RARE EARTH ELEMENT SEPARATION AND PROCESSING DEMONSTRATION PROJECT

ENVIRONMENTAL REPORT

In support of the application for source material possession license submitted to the US Nuclear Regulatory Commission

Rare Element Resources

SEPTEMBER 2022

Table of Contents

1 Introduction 1-1
1.1 Purpose and Need for the Proposed Action 1-1
1.2 Proposed Action 1-2
1.3 Applicable Regulatory Requirements, Permits, and Required Consultations 1-3
2 Alternatives 2-1
2.1 Detailed Description of the Alternatives 2-1
2.2 Alternatives Considered but Eliminated 2-4
2.3 Cumulative Effects 2-4
2.4 Comparison of the Predicted Environmental Impacts 2-5
3 Description of the Affected Environment 3-1
3.1 Land Use 3-1
3.2 Transportation 3-4
3.3 Topography, Soils, and Geology 3-8
3.4 Water Resources 3-17
3.5 Ecological Resources 3-26
3.6 Meteorology, Climate, and Air Quality 3-43
3.7 Noise 3-46
3.8 Historic and Cultural Resources 3-46
3.9 Visual/Scenic Resources 3-47
3.10 Socioeconomic 3-48
3.11 Environmental Justice 3-62
3.12 Public and Occupational Health 3-63
3.13 Waste Management 3-67
4 Environmental Impacts 4-1
4.1 Land Use Impacts 4-1
4.2 Transportation Impacts 4-2
4.3 Topography, Soils, and Geology Impacts 4-2
4.4 Water Resources Impacts 4-4
4.5 Ecological Resources Impacts 4-5
4.6 Air Quality Impacts 4-6
4.7 Noise Impacts 4-7

4.8 Historic and Cultural Resources Impacts 4-8
4.9 Visual/Scenic Resources Impacts 4-8
4.10 Socioeconomic Impacts 4-9
4.11 Environmental Justice Impacts 4-9
4.12 Public and Occupational Health Impacts 4-10
4.13 Waste Management Impacts 4-11
5 Mitigation Measures 5-1
6 Environmental Monitoring Programs 6-1
7 Cost Benefit Analysis 7-1
8 Summary of Environmental Consequences 8-1
9 References 9-1
10 List of Preparers 10-1

List of Tables

Table 1-1. Federal requirements, permits, and consultations
Table 1-2. State requirements, permits, and consultations
Table 1-3. Related and applicable submittals from Bear Lodge Project commercial facility license application (2015)
Table 2-1. Workforce and traffic (number of workers and vehicles per day)
Table 2-2. Alternatives considered but eliminated
Table 2-3. Comparison of predicted environmental impacts
Table 3-1. Land in farms and agricultural land use in Weston County
Table 3-2. Hunting statistics (WGFD 2020)
Table 3-3. Annual average daily traffic on roads in the vicinity of the Demonstration Plant site (WYDOT (2016-2020))
Table 3-4. Generalized stratigraphic section of rocks in the Upton Quadrangle (Mapel and Pillmore 1964)
Table 3-5. Summary of surface water monitoring exceedances
Table 3-6. Summary of groundwater monitoring exceedances
Table 3-7. Top five plants by lifeform documented for each dominant vegetation community (BKS 2014b)
Table 3-8. Potential occurrence and observed noxious weed locations in the study area
Table 3-9. Wyoming species of greatest conservation that could potentially occur in the vicinity of the Demonstration Plant site
Table 3-10. Birds of conservation concern that occur or may occur in the Demonstration Plant site
Table 3-11. Monthly climate summary for Upton, Wyoming, 1948-2005 (WRCC 2022)
Table 3-12. National and Wyoming air quality standards for criteria pollutants

Table 3-13. Background air pollutant concentrations
Table 3-14. Common outdoor sound pressure levels in rural and urban environments at different octave bands (Engineering Toolbox 2003)
Table 3-15. Inter-county commuter flows for nearby counties, 2018Q1 (WDWS 2019)
Table 3-16. Population trends and growth rates in Wyoming and nearby counties, 1980 - 2040
Table 3-17. Population by age in Wyoming and nearby counties (Census Bureau 2011, 2020)
Table 3-18. Per-capita personal income in Wyoming and local counties, 2000, 2012 (BEA 2014) and 2019, 2020 (BEA 2020a)
Table 3-19. Total full- and part-time employment in Wyoming and local counties, 2015-2020 (BEA 2020b)
Table 3-20. Employment by industrial sector in local counties, 2015 and 2020 (BEA 2020a, 2020b)
Table 3-21. Major employers (RER 2014; Northeast Wyoming Economic Development Coalition 2014)
Table 3-22. Location quotients by industry, 2017 and 2020 (BLS 2020)
Table 3-23. Selected housing characteristics in the study area, 2014-2019 (Census Bureau 2019)
Table 3-24. Short-term housing accommodations (RER 2014)
Table 3-25. School district enrollments, 2015-2021 (WDE 2022)
Table 3-26. Law enforcement personnel, 2010 and 2012 (RER 2014)
Table 3-27. Arrests by type of crime, 2010 and 2012 (RER 2014)
Table 3-28. Fire protection agencies (RER 2014; "All the Fire Departments of the USA" 2019)
Table 3-29. Weston County revenue sources, FY 2010 – FY 2014 (Price 2014)
Table 3-30. Sales and use tax revenue, FY 2007 – FY 2013 (RER 2014)
Table 3-31. Minority and low-income populations in Wyoming and the Demonstration Project area
Table 3-32. Summary of baseline radiological investigations
Table 5-1. Summary of project design features serving as mitigation measures for environmental impacts
Table 6-1. Summary of monitoring for environmental impacts

List of Figures

Figure 1. Anticipated Demonstration Project schedule
Figure 2. Geologic cross section A-A' (RER 2015a)
Figure 3. Geologic cross section B-B' (RER 2015a)
Figure 4. Stream profiles (RER 2015a)
Figure 5. Piper diagram major ion chemistry (RER 2015a)
Figure 6. Stiff diagrams Valley Fill and Weathered Shale monitoring wells (RER 2015a)
Figure 7. Piper diagram Valley Fill and Weathered Shale monitoring wells (RER 2015a)
Figure 8. Stiff diagrams Dakota Aquifer and Newcastle Sandstone monitoring wells (RER 2015a)
Figure 9. Piper diagram Dakota Aquifer and Newcastle Sandstone monitoring wells (RER 2015a)
Figure 10. Demonstration Plant wind rose (IML 2021)
Figure 11. Photograph of representative grasslands and viewsheds taken near the Demonstration Plant site looking northwest (RER 2015a)
Figure 12. View from the proposed Demonstration Plant site facing West across Buffalo Creek Road (BKS 2021)

Figure 13. View from the southeast corner of the Demonstration Plant site facing West. Demonstration Plant site visible in top right of photo (BKS 2021)
Figure 14. View from the northeast corner of the Demonstration Plant site looking west toward existing structures (BKS 2021)
Figure 15. View from the northwest corner of the Demonstration Plant site looking southeast toward existing structures (BKS 2021)
Figure 16. View of the main process facility (East side) after repairs in 2021
Figure 17. Aerial imagery of Demonstration Plant site (November 2021) after landowner cleanup of items identified in the *Environmental Site Assessment Phase 1 Report* (BKS 2021)

List of Maps

Map 1. Demonstration Project boundary near Upton, Wyoming
Map 2. Comparison of Demonstration Project and former Bear Lodge Project boundaries
Map 3. Proposed Site Plan for the Demonstration Project
Map 4. Demonstration Project environmental monitoring map
Map 5. Demonstration Project baseline monitoring map
Map 6. Demonstration Project cumulative effects study area
Map 7. Land ownership in the vicinity of the Demonstration Project
Map 8. Mineral resources in the vicinity of the Demonstration Project
Map 9. Roads and railways in the vicinity of the Demonstration Project
Map 10. Demonstration Project topography
Map 11. Demonstration Project soil types
Map 12. Historic earthquakes and seismic zones in Wyoming
Map 13. International building code 500-year event
Map 14. International building code 2,500-year event
Map 15. Belle Fourche River and Cheyenne River Drainage Basin
Map 16. Drainage basins and wetlands in the vicinity of the Demonstration Project
Map 17. 100-Year flood inundation boundaries
Map 18. Surface water rights within three miles of the Demonstration Project
Map 19. Water level elevations valley fill and weathered shale
Map 20. Water level elevations Dakota aquifer and Newcastle sandstone
Map 21. Groundwater rights within three miles of the Demonstration Project
Map 22. Vegetation communities
Map 23. Greater sage-grouse core area and leks in the vicinity of the Demonstration Project
Map 24. Environmental justice affected area
Map 25. Proposed site grading and stormwater control plan

List of Appendices

Appendix A: Monitor Well Lithologic Log and Schematic

Appendix B: Geotechnical Permeability Test Results

Appendix C: Water Data Tables

Appendix D: Surface Runoff Estimates

Appendix E: US Fish and Wildlife Service Letter

Appendix F: Radiological Dose Evaluation

Appendix G: USDA Forest Service Non-Federal Commercial Road Use Permit

Appendix H: Radiological Baseline Data

Appendix I: Air Quality Permit Application and Approval

Acronyms and Abbreviations

%g	percent of gravity
µCi mL^{-1}	microcuries per milliliter
µg m^{-3}	micrograms per cubic meter
µR h^{-1}	microroentgen per hour
ACE	US Army Corps of Engineers
ACS	American Community Survey
ADAMS	Agencywide Documents Access and Management System
ALARA	as low as is reasonably achievable
AQD	Air Quality Division
BBS	Breeding Bird Survey
BCC	Birds of Conservation Concern
BCR	Bird Conservation Region
BEA	US Bureau of Economic Analysis
bgs	below ground surface
BKS	BKS Environmental Associates, Inc.
BLM	US Bureau of Land Management
BLS	US Bureau of Labor Statistics
BNSF	Burlington Northern Santa Fe
BOR	US Bureau of Reclamation
BSS	big sagebrush shrubland
CDP	Census Designated Place
CFR	Code of Federal Regulations
cm s^{-1}	centimeters per second
CT	Census Tract
dBA	A-weighted decibels
DOD	US Department of Defense
DOE	US Department of Energy
DOT	US Department of Transportation
EPA	US Environmental Protection Agency
ERG	Environmental Restoration Group, Inc.
ESA	Endangered Species Act

FAA	Federal Aviation Administration
FOA	Funding Opportunity Announcement
FPD	Fire Protection District
ft / ft^2	feet / square feet
FWS	US Fish and Wildlife Service
GA	General Atomics
gpd ft^{-2}	gallons per day per square foot
gpm	gallons per minute
GS	greasewood shrubland
H3	H3 Environmental, LLC
HREE	heavy rare earth elements
HU	herd units
IAEA	International Atomic Energy Agency
IBC	International Building Code
ICF	ICF International
IML	IML Air Science
LD_{50}	oral lethal dose
LNV	LNV, an Ardurra Group, Inc. company
LQD	Land Quality Division
MBTA	Migratory Bird Treaty Act
MCL	Maximum Contaminant Level
MG	Meadow Grassland
mg L^{-1}	milligram per liter
mg m^{-3}	milligram per cubic meter
mi^2	square miles
mrem y^{-1}	millirem per year
MS	Mixed Shrubland
NAAQS	National Ambient Air Quality Standards
NAIP	National Agricultural Imagery Program
NCRP	National Council on Radiation Protection and Measurement
NEPA	National Environmental Policy Act
NMSS	Nuclear Material Safety and Safeguards
NOAA	National Oceanic and Atmospheric Administration
NPS	neodymium/praseodymium separation
NRC	US Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
pCi g^{-1}	picocuries per gram
pCi L^{-1}	picocuries per liter
pCi m^{-2} s^{-1}	picocuries per square meter per second
PM_{10}	particulate matter less than 10 microns in effective diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in effective diameter
PP	primary processing
ppb	parts per billion

PPE	personal protective equipment
ppm	parts per million
PUG	physical upgrade
PWR	Precision Wildlife Resources, LLC
QA/QC	quality assurance / quality control
REE	rare earth element
REO	rare earth oxide
RER	Rare Element Resources, Inc.
RG	Reclaimed Grassland
RPP	radiation protection program
RSO	Radiation Safety Officer
SD	school district/standard deviation
SEG	samarium/europium/gadolinium
SHPO	State Historic Preservation Office
SWAP	State Wildlife Action Plan
T&E	Threatened and Endangered
TBNG	Thunder Basin National Grassland
TCS	thorium/cerium separation
TDS	total dissolved solids
TREO	total rare earth oxide
TREO(Th)	total rare earth oxide with thorium concentrate
UBC	Uniform Building Code
UG	Upland Grassland
UIT	Umwelt-und Ingenieurtechnik GmbH Dresden
US	United States
USGS	US Geological Survey
USMW	Upton shallow monitor well
USP	Upton Sediment Pond
VFD	Volunteer Fire Department
WAAQS	Wyoming Ambient Air Quality Standards
WCDB	Weston Count Development Board
WCRM	Western Cultural Resource Management, Inc.
WCS	Waste Control Specialists, LLC
WDA	Wyoming Department of Agriculture
WDAI	Wyoming Department of Administration and Information
WDEQ	Wyoming Department of Environmental Quality
WDH	Wyoming Department of Health
WDWS	Wyoming Department of Workforce Services
WGFD	Wyoming Game and Fish Department
WHDP	Wyoming Housing Database Partnership
WNDD	Wyoming Natural Diversity Database
WQD	Water Quality Division
WRCC	Western Regional Climate Center
WY	Wyoming State Highway
WYDOT	Wyoming Department of Transportation

1 Introduction

Rare Element Resources, Inc. (RER) is proposing to conduct a Rare Earth Element (REE) Separation and Processing Demonstration Project (Demonstration Project) in northeastern Wyoming in collaboration with General Atomics (GA), GA's European affiliate Umwelt-und Ingenieurtechnik GmbH Dresden (UIT) and engineering and construction subcontractor LNV, an Ardurra Group, Inc. company (LNV). RER, GA, UIT, and LNV are collectively referred to in this document as the Team.

The Demonstration Project is being developed as a 50% commercial / 50% government-funded cooperative agreement between the Team and the US Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy under DOE's Critical Materials Funding Opportunity Announcement (FOA) with a total project budget of $43.8 million. The Demonstration Project includes the engineering, construction, and operation of a REE separation and processing Demonstration Plant.

The Demonstration Project proposes to demonstrate the domestic production of neodymium-praseodymium and other rare earth oxides (REOs). Approximately 1,000 tons of exploration sample removed previously from the Bear Lodge project in Wyoming are available for processing. The Team plans to design, construct, and operate a demonstration-scale hydrometallurgical, separation, and refining plant at a processing rate of up to 3 tons of feed material per day as a research and development scale-up. The Demonstration Plant is planned to operate for approximately one year.

RER will possess source material, as defined by the US Nuclear Regulatory Commission (NRC) in Title 10 of the *Code of Federal Regulations* Part 40.4 (10 CFR 40.4), incident to the recovery of REEs and will be required to obtain a radioactive material license. An Environmental Report is required by 10 CFR 51 to accompany an application to possess source material from the extraction of REEs. This Environmental Report has been prepared to meet the requirements of 10 CFR 51.45 and generally follows the guidance contained in chapter 6 of NUREG-1748, *Environmental Review Guidance for Licensing Actions Associated with NMSS Programs* (NRC 2003).

1.1 Purpose and Need for the Proposed Action

Combining the RER-owned REE deposits in the Bear Lodge district located in northeastern Wyoming with RER's proprietary extraction and separation technology, the team can produce neodymium-praseodymium at >99.5% purity and other REO to meet US national production and security needs.

