the license condition requirement related to the operational effluent and environmental monitoring program.

5.7.10.4 Evaluation Findings

The NRC staff concludes that the applicant has established an acceptable quality assurance program at the MEA. Therefore, the NRC staff has reasonable assurance that the applicant's quality assurance program, as described in its MEA TR, will comply with License Condition 11.1(D) (NRC, 2017).

5.7.10.5 References

CBR, 2017a. E-mail from L. Teahon, Cameco Resources, Crow Butte Operation, to R. Burrows, NRC, Quality Assurance Program, March 20, 2017, ADAMS Accession No.ML17080A486.

CBR, 2017b. Facsimile from W. Nelson, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, Marsland quality assurance program, November 8, 2017, ADAMS Accession No. ML17319A211.

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Renewed license, Crow Butte Resources, Inc., License No. SUA-1534, November 5, 2014, Accession No. ML13324A101.

NRC, 2007. "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) - Effluent Streams and the Environment," Revision 2, Regulatory Guide 4.15, Washington, DC: July 2007.

NRC, 2003. "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," NUREG–1569, June, 2003, ADAMS Accession No. ML032250177.

NRC, 1980. Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills", Revision 1, Washington, DC, April, 1980.

6.0 GROUNDWATER RESTORATION, RECLAMATION, AND DECOMMISSIONING

6.1 PLANS AND SCHEDULES FOR GROUNDWATER QUALITY AND RESTORATION

6.1.1 Regulatory Requirements

The staff determines whether the applicant has demonstrated that the proposed plans and schedules for groundwater quality restoration for the MEA meet the requirements of 10 CFR 40.32(c), 10 CFR Part 40.42, and Criterion 5B(5) of Appendix A to 10 CFR Part 40.

6.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria presented in Section 6.1.3 of NUREG-1569 (NRC, 2003).

6.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information submitted by CBR in its MEA TR (CBR, 2015). This section discusses plans for the groundwater quality restoration activities at the MEA. The plans include proposed restoration standards, background water quality evaluation, restoration methods, restoration stability monitoring, historical activities, and the proposed restoration schedule.

6.1.3.1 Restoration Standards

After uranium extraction is terminated, groundwater quality (i.e., concentrations of hazardous constituents) must be restored to the standards identified in Criterion 5B(5) of Appendix A to 10 CFR Part 40. Under Criterion 5B(5), the concentration of each hazardous constituent may not exceed (a) the Commission-approved background concentration; (b) the maximum values for groundwater protection in the Criterion 5C Table, if the constituent is listed in the table and if the background level is lower than the value in the table; or (c) an alternate concentration limit (ACL) proposed by a licensee and established by the NRC in accordance with Criterion 5B(6).

Alternate concentration limits (ACLs) that present no significant hazard may be proposed by licensees for NRC consideration. In determining whether to establish an ACL, the NRC will consider the factors described in Criterion 5B(6). A licensee that wants the NRC to establish an ACL must request a license amendment, which is subject to a safety and environmental review. As stated in Criterion 5B(6), the NRC will establish a site specific ACL for a hazardous constituent as provided in Criterion 5B(5) "if it finds that the proposed limit is as low as reasonably achievable (ALARA), after considering practicable corrective actions, and that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded." The factors that the NRC must consider before finding that a proposed ACL would not pose a substantial present or potential hazard are set forth in Criterion 5B(6).

In TR Section 6.1.3 (CBR, 2015), the applicant recognized that ISR licenses require groundwater quality to be restored to the standards listed in Criterion 5B(5) of 10 CFR Part 40, Appendix A. This requirement to restore groundwater to the standards in Criteria 5B(5) and 5B(6) is memorialized in License Condition 10.6 in the current CBR license (NRC, 2017a), and will apply to the MEA.

6.1.3.2 Restoration Methods

The applicant states that the groundwater restoration program at the MEA, like the one at the currently licensed CBR facility, will consist of four phases of active groundwater restoration followed by the stability groundwater monitoring phase (refer to TR Section 6.1 of CBR, 2015). The applicant's stability groundwater monitoring phase is evaluated in SER Section 6.1.3.6.

The four phases of active groundwater restoration proposed by the applicant for MEA will consist of the same groundwater restoration phases approved for the currently licensed CBR facility (NRC, 2014). These phases consist of the following steps: 1) groundwater transfer, 2) groundwater sweep, 3) groundwater treatment, and 4) groundwater recirculation (CBR, 2015). The first phase, groundwater transfer, consists of the exchange of groundwater between a new mine unit and that of a mine unit at the end of production. The second phase, groundwater sweep, consists of pumping groundwater from the mine unit without any corresponding injection back into the mine unit under restoration. This purpose of this phase is to more aggressively draw in impacted groundwater from the perimeter of the wellfield. The applicant states in TR Section 6.1.4.2 (CBR, 2015) that the extent of the sweep phase depends upon the presence of mine units along the mine unit perimeter, capacity of the wastewater disposal system, and success of the transfer phase to lower the total dissolved solids concentration. The third phase is the groundwater treatment phase, which consists of pumping groundwater from a mine unit, treating the groundwater to remove the constituents mobilized during the production, and injecting some or all the treated water back to the mine unit. The treatment consists of ion exchange (IX), reverse osmosis (RO) and/or electro Dialysis Reversal (EDR). The last phase the applicant may employ is groundwater recirculation, which is simply recirculating water pumped from the aquifer back into the aquifer to homogenize the groundwater quality (CBR, 2015).

The applicant states that the degree to which a restoration phase is incorporated into the restoration process for a particular mine unit will be determined based on operating experience at the currently licensed CBR facility and waste water system capacity (CBR, 2015). Additionally, the applicant states that during the treatment phase, chemical reductants, similar to those used at the currently licensed CBR facility, may be added to the injected water to improve the restoration performance (CBR, 2015). Chemical reductants change the oxidation/reduction potential of the groundwater in the wellfield to induce precipitation of uranium and other constituents to lower their concentration in the groundwater.

License Condition 10.7 (NRC, 2017a) requires CBR to maintain an overall inward hydraulic gradient in each individual wellfield from the time lixiviant is first injected in the production zone until the initiation of the stabilization period. This license condition will also apply to the MEA.

The NRC staff finds the description of the proposed groundwater restoration phases at the MEA is the same as those used at the currently licensed CBR facility (refer to Section 6.1.3.3 of NRC, 2014). Because the MEA has a similar formational hydrogeology and lixiviant chemistry to the currently licensed CBR facility, the NRC staff finds that the findings and conclusions from the prior review (NRC, 2014) apply to the MEA. The staff also finds that there are no safety concerns associated with the proposed groundwater restoration phases at the MEA that were not previously reviewed.

6.1.3.3 Pore Volume Estimates

The applicant estimates the pore volume (PV) for restoration as the product of affected ore zone area, average well completed thickness, flare factor, and porosity (CRB, 2015). The applicant estimates the PV value for an MEA wellfield to be 670,748,830 L (177,193,095 gal). This value is based on a conservatively estimated wellfield areal extent of 0.3 km^2 (75 acres), an average under-ream interval of 7.6 m (25 ft), an estimated flare factor of 0.20, and a porosity value of 0.29 (CBR, 2015). The flare factor of 0.20 was previously approved by the NRC (NRC, 2012) for the currently licensed CBR facility. Since the currently licensed CBR facility has a similar formational hydrogeology to that of the MEA, the staff has reasonable assurance that the estimated flare factor of 0.20 is appropriate for the MEA. Because the PV estimate takes into account the estimated porosity of the contaminated region and the lateral and vertical extent of contamination, and because the estimate is consistent with the calculation of the approved PV estimate for the currently licensed CBR facility (NRC, 2013), the staff finds the MEA calculated PV estimate to be acceptable.