REEs include the lanthanide series of 15 elements on the periodic table, beginning and ending with atomic numbers 57 (lanthanum) and 71 (lutetium). The non-lanthanide elements yttrium and scandium often occur in the same rare earth deposits and possess similar unique magnetic, phosphorescent, and catalytic properties which make them critical and essential ingredients of 21st century technologies. These 17 elements are described as "rare" because they are infrequently found concentrated as rare earth minerals in economically exploitable ore bodies.

REEs are used in green energy and other high technology applications. Some of the major applications include hybrid and plug-in electric automobiles, advanced wind turbines, nickel-metal-hydride batteries, computer hard drives, magnetic refrigeration technologies, compact fluorescent light bulbs,

metal alloys, additives in ceramics and glass, fluid and petroleum cracking catalysts, and critical military uses.

The need for the strategic development of REEs has become increasingly apparent. The DOE, for example, has identified lanthanides as a strategic resource (US 2017). The rationale for the DOE's development of a critical strategy for REEs included the US dependence on a sole supplier that is not domestic, the importance of REEs in certain defense applications, and forecasts of a surge in demand for commercial end uses that could strain global supplies.

Presidential Executive Order 13817, *A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals* (US 2017) identified a national strategy related to 'critical minerals.' On May 18, 2018, the US Department of the Interior published a Final List of Critical Minerals 2018 (US 2018), which included 'the rare elements group.'

In addition, three different organizations in the US Department of Defense (DOD) have identified 15 of the 17 REEs as critical to defense applications including coatings for jet engines, missile guidance systems, antimissile defense systems, satellites and communications systems. Neodymium-based magnets, made of an alloy of neodymium, iron, boron, and essential additives, particularly dysprosium, are the strongest known rare earth magnets. Though initially developed in the US, rare earth magnets are no longer produced here, even though they are critical components in numerous military systems, including Javelin missiles, F-35 fighter jets, and propulsion motors in the Columbia Class submarine. These critical magnets are produced from minerals mined primarily and separated in China. China has abundant sources of REEs and since the early 1990's has made it a national priority to control the world's supply. Where possible, China has invested globally in rare earth mines and as of 2017; they own a minority interest in the Mountain Pass mine in California, a major repository of US-based rare earths. China controls 70-80% of the world's supply of rare earths, thus it has become a dominant force in the manufacture and market pricing of neodymium-based magnets (Vakaso 2019).

1.2 Proposed Action

The proposed action is construction, operation, and decommissioning of the Demonstration Project (Map 1) and consists of five phases, described further in section 2.1.2.3 and in the license application technical report (RER 2022a):

1. Physical upgrading (PUG),
2. Primary processing (PP),
3. Thorium-cerium separation (TCS),
4. Neodymium/praseodymium separation and refining (NPS), and
5. Chemical recycling and waste facilities.

The Demonstration Plant site (Map 1) is located entirely on private land (approximately 8 acres) within the Upton Industrial Park.

Key dates and deadlines for the project are as follows (see Figure 1):

- October 2021 – beginning of 40-month project timeline
- April 2022 – NRC license application submittal

- October-November 2023 – 100% of exploration sample comminuted and stored onsite
- December 2023 – construction complete
- November 2024 – 100% of exploration sample processed
- January 2025 – facility released post-decommissioning

1.3 Applicable Regulatory Requirements, Permits, and Required Consultations

Regulatory requirements, permits, and consultations that are applicable to the construction, operations, and closure of the Demonstration Plant are summarized in Table 1-1 (federal) and Table 1-2 (state).

References are made in this *Environmental Report* to a May 4, 2015 submittal by RER to NRC which proposed the operation of a commercial scale REE processing facility ("commercial facility"), also referred to as the Bear Lodge Project, which consisted of two locations, the "Bull Hill Mine site" and "Upton Plant site" (RER 2015b). RER requested NRC to suspend its review of the commercial facility (Docket Number 040-38367) on January 21, 2016 (RER 2016). While the Demonstration Project is substantially limited in scope and scale compared to the commercial facility, the location of the proposed operations is less than 1 mile from the Bear Lodge Project "Upton Plant site" (Map 2). A baseline update study (RER 2019) evaluated applicability of previous studies to current conditions. In this *Environmental Report*, except where specified otherwise, cited baseline conditions characterized for the Upton Plant site have not changed and/or are considered representative of the Demonstration Project site due to their physical proximity and no indication that conditions would have changed in intervening years. A summary of previous studies with references and their applicability to the Demonstration Project is provided in Table 1-3, and Agencywide Documents Access and Management System (ADAMS) accession numbers for the cited submittals are provided in section 9.

Table 1-1. Federal requirements, permits, and consultations

Issuing Agency	Regulatory Authority	Name and Nature of Permit/Approval	Status
NRC	NEPA (Public Law 91-190) 40 CFR Parts 1500 – 1508 *NEPA Implementing Regulations* (Council on Environmental Quality) 10 CFR 51 *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*	NEPA determination	NEPA review to commence upon RER's submittal of this Environmental Report. DOE has agreed to cooperate on NRC's NEPA review.
NRC	10 CFR 19 *Notices, Instructions, and Reports to Workers* 10 CFR 20 *Standards for Protection Against Radiation* 10 CFR 40 *Domestic Licensing of Source Material*	NRC license	To commence upon receipt of the license from NRC
NRC	Section 7 of the Endangered Species Act, as amended (16 USC Chapter 35 1531 et seq.)	Section 7 consultation	See section 3.5: not required/no species
NRC	Antiquities Act of 1906, as amended (16 USC 431-433) Archaeological Resources Protection Act of 1979, as amended (16 USC 470aa-47011) Preservation of American Antiquities, as amended (43 CFR 3) National Historic Preservation Act, as amended (16 USC 470; 36 CFR 800), Section 106	Evaluation of antiquities and cultural resources; Section 106 consultation on historic and tribal issues	See section 3.8: a Class III report was prepared and submitted to the NRC; no eligible sites were found (WCRM 2013).
NRC	Executive Order 12898 of February 11, 1994 *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (US 1994)	Evaluation of environmental justice impacts	See section 3.11: no anticipated impacts
NRC	American Indian Religious Freedom Act of 1978 (42 USC 1996)	Identification of Native American religious concerns	See section 3.8; tribal and cultural resource surveys were completed; results were submitted to the NRC
OSHA	*Occupational Safety and Health Act* (Public Law 91-596) 29 CFR *Occupational Safety and Health Administration*	International Fire Code requirements implemented by the State (see Table 1-2)	Perform hazard and operability analysis (HAZOP), develop hazardous work authorization, operating procedures, and emergency response plan
USFS	United States Code Title 16 *Conservation; National Forest Roads and Trails Act*, 16 USC 535 and 537 36 CFR 212, Subpart A, *Administration of Forest Transportation System*	Road use permit required for access road modifications needed to transport exploration sample to the Demonstration Plant site	Permit approved 16 February 2022 – see Appendix G
FWS	Endangered Species Act of 1973, as amended (Public Law 93-205)	Informal or formal consultation under Section 7; Coordination under Section 9	See section 3.5: not required/no species
	Migratory Bird Treaty Act of 1918, as amended	Protection of birds that live, reproduce, or migrate within or across international borders	In compliance - timing limitations may apply
	Bald and Golden Eagle Protection Act of 1940, as amended (16 USC 668(a); 50 CFR 22)	Protection of bald and golden eagles	In compliance - timing limitations may apply
ACE	Section 404 of the Clean Water Act (33 USC 1344)	Section 404 permit for discharge to waters of the US	See section 3.4: not required/no discharge

ACE – US Army Corps of Engineers
CFR – Code of Federal Regulations
DOE – US Department of Energy
FAA – Federal Aviation Administration
FWS – US Fish and Wildlife Service
NEPA – National Environmental Policy Act
NRC – US Nuclear Regulatory Commission
SHPO – State Historic Preservation Office
USC – US Code
USFS – US Forestry Service

Table 1-2. State requirements, permits, and consultations

Issuing Agency	Regulatory Authority	Name and Nature of Permit/Approval	Status
WDEQ-WQD	WDEQ-WQD Water Quality Rules and Regulations Chapter 2, *Permit Regulations for Discharges to Wyoming Surface Waters*	WYPDES General permit for stormwater discharges from construction activities	RER will submit application in 2Q-3Q 2022.
		WYPDES Industrial Stormwater Permit	RER will submit application in 2Q-3Q 2022.
WDEQ-AQD	Wyoming Environmental Quality Act, Article 2, *Air Quality*, as amended (Wyoming Statute 35-11-201 through 35-11-212) Permitting requirements under WDEQ-AQD Standards and Regulations, Chapter 6	Air quality permit to construct Air quality permit to operate Asbestos survey	See section 4.6.2 and Appendix I; air quality permit application was approved August 2022.
WYFD	International Fire Code	Review and approval are required prior to operations for safe operation of the process and site	RER will submit packet for review and approval in 3Q 2022.
WGFD	Wyoming Executive Order 2011-05	Determine compliance through external review for greater sage-grouse core areas and management recommendations	RER has and continues to consult with WGFD.
	Wyoming Statute 35-11-406(b)(xiii), LQD Non-Coal Rules, Chapter 2, Section 1(f) WDEQ-LQD Guideline No. 5 (Wildlife)	Consult on mitigation measures, including protection of raptors from power lines	
SHPO	National Historic Preservation Act, as amended (16 USC 470; 36 CFR part 800), Section 106	Review and ensure compliance for any activities related to cultural resources	See section 3.8; tribal and cultural resource surveys were completed; results were submitted to the SHPO

AQD – Air Quality Division
LQD – Land Quality Division
SHPO – Wyoming State Historic Preservation Office
WDEQ – Wyoming Department of Environmental Quality
WGFD – Wyoming Game and Fish Department
WQD – Water Quality Division
WYFD – Wyoming Department of Fire Prevention and Electrical Safety
WYPDES - Wyoming Pollutant Discharge Elimination System

Table 1-3. Related and applicable submittals from Bear Lodge Project commercial facility license application (2015)

Date	Author	Title	Report No.	Reference	Applicability
Technical Report Submittals					
5/4/2015	RER	License application for source material possession	Cover letter and technical report	(RER 2015b)	Commercial facility context
5/31/2015	RER	Public Radiation Dose Evaluation in Support of the Development of Rare Element Resources Bear Lodge Project	Appendix D	(ERG 2015b)	Updated by Appendix F
11/12/2015	NRC	Acceptance of license application for review	Letter	(NRC 2015)	Commercial facility context
1/21/2016	RER	Request suspension of license application review	Letter	(RER 2016)	Commercial facility context
Environmental Report Submittals					
5/4/2015	RER	Environmental Report	Environmental Report	(RER 2015a)	Commercial facility context
4/30/2015	ERG	Baseline Radiological Investigation Report	Stand Alone Report 3	(ERG 2015a)	Baseline conditions have not changed
8/31/2013	BKS	Baseline Soil Assessment	Stand Alone Report 4	(BKS 2013)	Baseline conditions have not changed
3/27/2014	BKS	2012 Baseline Aquatic Resources Inventory	Stand Alone Report 5	(BKS 2014a)	Baseline conditions have not changed
12/4/2014	BKS	2012 Baseline Vegetation Assessment	Stand Alone Report 6	(BKS 2014b)	Baseline conditions have not changed
12/12/2014	BKS	Weed Management Plan	Stand Alone Report 7	(BKS 2014c)	Baseline conditions have not changed
3/31/2014	ICF	2012 and 2013 Wildlife Baseline	Stand Alone Report 8	(ICF 2014)	Baseline conditions have not changed
10/30/2012	Behrens and Associates, Inc.	Bull Hill Mine and Upton Site Plant Noise Evaluation	Stand Alone Report 9	(Behrens 2012)	Baseline conditions have not changed
11/21/2013	WCRM	A Class III Cultural Resource Inventory of the Bear Lodge Project	Stand Alone Report 10	(WCRM 2013)	Historical context; baseline survey updated (Antiquus 2022)
8/28/2014	Behrens and Associates, Inc.	Noise Impact Study	Stand Alone Report 11	(Behrens 2014)	Conservative modeling
9/30/2014	IML	Ambient Air Quality Model	Stand Alone Report 12	(IML 2014b)	Conservative modeling
11/30/2014	IML	Addendum to Ambient Air Quality Model	Stand Alone Report 13	(IML 2014a)	Conservative modeling
8/27/2014	Damian	Health & Ecological Effects	Stand Alone Report 14	(Damian 2014)	Literature review
5/31/2015	ERG	Public Radiation Dose Evaluation in Support of the Development of Rare Element Resources Bear Lodge Project	Stand Alone Report 15	(ERG 2015b)	Updated by Appendix F
8/31/2014	ERG	Revised Occupational Dose Evaluation in Support of the Development of Rare Element Resource Bear Lodge Project	Stand Alone Report 16	(ERG 2014)	Updated by Appendix F

BKS – BKS Environmental Associates
ERG – Environmental Restoration Group, Inc.
ICF – ICF International
IML – IML Air Science, a division of Pace Analytical Services, LLC
NRC – US Nuclear Regulatory Commission
RER – Rare Element Resources, Inc.
WCRM – Western Cultural Resource Management, Inc.

2 Alternatives

This section addresses the alternatives to the operation of the Demonstration Plant at the proposed location in Upton, Wyoming (Map 1). The alternatives include no action, the proposed action, and several potential alternative actions.

2.1 Detailed Description of the Alternatives

2.1.1 No Action

Under the no action alternative, neither the construction and operation of the Demonstration Plant nor the environmental effects associated with site development would occur. The no action alternative maintains conditions as status quo and represents the baseline against which the proposed action and any reasonable alternatives can be compared. No action would include the following:

- No facilities would be constructed,
- No liquid effluents or solid wastes would be generated,
- No source material would be possessed,
- No decommissioning activities would occur,
- No project-related increases in local employment and tax revenues,
- China would continue to dominate the market for REE, and
- Potential shortages of REE from non-China sources could occur.

One critical impact of the no action alternative would be the absence of project-related increases in local employment and tax revenues resulting in unrealized economic benefits to the local and regional economy.

Similarly, the no action alternative would halt the progress toward demonstrating a new REE separation and processing technology and path forward for commercial development. No action would increase the risk of Chinese influence over REE supply and technology. In February 2021, President Biden issued an Executive Order (US 2021) for an expedited 100-day review to address sustainable US supply chains for four vital sectors, including critical minerals and rare earth elements. Specifically, the Department of Defense must submit a report identifying risks in the supply chain of critical materials, including rare earths, and make policy recommendations to address such risks. Additional details on national security and strategic need for the proposed action (which would be unrealized in the no action alternative) are provided in section 1.1.

2.1.2 Proposed Action

The following subsections describe the proposed Demonstration Project, identified in section 1.2.

2.1.2.1 Site Location and Description

The Demonstration Plant site is in northwest Weston County, Wyoming, approximately 2 miles northwest of Upton and 20 miles south of Interstate 90. General access to the site is from US Highway (US) 16 (Map 1). The physical location of operations is provided as item 3 on NRC Form 313 [Appendix A to the license application (RER 2022a)].

2.1.2.2 Property Boundaries and Disturbance

An approximately 8-acre parcel within the Upton Industrial Park will be used for the Demonstration Plant (see Map 3), and it is anticipated that the full 8 acres will be disturbed during construction, operation, and decommissioning.

Access to the site will be controlled with a 6-foot chain-link fence topped with three strands of barbed wire, and the restricted area will be further enclosed within a second 6-foot chain-link fence topped with three strands of barbed wire. Facilities inside the restricted area will include the PUG/Sample Storage Facility, Main Process Facility, Equipment Building, Chemical Containment Area, and Clean Room as well as loading and unloading areas. Ancillary facilities outside the restricted area will include the office trailer, laydown yard, access roads, and a parking area for employees and visitors.

2.1.2.3 Project Description

As described in the license application (RER 2022a), the Demonstration Plant will consist of the following process stages:

1. Physical upgrade (PUG): comminution and screening of the extracted exploration sample containing source material.

2. Primary processing (PP): primary hydrometallurgical processing of the comminuted exploration sample to produce a highly pure TREO(Th) concentrate (the precursor), which separates out a significant portion of the natural radioactivity contained in the exploration sample.

3. Thorium-cerium separation (TCS): removal of radioactivity, mainly thorium and its decay products, together with cerium, which is not currently considered to be a marketable REO product. An innovative technology allows the effectively complete removal of the source material. It allows for significant recycling of process streams and reduces the production of waste significantly.

4. Neodymium/praseodymium separation (NPS) and refining of REE groups including high purity neodymium/praseodymium oxide (the primary product), a lanthanum, cerium concentrate, a samarium, europium, gadolinium (SEG) concentrate, and a heavy rare earth elements (HREE) concentrate. The innovative technology applies multifunctional separators in a network for the recycling of valuable product streams to optimize the product quality and yield. The network is controlled by proprietary software combining real-time monitoring data of critical process streams with unique process simulation software.

The process will produce these main products and byproducts as well as implement extensive materials recycling to reduce waste as much as possible.

Map 3 shows the layout of facilities that are part of the proposed action.

2.1.2.4 Schedule

Subject to the receipt of all required permits, approvals, and financing, the key dates and deadlines applicable to the Demonstration Project (see Figure 1) are listed in section 1.2.

2.1.2.5 Workforce

Construction of the Demonstration Plant will require about 30 workers over a 10-month construction schedule. The construction workforce will be lowest during its first four months during the preparation of the site, and highest in its final six months as the facilities near completion (Table 2-1). The operational workforce at the Demonstration Plant will include 17 skilled laborers with additional technical and managerial support staff (Table 2-1). Closure and reclamation of the Demonstration Plant are estimated to require approximately 28 workers (RER 2022b).

2.1.2.6 Traffic

Light vehicles associated with construction, operation, and decommissioning of the Demonstration Plant (Table 2-1) will be those for workers, supervisors, inspectors, and light delivery trucks. Approximately half of the workforce is expected to carpool and half is expected to travel to the site individually.

Heavy vehicles (Table 2-1) will include enclosed and semi-trailer truck deliveries with cargo originating in Gillette and Texas. Transports will only occur Monday through Friday, approximately 8 hours per day, excluding holidays. Delivery of modular, prefabricated process equipment and construction materials will occur in construction months 1-4. Delivery of the exploration sample is anticipated to occur over a 20-day period, with delivery by covered trucks in loads of 18-20 tons each. Approximately 50-80 tons of sample will be delivered per day, or approximately 2-4 delivery trucks per day. The estimated number of heavy vehicles and drivers for construction months 5-10 and operation months 1-12 includes delivery of materials and equipment, process chemicals, and supplies. Routine waste shipments will include approximately one 30-ton roll-off bin of waste per week, see section 4.13. The REE product will be stored onsite during operations and will be transported in accordance with a sale agreement at the termination of the project.

Project-related traffic during decommissioning of the Demonstration Plant (Table 2-1) will include worker vehicles and trucks hauling demolished materials away for disposal or recycling. Heavy vehicles and equipment required for closure and reclamation, including bulldozers, excavators, motor graders, scrapers, and compactors, will be mobilized to the site on heavy-haul vehicles and remain on-site if needed.

Table 2-1. Workforce and traffic (number of workers and vehicles per day)

Months	Workforce (people per day)				Traffic (vehicles per day)		
	Managers	Workers	Drivers	Total Personnel	Light Vehicles	Heavy Vehicles	Total Vehicles
Construction months 1-4	1	20	6	27	21	6	27
Sample delivery (20-day period during months 5-10)	0	0	4	4	0	4	4
Construction months 5-10	1	20	6	27	21	6	27
Operation months 1-12	2	18	2	20	20	2	22
Decommissioning months 1-3 [a]	2	28	6	36	30	6	36

[a] (RER 2022b)

2.1.2.7 Closure

Decommissioning of the Demonstration Plant is expected to take two months after the processing ends. RER is committed to the successful closure and reclamation of the Demonstration Plant and has submitted a *Decommissioning Funding Plan* to the NRC as Appendix B to the license application (RER 2022b). In addition, RER will provide financial assurance that covers the successful closure of the Demonstration Plant in accordance with applicable guidance. Post-closure monitoring at the Demonstration Plant is not anticipated.

2.2 Alternatives Considered but Eliminated

RER evaluated alternatives to the proposed action including alternative means of processing the exploration sample and alternative sites for the Demonstration Plant. Table 2-2 provides a summary of the evaluation. While shipping the exploration sample to an alternative processor may extend the operational life of an existing processing facility and offer local area economic benefits, these alternatives would also offer no demonstration of new technology or path forward for commercial development. Alternative locations for the Demonstration Plant summarized in Table 2-2 were reviewed thoroughly during the commercial facility application process; additional details are presented in that submittal (RER 2015a, Section 2.3 and Appendix B).

Table 2-2. Alternatives considered but eliminated

Alternative	Description	Reason Eliminated
Mountain Pass	Ship exploration sample to Mountain Pass, California facility for REE separation and refining	No demonstration of new technology or path forward for commercial development. Risk of Chinese influence over RER's technology
Commercial Laboratory	Ship exploration sample to a commercial laboratory for REE separation and refining	No demonstration of new technology or path forward for commercial development. Unknown if sufficient infrastructure exists
Bull Hill Mine site	Construct the Demonstration Plant at the Bull Hill Mine site	Transporting chemicals (primarily acid) to the Demonstration Plant, using these chemicals within the Black Hills National Forest, and transporting the TREO product from the Bull Hill Mine would present undue risk to human health and the environment, especially during inclement weather and winter conditions. Future development would also require disturbance of National Forest System lands.
Western Research Institute	Construct the Demonstration Plant approximately 3 miles North of Laramie, Wyoming at an existing research facility	Long haulage distance from the exploration sample location; and the lack of adequate infrastructure and transportation networks to support future commercial development.

REE – rare earth element
RER – Rare Element Resources, Inc.
TREO – total rare earth oxide

2.3 Cumulative Effects

Cumulative effects are defined (40 CFR 1508.7) as "...the impact on the environment that results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." An analysis of cumulative effects typically encompasses broader areas and timeframes than the

analysis of direct and indirect effects. The actions and effects selected for analysis depend on access to reasonably available data.

Cumulative effects are the additive results that combine the proposed action with past, present, and reasonably foreseeable future actions within the cumulative effects study area. Due to the absence of reasonably foreseeable future actions within the cumulative effects study area described below, the additive result would be limited to the direct and indirect effects of the project, which are analyzed in section 4.

The cumulative effects study area (Map 6) encompasses the Soda Creek / Beaver Creek and Iron Creek hydrologic unit code 12 sub-watersheds, which are part of the Upper Creek Watershed. The Soda Creek / Beaver Creek and Iron Creek sub-watersheds cover 41,345 and 43,102 acres, respectively (84,447 acres total).

This section provides the past, present, and reasonably foreseeable future actions within the cumulative effects study area. Foreseeable actions for this analysis are limited to those for which a formal notice or permit application has been made and does not include potential developments, which are speculative.

Generally, past and ongoing activities (natural and man-made) that have and/or are affecting the project and surrounding areas include at least the following:

- mining,
- oil and gas exploration and development,
- industrial development,
- rights-of-way or other land uses (power lines, pipelines, roads),
- wildland fire,
- drought,
- wildlife utilization,
- livestock grazing,
- dispersed recreation (*i.e.*, hunting, camping, etc.), and
- off-highway vehicle use.

Ongoing activities within the cumulative effects study area include the Upton Industrial Park and Upton, its only population center. Outside of this project, the primary other development project in the area is a hotel planned in Upton. The Teckla-Osage-Rapid City Transmission Line is located approximately 8 miles south of the Demonstration Plant site. It crosses the southern boundary of the Soda Creek/Beaver Creek hydrologic unit code 12 sub-watershed on National Forest land (Map 6).

2.4 Comparison of the Predicted Environmental Impacts

A comparison of predicted environmental impacts of the proposed action and alternatives is provided in Table 2-3.

Table 2-3. Comparison of predicted environmental impacts

Alternative	Summary	Predicted Environmental Impacts
No action	No processing of exploration sample	No project-related increases in local employment and tax revenues, China would continue to dominate the

		market for REE, and potential shortages of REE from non-China sources could occur.
Proposed action	REE separation and processing Demonstration Project	No environmental consequences expected from the proposed action, given the environmental setting, short-term nature of the project and proposed mitigation measures summarized in section 1.
Alternatives considered but eliminated	Two alternative processors for the exploration sample	Potentially extend operational life of an existing processing facility, but no demonstration of new technology or path forward for commercial development and risk of Chinese influence over REE technology.
	Two alternative locations for the Demonstration Plant	Similar to proposed action but limited to alternative locations.

REE – rare earth elements

3 Description of the Affected Environment

This section describes baseline conditions of the affected environment. Previous characterization reports submitted to the NRC in support of the 2015 Bear Lodge Project license application (see Table 1-3) are cited where applicable and where conditions have not changed.

3.1 Land Use

The Demonstration Plant site is in northeast Wyoming, approximately 2 miles northwest of the Town of Upton in Weston County (Map 1). The description of land use patterns in this section focuses on Weston County where the proposed Demonstration Plant will be located.

3.1.1 Land Ownership

The surface area of Weston County is approximately 2,400 square miles, 72% of which is privately owned. The US Forest Service (USFS) and Bureau of Land Management (BLM) are the dominant public land managers, jointly managing approximately 20% of the county's surface. The State of Wyoming manages approximately 8% of Weston County's land surface and local governments (including the county, cities, school districts, and other local entities) manage approximately 0.3% (WGFD 2021a).

The Demonstration Plant site (Map 1) is on a parcel of privately-owned land that was purchased by the Weston County Development Board (WCDB) and the Town of Upton from American Colloid Co. in 2003. This land was then part of a Brownfield Assessment conducted by WCDB in conjunction with the Wyoming Department of Environmental Quality (WDEQ). A letter of Conditional Certificate of Completion from the WDEQ was received by the Weston County Development Board and the Town of Upton and on January 24, 2008 (WDEQ 2008). Tiger Transfer, LLC purchased the Upton Industrial Park from the WCDB in 2012 (BKS 2021). A tenant, Western Biomass Energy, LLC, operated an ethanol plant at the site from 2005-2013 (BKS 2021).

Adjacent to the east, north, and west are open fields owned by the Upton Industrial Park; across Buffalo Creek Road to the south is an open field also owned by the Upton Industrial Park. These lots have never been leased to any company as part of the Upton Industrial Park. Other properties in the radius of one mile from the Demonstration Plant site are predominantly commercial or agricultural (BKS 2021).

3.1.2 Agriculture

3.1.2.1 Farming and Ranching

Agriculture is the predominant use of public and private lands in Weston County. In 2017, land used for farming and ranching covered approximately 80% of the county's surface area. Livestock grazing is the dominant agricultural practice in Weston County, therefore farm and ranching operations in the county tend to be large. In 2017, the average size of farms in Weston County was 4,968 acres. However, individual farm holdings tend to be much smaller. The median farm size in the county was 465 acres in 2017 (USDA 2019).

Agricultural operations in Weston County consolidated and intensified between 2002 and 2017, when Weston County lost approximately 378,625 acres of farmland (a 23% decrease), a substantial portion of which was used as pasture, grazing, and rangeland. These loses were influenced by increased demand for housing developments and evolving farming economics and demographics. Despite these losses, the amount of harvested cropland increased by 8,218 acres (a 61% increase). The inventories of cattle and calves remained relatively steady between 2002 and 2012 but declined by 5,512 (an 11% decrease) in 2017 (Table 3-1).

Table 3-1. Land in farms and agricultural land use in Weston County

Agricultural Statistic	2002 (USDA 2009)	2012 (USDA 2014)	2017 (USDA 2019)
Number of Farms	221	264	247
Farms with Cattle/Calving Operations	159	150	130
Cattle/Calf Inventory	50,325	50,139	44,627
Land in Farms (acres)	1,605,637	1,290,373	1,227,012
Average Farm Size (acres)	7,265	4,888	4,968
Median Farm Size (acres)	2,882	507	465
Total Cropland (acres)	70,902	57,046	37,507
Harvested Cropland (acres)	13,363	20,809	21,581
Cropland Used For Pasture or Grazing (acres)	38,814	5,100	1,106
Other Cropland (acres)	18,725	31,137	14,820
Total Woodland (acres)	48,695	56,324	28,126
Permanent Pasture and Rangeland (acres)	1,454,687	1,171,948	1,157,923

3.1.2.2 Grazing

Cattle and calves are the predominant livestock in Weston County. Nearly 53% of the county's farms have cattle/calving operations. In 2017, permanent pasture and rangeland accounted for 94% of the county's farmland and hay was the primary crop grown on the remaining farmland (USDA 2019). The Demonstration Plant site is not currently used for grazing, and the site's grazing production is considered below average for the region due to its shallow topsoil and a clay-based foundation.

3.1.2.3 Forestry

Trees conducive to commercial forestry (*e.g.*, ponderosa pine and white spruce) are limited in Weston County, which makes a negligible contribution to statewide forestry harvests. There is no forestry in the Upton Industrial Park.

3.1.3 Mineral Resources and Mining

Although mineral resources in northeast Wyoming include coal, oil, natural gas, bentonite, sand, uranium, vanadium, and REE, most of these resources are located outside Weston County. Campbell County accounts for most of the region's coal, oil, and natural gas production. Uranium and vanadium resources are in Campbell and Crook Counties. REEs are in Crook County (Map 8). In 2021, Weston County accounted for less than 1% of the state's oil and natural gas production (ShaleXP 2021). There is no oil or gas drilling or production on the Demonstration Plant site.

There is one inactive bentonite mine in Weston County. Historical photographs indicate some bentonite mining in the vicinity of the Demonstration Plant site (BKS 2021).

3.1.4 Recreation

Recreation in Weston County is widespread and includes hunting, fishing, cross-county skiing, off-highway vehicles, and snowmobiling. Hunting areas designated by the Wyoming Game and Fish Department (WGFD) in the vicinity of the Demonstration Plant site include Antelope Hunt Area 7 and Deer Hunt Area 8. Mule deer and white-tailed deer are harvested in Deer Hunt Area 8. Table 3-2 summarizes the numbers of hunters and harvested game in Antelope Hunt Area 7 and Deer Hunt Area 8 between 2017 and 2020. The site does not coincide with any habitat used by elk, and elk harvest is not included in the table.

Sharp-tailed grouse, pheasant, ruffed grouse, chukar, gray partridge, greater sage-grouse and wild turkeys may also be hunted in the vicinity of the Demonstration Plant site. The sage-grouse hunting season is in September. Other upland game birds are harvested September-November or may extend through December (pheasant and sharp-tailed grouse) and January (partridge). There are two wild turkey seasons: the spring hunting season of April and May, and the fall hunting season of September 1 to December 31 (WGFD 2018). Small game (cottontail rabbits, squirrels) may also be hunted in the project vicinity between September and March along with a variety of furbearing mammals, generally hunted or trapped from October through April, depending on the species (WGFD 2018).

The Demonstration Plant site does not contain any crucial or enhancement habitat priority areas as identified by the WGFD and there are no special habitat protection or management activities at the site. Hunting on private land is subject to landowner permission and does not currently occur on the Demonstration Plant site.