In TR Section 6.1.4.2 (CBR, 2015), the applicant proposed a restoration process to meet the restoration goals. The applicant estimated that three PVs through the IX treatment phase, six PVs through the RO treatment, and two PVs for recirculation would be displaced during groundwater restoration, for a total of 11 PVs (CBR, 2015), which is also the approved estimated number of PVs for the currently licensed CBR facility. Since the MEA has a similar formational hydrogeology to that of the currently licensed CBR facility, the ISR production aquifer at the currently licensed CBR facility is similar to that at the MEA. Based on this analysis, the staff finds this initial estimate of number of restoration pore volumes to complete restoration in a mine unit is acceptable and meets acceptance criteria (2) in Section 6.1.3 of NUREG-1569 (NRC, 2003).

6.1.3.4 Restoration Wastewater Disposal

The applicant projects that up to four mine units will concurrently be undergoing ion exchange (IX) or reverse osmosis (RO) groundwater treatment over the entire restoration period (see TR Appendix T in CBR, 2015). Between the 2nd quarter of 2020 and 2nd quarter of 2035 within the projected mining and restoration schedule shown in TR Figure 1.7-4 (CBR, 2015), the range of cumulative anticipated IX flows is expected to vary from 757 to 3,028 Lpm (200 to 800 gpm). The 2 percent bleed from these IX flows will cumulatively amount to between 15 and 61 Lpm (4 and 16 gpm). Between the 1st quarter of 2021 and 4th quarter of 2037, projected cumulative RO flows are expected to range from 1,893 to 2,839 Lpm (500 to 750 gpm). The 30 percent brine generation from these RO flows will cumulatively amount to between 568 and 852 Lpm (150 to 225 gpm). The combined bleed from IX flows and the brine generation from RO flows over the entire restoration period from 2020 to 2038 seen in TR Figure 1.7-4 (CBR, 2015) range from 583 to 912 Lpm (154 to 241 gpm). Combining these totals with the bleed from MEA mine units concurrently in production yields an estimated maximum needed disposal capacity of 1,158 Lpm (306 gpm) (see TR Table 3.1-7 in CBR, 2015).

The maximum disposal rate for deep disposal well No. 1 at the currently licensed CBR facility is estimated to be 757 to1,514 Lpm (200 to 400 gpm) (NRC, 2014). Adequate disposal capacity is critical for ISR operations and restoration. The applicant has committed to installing additional deep disposal wells or surge/evaporation ponds, in addition to the two planned deep disposal wells, if needed to satisfy the wastewater capacity requirements (CBR, 2015). To ensure adequate capacity for disposal of byproduct material, the staff will impose a license condition that requires the applicant to ensure that the MEA liquid disposal methods provide adequate combined disposal capacity to handle the disposal of the total liquid effluent generation at the MEA from both production and restoration phases. This license condition is presented in SER Section 4.2.4.

6.1.3.5 Restoration Stability Monitoring

TR Section 6.1.4 (CBR, 2015) states, “Throughout restoration and stabilization, excursion monitoring consistent with Section 5.7.8.2 will continue until NRC determines that groundwater stabilization has been demonstrated." As discussed in SER Section 5.7.9, NRC found the strategy for monitoring excursions to be acceptable.

Stability monitoring at the MEA will be conducted in the same manner as it is conducted at the currently licensed CBR facility. For each mine unit, the applicant would begin a groundwater stability monitoring program upon completion of the active restoration within that mine unit. The monitoring program during the restoration stability monitoring phase would include sampling of groundwater from restoration wells and from any monitoring wells that are on excursion status during MEA operations (CBR, 2015). The groundwater samples will be analyzed for the restoration parameters listed in TR Table 6.1-1 (CBR, 2015). Existing License Condition 10.6 requires sampling of all constituents of concern on a quarter year basis during restoration stability monitoring (NRC, 2017a). This license condition requires the applicant to continue the stability monitoring until the data show that the most recent four consecutive quarters indicate no statistically significant increasing trend for any of the constituents of concern which would lead to an exceedance above the respective Criterion 5B(5) standard. This license condition will apply to the MEA.

6.1.3.6 Well Plugging and Abandonment

The applicant states in TR Section 6.2.3.1 (CBR, 2015) that after groundwater restoration is completed, it will remove pumps and piping from the wellfields. All drill holes and production, injection, and monitor wells will be plugged and abandoned in accordance with NDEQ rules and regulations (CBR, 2015). The proposed plans (procedures and methods) to conduct well plugging and abandonment at the MEA (CBR 2015) are consistent with well plugging and abandonment procedures and methods for the currently licensed CBR facility (refer to TR Section 6.2.3 of NRC, 2014). Considering that the well plugging and abandonment procedures and methods will be the same as those applied at currently licensed CBR facility, the NRC staff finds the applicant's plans to conduct well plugging and abandonment is relevant and effective for the MEA. The staff also finds that there are no safety concerns associated with the proposed groundwater restoration phases and methods at the MEA that were not previously reviewed.

6.1.3.7 Restoration Schedule

The applicant provided a preliminary wellfield restoration schedule in TR Figure 1.7-4 (CBR, 2015). The applicant reported that it will take approximately 4.5 to 6 years to restore each mine unit at the MEA. Under 10 CFR 40.42(h)(1), a licensee must complete decommissioning of a mine unit no later than 24 months following the initiation of decommissioning, unless the NRC approves an alternate schedule for decommissioning based on the factors listed in 10 CFR 40.42(i). This requirement also appears in License Condition 10.6 of the applicant's license for the currently licensed CBR facility (NRC, 2017a). This license condition will also apply to the MEA. For an ISR facility, the NRC considers decommissioning of a mine unit to begin when a licensee permanently ceases the injection of lixiviant in the wellfield (NRC, 2008). The applicant has previously submitted and received approval for an alternate decommissioning schedule for the currently licensed CBR facility (NRC, 2017b). If, prior to initiating restoration activities at the MEA, the applicant determines that these activities will exceed 24 months, it will be required under the above regulations and license condition to submit a license amendment request for an alternate schedule for decommissioning, and the NRC will conduct a safety of that request.

6.1.4 Evaluation Findings

The staff reviewed the plans and schedules for groundwater quality restoration of the proposed MEA in accordance with Section 6.1.3 of NUREG-1569 (NRC, 2003). The applicant is required by standard license condition to adopt wellfield groundwater restoration standards that meet the requirements of 10 CFR Part 40, Appendix A, Criteria 5B(5). The applicant's method for estimating wellfield pore volume is acceptable, taking into account the estimated porosity of the contaminated region and the lateral and vertical extent of contamination. With respect to the methodology for undertaking restoration, the applicant provided an acceptable approach that includes a mix of groundwater sweep, groundwater transfer, and groundwater treatment and recirculation. The staff will include a license condition, described in SER Section 4.2, to ensure that the adequate disposal capacity is in place at the facility.

As discussed in earlier sections, the applicant's list of indicator constituents, its stability monitoring program, and its methods for abandoning and sealing wells are acceptable. The wellfield restoration schedule submitted by the applicant projects that it will take more than 24 months to complete decommissioning activities, which exceeds the 24 months contemplated in the applicant's current standard License Condition 10.6 (NRC 2017a). Therefore, as required by the standard license, prior to initiation of groundwater restoration activities, the licensee shall determine the restoration schedule. If the licensee determines that these activities are expected to exceed 24 months or a schedule previously approved by NRC, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR 40.42.

Based on the staff's review, the information provided in the TR, as supplemented by license conditions as discussed above, is sufficient and meets the applicable acceptance criteria of Section 6.1.3 of NUREG-1569 (NRC, 2003). Therefore, the staff has reasonable assurance that the applicant will comply with the requirements of 10 CFR 40.32(c), 10 CFR 40.42, and Criterion 5B(5) of Appendix A to 10 CFR Part 40.