Table 3-2. Hunting statistics (WGFD 2020)

Hunting Statistics	Antelope Hunt Area 7[a]	Mule Deer Hunt Area 8[a]	White-tailed Deer Hunt Area 8[a]
2017 Hunting Season			
Hunters	644	176	58
Harvest	589	140	19
Success Rate	91.5%	64.8%	32.8%
2018 Hunting Season			
Hunters	736	215	74
Harvest	641	126	28
Success Rate	87.1%	58.6%	22.1%
2019 Hunting Season			
Hunters	787	240	48
Harvest	666	123	6
Success Rate	84.6%	51.3%	12.5%
2020 Hunting Season			
Hunters	568	260	110
Harvest	475	113	39
Success Rate	83.6%	33.9%	35.5%

[a] The hunting season in Antelope Hunt Area 7 and Deer Hunt Area 8 is typically October 1 – 15.

3.1.5 Land Use Planning

Weston County's process for the approval of subdivisions influences land use planning at the Demonstration Plant site. Weston County has no zoning and has an inactive land use plan that was issued in 1977. There are no special land use classifications for the Demonstration Plant site, *e.g.*,

Native American or military reservation, wild and scenic rivers, state and national parks, national forests, wildlife areas, or prime and unique farmlands.

3.2 Transportation

The description of transportation systems in this section focuses on roads in Weston and Crook counties that will be used by commuting workers and supply vehicles to access the Demonstration Plant. This section also addresses railway networks in the vicinity of the Demonstration Plant site.

3.2.1 Roadway Systems

Interstate 90, US 85, and WY 59 are the major roadways that connect the Demonstration Plant site with the remainder of Wyoming and surrounding states. To the east, Interstate 90 crosses through South Dakota, providing access to Spearfish and Rapid City, and continues eastward to Chicago. To the west, Interstate 90 intersects Interstate 25 at Buffalo and continues northwest through Montana, Idaho, and Washington. Interstate 25 extends south from Buffalo through Colorado and New Mexico. US 85 runs along the eastern edge of Wyoming, extending north of Newcastle into South Dakota and south to Lusk, Torrington, and Cheyenne. WY 59 passes through Gillette, to the south connecting with Interstate 25 at Douglas, and to the north entering Montana.

Map 9 shows the primary roads that will be used to access the Demonstration Plant, including Interstate 90, US 14, US 16, WY113, and WY 116. Northwest of the site, US 16 exits Interstate 90 at Moorcroft (Exit 154). To the northeast, WY 116 exits Interstate 90 at Sundance (Exit 185). Interstate 90 is a 4-lane divided highway and US 14, US 16, WY 113, and WY 116 are paved, 2-lane rural highways. Buffalo Creek Road, which leads from US 16 to the Demonstration Plant site, is the only Weston County Road that will be used to access the Demonstration Plant.

3.2.2 Traffic Patterns

Table 3-3 shows the annual averages of daily traffic of semi-trailer trucks and all vehicles on highways in the vicinity of the Demonstration Plant site in 2016-2017 and 2019-2020 (Wyoming Department of Transportation (WYDOT 2016-2020). Traffic is highest on Interstate 90, followed by US 16 between Moorcroft and Newcastle. The highest proportions of truck traffic are on Interstate 90 (18%) and WY 116 between Sundance and Upton (16%). Between 2016 and 2020, traffic increased approximately 50% on US 16, approximately 4% on US 14, approximately 15% on WY 116, and approximately 8% on WY 113 between Pine Haven and Interstate 90. Traffic on Interstate 90 then decreased by approximately 8%.

Traffic data for Buffalo Creek Road comes from a 2014 KLJ Engineering traffic study commissioned by Weston County in anticipation of growth and expansion at the Upton Industrial Park (McMurtry 2014). KLJ Engineering's 2014 traffic study also reports traffic within the Upton Industrial Park which includes worker vehicles and haul trucks (McMurtry 2014).

3.2.3 Traffic Crashes

The highest number of crash reports for Weston County in 2015-2020 occurred on US 16, running from Moorcroft to Newcastle through Upton (WYDOT 2021). This is followed by US 85, WY 450, WY

116, and WY 585 (WYDOT 2021). Details of crash events including fatalities, injuries, and other damage can be found in the *Segment Crash History Report for Weston County* (WYDOT 2021).

3.2.4 Railroads

Rail lines link the Demonstration Plant site to Montana, Idaho, and Washington to the northwest; eastern Wyoming, Colorado, and New Mexico to the south; and South Dakota, Nebraska, and midwestern and eastern states to the southeast (Map 9). Burlington Northern Santa Fe (BNSF) is the dominant rail operator in northeast Wyoming, transporting coal out of Campbell County's southern Powder River Basin, which is the largest bulk-commodity sourcing area in the country. The highest traffic in the Powder River Basin originates on the southern rail line between the Donkey Creek station near Gillette and Shawnee station east of Douglas in Converse County, which is jointly owned and operated by BNSF and Union Pacific. Rail traffic on the Joint Line includes up to 88 loaded coal unit trains per day, each containing 125 to 150 cars (BNSF 2011).

The current levels of rail traffic in the Upton Industrial Park vary weekly and monthly. As part of the 2014 traffic study, KLJ Engineering estimated that rail traffic in the Upton Industrial Park area averages 10 in-bound 45 out-bound train cars per week, respectively (McMurtry 2014).

Table 3-3. Annual average daily traffic on roads in the vicinity of the Demonstration Plant site (WYDOT (2016-2020))

Route and Road Segment Starting Point	Milepost		2016		2017		2019		2020	
	Start	End	All Vehicles	Trucks	All Vehicles	Trucks	All Vehicles	Trucks	All Vehicles	Trucks
Gillette to South Dakota State Line: Interstate-90										
Junction Route 43 (WY 59 INT)	126.387	128.090	4,700	320	4,634	685	4,117	376	4,256	361
Junction Routes 62 & 303 (E GIL INT)	128.090	129.104	4,210	292	4,844	716	4,192	384	4,449	377
Garner Lake Road	129.104	132.991	4,250	358	5,325	787	4,157	385	4,890	386
Wyodak	132.991	141.237	3,896	421	3,875	832	4,097	545	3,663	526
Rozet	141.237	147.446	4,406	655	3,827	599	3,309	483	3,515	487
Campbell – Crook county line	147.446	153.412	3,715	231	3,827	599	3,309	483	3,515	525
West Moorcroft	153.412	154.686	3,715	623	2,559	401	2,480	459	2,350	557
East Moorcroft	154.686	160.658	3,715	604	2,001	313	2,110	488	1,837	564
Wind Creek	160.658	165.677	2,013	585	2,022	315	2,101	489	1,857	589
Pine Ridge	165.677	172.092	2,028	556	1,919	299	2,009	466	1,762	604
Inyan Kara	172.092	178.916	1,931	116	1,930	302	2,015	466	1,772	613
Coal Divide	178.916	185.733	1,946	492	2,038	319	2,065	467	1,872	609
West Sundance	185.733	187.533	2,545	456	2,289	358	2,206	467	2,103	587
WY 585 intersection	187.533	188.998	2,308	434	3,158	495	2,545	471	2,900	578
East Sundance	188.998	191.916	2,308	425	2,817	441	2,619	468	2,587	570
Moskee	191.916	199.310	2,786	414	2,813	440	2,573	475	2,583	550
Aladdin exit (WY 111 junction)	199.310	205.895	2,765	350	2,779	728	2,741	460	2,533	502
Beulah	205.895	207.140	2,765	350	2,779	728	2,741	460	2,533	502
Moorcroft to Newcastle: US 16										
Interstate 90 junction	153.412	153.562	1,395	320	2,412	188	2,474	183	2,366	176
JCT Route 303 (WY 51)	153.562	153.928	2,410	560	2,468	193	2,531	178	2,420	168
Moorcroft western city limit	153.928	200.000	1,046	455	3,331	261	3,416	175	3,267	165
JCT Route 607 (US 14)	200.00	200.198	1,450	620	3,283	257	3,367	159	3,220	138
Interstate-90 Business	200.198	200.454	1,453	620	2,038	159	2,090	160	1,999	138
Moorcroft eastern city limit	200.454	210.461	1,452	620	1,486	116	1,524	161	1,457	138
Crook – Weston County line	210.461	213.261	1,167	208	1,581	123	1,260	278	1,205	185
Thorton	213.261	219.245	1,439	175	1,473	114	1,511	272	1,445	183
Upton west town limits	219.245	219.827	1,455	280	2,446	191	2,509	274	2,399	252
WY 116 North	219.827	220.131	1,276	250	2,147	168	2,202	276	2,106	258
WY 116 South	220.131	220.501	1,665	368	2,798	219	2,870	276	2,744	261
Upton east town limits	220.501	233.293	923	310	1,552	121	1,591	229	1,519	208
Osage	233.293	241.380	963	213	1,620	126	1,661	300	1,588	350
Airport Road/ County Road 116	241.380	245.668	1,658	205	1,697	132	1,741	332	1,665	343
WY 450 junction	245.668	247.322	2,475	99	2,535	198	2,599	332	2,486	314
Newcastle west city limits	247.322	247.343	3,810	99	5,068	397	5,198	334	4,971	319
Sundance to Upton: WY 116										
US 14 junction at Sundance	0.000	6.640	463	40	459	40	534	131	522	131
JCT County Road east to WY 585	6.640	16.462	390	50	435	56	420	90	410	90
Crook – Weston County line	16.462	22.360	342	22	360	23	55	55	546	55
Dry Draw	22.360	23.213	599	62	535	55	559	55	546	55
Arch Creek County Road junction	23.213	27.638	862	29	909	30	948	93	927	93
Upton town limits	27.638	28.210	692	85	736	90	--	--	--	--
Sundance to Bull Hill Mine Site: US 14										
Route 600 (WY 116)	200.736	201.472	2,081	246	2,117	361	3,336	123	3,267	146
WY 116 junction	200.538	200.736	2,081	281	2,418	326	--	--	--	--

Route and Road Segment Starting Point	Milepost		2016		2017		2019		2020	
	Start	End	All Vehicles	Trucks	All Vehicles	Trucks	All Vehicles	Trucks	All Vehicles	Trucks
Taylor Divide Road	199.341	200.538	1,861	196	1,606	169	--	--	--	--
Black Hills NF boundary	186.895	199.341	773	85	735	81	767	213	750	151
WY 24 junction	181.192	186.895	834	47	879	49	472	47	477	47
Pine Haven to Interstate 90: US 14 and WY 113										
US 14: Moorcroft N town limit	155.239	159.668	2,471	231	1,989	185	--	--	--	--
WY 113: US 14 junction	10.000	16.610	869	43	917	42	957	94	936	94

3.3 Topography, Soils, and Geology

The following sections address the topography, soils, and geology at the Demonstration Plant site.

3.3.1 Topography

The topography of the Demonstration Plant site is generally flat with slightly higher elevations noted on the south and west end of the property. The lower elevation on the southeast corner is a ponding area which may be a natural feature or a depression enhanced by past bentonite mining (BKS 2021). Map 10 presents the topography of the site.

3.3.2 Soils

A *Baseline Soil Assessment* for the area was conducted and reported as part of the Bear Lodge Project (BKS 2013). The soils inventory consisted of a refinement of the current Natural Resource Conservation Service (NRCS) mapping for the respective areas. In 2021, a general query of the NRCS soil survey was conducted for the Demonstration Plant site (BKS 2021). A baseline radiological characterization in soil (ERG 2015a) is described further in section 3.12.2 with measured radionuclide soil concentrations provided in Table 3-32. Further site-specific soil investigation was conducted for the Demonstration Plant site in 2022 at the locations identified in Map 4 (Inberg-Miller Engineers 2022); radiological analytical results are summarized in Table 3-32.

The soils at the Demonstration Plant site (Map 11) are generally clay loam or clay textured (BKS 2021). The surrounding area contains moderately to very deep soils near floodplains and toe slopes, with shallow to very shallow soils on upland hills, shoulder slopes, and breaks. Soils are typical of semi-arid grasslands and shrublands in the western US. Parent material includes shales and claystone, alluvium, colluvium, and residuum (BKS 2013). The overall soil type is Grummit-Maggin association (Map 11).

Prime farmland was assessed by the District Conservationist located in Gillette, Wyoming. No prime farmlands or agricultural lands of statewide importance were indicated within the Demonstration Plant site.

The hazard for both wind and water erosion at the Demonstration Plant site is moderate based on the descriptions of the soil mapping units. The potential for wind and water erosion is mainly a factor of soil surface characteristics, including texture and organic matter content. Given the fine, clayey nature of surface horizons throughout most of the site, the soils are more susceptible to erosion from water than wind (BKS 2013). Shrink-swell risk is generally a problem in these soils as much of the clay is montmorillonite. In addition, these soils are generally low acid, low fertility, and can contain high amounts of sodium. Reclamation success in these soils is generally poor (BKS 2021).

3.3.3 Geology

The sections below describe the geological setting for the Demonstration Project.

3.3.3.1 Surficial Geology

The Demonstration Plant site and surrounding area were mapped by the US Geological Survey (USGS) in the Upton 15-minute quadrangle (Mapel and Pillmore 1964). Figure 2 and Figure 3 show the surficial geology for the Demonstration Plant site alongside geological cross sections developed

in 2015 (RER 2015a). Coyote Creek and Beaver Creek occupy northwest-trending strike valleys in shale formations that weather more recessively than an intervening sandstone formation (Turner Sandstone Member of the Carlile Shale) which forms a low hogback ridge in the western portion of the Demonstration Plant site. The primary surficial geologic unit is the Belle Fourche Shale, which dips gently to the west and is exposed in a 1-mile-wide band that traverses the Demonstration Plant site. In the western portion of the project area, minor outcrops of the overlying Greenhorn Formation (overlying the Belle Fourche Shale) and Carlile Shale are present (Horton 2017).

3.3.3.2 Structural Geology

The Demonstration Plant site is on the west side of the Black Hills uplift where rocks dip southwestward into the Powder River Basin. The site is west of Upton and lies on the eastern limb of the Black Hills monocline, which extends northwest-southeast and separates more gently dipping rock on either side of the structure. The Black Hills Monocline is the major structural feature in the vicinity of the Demonstration Plant site and is a basin flexure that marks the eastern edge of the Powder River Basin. In the Upton area, the monocline is a well-defined fold that is approximately 3 to 4 miles wide where rock formations to the northeast are uplifted approximately 4,000 feet (ft) relative to the basinward ones to the southwest. Formations ranging from the upper part of the Belle Fourche Shale to the Fox Hills Sandstone are tilted from 10 to 30 degrees and crop out locally along the flank of the monocline (Mapel and Pillmore 1964).

Minor northeastern-trending faults occur in four locations along the Monocline within the upper portion of the Belle Fourche Shale. These faults are noted to extend approximately 0.5 mile or less and displacement was observed between 20 and 30 ft in the bentonite beds of the Belle Fourche Shale, downthrown on the southeast side (Mapel and Pillmore 1964).

North of the project area, the Thornton Dome is a sharply folded and elongated dome trending northwest that is 3 miles long by 1.5 miles wide. The center of the dome is composed of the Skull Creek and Mowry Shale formations which dip away from the crest at approximately 10 to 15 degrees. East of Upton, the 6-mile-long Pump Creek Anticline has the Fall River Formation exposed at its crest. North of this anticline is the Arch Creek Anticline, another structural feature which is a broad 2-mile-long fold (Mapel and Pillmore 1964).

3.3.3.3 Stratigraphy at the Demonstration Plant

The Belle Fourche Shale is Upper Cretaceous in age and is the surficial geologic unit for most of the project area (Table 3-4). Minor outcrops of the younger Greenhorn Formation and Carlile Shale are present. The Belle Fourche Shale ranges from 150 to over 700 ft thick and deepens to the west. Older Upper Cretaceous geological formations consist of the Mowry Shale (about 200 to 250 ft thick in the region) and the Newcastle Sandstone (20 to 50 ft thick). These units are underlain by Lower Cretaceous rock units including the Skull Creek Shale (185 to 210 ft thick) and the Inyan Kara Group, which is comprised of the Fall River Formation (130 ft thick) and the Lakota Formation (100 to 125 ft thick). Beneath the Cretaceous section, an additional 3,000 ft of sedimentary rock represents deposition from the Jurassic Morrison Formation through the Cambrian-Ordovician Deadwood Formation. The top of the Jurassic Morrison Formation likely occurs at depths between 800 and 1,400 ft within the Demonstration Plant site.