6.1.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017a. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2017b. Crow Butte Alternate Decommissioning Schedule Request, Crow Butte Resources, Inc., Crawford, Nebraska, October 5, 2017, ADAMS Accession No. ML17013A659.

NRC, 2014. Safety Evaluation Report, Cameco Resources, Inc., Crow Butte Operation License Renewal (Revision 1), August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2013. Letter to Crow Butte Resources, Inc., License Amendment No. 27, 2012 and 2013, Surety Updates, Crow Butte Resources, Inc., Crawford, Nebraska, Source Materials License SUA-1534, Nov 12, 2013, ADAMS Accession No. ML13311A159.

NRC, 2012. Letter to Crow Butte Resources, Inc., License Amendment No. 26, 2011 Surety Update, Crow Butte Resources, Inc., Crawford, Nebraska, Source Materials License SUA-1534, March 6, 2012, ADAMS Accession No. ML110320362 (Package).

NRC, 2008. NRC letter to Crow Butte Resources, Inc., Compliance with 10CFR40.42's Timely Decommissioning Requirements, July 7, 2008, ADAMS Accession No. ML081480259.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

6.2 PLANS FOR RECLAIMING DISTURBED LANDS

6.2.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the proposed plans for reclaiming disturbed lands at the MEA will meet the requirements of 10 CFR 40.42 and Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40, using the acceptance criteria presented in Section 6.2.3 of NUREG-1569 (NRC, 2003).

6.2.3 NRC Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information submitted by CBR in its MEA TR (CBR, 2015).

TR Section 6.2 (CBR, 2015) describes general surface reclamation procedures involving topsoil replacement, backfilling and contouring of disturbed lands, revegetation, facility site reclamation, and wellfield decommissioning including well plugging and abandonment. The applicant commits to surveying and sampling all facilities and processing related equipment and materials onsite to determine contamination levels and to identify the potential for personnel exposure prior to and during decommissioning. At the end of decommissioning, the applicant will survey and release uncontaminated materials and equipment for reuse. Contaminated materials will be relocated and disposed at a licensed disposal facility. The applicant has committed to surveying excavation areas for contamination and removal of contaminated materials, as well as performing a final site soil radiation survey. (CBR, 2015)

The applicant states that records of information important to CBR's decommissioning will be maintained in the office of the onsite radiation safety officer. Under License Condition 10.11 in CBR's license (SUA-1534), CBR will be required to submit a detailed decommissioning plan for NRC review and approval at least 12 months before final decommissioning begins (NRC, 2017).

Decommissioning will be accomplished in accordance with the approved decommissioning plan and license provisions in effect at the time of the decommissioning activity. (CBR, 2015)

The NRC staff has reviewed the applicant's plans for reclaiming disturbed lands proposed by the applicant for the MEA (CBR, 2015) and concludes that the applicant's plans for reclaiming disturbed lands proposed by the applicant for the MEA (CBR, 2015) are consistent with those used at its currently licensed CBR facility (see Section 6.2 of NRC, 2014). The NRC staff previously found the applicant's plans for reclaiming disturbed lands at its currently licensed CBR facility to be acceptable (NRC, 2014). The NRC staff finds that plans for reclaiming disturbed lands at the MEA are sufficiently similar to those at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. Therefore, in accordance with 40.32(c), the NRC staff has reasonable assurance that the plans for reclaiming disturbed lands will be adequate to protect health and minimize danger to life or property at the MEA.

6.2.4 Evaluation Findings

The NRC staff reviewed the plans for reclaiming disturbed lands of the proposed MEA project (CBR, 2015) for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.2.3 of NUREG-1569 (NRC, 2003). In TR Section 6.2, the applicant describes various aspects of proposed reclamation activities for the MEA on a general, site-wide basis. Based on the information provided in the MEA TR and the license condition requiring submittal of a final decommissioning plan at least 12 months before decommissioning, the NRC staff concludes that the plans for reclaiming disturbed lands meet the acceptance criteria of Section 6.2.3 of NUREG-1569 (NRC, 2003) and the requirements of 10 CFR 40.42 and Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.2.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report - License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534., Docket No. 40-8943, August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

6.3 REMOVAL AND DISPOSAL OF STRUCTURES, WASTE MATERIAL, AND EQUIPMENT

This section evaluates the methodologies proposed by the applicant for the removal and disposal of contaminated structures and equipment used during in situ recovery operations, as well as techniques for managing radioactive waste materials.

6.3.1 Regulatory Requirements

Section 6.3.4 of NUREG-1569 (NRC, 2003) identifies the following regulatory requirements applicable to the NRC staff's review of the plans for the removal and disposal of structures, waste material and equipment at ISR facilities: 10 CFR 40.32(c), 40.41(c), 40.42(g)(4); and 10 CFR Part 40, Appendix A, Criterion 2. In this section, the staff determines whether the applicant has demonstrated that it will comply with these requirements.

6.3.2 Regulatory Acceptance Criteria

For the removal and disposal of contaminated structures and equipment at the MEA, as well as techniques for managing radioactive waste materials, the NRC staff determines whether the applicant has demonstrated that operations at the MEA will comply with 10 CFR 40.32(c), 40.41(c), 40.42(g)(4); and 10 CFR Part 40, Appendix A, Criterion 2. The proposed methodologies for the removal and disposal of contaminated structures and equipment used during in situ recovery operations, as well as techniques for managing radioactive waste materials at the MEA, were reviewed for compliance with these requirements by comparing them to the acceptance criteria in NUREG-1569, Section 6.3.3 (NRC, 2003).

6.3.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in its MEA TR (CBR, 2015).

<u>Control of Residual Contamination on Structures and Equipment</u>

The applicant provided a description of its program for controlling residual contamination on structures and equipment in TR Section 6.3 (CBR, 2015). The applicant plans to conduct a radiation survey to establish that any contamination is within contamination limits before the release of structures and equipment (CBR, 2015). This includes the interior and exterior of the surfaces of pipes, drain lines and duct work (CBR, 2015). As discussed in SER Section 5.7.7, License Condition 9.6 of CBR's license requires the release of material for unrestricted use to be in accordance with the "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials" (NRC, 1993), or an approved NRC alternative program (refer to License Condition 9.6 in NRC, 2017). This license condition will also apply to the MEA. The applicant states that all surfaces of premises, equipment, or scrap likely to be contaminated but that cannot be measured will be assumed to be contaminated in excess of limits and will be properly disposed (CBR, 2015).

The NRC staff finds that the applicant's proposed plan for the control of residual contamination on structures and equipment meets acceptance criteria (1) through (4) in Sections 6.3.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed plan for the control of residual contamination on structures and equipment will comply with 10 CFR 40.32(c) and 40.41(c).

Disposal of 11e.(2) Byproduct Material

Criterion 2 of Appendix A to 10 CFR Part 40 requires that byproduct material from in situ recovery operations be disposed of at existing licensed disposal facilities unless an applicant can justify an alternative. In TR Section 6.3.3 (CBR, 2015), the applicant states that it currently maintains 11e.(2) byproduct material disposal agreements with two facilities in Utah and Wyoming. The NRC reviewed the 11e.(2) byproduct material disposal agreement during an inspection and found that it was valid until 2020 and acceptable (refer to Section 5.2(b) of NRC, 2016). The NRC staff finds that the applicant's proposed plan for the disposal of 11e.(2) byproduct material meets acceptance criterion (5) in Section 6.3.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed plan for the disposal of 11e.(2) byproduct material complies with Criterion 2 of Appendix A to 10 CFR Part 40.

Decommissioning Plan

10 CFR 40.42(g)(4) specifies what must be included in a final decommissioning plan. The applicant discussed its plans for final decommissioning in TR Section 6.3 (CBR, 2015) and will include a description of structures and equipment to be decommissioned, as well as methods to ensure the protection of workers and the environment against radiation hazards. License Condition 10.11 of the applicant's current license requires the applicant to submit a detailed decommissioning plan at least 12 months prior to the planned final shutdown of mine unit operations (NRC, 2017). This license condition will also apply to the MEA. The NRC staff finds that the applicant's proposed plan for final decommissioning meets acceptance criterion (6) in Section 6.3.3 of NUREG-1569 (NRC, 2003). Therefore, the NRC staff has reasonable assurance that the applicant's proposed plan for final decommissioning will comply with 10 CFR 40.42(g)(4).

6.3.4 Evaluation Findings

The applicant has established acceptable methodologies for the removal and disposal of contaminated structures and equipment used during in situ recovery operations, as well as techniques for managing radioactive waste materials at the MEA. The NRC staff concludes that the applicant's program, as described in its MEA TR, complies with 10 CFR 40.32(c), 40.41(c), 40.42(g)(4), and 10 CFR Part 40, Appendix A, Criterion 2.

6.3.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2016. Letter from U.S. NRC, to L. Teahon, Crow Butte Resources, Inc., Inspection Report 040-08943/2016-001 and Notice of Violation, April 12, 2016, Accession No. ML16092A101.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 1993. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," U.S. Nuclear Regulatory Commission, April 1993, ADAMS Accession NO. ML003745526.

6.4 METHOLOGIES FOR POST RECLAMATION AND DECOMMISSIONING SURVEYS

This section evaluates the applicant's proposed methodologies for conducting post-reclamation and decommissioning radiological surveys at the MEA.

6.4.1 Regulatory Requirements

Section 6.4.4 of NUREG-1569 (NRC, 2003) identifies the following regulatory requirements applicable to the NRC staff's review of the methodologies for conducting post-reclamation and decommissioning radiological surveys at ISR facilities: 10 CFR 40.32(c) and (d); 40.41(c); 10 CFR 51.45(c); and 10 CFR Part 40, Appendix A, Criterion 6(6). In this section, the staff determines whether the applicant has demonstrated it will comply with these requirements, with the exception noted below.

10 CFR 51.45 pertains to the adequacy of the applicant's environmental report for the NRC staff's environmental review under the National Environmental Policy Act. As such, the requirement found in 10 CFR 51.45 is not applicable to this safety review.

Therefore, for the purpose of this review, the applicant must demonstrate that the proposed methodologies for conducting post-reclamation and decommissioning radiological surveys at the MEA is in compliance with 10 CFR 40.32(c) and (d); 40.41(c); and 10 CFR Part 40, Appendix A, Criterion 6(6).

6.4.2 Regulatory Acceptance Criteria

For the proposed methodologies for conducting post-reclamation and decommissioning radiological surveys at the MEA, the NRC staff determines whether the applicant has demonstrated that it will comply with 10 CFR 40.32(c) and (d); 40.41(c); and 10 CFR Part 40, Appendix A, Criterion 6(6). The proposed methodologies for conducting post-reclamation and decommissioning radiological surveys at the MEA were reviewed for compliance with these requirements by comparing them to the acceptance criteria in NUREG-1569, Section 6.4.3 (NRC, 2003).

6.4.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their MEA TR (CBR, 2015) and as updated (CBR, 2017a and 2017b).

6.4.3.1 Cleanup Criteria

The applicant's proposed cleanup limits and ALARA goals are identified in TR Section 6.4.1 (CBR, 2017a) and summarized in TR Table 6.4.1 (CBR, 2015). For radium-226 (Ra-226) in surface and subsurface soil, the limits are 5 picocuries per gram (pCi/g) and 15 pCi/g above background levels, respectively (CBR, 2015). The applicant established ALARA goals for Ra-226 in surface and subsurface soil at 5 pCi/g and 10 pCi/g above background levels, respectively (CBR, 2015). The applicant committed (CBR, 2017a) to establish background radionuclide concentrations in soil in a manner consistent with Section 2.9 of NUREG-1569 (NRC, 2003). This commitment is captured in a license condition (refer to SER Section 2.6.4). The NRC staff finds that the applicant's proposed cleanup criteria for radium meets acceptance criteria (1) and (2) in Sections 6.4.3 of NUREG-1569 (NRC, 2003).

The benchmark dose is a method specified in 10 CFR 40, Appendix A, Criterion 6(6), to derive cleanup standards for radionuclides other than Ra-226. The applicant states that the benchmark dose for natural uranium was modeled using RESRAD (Version 7.0) (for an explanation of this code, see DOE, 2001). The results of the RESRAD model are presented in TR Appendix N (CBR, 2015). The applicant modeled two scenarios for the use of the MEA land after decommissioning (CBR, 2015). These scenarios included an individual working at home and a resident farmer (CBR, 2015). The applicant indicated that the resident farmer scenario is the most likely future use of the MEA land; therefore, this scenario was used to derive the benchmark dose (CBR, 2015). In the resident farmer scenario, a family is assumed to move onto the site after it has been released for use without radiological restrictions, build a home, and raise crops and livestock for family consumption (refer to Section 2.4 of DOE, 2001). Based on the current description and use of land in and around the MEA (refer to TR Section 2.8.5.3 of CBR, 2015), the NRC staff finds the resident farmer scenario reasonable. In any case, both scenarios modeled by the applicant resulted in essentially the same benchmark dose (CBR, 2015).

The applicant states that the result of RESRAD modeling shows that a concentration of 600 pCi/g (above background levels) for natural uranium in the top 15 cm (5.9 in.) of soil for the resident farmer scenario is equivalent to the benchmark dose derived from a concentration of 5 pCi/g (above background levels) of Ra-226. For natural uranium in surface and subsurface soil, the applicant established a limit of 230 pCi/g above background levels for both surface and subsurface soil based on uranium toxicity (CBR, 2015). The applicant established ALARA goals for natural uranium in surface and subsurface at 150 and 230 pCi/g above background levels, respectively (CBR, 2015).

The NRC staff finds that the applicant's proposed cleanup criteria for uranium meets acceptance criteria (2) and (3) in Sections 6.4.3 of NUREG-1569 (NRC, 2003).

The applicant states that spills of process solutions are not likely to contain substantial amounts of thorium-230 (Th-230) and therefore the development of a soil cleanup criterion for Th-230 is not appropriate at this time (CBR, 2015, 2017a). License Condition 10.11 of the applicant's current license requires the applicant to submit a detailed decommissioning plan to the NRC for review and approval at least 12 months prior to the planned shutdown of mine unit extraction operations (NRC, 2017). This license condition will also apply to the MEA. In the event that Th-230 is present in significant quantities, a cleanup criterion will be developed using the radium dose benchmark method and submitted to the NRC for approval prior to final site decommissioning (CBR, 2017a).

The NRC staff finds that the applicant's proposed cleanup criteria for thorium meets acceptance criteria (2) and (4) in Sections 6.4.3 of NUREG-1569 (NRC, 2003).

6.4.3.2 Surface and Subsurface Soil Cleanup Verification and Sampling Plan

In TR Section 6.4.2, the applicant states that the cleanup of surface soils will be restricted to those areas where there are known spills and potentially small spills near wellheads (CBR, 2017a). The applicant will follow the survey methodology described in NUREG-1575 (NRC, 2000). The applicant also stated that an NRC-approved statistical test will be conducted to demonstrate that the survey method provides for 95 percent confidence that the cleanup guidelines have been met (CBR, 2017a).