Several monitoring wells were constructed in the vicinity of the site as discussed in section 3.4.2 below. Lithological logs and well completion schematics were developed from drilling operations and used to

develop the cross sections provided in Figure 2 and Figure 3 (RER 2015a). The lithologic logs and well completion schematics are displayed in Appendix A.

Gammon Ferruginous Member

The Gammon Ferruginous Member is the lowermost member of the Upper Cretaceous Pierre Shale. The Gammon consists mostly of dark to medium gray noncalcareous shale that weathers medium to light gray. Some of the shale is silty and thin lenses of very fine-grained glauconitic sandstone crop out locally near the middle of the member. Soil formed on the Gammon generally is thin and noticeably lighter in color than soils on the adjacent units. The member is characterized by many beds of closely spaced tabular ferruginous concretions that weather orange red to dark red and are generally 1 to 6 inches thick and several yards long. Gray-weathering septarian limestone concretions that are mostly 1 to 2 ft long occur in the top 50 to 75 ft. This part of the Gammon forms the crest of a low ridge at many places. The basal 100 ft of the Gammon is calcareous gray shale that lacks ferruginous concretions and appears to grade downward into the underlying Niobrara Formation. The contact with the Niobrara is mapped at the top of a thin zone of bentonite beds that approximately mark the upper limit of yellow-weathering chalky shale in the Niobrara (Mapel and Pillmore 1964).

Niobrara Formation

The Upper Cretaceous Niobrara Formation is a marl and shale. The Niobrara is 185 to 210 ft thick and consists mostly of nonresistant calcareous shale and marl. Calcareous beds in the Niobrara weather light gray, yellow, or bright orange and are distinguished easily in outcrops from gray-weathering shale of the adjacent formations. Several thin beds of bentonite less than 0.5 ft thick occur at the top and near the base of the Niobrara Formation, and a few platy masses of coquina. The contact with the underlying Sage Breaks Member of the Carlile Shale is sharp but conformable (Mapel and Pillmore 1964).

Carlile Shale

The Carlile Shale is present in outcrop in the western portion of the project area. This formation consists primarily of dark-gray shale interbedded in the lower portion of the formation with minor siltstone and sandstone. The formation in the region is 500 to 525 ft thick and includes from oldest to youngest the Pool Creek Shale Member, Turner Sandy Member, and Sage Breaks Shale Member. The sandstone bed at the base of the Turner Sandy Member generally forms a low ridge, observed in the western portion of the project area (Mapel and Pillmore 1964).

The Poole Creek Shale is approximately 40 to 50 ft thick and is composed primarily of dark-gray noncalcareous shale (Mapel and Pillmore 1964).

The Turner Sandy Member is approximately 185 ft thick consisting primarily of dark-gray shale interbedded with light gray siltstones. At the base of the Turner is a distinctive ledge-forming bed 2 to 6 ft thick composed of fine- to medium-grained calcareous sandstone. The remainder of the formation is nonresistant (Mapel and Pillmore 1964).

The overlying Sage Breaks Shale Member is approximately 290 ft thick and consists of gray-black shale containing several beds of distinctive limestone concretions (Mapel and Pillmore 1964).

Within the project area, the maximum thickness of the Carlile Shale is likely on the order of 250 ft or less at the far western edge of the project area. Drilling activities associated with monitoring well installations were not conducted in the areas where the Carlile Shale is present.

Greenhorn Formation

The Upper Cretaceous Greenhorn Formation is a dark gray, noncalcareous shale that weathers olive gray, is locally slightly silty or sandy, contains severed beds of septarian limestone concretions, and grades northwestward to dark gray noncalcareous shale containing large light-gray septarian limestone concretions and marine fossils. Near the Thornton dome northwest of Upton, the thickness of the formation is approximately 70 ft and widens to approximately 170 ft approximately 8 miles to the southeast (Mapel and Pillmore 1964). Drilling associated with monitoring well installations was not conducted in the areas where the Greenhorn is present.

Belle Fourche Shale

The Upper Cretaceous Belle Fourche Shale is the dominant surficial geologic unit within the project area and is composed primarily of gray-black shale interbedded with light-colored bentonite. Geophysical logging (or other method) during the installation of monitoring wells indicates that the observed thickness of this formation is 150 ft at wells UMW-02 and UMW-04 to over 700 ft at well UMW-05. The regional thickness of the formation is 650 to 750 ft. The unit contains various concretions of siderite, iron concretions and septarian limestone types. Marine fossils have been found in the upper part (Mapel and Pillmore 1964).

Mowry Shale

The Upper Cretaceous Mowry Shale is composed of dark gray to brownish-gray siliceous shale containing numerous bentonite beds, including the Clay Spur bentonite bed near the top of the formation that is 2.5 to 4.5 ft thick. The highest thickness of the Mowry Shale in the vicinity of the Thornton Dome north of the project area is approximately 215 ft (Mapel and Pillmore 1964).

Newcastle Sandstone

The Upper Cretaceous Newcastle Sandstone consists primarily of light to medium-gray siltstone and silty bentonitic claystone. A 2 to 5 ft thick resistant bed of grayish white very fine-grained sandstone is found near the top of the formation and other discontinuous thin sandstone beds are also present. Thin beds of brown to black carbonaceous shale and one or more bentonite beds are also found within the Newcastle. Thickness of the Newcastle in the region are 20 to 50 ft (Mapel and Pillmore 1964). They note that the Newcastle is generally inconspicuous and not easily identified in electric logs from holes drilled in the western portion of the Upton quadrangle, due to thinning and claystone or shale composition. Based on geophysical logging conducted during the installation of monitoring wells, the porous (relative to overlying and underlying shale based on gamma and resistivity data) sections of the Newcastle are approximately 10 to 20 ft thick (Appendix A).

Skull Creek Shale

The Lower Cretaceous Skull Creek Shale consists mainly of grayish-black shale with a reported thickness of 185 to 210 ft in the area (Mapel and Pillmore 1964). The Skull Creek grades into the underlying Fall River Formation in the bottom 10 to 15 ft where black shale is interbedded with light-gray and yellow-gray sandstone. Geophysical logs of wells drilled and completed to the Fall River Formation indicate a thickness of 200 to 220 ft (Appendix A).

Inyan Kara Group

The Lower Cretaceous Inyan Kara Group consists of the lower Lakota Formation and upper Fall River Formation. The Lakota Formation consists of interfingered deposits of paludal and fluvial sandstone, siltstone, and claystone and the thickness of this unit is 100 to 125 ft (Mapel and Pillmore 1964). The

lower Lakota is primarily tabular-bedded sandstone interbedded with carbonaceous siltstone and shale. The upper Lakota contains cross-bedded, conglomeratic cliff-forming sandstone with claystone in the upper few ft. The underlying contact with the Morrison Formation is defined by the lowermost sandstone or carbonaceous bed above the interbedded claystone and limestone beds of the Morrison.

The upper member of the Inyan Kara Group, the Fall River Formation, is approximately 130 ft thick (Mapel and Pillmore 1964). The lower Fall River is 45 to 80 ft thick and consists of thin-bedded light to dark-gray siltstone interbedded with silty carbonaceous shale and a few beds of light gray, very fine-grained sandstone. The upper portion of the Fall River is composed of thin, slabby beds of sandstone interbedded with light to dark gray siltstone and shale.

Table 3-4. Generalized stratigraphic section of rocks in the Upton Quadrangle (Mapel and Pillmore 1964)

System	Series	Group, Formation, and Member		Thickness (feet)	Lithology
Cretaceous	Upper Cretaceous	Lance Formation		800+	Light gray sandstone and dark-gray shale and sandy shale; nonmarine fossils.
		Fox Hills Sandstone		175	Light gray and light yellowish-gray sandstone, dark-gray shale; marine fossils
		Pierre Shale	Upper part	300	Dark gray shale, sandy and silty near top; septarian limestone concretions that weather medium gray; marine fossils.
			Kara Bentonitic Member	90	Dark gray bentonitic shale; some barite concretions and a few limestone concretions that weather medium gray; marine fossils.
			Middle part	900	Dark gray shale, silty in lower part; dark gray and grayish red septarian limestone concretions; marine fossils.
			Mitten Black Shale Member	650	Upper part: grayish-black shale containing dark-gray and dark red septarian limestone concretions. Lower part. dark gray to brown hard platy shale; many bentonite beds in basal 30-40 ft in southeast part of quadrangle; marine fossils.
			Gammon Ferruginous Member	575-750	Medium to dark gray shale, thin sandstone, and siltstone layers locally; many thin tabular dark-red siderite concretions; a few gray septarian limestone concretions in upper 50-100 ft; sparse marine fossils.
		Niobrara Formation		185-210	Marl and shale; weathers light gray and yellowish orange; several thin beds of bentonite: marine fossils.
Cretaceous	Upper Cretaceous	Carlile Shale	Sage Breaks Shale Member	290	Grayish-black shale; several beds of septarian limestone concretions that weather light gray; sparse marine fossils.
			Turner Sandy Member	185	Dark gray shale and sandy shale; interlaminated and interbedded with light-gray siltstone and very fine-grained sandstone; tan-weathering silty septarian limestone concretions; marine fossils
			Pool Creek Shale Member	40-50	Dark gray shale; a few silty partings; thin bentonite bed in lower part; marine fossils.
		Greenhorn Formation		75-170	In southeast part of quadrangle, dark gray to brownish-gray calcareous and non-calcareous shale that contains thin seams of light gray limestone and a few beds of gray septarian limestone concretions in the upper part; grades northwestward to dark gray non-calcareous shale containing large light gray septarian limestone concretions; marine fossils.
		Belle Fourche Shale		650-750	Grayish-black shale; dark-red siderite concretions in lower part; light-gray, tan, and yellowish gray septarian limestone concretions in upper part; several thick bentonite beds; marine fossils in upper part.
		Mowry Shale		200-215	Siliceous light-gray shale grading to dark-gray shale in basal 15-20 ft; many bentonite beds; marine fossils.
		Newcastle Sandstone		20-50	Light-gray sandstone, brown and gray carbonaceous shale, and bentonite; marine and nonmarine fossils.
Cretaceous	Lower Cretaceous	Skull Creek Shale		185-210	Grayish-black shale; local siltstone parting sparse marine fossils.
		Inyan Kara Group	Fall River Formation	130	Brown-weathering sandstone, light to dark- gray siltstone, and dark-gray shale; locally carbonaceous.
			Lakota Formation	100-125	Light-gray sandstone and conglomeratic sandstone; variegated sandy claystone; nonmarine fossils.

System	Series	Group, Formation, and Member	Thickness (feet)	Lithology
Jurassic	Upper Jurassic	Morrison Formation	80-100	Greenish-gray and grayish-red claystone and marl, some grayish-white sandstone; nonmarine fossils.
		Sundance Formation	370	Greenish-gray shale, light-gray and light yellowish-gray sandstone, pink and tan siltstone, and light-gray glauconitic limestone; divided from top to bottom into the Redwater Shale, Lak, Hulett Sandstone, Stockade Beaver Shale, and Canyon Springs Sandstone Members.
	Middle Jurassic	Gypsum Spring Formation	10±	Massive white gypsum and red claystone. May be absent locally.
Triassic		Spearfish Formation	550	Red siltstone, sandstone, and claystone; thick gypsum beds in the lower part.
Permian		Minnekahta Limestone	40	Light-gray limestone.
		Opeche Shale	100	Red siltstone.
Carboniferous	Pennsylvanian / Lower Mississippian	Minnelusa Formation	800-850	Light-gray and red sandstone, gray limestone and dolomite, red shale; gypsum and anhydrite locally.
	Mississippian / Lower Mississippian	Pahasapa Limestone	500	Light gray locally dolomitic limestone.
		Englewood Limestone	50	Pinkish-gray limestone.
Ordovician	Upper Ordovician	Whitewood Dolomite	50±	Light gray to tan dolomite. May be absent in southern part of the quadrangle.
	Middle Ordovician	Winnipeg Formation	50±	Light yellowish-gray to greenish-gray silt-stone and greenish-gray shale. May be absent in southern part of the quadrangle
Cambrian	Upper Cambrian and Lower Ordovician	Deadwood Formation	300±	Mostly brown sandstone; some greenish-gray siltstone and shale, and gray limestone.
Precambrian				Metamorphic and igneous rocks.

3.3.3.4 Geotechnical Investigations

A geotechnical investigation was conducted for the Demonstration Plant site in 2022 (locations identified in Map 4) (Inberg-Miller Engineers 2022). Previous baseline work in the vicinity of the Demonstration Plant site involved geotechnical field exploration and laboratory testing programs in 2011 to 2013 to support conceptual and prefeasibility-level design studies (Golder 2013). A core hole (UCH-01) was drilled to determine the permeability of the material (Figure 2 and Figure 3 (RER 2015a)). The hole was drilled to 100 ft with core samples taken at 25, 50, and 100 ft. Permeability tests were conducted on these samples by Advanced Terra Testing of Lakewood, Colorado. The results of the testing indicate that the permeability is 1.8×10^{-9} centimeters per second (cm s^{-1}), 3.2×10^{-10} cm s^{-1} and 3.4×10^{-10} cm s^{-1} at 25, 50, and 100 ft, respectively. These laboratory results are presented in Appendix B.

3.3.3.5 Seismic Hazard Review

The seismic hazard review for the Demonstration Plant site is based on an analysis of available literature and historical seismicity. According to the USGS, there are no capable faults, *i.e.* active faults, with surface expression mapped within or near the site (USGS 2014). The closest capable fault to the site is the Stagner Creek fault system located in central Wyoming approximately 185 miles (298 km) to the west-southwest. The faults at Yellowstone National Park are located approximately 275 miles (443 km) to the west-northwest.

Seismicity

Earthquakes are common in Wyoming and have occurred in every county in the state over the past 120 years. Most of these have occurred in the northwestern part of the state (J.C. Case and Green 2000). Map 12 shows these historic earthquakes. Twenty-four recorded earthquakes with a magnitude greater than 2.5 (Richter Magnitude Scale) or intensity greater than III (Modified Mercalli Intensity Scale) have been recorded within a 60-mile radius of the Demonstration Plant site. Of these, two have occurred in Weston County. The earliest occurred near Osage on May 1, 1926, approximately 19 miles southeast of Upton, and was intensity IV. The second was a magnitude 2.7 earthquake that occurred on May 2, 2006, approximately 18 miles southwest of the Demonstration Plant site. Within 60 miles of the Demonstration Plant site, four earthquakes occurred including the intensity IV-V earthquake southwest of Sundance in 1897. There was a magnitude 3.7 earthquake near Moorcroft in 2004, magnitude 4.3 earthquake approximately 28 miles northwest of Upton in 1972, and magnitude 3.8 earthquake near Gillette in 2012. Several other earthquakes have occurred in Campbell County within 60 miles of the Demonstration Plant site. On February 6, 1996, a magnitude 3.7, intensity V earthquake was recorded near Hill City, South Dakota. Seven other earthquakes of magnitude 2.5 or greater have occurred in South Dakota within a 60-mile radius.

Natural earthquakes in Wyoming occur because of movements on existing or newly created faults or movements of (or in) the magma chamber beneath Yellowstone National Park. As discussed in the preceding section, no faults have been mapped within 185 miles of the Demonstration Plant site.