The applicant states that for subsurface soils, it will adopt different survey and sample protocols, depending on the type and size of the excavation (CBR, 2017a). The applicant will rely on sampling for Ra-226 and natural uranium analysis over surveying to verify cleanup of subsurface excavations (CBR, 2017a). As stated above, the applicant is required by License Condition 10.11 to submit a detailed decommissioning plan to the NRC for review and approval at least 12 months prior to the planned shutdown of mine unit extraction operations (NRC, 2017). At that time, the applicant will elaborate on actual site conditions as it relates to the decommissioning plan (CBR, 2017a).

The NRC staff finds that the applicant's proposed plan for the sampling and verification of surface and subsurface soil cleanup meets acceptance criteria found in Section 6.4.3(5) of NUREG-1569 (NRC, 2003).

6.4.4 Evaluation Findings

The applicant has established acceptable methodologies for conducting post-reclamation and decommissioning radiological surveys at the MEA. The NRC staff concludes that the applicant's program, as described in its MEA TR, complies with 10 CFR 40.32(c) and (d); 40.41(c); and 10 CFR Part 40, Appendix A, Criterion 6(6).

6.4.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

CBR, 2017a. Letter from L. Teahon, Cameco Resources, Crow Butte Operation, to T. Lancaster, U.S. NRC, Response to Open Issues – Marsland Expansion Area Technical Report, Teleconference on June 14, 2016, June 27, 2017, ADAMS Accession No. ML17193A311 (Package).

CBR, 2017b. Email from L. Teahon, Crow Butte Resources, Inc., Crow Butte Operation, to T. Lancaster, U.S. NRC, MEA TR Replacement Pages, August 31, 2017, ADAMS Accession No. ML17251A260.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

DOE, 2001. "User's Manual for RESRAD Version 6." ANL/EAD-4. Washington, DC: US Department of Energy. July 2001. http://web.ead.anl.gov/resrad/documents/resrad6.pdf, accessed November 6, 2017.

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, ADAMS Accession No. ML17062A588.

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report," June, 2003, ADAMS Accession No. ML032250177.

NRC, 2000. NUREG-1575, Revision 1, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," ADAMS Accession No. ML003761445.

6.5 FINANCIAL ASSURANCE

6.5.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the proposed financial assurance for the Crow Butte MEA facility meets the requirements of Criterion 9 of Appendix A to 10 CFR Part 40.

6.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for consistency with applicable regulations of 10 CFR Part 40 using the acceptance criteria presented in Section 6.5.3 of NUREG-1569 (NRC, 2003).

6.5.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information submitted by CBR in its MEA TR (CBR, 2015).

Sections 6.1 to 6.4 of this SER reviewed the applicant's proposed plans for groundwater restoration; reclamation of disturbed lands; removal and disposal of structures, waste materials, and equipment; and methods for conducting post-reclamation and decommissioning surveys. In Table P.1-2 of Appendix P to the TR (CBR, 2015), the applicant provides cost estimates for five general categories of decommissioning costs: groundwater restoration, wellfield reclamation, commercial plant (i.e., satellite building) reclamation and decommissioning, miscellaneous site reclamation, and DDW reclamation. Tables P.1-3 through P.1-9 of Appendix P provide detailed cost estimates for each of these general categories. Based on a review of the information in Appendix P of the TR, the staff finds that the cost estimate covers activities reviewed in Sections 6.1 to 6.4 of the SER.

In Section 9.2.9 of the TR (CBR, 2015), the applicant commits to following the outline in Appendix C of NUREG-1569 for reclamation or decommissioning plan cost estimates and annual updates.

Appendix C provides an outline of cost categories that includes demolition, decontamination and release or disposal of buildings and equipment; removal and disposal of 11.e.2 byproduct material at a licensed disposal site, reclamation of wellfields; groundwater restoration and well plugging, and radiological surveys and environmental monitoring. The staff finds that the applicant's cost estimate addresses costs in these categories, and includes, for each category, costs for project management, labor, equipment and overhead, and contingency.

The licensee has experience with wellfield decommissioning and restoration at the currently licensed CBR facility (refer to Sections 6.1 to 6.4 in NRC, 2014), and has used similar cost categories and estimation methods for the MEA surety cost estimate. The staff finds this reasonable given the proximity of the MEA to the currently licensed CBR facility and the similar site characteristics and proposed operations at the MEA. Therefore, the NRC staff finds that the methodology used in the applicant's cost estimate for decommissioning and reclamation of one wellfield at the MEA (Appendix P of CBR, 2015) is acceptable, and that the costs were reasonable at the time the estimate was developed. However, because the cost estimate provided with the MEA application was created in 2013, and is based on 2011 dollars, the NRC staff is imposing a license condition that will require the applicant to provide an updated estimate, based on current dollars, of the costs associated with decommissioning and reclamation of one wellfield at the MEA prior to commencement of construction related to NRC-licensed activities at the MEA. This new MEA-specific license condition is presented later in this section.

The costs estimate and corresponding financial assurance adjustments associated with decommissioning and reclamation of subsequent wellfields developed at the MEA, and the associated updates to the financial assurance arrangement, are covered by provisions in existing License Condition 9.5 (NRC, 2017) (the requirement for annual updates and the requirement to provide an update 90 days prior to a planned expansion or operational change not included in the annual update).

Based on the foregoing review, the staff concludes that the proposed cost estimate for decommissioning and reclamation costs for the MEA meets acceptance criteria (2)-(5) and (13) in NUREG-1569.

Existing License Condition 9.5 imposes several requirements related to the financial surety arrangement for the currently licensed CBR facility that will also apply to the financial surety arrangement for the MEA. These include a requirement to provide annual surety updates to the NRC; a requirement to submit proposed revisions to the financial assurance arrangement within 90 days of NRC approval of revised decommissioning plans; a requirement to extend existing arrangements if NRC approval of a proposed revision has not been received; a requirement to provide supporting documentation with proposed surety revisions or updates; and a requirement to submit surety-related correspondence, including the approved financial assurance arrangements, submitted to and received from the State of Nebraska (NRC, 2017).

In Section 9.2.9 of the TR, the applicant commits to adjusting the surety cost estimates as additional mine units are brought on line, and acknowledges that an updated surety arrangement is required at least 90 days prior to commencing construction of a new mine unit or other significant expansion (CBR, 2015). The applicant also commits to annual updates of the cost estimate.

These commitments, in addition to the requirements in License Condition 9.5 identified above, meet the acceptance criteria (8) through (12) in Section 6.5.3 of NUREG-1569.

Under 10 CFR Part 40, Appendix A, Criterion 9, the applicant is required to establish a surety arrangement for the MEA prior to commencement of operations at the MEA. The NRC staff considers “commencement of operations” to be commencement of construction related to NRC-licensed activities (i.e., construction related to ISR operations). In Section 9.2.9 of the TR, the applicant commits to providing evidence of financial responsibility in the form of a letter or credit or other satisfactory form to NDEQ, along with an audit statement from an independent auditing firm. To ensure that the applicant will have a financial assurance arrangement that meets the requirements of Criterion 9 in Appendix A of Part 40 in place before commencement of operations (as defined above), the staff is imposing a license condition, which also includes the condition related to an updated cost estimate discussed earlier. The license condition is presented in SER Section 6.5.4.

6.5.4 Evaluation Findings

The staff finds the applicant has provided a cost estimate that addresses the cost categories in Appendix C of NUREG-1569 (NRC 2003). For decommissioning, reclamation, waste disposal, groundwater restoration and well plugging, radiological survey and environmental monitoring, the applicant included a breakdown of costs and the basis for the cost estimate. Financial assurance assumptions are based on analyses of the proposed MEA (CBR, 2015), experiences at the currently licensed CBR facility, and generally accepted industry practices. The financial assurance analysis is based on reasonable costs for the required activities.