Earthquakes generally do not rupture the ground surface unless the magnitude of the event is greater than 6.5. Because of this, areas of the state that do not have active faults exposed at the surface, such as the Demonstration Plant site, are generally thought to be incapable of having earthquakes with magnitudes over 6.5 (Map 12). Earthquakes with magnitudes less than 6.5 would cause little damage to specially built structures but could cause considerable damage to ordinary buildings and severe

damage to poorly built structures. Underground pipes would generally not be broken, and ground cracking would not occur or would be minor (J.C. Case and Green 2000).

Seismic Risk

The Uniform Building Code (UBC) contains information and guidance on designing buildings and structures to withstand seismic events. The last and most current (1997) UBC Seismic Zone Map divides Wyoming into five zones (Zones 0 to Zone 4) defined in order of increasing probability of having a certain level of ground shaking (horizontal acceleration) in 50 years (Map 12).

Weston County is in UBC Seismic Zone 0 and Zone 1. Upton and the Demonstration Plant site are in Zone 0 so there is a 90% probability that an earthquake with a ground acceleration of 5 percent of gravity (%g) would not occur within any 50-year period. An average peak ground acceleration of 5%g could be applied to non-critical facilities but is significantly less than values suggested by newer building codes (Case, Toner, and Kirkwood 2002). Recently, the UBC has been replaced by the International Building Code (IBC), which is based on probabilistic analyses (Case, Toner, and Kirkwood 2002).

Some regulations require an analysis of the earthquake potential in areas where active faults are not exposed, and where earthquakes are tied to buried faults with no surface expression. Regions with a uniform potential for the occurrence of such earthquakes are called tectonic provinces. The USGS identified tectonic provinces in *Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States* (Algermissen et al. 1982; Case, Toner, and Kirkwood 2002).

Earthquakes associated with buried faults within a tectonic province are assumed to occur randomly and are sometimes referred to as “floating earthquakes.” Sometimes regulations or prudent design requires that a floating earthquake be used for the design of a facility. Those regulations typically also specify at what distance a floating earthquake is to be placed from a facility. For example, a magnitude 6.25 floating earthquake placed within 15 kilometers (km) of any structure within Weston County would produce horizontal accelerations of 15%g at the site. This would provide a fairly conservative estimate for design ground accelerations (Case, Toner, and Kirkwood 2002).

Probabilistic Seismic Hazard Analysis

The estimated peak horizontal acceleration in the Demonstration Plant site is about 2%g, based on the 500-year map (10% probability of exceedance in 50 years) (Map 13). This relates to an intensity IV earthquake, which would be felt by many people indoors, but few outdoors. It would feel like a heavy truck passing nearby. The estimated peak horizontal acceleration at the site is about 6.5%g, based on the 1,000-year map (5% probability of exceedance in 50 years). This corresponds to an intensity V earthquake, which would be felt by almost all people, some of whom could be awakened. Small objects could be moved, and trees and poles may shake. The 2,500-year map (2% probability of exceedance in 50 years) (Map 14) indicates a peak horizontal acceleration of 10.0%g, correlating to an intensity VI earthquake, which would be felt by all people. Some heavy furniture would be moved, and some plaster could fall. Chimneys could be damaged slightly.

There is no indication of a 2,500-year event in the limited historic record of Weston County. The WSGS suggests that the 2,500-year probabilistic map (Map 14) be used for seismic analysis in design of critical facilities in this part of Wyoming because of the 1) uncertainty involved and 2) new IBC uses 2,500-year events for the design of buildings. Additionally, it should be assumed the Demonstration

Plant site is in an intensity VI earthquake area. This conservative approach is in the interest of public safety.

3.4 Water Resources

This section addresses baseline conditions for surface water, groundwater, and wetlands.

3.4.1 Surface Water

3.4.1.1 Regional Surface Water Hydrology

The Demonstration Plant site is in the northern plains of the Cheyenne River Basin (Hydrologic Unit Code 101201, Map 15). The Cheyenne River originates in northeastern Wyoming and flows easterly to the Wyoming-South Dakota state line into southwestern South Dakota, then northeasterly until it empties into the Missouri River at Lake Oahe. Its stream length is approximately 295 miles and it drains an area of approximately 24,300 mi^2 (USGS 2009).

The Demonstration Plant site is near the headwaters of Coyote Creek, a tributary to Iron Creek. Coyote Creek flows approximately 5 stream channel-miles to Iron Creek. Iron Creek is a tributary to Beaver Creek. It flows approximately 11.6 stream channel-miles to Beaver Creek. Beaver Creek flows approximately 117 stream channel-miles to where it empties into the Cheyenne River near the Wyoming-South Dakota state line.

There are no USGS gaging stations on Coyote Creek, Iron Creek, or Beaver Creek. Seven USGS gaging stations are located on the Cheyenne River downstream of the Beaver Creek–Cheyenne River confluence and before the point at which the Cheyenne River empties into Lake Oahe (Map 15). Appendix C lists the names, locations, and mean discharge rates for the nearest USGS gaging stations and peak annual flows at the Edgemont, South Dakota gaging station below the Beaver Creek–Cheyenne River confluence. The timing of these peak flows indicates that spring runoff and snow melt result in the highest flows of the Cheyenne River drainage basin.

3.4.1.2 Local Drainage Basin

There is no water flow at the surface at the Demonstration Plant site, other than stormwater (BKS 2021). Surface water hydrology near the Demonstration Plant site (Map 16) is dominated by the southeastward flowing Coyote Creek and its associated tributaries. Most of the Coyote Creek drainage area is composed of minor ephemeral stream channels which have been determined by the US Army Corps of Engineers (ACE) to be non-jurisdictional waterways (ACE 2013). Coyote Creek continues southeastward until it empties into Iron Creek, after leaving the Demonstration Plant site.

The Coyote Creek drainage basin in the vicinity of the Demonstration Plant site is composed of rolling plains and rangeland. The maximum basin relief is approximately 200 ft. Stream channels generally slope at less than 1 to 2%. Soils within the Demonstration Plant site drainage area are strictly of hydrologic soil group D (USDA 2012).

Surface Runoff Estimates

There are no long-term stream flow records within or adjacent to the Demonstration Plant site. Therefore, an ACE HEC-HMS model was used to estimate the peaks and volumes of floods for various recurrence intervals on Coyote Creek (Appendix D). The Coyote Creek flood inundation for the 100-year, 24-hour precipitation event is depicted on Map 17.

The procedures used to apply these methods are in the *HEC-HMS User's Manual* (ACE 2010), *HEC-HMS Technical Reference Manual* (ACE 2000), and US Bureau of Reclamation (BOR) *Design of Small Dams* (BOR 1987). The values for precipitation were determined from National Oceanic and Atmospheric Administration (NOAA) Atlas No. 2 for Wyoming (NOAA 2011). The values for runoff curves were calculated by area-weighting the soil types of the drainage basin according to hydrologic soil group as determined from the NRCS web soil survey information obtained for the project area within Weston County, Wyoming (USDA 2012).

Surface Water Use

A search of surface water rights for the Demonstration Plant site was completed using the Wyoming State Engineer's Office (WYSEO) e-Permit database. Surface water rights within and adjacent to the project boundary are depicted on Map 18. The search revealed several uses for surface water, which include at least stock watering, irrigation, reservoir supply, and fish propagation (WYSEO 2015).

Categorizing the use of surface water can also be done by applying WDEQ Water Quality Division (WDEQ-WQD) Classification Standards. All surface waters of the state are classified according to use and suitability thereof. Coyote Creek is classified a 3B stream. Class 3B streams are intermittent or ephemeral streams incapable of supporting fish populations or drinking water supplies (WDEQ 2001). Coyote Creek empties into Iron Creek, which is also classified as a 3B stream.

In terms of the existing buildings on the Demonstration Plant site, the location of and historical practices for the disposal of gray and black water for the main shop building are unknown. There is a leach field on the northwest side of the main shop building. The Upton sewer line is north of the property and may have been accessed improperly by the previous tenant (BKS 2021).

Stream Channels

Longitudinal profiles of stream channels and their slopes are shown on Figure 4. The channel bed of Coyote Creek alternates between being vegetated and bare soil. The stream channel is composed of clay, and therefore is very smooth with little roughness other than vegetation or plant debris. Coyote Creek is stable for normal spring runoff and is characterized by marginal sedimentation.

Surface Water Monitoring

Surface water has been monitored at the six locations in the vicinity of the Demonstration Plant site (Map 5, Map 16). Three stations are on Coyote Creek: UCC-01, UCC-02, and UCC-03. The remainder are at the three unnamed sediment ponds that remained after closure of a nearby bentonite mine: Upton sediment pond (USP)-01, USP-02, and USP-03. Stations UCC-01 and UCC-02 are both downstream of Coyote Creek's culvert under Buffalo Creek Road by approximately 20 and 10 ft, respectively.

Surface Water Quality

RER initiated the sampling of surface water near the Demonstration Plant site in March 2012 (BKS 2014a) and conducted baseline update sampling 2018 (RER 2019). The results are presented in the following:

- Appendix C, Table 10 provides a summary of the monitoring results from the surface water stations in the original baseline study (BKS 2014a)
- A piper diagram of the major ion chemistry for each station is presented in Figure 5 (BKS 2014a).

- Appendix C, Table 20 (Surface Water Flow) and Table 21 (Surface Water Monitoring Results) provide updates from 2018 (RER 2019)

Within Coyote Creek, surface water is somewhat consistently sodium sulfate type with contributions from bicarbonate cations (BKS 2014a) (RER 2019). Water quality varied in the sediment pond samples collected at USP-01 through USP-03. The results indicate that the water is magnesium-calcium-sodium sulfate type at USP-01; sodium sulfate type at USP-02; and sodium-bicarbonate type at USP-03 (BKS 2014a).

A summary of surface water monitoring exceedances is included in Table 3-5. In the original baseline study, concentrations of metals at the surface water stations were generally low to non-detect. However, iron and aluminum concentrations were consistently high at each station, and exceedances of arsenic, beryllium, lead, gross alpha, and radium drinking water maximum contaminant levels were noted (BKS 2014a).

Concentrations of total dissolved solids (TDS) varied along Coyote Creek and in the sampled sediment ponds. Concentrations of total suspended solids (TSS) in Coyote Creek were less than 10 to 470 milligram per liter (mg L^{-1}) at UCC-01 and UCC-02; and approximately 20 to 170 mg L^{-1} at UCC-03. The concentrations of TSS in the sediment ponds were generally less than those in Coyote Creek (BKS 2014a).

In the 2018 sampling effort (RER 2019), similar values were measured, indicating unchanged baseline surface water quality, with TDS, metals, and radionuclide concentrations higher in the spring than in the fall.

Table 3-5. Summary of surface water monitoring exceedances

Constituent	Standard		Exceedances	
	MCL	Alternate [a]	Year	Station/sample
Arsenic	0.01 mg L^{-1}	--	2012 2018	UCC-02; USP-03 CCI
Beryllium	0.01 mg L^{-1}	--	2012	UCC-02
Lead	0.015 mg L^{-1}	--	2012 2018	UCC-01, UCC-02, UCC-03; USP-03 CCI, CCO
Gross Alpha	15 pCi L^{-1}	--	2012 2018	UCC-01, UCC-02, UCC-03; USP-03 CCI
Radium-226 + Radium-228	5 pCi L^{-1}	--	2012 2018	UCC-02 CCI, CCO
TDS	--	500 mg L^{-1}	2012	All stations
Sulfate	--	250 mg L^{-1}	2012	All stations
Fluoride	--	2.0 mg L^{-1}	2012	USP-01
Aluminum	--	0.75 mg L^{-1}	2018 [b]	Three samples
	--	0.05 – 0.2 mg L^{-1}	2012	All stations
pH	--	6.5 – 8.5	2012	USP-01
Manganese	--	0.05 mg L^{-1}	2012	All stations
Iron	--	1 mg L^{-1}	2018 [b]	Three samples
	--	0.3 mg L^{-1}	2012	All stations

[a] Unless otherwise specified, alternate standard is EPA secondary drinking water standard
[b] Compared WDEQ surface water quality standard, aquatic life acute criteria

3.4.2 Groundwater

RER installed ten groundwater monitoring wells near the Demonstration Plant site (Map 19, Map 20) to collect geophysical data, perform aquifer characterization tests, and monitor water quality. The wells include four deep wells completed in the Dakota Sandstone, one deep well completed in the Newcastle/Muddy Sandstone and five shallow wells (less than 20 ft) completed in alluvium adjacent to Coyote Creek and Little Beaver Creek. The following sections describe information relevant to these tests and present monitoring results.

3.4.2.1 Regional Geohydrology

The Demonstration Plant site lies within the Upton quadrangle, which includes about 215 mi^2 on the west side of the Black Hills, South Dakota. In the Upton quadrangle, exposed sedimentary rocks are approximately 5,900 ft thick including strata of Late Jurassic and Cretaceous age. These rocks overlie as much as 2,800 ft of unexposed sedimentary rocks of Cambrian to Jurassic age (Mapel and Pillmore 1964).

The Demonstration Plant site also lies on top of a thick sequence of marine shale, which extends from the southeastern to northwestern corners of Weston County (Lowry et al. 1986). Wells completed in the shale sequence generally yield small quantities of highly mineralized waters, which are unsuitable for most uses.

The seven geohydrologic units within Weston County include (1) igneous and metamorphic rocks, (2) the marine carbonate and sandstone sequence (Deadwood to Minnelusa formations), (3) red-bed and gypsum sequence (Opeche Shale to Gypsum Spring Formation), (4) marine, marginal marine, and continental sandstone and shale sequence (Sundance through Inyan Kara), (5) marine shale sequence (Skull Creek to Pierre Shale), (6) continental sandstone and shale sequence (Fox Hills to Fort Union Formation), and (7) Quaternary-age alluvium deposits (Lowry et al. 1986).

Further discussion is restricted to the primary aquifers in the region: the Deadwood to Minnelusa formations, the Sundance to Inyan Kara, the Fox Hills to Fort Union, and Quaternary deposits.

The Deadwood to Minnelusa unit includes the Late Cambrian and Early Ordovician-age Deadwood Formation, Ordovician-age Winnipeg Formation and Whitewood Dolomite, Devonian, and Early Mississippian age Pahasapa Limestone (Madison equivalent), and Pennsylvanian and Early Permian-age Minnelusa Formation. The largest yields in the area are generally from the Pahasapa Limestone, reported at more than 1,000 gallons per minute (gpm). The second major water-bearing formation is the Minnelusa Formation, with the largest yields of 300 gpm reported in Weston County (Lowry et al. 1986).

The Sundance, Morrison and Lakota and Fall River formations of the Inyan Kara Group are approximately 650 ft thick in Weston County. Sandstones and conglomerates in the Inyan Kara Group can yield as much as 146 gpm to wells. The Lakota is generally a more productive aquifer than the Fall River, as more wells are drilled deeper to the Lakota to obtain adequate supply, and the Lakota

generally supplies higher quality water. Most Lakota wells are flowing at the surface, generally yielding less than 30 gpm, which could be increased by pumping. Yields in the Sundance are similar to the Lakota, though most Sundance wells are shallow and drilled near outcrops (Lowry et al. 1986).

The Fox Hills to Fort Union sequence is composed of the marginal marine Fox Hills sandstone, overlain by the continental deposits of the Late Cretaceous Lance Formation and Paleocene-age Fort Union Formation. Wells are completed in the sandstone intervals of these formations at depths of less than 600 ft. Yields are suitable in quantity and quality for domestic and stock usage.

Quaternary-age alluvium deposits consist of primarily silt, clay, and fine-grained sand in the alluvial valleys of Weston County. Most stream valleys are less than a ¼-mile wide. Alluvial deposits are less than 100 ft thick. Permeability is generally low, and yields are small, due to the fine-grained sediments. Reported yields are generally less than 10 gpm, extending up to above 60 gpm in Beaver Creek and Stockade Beaver Creek. The largest yields occur along the Cheyenne River, where yields from 200 to 900 gpm have been reported (Lowry et al. 1986).