The applicant has committed to maintaining a financial assurance arrangement with sufficient funds to cover costs of groundwater restoration, decontamination, decommissioning, and surface reclamation at the MEA by an independent contractor (CBR, 2015).

To ensure that the financial assurance arrangement for the MEA is updated to reflect costs in current dollars, and to ensure that a financial assurance arrangement for the MEA that complies with 10 CFR Part 40, Appendix A, Criterion 9 is established prior to commencement of operations at the MEA, the NRC is imposing the following license condition.

> At least 90 days prior to commencement of construction associated with NRC-licensed activities at the MEA, the applicant shall provide to the NRC for review and written approval an updated cost estimate that covers decommissioning and reclamation costs for the first MEA wellfield, along with a copy of the financial surety arrangement that covers those costs and that meets the requirements of Criterion 9 in 10 CFR Part 40, Appendix A. Updated cost estimates and financial assurance arrangements to cover the decommissioning and reclamation costs for subsequent wellfields at the MEA will be submitted in accordance with the update requirements in LC 9.5.

Based on the staff’s review of the existing financial surety under CBR’s license (SUA-1534) and information provided in the MEA TR, which will be supplemented by information to be submitted in accordance with the above license condition and License Condition 9.5 in the existing Crow Butte license (SUA-1534), the staff concludes that the financial assurance arrangement and cost estimate for the MEA meet the applicable acceptance criteria of Section 6.5.3 of NUREG-1569

(NRC, 2003). Therefore, the staff has reasonable assurance that the applicant will comply with the requirements of 10 CFR Part 40, Appendix A, Criterion 9.

6.5.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

CBR, 2015. Crow Butte Resources, Inc., Revised Marsland Expansion Area Technical Report, Incorporating all Responses to the Request for Additional Information, November 12, 2015, ADAMS Accession No. ML15328A422 (Package).

NRC, 2017. License Amendment No. 2, Crow Butte Resources, Inc., License No. SUA-1534, October 5, 2017, Accession No. ML17062A588.

NRC, 2014. Safety Evaluation Report - License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534., Docket No. 40-8943, August 14, 2014, ADAMS Accession No. ML14149A433.

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report,” June, 2003.

7.0 ACCIDENTS

7.1 Regulatory Requirements

In this section, the staff determines whether the applicant has addressed potential accidents at the proposed MEA and has demonstrated that the applicant will meet the requirements of 10 CFR 40.32(c), 10 CFR 20.2202 and 20.2203. 10 CFR 40.32(c) requires that the applicant’s proposed equipment, facilities and procedures be adequate to protect health and minimize danger to life or property. 10 CFR 20.2202 and 20.2203 define response program requirements for radiological accidents.

7.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 and 40 using the acceptance criteria presented in Section 7.5.3 of NUREG-1569 (NRC, 2003).

7.3 NRC Staff Review and Analysis

This section addresses potential accidents that could occur at the MEA, the designs and measures proposed by the applicant to prevent those accidents, and the plans (including training) proposed by the applicant to cope with the possible occurrence of those accidents. Unless specifically stated otherwise, the information reviewed for this section consists of the information submitted by Crow Butte Resources (CBR) in Section 7.5 of the MEA TR (CBR, 2015) and as updated (CBR, 2017).

In the MEA TR (CBR, 2015), the applicant provides information on the potential accidents that could occur at the MEA, including potential health and safety impacts should an accident occur involving radiological and non-radiological materials. The applicant also identified the procedures and training programs that it will implement to mitigate or reduce the likelihood of one or more identified accidents. The following sections address specific information provided by the applicant on the effects of chemical accidents, radiological release accidents, transportation accidents, fires and explosions, and natural disasters.

7.3.1 Chemical Accidents

In TR Section 3.2.2.1 (CBR, 2015), the applicant identifies ISR process-related chemicals that would be stored in bulk on site and summarizes the hazards associated with the use and storage of those chemicals. Those chemicals consist of carbon dioxide, oxygen, hydrogen peroxide, and sodium sulfide. In TR Section 7.5.1.3 (CBR, 2015), the applicant also identifies sodium bicarbonate (a non-hazardous bulk chemical) as an additional chemical that would be used at the MEA. TR Section 3.2.2.1 (CBR, 2015) states that CBR has never used hydrogen sulfide gas at the currently licensed CBR facility, and if it is necessary to use it in the future, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety. In addition, pursuant to License Condition 10.10 of CBR's license SUA-1534 (NRC, 2017), in order to use hydrogen sulfide, CBR would be required to provide storage and handling procedures to the NRC for review and approval. This license condition will also apply to the MEA.

According to TR Section 7.5 (CBR, 2015), chemical storage vessels for hazardous chemicals (carbon dioxide, oxygen, and sodium sulfide) are located outside of the MEA satellite building and segregated from areas in which licensed materials are stored. For chemicals which could spill onto the ground surface, the applicant states that appropriately sized secondary containment structures surround individual storage vessels as well as the entire MEA satellite building. Emergency response instructions for spills and fires involving the above-referenced hazardous chemicals are contained in the applicant's Safety, Health, Environment, and Quality Management System (SHEQ MS) Program Volume VIII, Emergency Manual (refer to TR Section 7.5.1, CBR, 2015).

The information provided in the TR indicates that the ISR process chemicals proposed for use at the MEA will be the same as those used at the currently licensed CBR facility and will be stored and used in a similar manner to the process chemicals at the current licensed CBR facility. In addition, the procedures to address potential accidents and corresponding appropriate mitigation measures for the MEA will be the same as those for the currently licensed CBR facility. The NRC staff has reviewed the applicant's analysis of probable consequences of possible accidents involving ISR process chemicals and the corresponding appropriate mitigation measures at the MEA (CBR, 2015) and concludes that the applicant's chemical accident scenarios and the procedures for addressing chemical accidents are consistent with those used at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the NRC staff found the applicant's analysis of chemical accident scenarios and consequences, including procedures for responding to chemical accidents and mitigation measures, to be acceptable (NRC, 2014). The NRC staff finds that the potential chemical accident scenarios at the MEA, and the procedures for addressing them, are sufficiently similar to those at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with chemical accidents at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed equipment, facilities and procedures will be adequate to protect health and minimize danger to life or property with respect to chemical accidents.

7.3.2 Radiological Release Accidents

In TR Section 7.5.2, the applicant identifies tank and MEA satellite building pipe failures as potential accidents that could pose a radiological risk (CBR, 2015). The applicant states that the MEA satellite building structure and concrete curbs will contain spills from tanks and MEA satellite building pipe leaks. The floor sump system will direct liquids back into the MEA satellite building process circuit or waste disposal system.

Outside the satellite building, wellfield houses will be equipped with building alarms to detect the presence of liquids in the floor sumps caused by piping leaks (refer to TR Section 3.3 in CBR, 2015). Injection and production flows and pressures will be monitored with sensors in the wellfield houses and by a central computer system at the satellite control room. The described instrumentation and controls at the MEA will be consistent with those at the currently licensed CBR facility. In addition to the monitoring instrumentation and controls, wellfield operators will inspect wellfields to detect pipeline leaks (CBR, 2015) and respond to leaks as prescribed in the applicant's Emergency Manual (CBR, 2015, 2014). If a leak occurs, any affected soil will be surveyed and reclaimed as appropriate (CBR, 2015). The design features, inspections, and procedures described above are consistent with those at the currently licensed CBR facility.

In TR Section 7.5.4, the applicant describes scenarios involving rupture of an injection or recovery line in a wellfield, or rupture of a trunkline between the wellfields and the MEA satellite building, that would release barren or pregnant lixiviant (CBR, 2015). According to the applicant, such a release could contaminate the ground and subsurface soil. Such releases would be detected and mitigated by pressure and flow monitors that will be installed in the wellhouses and monitored in the control room. Furthermore, the applicant will use roving wellfield operators performing periodic inspections to find smaller leaks. The applicant's past experience at the currently licensed CBR facility, based on surveying and sampling, indicates that small leaks typically occur in the injection system and seldom result in contamination.

Contamination from spills will be isolated from surface water due to the construction of berms around the wellfields (refer to TR Section 7.2.6.2 of CBR, 2015). Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of SHEQ MS Volume VIII, Emergency Manual. Potential contamination of the uppermost aquifer by spills would be detected by the shallow groundwater monitoring network. Detections of contaminants would be classified as excursions, and would be addressed as described in TR Sections 5.7.9.2 and 5.7.9.3 (CBR, 2015), subject to the excursion monitoring and corrective action requirements in license condition 11.5 (NRC, 2017).

The applicant states that response procedures for radiological risks are contained in its SHEQ MS Volume VIII, Emergency Manual. This manual also contains notification requirements including notification to NRC pursuant to the requirements of 10 CFR 20.2202 and 20.2203 (refer to TR Section 7.5.2.2 of CBR, 2015).

The NRC staff has reviewed the applicant's radiological release accident scenarios and procedures for addressing radiological release accidents at the MEA (CBR, 2015) and finds that the applicant's radiological release accident scenarios and the procedures for addressing them are consistent with those used at its currently licensed CBR facility (see Section 7.3.2 of NRC, 2014). The staff also finds that the design features, inspections, and procedures to prevent or minimize leaks and spills are consistent with those at the currently licensed CBR facility. In its prior safety review of the currently licensed CBR facility, the NRC staff found the applicant's radiological release accident scenarios and response procedures to be acceptable (NRC, 2014). The NRC staff finds that the potential radiological release accident scenarios at the MEA, and the procedures for addressing them, are sufficiently similar to those at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with radiological accidents at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed equipment, facilities and procedures will be adequate to protect health and minimize danger to life or property with respect to radiological release accidents.

7.3.3 Groundwater Contamination

The applicant states that excursions of lixiviant could potentially contaminate adjacent aquifers with radioactive and trace elements (CBR, 2015). TR Section 7.5.3 (CBR, 2015) discusses these occurrences, potential causes, and general monitoring requirements. The applicant proposes to use the same excursion monitoring program approved for the currently licensed CBR facility at the MEA. Excursions may occur vertically or horizontally. The monitoring well ring is used to detect horizontal excursions that could result from injection or production imbalances, or both, as well as preferential flow paths. Monitoring well patterns above and below the extraction zone are used to detect vertical excursions that could occur from well casing failures, poor well construction, confining layer fractures, or leaks.

The following current license conditions (NRC, 2017) will address the potential for groundwater contamination at the MEA:

- License Condition 10.4 – production monitoring well spacing
- License Condition 10.5 – well construction and integrity testing
- License Condition 10.7 – overall inward hydraulic gradient
- License Condition 11.3 – pre-operational baseline water quality
- License Condition 11.4 – upper control limit calculation
- License Condition 11.5 – excursion monitoring

The NRC staff determined that, in implementing these conditions at the currently licensed CBR facility, the applicant has properly calculated baseline groundwater concentrations and upper control limits and has demonstrated that it has the ability to identify well casing failures and excursions. In addition to the excursion monitoring discussed in TR Sections 5.7.9.2 and 5.7.9.3 (CBR, 2015) and required by License Condition 11.5 (NRC, 2017), the applicant committed to sampling all private wells within two kilometers of the MEA wellfield area boundary quarterly with the consent of the landowner of each private well (refer to Section 5.7.9.1 of CBR, 2015 and Table 5.7.1 of CBR, 2017). As described in TR Section 5.7.9.1 (CBR, 2015), MEA groundwater samples will be collected in accordance with the instructions contained in SHEQ MS Program Volume VI, *Environmental Manual.* Samples will be analyzed for dissolved and suspended natural uranium, Ra-226, Th-230, PB-210, and Po-210 (refer to TR Section 5.7.9.1 of CBR, 2015 and Table 5.7.1 of CBR, 2017). This commitment, which is consistent with sampling performed at the currently licensed CBR facility, adds an additional layer of protection against exposure to groundwater contamination, if such contamination were to occur due to activities at the MEA.

The NRC staff has reviewed the applicant's groundwater contamination accident scenarios and procedures for addressing groundwater contamination accidents at the MEA (TR Section 7.5.3 in CBR, 2015) and concludes that the applicant's groundwater accident contamination scenarios and response procedures are consistent with those used at its currently licensed CBR facility (see Section 7.3.2 of NRC, 2014). The NRC staff previously found the applicant's groundwater contamination accident scenarios and response procedures for addressing groundwater contamination accidents at its currently licensed CBR facility to be acceptable (NRC, 2014). The NRC staff finds that the potential groundwater contamination accident scenarios at the MEA, and the procedures for addressing them, are sufficiently similar to those at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with groundwater contamination accidents at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed equipment, facilities and procedures will be adequate to protect health and minimize danger to life or property with respect to potential groundwater contamination accidents at the MEA.

7.3.4 Transportation Accidents

7.3.4.1 Chemical and Byproduct Material

In TR Section 7.5.5 (CBR, 2015), the applicant considered the potential for transportation accidents involving shipments of process chemicals and fuel from suppliers and radioactive waste from the MEA facility to a licensed disposal facility. The applicant states that it will receive approximately 150 shipments of bulk chemicals (fuel or process chemicals) per year. For process chemicals, the applicant states that accident risk will not increase by operating the MEA, because those operations are essentially replacing similar operations that are decreasing at the currently licensed CBR facility. Regarding byproduct material waste, the applicant states that the impact of an accident is minimal since the activity of these materials is low.

The NRC regulates shipments of chemicals only to the extent that such shipments can affect radiological health and safety. Typical chemical deliveries will include carbon dioxide, oxygen, hydrogen peroxide, and soda ash. On average, only one truck delivery per day is expected through the operating life of the MEA facility. All chemicals and products delivered to or transported from the satellite facility are required to be carried in DOT-approved packaging. In the event of an accident, the applicant has identified procedures are currently in place in the SHEQ MS Volume VIII, Emergency Manual, to ensure a rapid response (TR Section 4.3.1.1 of CBR, 2015).

The applicant is required to ship byproduct material to a licensed disposal facility per License Condition 9.9 (NRC, 2017). The applicant must comply with the NRC's regulations in 10 CFR Part 71 and the U.S. Department of Transportation (DOT) regulations in 49 CFR Part 173 when shipping byproduct material to a disposal facility. The NRC staff finds that the applicant's chemical and byproduct material transportation accident scenarios and the procedures for addressing them (CBR, 2015) are consistent with the chemical and byproduct material transportation accident scenarios and response procedures at the currently licensed CBR facility. The NRC staff previously found the applicant's chemical and byproduct material transportation accident scenarios and response procedures acceptable for its currently licensed CBR facility (see Section 7.3.3 of NRC, 2014). The NRC staff finds that the potential chemical and byproduct material transportation accident scenarios at the MEA, and the procedures for addressing them, are sufficiently similar to those at the currently licensed CBR facility that the findings and conclusions from the prior staff review apply to the MEA as well. Therefore, the NRC staff has reasonable assurance that the applicant's proposed equipment, facilities and procedures will be adequate to protect health and minimize danger to life or property with respect to potential chemical and byproduct material transportation accidents at the MEA.