3.4.2.2 Groundwater Monitoring Program

Information regarding RER's ten monitoring wells is in Table 11 in Appendix C (Map 19, Map 20). Groundwater is grouped for further discussion into the shallow waters encountered in the Valley Fill and Weathered Shale, and into the deeper waters of the Newcastle Sandstone and Dakota Aquifer.

Shallow Wells: Valley Fill and Weathered Shale

Shallow groundwater (less than 20 ft) is limited to accumulations in perched and isolated zones within alluvial valley fill and the weathered upper portion of the surficial geologic formation: the Belle Fourche Shale. These two layers are considered a single hydrostratigraphic unit. The unit is not considered an aquifer, as (1) well yields in the fine-grained alluvium and weathered shale are low (based on groundwater sampling) and (2) the waters are highly mineralized and not suitable for any use.

The five wells in the Valley Fill and Weathered Shale layers are identified as USMW (Upton shallow monitor well in the well name, *e.g.*, USMW-01) and include:

- Three wells (USMW-01, USMW-02, and USMW-03), drilled to between 8.5 and 19 ft below ground surface (bgs) in the Valley Fill in the Coyote Creek drainage, and
- Two wells (USMW-04 and USMW-05) in the Weathered Shale to 8.2 and 16.75 ft bgs, respectively, upstream of the Brown Reservoir identified on topographic maps.

Water levels were monitored during groundwater sampling events, but due to the isolated nature of groundwater and low yields in this shallow unit, no hydrologic testing was conducted. Based on the high percentage of fine-grained sediments, the hydraulic conductivities of this unit are expected to be very low.

Deep Wells: Newcastle Sandstone and Dakota Aquifer

Deeper groundwater is found several hundred ft below the uppermost Belle Fourche Shale and Mowry Shale, in the Newcastle Sandstone and the Inyan Kara Group. Regionally, the Fall River and Lakota formations of the Inyan Kara Group are referred to as the Dakota Aquifer System. The Newcastle Sandstone is a minor unit of the Dakota Aquifer System that also includes the deeper Inyan Kara Group. Below the Newcastle is the underlying Skull Creek Shale. The depth extending to the Dakota

Aquifer is due to the westward dipping Black Hills Monocline. Well logs and completion data are provided in Appendix A.

The five wells are as follows:

- Newcastle Sandstone well UMW-04 was drilled to 365 ft bgs to the Newcastle Sandstone. Water levels in the well have been measured at approximately 329 ft below top of casing to almost dry since its installation in March 2012 (Table 12 in Appendix C).
- Dakota Aquifer well UMW-01 was drilled to 935 ft bgs and screened from 893 to 933 ft bgs;
- Dakota Aquifer well UMW-02 was drilled to 687 ft bgs and screened from 610 to 650 ft bgs;
- Dakota Aquifer well UMW-03 was drilled to 860 ft bgs and screened from 800 to 840 ft bgs;
- Dakota Aquifer well UMW-05 was drilled to 1,265 ft bgs and has two screened intervals from 1,227 to 1,237 ft bgs and 1,242 to 1,252 ft bgs. Well UMW-05 is the westernmost well completed to the Dakota Aquifer.

No hydrologic testing was conducted within these layers. The porous interval of the Newcastle Sandstone is approximately 10 to 20 ft thick at this well location, based on geophysical logging. Regional information related to permeability in this aquifer indicates that the Newcastle Sandstone is exploited only near outcrops. Data from oil fields in the region indicate a porosity between 5 and 27%, with permeabilities less than 11 gallons per day per square foot (gpd ft^{-2}), and transmissivities from 0 to 140 gpd ft^{-2} (HKM Engineering 2002). Few wells are reported in the northern Black Hills, and wells completed near outcrops generally have yields adequate for stock and domestic uses. The Fall River and Lakota formations have flowing yields of 1 to 10 gpm, with higher yields of 150 gpm reported in the Lakota.

3.4.2.3 Potentiometry, Gradients, Recharge/Discharge Areas, and Hydrograph Analysis

Valley Fill and Weathered Shale

The three wells in the Coyote Creek drainage (wells USMW-01, USMW-02, and USMW-03) completed in the valley fill appear to be connected within the small area in the drainage. Wells completed in the weathered shale (USMW-04 and USMW-05) appear to be completed in a separate shallow area of groundwater, based on water level elevations and topography. The wells completed in the weathered shale are in the southwestern portion of the Demonstration Plant site on the western side of a drainage divide, west of the Coyote Creek drainage. Water level data for these wells are presented in Table 12 in Appendix C.

A potentiometric surface map of the three wells completed in the Coyote Creek drainage, produced from the water level measurements made in November 2013, is presented on Map 19. Groundwater flow follows topography to the south. A potentiometric surface map of the two wells located west of the drainage divide could not be constructed based on only two data points; however, the water level elevation in the upgradient well USMW-05 (located approximately 200 ft from USMW-04) is approximately 13 ft higher.

The Valley Fill and Weathered Shale units recharge through infiltration of precipitation and via surface water infiltration when the ephemeral streams are flowing. Discharge of groundwater in these units is unknown and likely occurs as eventual discharge to further downstream portions of Beaver Creek and via evapotranspiration.

The limited data for water levels in wells completed in these shallow units do not show strong seasonal trends. This may be due to the limited number of measurements available from groundwater sampling events (section 3.4.2.4). It is likely that groundwater levels increase seasonally in response to spring thaw and early summer precipitation events, and eventually decline through the summer as evapotranspiration increases.

Newcastle Sandstone and Dakota Aquifer

The wells completed in the deeper groundwater formations near the Demonstration Plant site include one in the Newcastle Sandstone and four in the Fall River Formation of the Dakota Aquifer. Regional information about the potentiometric surfaces of these units indicates that groundwater flow from the northeast at the upland recharge areas of the Black Hills to the west and southwest into the Powder River Basin, eventually flowing northward.

Potentiometric elevations of the five deeper groundwater wells from August 2013 are shown on Map 20. The potentiometric elevation at well UMW-04 (Newcastle Sandstone) is almost 350 ft lower than in nearby well UMW-02, which is artesian and completed in the Dakota Aquifer. Based on potentiometric elevations at wells UMW-02 (approximately 4,264 ft above mean sea level), UMW-03 (4,238 ft above mean sea level), and UMW-05 (4,223 ft above mean sea level), the direction of groundwater flow can be inferred to the west, as expected based on regional aquifer data and groundwater flowing away from the Black Hills Uplift into the Powder River Basin. The potentiometric data from well UMW-01 do not match this inferred groundwater direction, as its water level elevations are almost 30 ft lower than observed at well UMW-05, which is located approximately 1,700 ft to the west of well UMW-01. It is unclear why the potentiometric elevation at this well is significantly lower than expected.

The screened intervals for the four Dakota Aquifer wells are located within 40 to 80 ft (based on the bottom depth) of the top of the Dakota aquifer, based on geophysical logs and details of well construction. This top is defined by the distinct increase in resistivity and corresponding decrease in levels of (natural) gamma radiation that indicates permeable and sandier water-bearing intervals. It is possible that there may be hydraulic segregation within the Fall River Formation, as the geophysical logs indicate sandstone intervals interbedded with shaley intervals.

Recharge to these aquifers is primarily through direct infiltration of precipitation or stream losses in areas of outcrop northeast of the Demonstration Plant site, on the southwestern flanks of the Black Hills. Discharge for these confined aquifers is via groundwater withdrawal from wells and eventual discharge to distant areas in eastern North Dakota and South Dakota (Driscoll et al. 2002).

3.4.2.4 Groundwater Quality

The monitoring well network was sampled quarterly between 2012-2014 and once in 2018 (RER 2019; BKS 2014a). Results are presented in Appendix C in the following locations:

- Measured field parameters 2012-2014: Table 12
- Sampling frequency 2012-2014: Table 13
- Concentrations of major ions, non-metals, and data quality results: Table 14 (2012-2014), Table 23 and Table 24 (2018)
- Concentrations of dissolved metals: Table 15 (2012-2014), Table 23 and Table 24 (2018)
- Concentrations of radionuclides: Table 16 (2012-2014), Table 23 and Table 24 (2018)

- Concentrations of volatile and semi-volatile organics: Tables 17 and 18 (2012-2014)

Shallow Wells: Valley Fill and Weathered Shale

Groundwater in the wells completed in the shallow Valley Fill and Weathered Shale units are of a sodium sulfate type.

Table 3-6 summarizes exceedances of EPA Maximum Contaminant levels (MCLs) or Secondary Drinking Water Standards for the Valley Fill and Weathered Shale wells. Groundwater in the Valley Fill and Weathered Shale units exceeds multiple standards for WDEQ Class, I, Class II, and Class III groundwaters of the state, and water quality results were generally unchanged between the 2012-2014 and 2018 sampling events (RER 2019).

The average reported concentrations of TDS for wells USMW-01, USMW-02, USMW-03, USMW-04 and USMW-05 exceed 11,000; 8,000; 69,000; 55,000; and 32,000 mg/L, respectively. Stiff diagrams and a piper diagram of the shallow groundwater wells are presented in Figure 6 and Figure 7, respectively (RER 2015a).

Deep Wells: Newcastle Sandstone and Dakota Aquifer

Groundwater in wells completed in the Newcastle Sandstone and Dakota Aquifer are either of sodium bicarbonate type (wells UMW-01 and UMW-05) or sodium sulfate type (wells UMW-02, UMW-03, and UMW-04).

Groundwater in the Newcastle Sandstone and Dakota Aquifer units exceeds multiple standards for WDEQ Class, I, Class II, and Class III groundwaters of the state, and water quality results were generally unchanged between the 2012-2014 and 2018 sampling events (RER 2019). Table 3-6 summarizes exceedances of EPA MCLs or Secondary Drinking Water Standards for the deep monitoring wells.

Average concentrations of TDS in the four Dakota Aquifer wells are between 621 and 826 mg L^{-1}. The average concentration of TDS in well UMW-04 completed in the shallower Newcastle Sandstone is significantly higher: exceeding 7,000 mg L^{-1}. Stiff diagrams and a piper diagram of the deeper groundwater wells is presented in Figure 8 and Figure 9, respectively (RER 2015a).

Table 3-6. Summary of groundwater monitoring exceedances

Constituent	Standard		Exceedances	
	MCL	Alternate [a]	Valley Fill and Weathered Shale (Shallow)	Newcastle Sandstone and Dakota Aquifer (Deep)
Selenium	0.05 mg L^{-1}	--	USMW-01, USMW-03	--
Uranium	0.03 mg L^{-1}	--	All wells	--
Gross Alpha	15 pCi L^{-1}	--	All wells	UMW-04
Radium-226 + Radium-228	5 pCi L^{-1}	--	USMW-02, USMW-03, USMW-04	--
Benzene	0.005 mg L^{-1}	--	--	UMW-03
TDS	--	500 mg L^{-1}	All wells	All wells
Chloride	--	250 mg L^{-1}	USMW-04	UMW-04

Constituent	Standard		Exceedances	
	MCL	Alternate [a]	Valley Fill and Weathered Shale (Shallow)	Newcastle Sandstone and Dakota Aquifer (Deep)
Sulfate	--	250 mg L^{-1}	All wells	UMW-02, UMW-03, UMW-04
Fluoride	4.0 mg L^{-1}	2.0 mg L^{-1}	USMW-03 (exceeds MCL) USMW-01, USMW-04, and USMW-05 (exceeds secondary)	UMW-04 (exceeds secondary)
Aluminum	--	0.05 – 0.2 mg L^{-1}	All wells	UMW-01, UMW-03, UMW-04
pH	--	6.5 – 8.5	USMW-05	All wells
Manganese	--	0.05 mg L^{-1}	All wells	UMW-04
Iron	--	0.3 mg L^{-1}	All wells	UMW-04

[a] Alternate standard is EPA secondary drinking water standard

EPA – US Environmental Protection Agency
MCL – EPA Maximum Contaminant Level
mg L^{-1} – milligrams per liter
pCi L^{-1} – picocuries per liter
TDS – total dissolved solids
WDEQ – Wyoming Department of Environmental Quality

3.4.2.5 Groundwater Use

A search of groundwater rights was completed for the Demonstration Plant site using the WYSEO database. Groundwater rights in the area are presented in Table 19 in Appendix E and depicted on Map 21. The search revealed several uses for groundwater. Usage includes at least stock, monitoring, municipal, domestic needs, and miscellaneous (WYSEO 2015).

Within one mile of the Demonstration Plant site, there are both private wells (permitted by the state or local agency) and a federal (USGS) well (permitted under federal jurisdiction). Three wells for the Town of Upton, two private wells for domestic or stock use and two oil and gas wells are located within one mile of the site. Both oil and gas wells are permanently abandoned. WDEQ maintains one monitoring well in section 35, T48N R65W (BKS 2021).

3.4.3 Wetlands

Field work to delineate wetlands was conducted on June 28, 2012 and reported in *Baseline Aquatic Resources Inventory* (BKS 2014a), and a search of the National Wetlands Inventory was conducted in 2021 (BKS 2021). Intrusive soil sampling for hydric soils was conducted to a maximum depth of 20 inches and observations of hydrophytic plants and hydrology were made. Global Positioning System coordinates were recorded at areas that were investigated and where soil sampling occurred.

The wetlands (Map 16) are generally located west of the Demonstration Plant site. One wetland was identified within the site boundary and is classified as Palustrine Aquatic Bed, semi-permanently flooded, excavated (PABFx), indicating a potential for past bentonite mining at the site (BKS 2021). Approximately 15 acres of wetlands were identified near the site including natural features associated with Coyote Creek and Beaver Creek, and reservoirs resulting from the reclamation of bentonite mining activities.

As a result of the 2012 inventory, ACE approved a jurisdictional determination that states Coyote Creek and its adjacent wetlands and waters do not meet the Significant Nexus standard when evaluating their relationship to the nearest traditional navigable water (ACE 2013). A further aquatic survey is planned for summer 2022 which will be used to obtain an updated ACE jurisdictional determination for the Demonstration Plant site.

3.5 Ecological Resources

3.5.1 Vegetation

The current ground cover at the Demonstration Plant site consists primarily of gravel. Concrete slabs are present in association with the buildings, either inside or adjacent to them. Some remnants of weeds (Canada thistle) were noted on the northern edge of the site (BKS 2021).

Baseline vegetation sampling was completed in July-August 2012 to identify pre-operational vegetation communities, as reported in the *2012 Baseline Vegetation Assessment* (BKS 2014b). All sampling procedures outlined in the approved WDEQ baseline vegetation sampling methodology were executed as approved. The dominant vegetation communities were mapped using USDA National Agricultural Imagery Program (NAIP) true color ortho aerial imagery, then field-verified and agreed upon during field surveys by WDEQ, RER, and BKS (BKS 2014b). Vegetation communities were also mapped based on a review of the 2011 USDA NAIP aerial imagery and field-visits to the Project area. Six dominant vegetation communities were identified:

- Mixed Shrubland,
- Greasewood Shrubland,
- Big Sagebrush Shrubland,
- Upland Grassland,
- Meadow Grassland, and
- Reclaimed Grassland.

Map 22 depicts the distribution of each mapped vegetation community as well as areas identified as previously disturbed by human activities and covered by water. Table 3-7 identifies the top five species by lifeform for each vegetation community in the survey area. Most of the Demonstration Plant site is “Disturbed” with a small portion of “Upland Grassland.”

A supplemental baseline vegetation assessment completed in 2018 found no updates to the vegetation community acreages or mapping (RER 2019).