7.3.4.2 Resin Transfer

Transportation accidents involving resin transfers to and from the currently licensed CBR facility and the MEA is an additional risk that was not evaluated in the staff's prior licensing reviews for the currently licensed CBR facility. For accidents involving resin transfer trucks, the applicant states that one 4,000-gallon tanker trailer will transport loaded resin to the currently licensed CBR facility and return with regenerated resin on a daily basis. The planned route will occur on Nebraska Highway 2/71 and county and private roads. Resin shipments will be shipped as Low Specific Activity (LSA) material per NRC's regulations in 10 CFR Part 71. The applicant outlines its procedures for transporting the resins and included commitments to adhere to NRC and US DOT regulations. The applicant's emergency response plan for transportation accidents during resin shipments to or from the MEA is contained in the Transportation Emergencies chapter of the SHEQ MS Volume VIII, Emergency Manual. The Transportation Emergencies chapter provides instructions for proper packaging, documentation, driver emergency and accident response procedures, and cleanup and recovery actions. This Transportation Emergencies chapter includes instructions that specifically address the CBR emergency action plan for responding to a transportation accident involving a shipment of eluent or IX resin transported to or from the currently licensed CBR facility (refer to TR Section 5.7.1.3 of CBR, 2015).

In TR Section 7.5.5.3 (CBR, 2015), the applicant states that the worst-case scenario in a resin shipment accident is a loss of truck contents. However, because the uranium is adsorbed to the resin and is wet, the lost resin is unlikely to migrate far from the spill site. The primary means of remediating an accident is physical removal of the resin and potentially affected soil. (CBR, 2015)

The NRC staff has determined that the applicant's description of credible scenarios and procedures for resin transfer meets acceptance criteria (1) in Section 7.5.3 of NUREG-1569 (NRC, 2003) because the applicant describes credible resin transfer accident scenarios and procedures for remediating such accidents.

7.3.5 Natural Disasters

Consistent with NUREG/CR-6733 (Mackin et al., 2001), the applicant provides a description of the potential hazard from earthquakes and tornadoes at the proposed MEA and commits to applicable industry practices during design and construction of the MEA (TR Section 7.5.6 in CBR, 2017). NUREG/CR 6733 concludes that structures at ISR facilities were not designed to withstand tornado winds, but that no design, operational changes or special measures were necessary to mitigate potential risks from tornado or seismic hazards. The applicant identified potential hazards from these natural events as being from dispersal of yellowcake as well as failure of chemical storage facilities and possible reaction of released process chemicals. The NRC staff finds that the hazards identified by the applicant are consistent with NUREG/CR 6733, but finds that dispersal of yellowcake is not a hazard at the MEA since yellowcake will not be produced at the MEA.

The U.S. Geological Survey's National Seismic Hazard Maps for the Conterminous U.S. (USGS, 2014) shows that the MEA and the surrounding region are in an area of low seismic hazard and only minor damage is expected from earthquakes in this zone (refer to the discussion in SER Section 2.3 and TR Section 2.6.1.4 of CBR, 2015 and TR Section 7.5.6.2 of CBR, 2017).

The MEA is in an area that is subject to tornados. In TR Section 7.5.6.1 (CBR, 2017) of the TR, the applicant reports that eight tornado events occurred outside of the proposed MEA in Dawes County, Nebraska from 2000 to 2017. With the exception of a magnitude Enhanced Fujita Scale 1 tornado (EF1) that occurred on June 11, 2013 (NOAA, 2016), these tornado events did not exceed a Fujita or Enhanced Fujita scale (F- or EF-scale, respectively) magnitude of F0 or EF0 and no injuries, deaths, property or crop damage occurred (EFO wind scale ranges from 65-85 mph and EF1 wind scales range from 86-110 mph). As reported by the applicant, NRC's Draft Generic Environmental Impact Statement on Uranium Mining (NRC, 1980) indicated that within the region of the MEA, the mean annual frequency for tornadoes in intensity Category I at Rapid City, Nebraska is of 0.6. Such events are addressed in CBR's SHEQ MS Volume VIII, Emergency Manual, which provides response and mitigation of natural disasters and spills or radioactive materials (e.g., notification to personnel of severe weather; evacuation procedures, security plans and threats associated with source material, medical emergencies, damage inspection/assessment and reporting, and cleanup and mitigation of spills of chemicals) (refer to TR Section 7.5.6.1 of CBR, 2017). Additionally, CBR reports that standard operating procedures, training, and personnel protective equipment will be available to personnel for response and mitigation of hazardous chemical releases. In TR Section 7.5.6 (CBR, 2017), CBR commits to assessing the location(s) and construction of chemical storage tanks and containment features in order to reduce the risk of potential leaks caused by tornado damage that may result in harmful chemical reactions. The applicant also states that the MEA will have separate containment berms around storage tanks to reduce the risk of mixing of incompatible chemicals in the event of a spill.

The applicant also analyzes the potential for wildfires to impact CBR's proposed operations at the MEA and indicates that there have been no wildfires of any significance during CBR commercial operations in the vicinity of the currently licensed CBR facility, and states that wildfires have typically not been a problem in the area of the MEA (CBR, 2015). Historically, in July 2006, a wildfire occurred east of the currently licensed CBR facility (CBR, 2006). In response to this event, the applicant called the NRC's Emergency Operations Center and the NRC project manager to provide notification of a potential evacuation. More recently, nearby fires affected the currently licensed CBR facility causing shutdown and evacuation of the site (refer to TR Section 7.5.6.3 of CBR 2015). CBR advised the NRC of these events in a timely manner. CBR's Emergency Manual maintains procedures for dealing with potential wildfires or fires associated with man-made events. The NRC staff inspected the applicant's program for responding to fires and found it acceptable (NRC, 2006).

The NRC staff reviewed the applicant's Emergency Manual for emergency preparedness, fire protection, and emergency procedures during inspections in 2006 (NRC, 2006) and 2011 (NRC, 2011) at its currently licensed CBR facility. During these inspections, the NRC staff determined that CBR's emergency procedures were adequate for emergencies that could involve natural disasters.

The NRC staff has determined that the applicant's description of natural disaster hazards and mitigation measures meets acceptance criteria (2) and (3) in Section 7.5.3 of NUREG-1569 (NRC, 2003) because the applicant describes natural disaster hazard scenarios and procedures for remediating such incidents. The NRC staff also finds that the applicant's procedures for response and mitigation of natural disasters and spills of radioactive materials; procedures for dealing with potential wildfires or fires associated with man-made events; and emergency procedures for natural disasters at the MEA will be equivalent to those employed at the currently licensed CBR facility. In its prior safety review for the currently licensed CBR facility, the staff found these procedures acceptable. Because the same procedures will be used at the MEA, the findings and conclusions from the prior staff review apply to the MEA as well. The staff also finds that there are no safety concerns associated with procedures for responding to natural disasters at the MEA that were not previously reviewed. Therefore, the NRC staff has reasonable assurance that the applicant's proposed equipment, facilities and procedures will be adequate to protect health and minimize danger to life or property with respect to potential natural disasters at the MEA.

7.4 Evaluation Findings

The NRC staff reviewed potential accidents that could occur at the MEA in accordance with acceptance criteria in Section 7.5.3 of NUREG-1569 (NRC, 2003). Accident scenarios included chemical accidents, radiological releases, groundwater contamination, transportation accidents, and natural disasters. The applicant has acceptably described likely significant effects of accidents from operations by providing an acceptable analysis of probable accidents and their consequences consistent with the project's design, site features, and planned operations. The applicant discussed mitigation measures, preventative procedures, and training for personnel to implement adequate response and remedial measures.

Based on the information provided in the TR and the detailed review of the effects of accidents at the proposed MEA, the NRC staff has reasonable assurance that the applicant will comply with 10 CFR 40.32(c), which requires that the applicant's proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; and 10 CFR 20.2202 and 20.2203, which define response program requirements for radiological accidents.

7.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

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