Table 3-7. Top five plants by lifeform documented for each dominant vegetation community (BKS 2014b)

Common Name	Scientific Name	Dominant Vegetation Types Located
Shrubs		
Big sagebrush	*Artemisia tridentate*	BSS, GS, MS, UG
Greasewood	*Sarcobatus vermiculatus*	GS
Forbs		
Sweetclover*	*Melilotus officinalis*	UG
Grasses		

Common Name	Scientific Name	Dominant Vegetation Types Located
Crested wheatgrass*	*Agropyron cristatum*	BSS, GS, MS, RG, UG
Prairie sandreed	*Calamovilfa longifolia*	UG
Nebraska sedge	*Carex nebrascensis*	MG
Common spikerush	*Eleocharis palustris*	MG
Western wheatgrass	*Elymus smithii*	BSS, GS, MG, MS, RG, UG
Bluebunch wheatgrass	*Elymus spicatus*	RG
Prairie junegrass	*Koeleria macrantha*	RG, UG
Green needlegrass	*Nassella viridula*	BSS, MS
Kentucky bluegrass*	*Poa pratensis*	MG
Sandberg bluegrass	*Poa secunda*	BSS, GS, MS, RG, UG
Prairie cordgrass	*Spartina pectinate*	MG

* Indicates introduced grasses or forbs

BSS – Big Sagebrush Shrubland
GS – Greasewood Shrubland
MG – Meadow Grassland
MS – Mixed Shrubland
RG – Reclaimed Grassland
UG – Upland Grassland

3.5.2 Invasive, Non-Native Species

Noxious weeds are plants that are aggressive competitors, non-native to an area, and are an increasingly serious problem. Most have come from Europe or Asia, either accidentally or as ornamentals that have escaped. Noxious weeds take advantage of any disturbance of the soil and are dispersed by wind, water, animals, people, and vehicles. Once established in a new environment they tend to spread quickly because insects, diseases, and animals that normally control them are absent.

The State of Wyoming designates 30 plants as noxious weeds that the Wyoming Weed and Pest Council (WWPC) and Wyoming Department of Agriculture (WDA) have found to be detrimental, destructive, injurious, or poisonous and should be controlled within Wyoming (WWPC 2019c). Additionally, the WDA and WWPC have identified nine other weeds in Weston County as “declared weeds” that are detrimental to the general welfare of persons residing within the county, and should be controlled if documented (WWPC 2019b). These species are included in Table 3-8 which identifies the 30 Wyoming designated weeds, and the nine declared weeds in Weston County.

A pre-assessment weed inventory was conducted in the vicinity of the Demonstration Plant site on August 1, 2012 to determine if any state designated noxious weeds, Weston County declared weeds, or potentially invasive introduced plant species were present (BKS 2014c). Weeds were also noted in a 2021 assessment (BKS 2021). Canada thistle was the only state-designated noxious weed observed within the Big Sagebrush Shrubland, Meadow Grassland, and Mixed Shrubland vegetation communities either as scattered populations along stream channels and reservoirs or as small, isolated populations scattered throughout the study area. Three Weston County declared weeds were encountered during surveys: wild licorice, broom snakeweed, and curly dock (BKS 2014b, 2014c). Occurrences of these species were typically within and along existing disturbances; however, observations also occurred within native areas proposed for disturbance.

A site visit in 2021 noted Canada thistle appears to be common on the north edge of the Subject Property and likely has been there for some time (BKS 2021).

Table 3-8. Potential occurrence and observed noxious weed locations in the study area

Common Name/ Scientific Name	**Characteristics [a]**	**Distribution/Location in Relation to the Proposed Action [b,c]**
State of Wyoming Designated Weeds		
Field bindweed *Convolvulus arvensis*	Occurs in cultivated fields and waste places; reproduces by seeds and root stalks.	Rocky Mountain herbarium sites throughout Weston County.
Canada thistle *Cirsium arvense*	Initially establishes itself in disturbed soils; reproduces by seed and creeping rootstock.	Located in Big Sagebrush Shrubland, Mixed Shrubland, and Meadow Grassland in study area. Recorded on the north edge of the subject property.
Leafy spurge *Euphorbia esula*	Grows in nearly all soil types and habitats; reproduces by seed and rootstalks.	Recorded sites and Rocky Mountain herbarium sites throughout north Weston County.
Perennial sowthistle *Sonchus arvensis*	Common in gardens, cultivated crops, ditch banks, and fertile waste areas; reproduces by seed and creeping roots.	One Rocky Mountain herbarium site in northeast Weston County.
Quackgrass *Agropyron repens*	Occurs in croplands, pastures, rangeland, and roadsides; reproduces by seed or spreading by rhizomes.	No information for Weston County.
Hoary cress (Whitetop) *Cardaria draba (C. pubescens)*	Prevalent in areas with alkaline or disturbed soils; reproduces from seed and rood segments.	Recorded along State Highway 16 in Weston County.
Perennial pepperweed (giant whitetop) *Lepidium latifolium*	Occurs in riparian areas, waste areas, ditches, roadsides, croplands, range and meadows, and disturbed areas; reproduces by seed and deep-seated rootstalks.	Not known in Weston County.
Ox-eye daisy *Chrysanthemum leucanthemum*	Found in meadows, roadsides, and waste places; reproduces by seed.	Not known in Weston County.
Skeleton bursage *Franseria discolor*	Aggressive growth habits; spread mainly by creeping roots.	One Rocky Mountain herbarium site in southwest Weston County.
Russian knapweed *Centaurea repens*	Occurs in a variety of habitats and forms colonies in cultivated fields, orchards, pastures, and roadsides; reproduces by seeds and creeping rootstocks.	Rocky Mountain herbarium sites in northwest Weston County.
Yellow toadflax *Linaria vulgaris*	Occurs in rangelands, along roadsides, waste places, and cultivated fields; reproduces by seed and creeping roots.	Not known in Weston County.
Dalmation toadflax *Linaria dalmatica*	Found along roadsides and on rangeland; reproduces by seed and underground rootstalks.	Rocky Mountain herbarium sites in northwest and extreme southeast Weston County.
Scotch thistle *Onopordum acanthium*	Found along waste areas and roadsides; very aggressive; reproduces by seed.	Two Rocky Mountain herbarium sites in north Weston County.
Musk thistle *Carduus nutans*	Invades pastures, range and forest lands, roadsides, waste areas, ditch banks, stream banks, and grain fields; reproduces rapidly by seed.	Rocky Mountain herbarium sites in northeast Weston County.
Common burdock *Arctium minus*	Commonly found growing along roadsides, ditch banks, in pastures and waste areas; reproduces by seed.	One Rocky Mountain herbarium site in east Weston County.
Plumeless thistle *Carduus acanthoides*	Occurs in pastures, stream valleys, fields, and roadsides; reproduces by seed.	Not known in Weston County.
Dyers woad *Isatis tinctoria*	Occurs along roadsides and disturbed sites and spreads from there to rangeland and cropland by seeds.	Not known in Weston County.

Common Name/ Scientific Name	Characteristics [a]	Distribution/Location in Relation to the Proposed Action [b,c]
Houndstongue *Cynoglossum officinale*	Found in pastures, along roadsides, and in disturbed habitats; reproduces by seed.	Rocky Mountain herbarium sites likely along State Highway 16 in Weston County.
Spotted knapweed *Centaurea maculosa*	Establish in disturbed soils; very aggressive; reproduces by seed.	Rocky Mountain herbarium sites in southwest Weston County.
Diffuse knapweed *Centaurea diffusa*	Occurs along roadsides, waste areas, and dry rangelands and dominates disturbed areas; reproduces by seed.	Not known in Weston County.
Purple loosestrife *Lythrum salicaria*	Infest moist, marshy, or wet areas such as canals, ditches, or lake edges; reproduce by seed.	Not known in Weston County.
Saltcedar (Tamarisk) *Tamarix* spp.	Invades wetlands, moist ranges, lake sides, stream banks, sandbars, and other saline environments; reproduces by seed.	Rocky Mountain herbarium sites in extreme south Weston County.
Common St. Johnswort *Hypericum perforatum*	Frequently found on sandy or gravelly soils; reproduce by seed or short runners.	One Rocky Mountain herbarium site in extreme southeast Weston County.
Common tansy *Tanacetum vulgare*	Found along roadsides, waste areas, stream banks, and in pastures; reproduces from seed and rootstalks.	Not known in Weston County.
Russian olive *Elaeagnus angustifolia*	Invade low-lying pastures, meadows, or waterways; reproduces by seed.	Rocky Mountain herbarium sites in east and south Weston County.
Black Henbane *Hyoscyamus Niger*	Invades disturbed soils and waste areas.	Rocky Mountain herbarium sites in central and southeast Weston County.
Common Mullein *Verbascum thapsus*	Invasive in disturbed soils and on well-drained rocky soils.	Not known in Weston County.
Yellow starthistle *Centaurea solstitialis*	Found in rangeland, edges of cropland, abandoned farmlands and pastures, along roadsides, railways, and recreational areas.	Not known in Weston County.
Ventenata *Ventenata dubia (Leers)*	Aggressive invader of rangeland and disturbed sites and found in grain crops.	No information for Weston County.
Medusahead rye *Taeniatherum caput-medusae*	Invades rangeland and grows in variety of conditions.	Not known in Weston County.
Weston County Declared Weeds		
Wild licorice *Glycyrrhiza lepidota*	Commonly found in moist, sandy soils of meadows, pastures, prairies, ditches and riverbanks, and waste areas; reproduces from deep roots and seed.	Found in Mixed Grassland; no previous records identified in Weston County (WWPC, 2014c).
Puncturevine *Tribulus terrestris*	Invade roadsides, pastures, fields, and other disturbed areas; foliage toxic to sheep and other grazers; reproduces from seed.	Not known in Weston County.
Sulfur cinquefoil *Potentilla recta*	Found in disturbed areas such as roadsides and pastures; colonies are also often seen in undisturbed sites; flowers from May to July.	Not known in Weston County.
Broom snakeweed *Gutierrezia sarothrae*	Found on rocky plains, dry foothills, ridgetops, mountain slopes, and semi-desert valleys; flowers from August to October.	Located in Big Sagebrush Shrubland; Rocky Mountain herbarium sites throughout Weston County.
Downy brome (cheatgrass) *Bromus tectorum*	Invades roadsides, cropland, hay land, pastureland, rangeland, and waste places, usually on dry, alkaline soils; reproduces from seed.	Present in study area; Rocky Mountain herbarium sites throughout Weston County; recorded sites in northeast Weston County.
Musk mustard *Chorispora tenella*	Occurs in dry meadows; flowers from April through June.	No information for Weston County.

Common Name/ Scientific Name	Characteristics [a]	Distribution/Location in Relation to the Proposed Action [b,c]
Black medic *Medicago lupulina*	Occurs in a variety of habitats including turf, agricultural land, and disturbed areas; reproduces from seed; flowering occurs from April to July.	Rocky Mountain herbarium sites scattered throughout Weston County.
Common purslane *Portulaca oleracea*	Invades vegetable gardens, bare areas, roadsides, and agricultural areas; flowers from May through September; reproduces by seed or stem fragments.	Not known in Weston County.
Curly dock *Rumex crispus*	Occurs in ditches, roadsides, wetlands, pastures, agricultural areas, disturbed areas; flowers year-round; seeds dispersed by wind and water.	Located in Meadow Grassland; Rocky Mountain herbarium sites scattered throughout Weston County.

[a] Sources: (WWPC 2019c, 2019b)
[b] Sources: (BKS 2014b, 2014c, 2021)
[c] (WWPC 2019a)

3.5.3 Plant and Animal Species of Special Status

Section 6.3.5 of NUREG 1748 requires a discussion of important wildlife species and their spatial and temporal distributions, including their relative abundance and life histories, critical life stages, biologically significant activities, seasonal habitat requirements and population fluctuations, food chain, and other interspecific relationships (NRC 2003). To the extent that such information is known for wildlife within the project area and vicinity, “important species” include those that (1) are protected by federal statute (Endangered Species Act (ESA), Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act [MBTA]), (2) are potentially “at risk” and have a special management status assigned by the state wildlife agency and/or federal land management agency, and (3) are managed by the state wildlife agency for harvest, recreation, and revenue within the state.

3.5.3.1 Species and Habitat Surveys

Wildlife surveys were conducted within the vicinity of the Demonstration Plant site on several occasions between 2011 and 2018. Results of the 2011-2013 baseline survey are in *2012 and 2013 Wildlife Baseline* (ICF 2014). The 2018 *Baseline Data Supplemental Report* describes additional wildlife assessments completed in 2014, 2015, and 2018 by Precision Wildlife Resources, LLC (PWR) (RER 2019).

Wildlife surveys included the following:

- an assessment of the available habitats for potential use by threatened and endangered species and/or other high-value or unusual wildlife;
- big game winter distribution surveys;
- searches for new upland game bird leks and counts with activity confirmation at known leks;
- winter use surveys for upland game birds (primarily greater sage-grouse, *Centrocercus urophasianus*);
- searches for new raptor nests and occupancy surveys at known nests or territories;
- migratory and breeding bird surveys (BBS), including focused surveys for migrating and brooding waterfowl and shorebirds;
- mountain plover (*Charadrius montanus*) surveys;

- searches for and delineation of prairie dog (*Cynomys* spp.) colonies;
- spotlight surveys for lagomorphs (rabbits and hares); and
- spotlight surveys for swift fox (*Vulpes velox*).

All incidental sightings of wildlife (including any federally listed species and other species of concern) within the survey areas were recorded. All survey protocols were designed to meet federal (Forest Service and FWS) and state (WGFD and WDEQ) agency standards. No surveys were conducted for mammalian predators, furbearers, small mammals, bats, reptiles, amphibians, fisheries, aquatic or terrestrial invertebrates, or periphyton as part of the baseline study.

The surveyed area comprised the Bear Lodge Project area plus a 2-mile buffer which encompasses the Demonstration Plant site and included four wildlife habitats: (1) upland shrub, (2) bottomland shrub, (3) grasslands, and (4) woodlands. They also noted presence of disturbed areas, altered by human activity. These habitats somewhat correspond to vegetation types that occur within the vegetation baseline survey area (no woodlands are present), described in section 3.5.1:

1. Upland Shrubland corresponds to Big Sagebrush Shrubland;
2. Bottomland Shrubland corresponds to Greasewood Shrubland and Mixed Shrubland;
3. Grassland corresponds to Meadow Grassland, Upland Grassland, and Reclaimed Grassland.

3.5.3.2 Federally Listed Species

The 2012 wildlife baseline study (ICF 2014) found that the proposed action would not adversely affect any threatened or endangered species (Appendix E). The updated wildlife baseline completed by PWR found that as of November 2018, there were two species listed under the ESA for Weston County including the Ute ladies'-tresses (*Spiranthes diluvialis)* and northern long-eared bat *(Myotis septentrionalis)* (RER 2019).

The greater sage-grouse (*Centrocercus urophasianus*) was previously listed as a candidate species under the ESA, but in 2015 the FWS determined it was not warranted for listing and would no longer be a candidate species (RER 2019). However, sage grouse are still managed at the state level through implementation of the sage-grouse core population and connectivity area policy.

Each of these species is described below.

Ute Ladies'-Tresses

Ute ladies'-tresses orchid was listed as threatened in 1992 (FWS 1992). Populations have been reported in northern Niobrara, Converse, Goshen, and Laramie counties but not in Weston County (Walter Fertig, Rick Black, and Paige Wolken 2005). Ute ladies'-tresses inhabits seasonally flooded river terraces, sub-irrigated or spring-fed abandoned stream channels and valleys, and lakeshores (FWS 1992). Surveys for the species conducted during the past decade have located additional populations along irrigation canals, berms, levees, irrigated meadows, excavated gravel pits, roadside barrow pits, reservoirs, and other human-modified wetlands (Walter Fertig, Rick Black, and Paige Wolken 2005).

Surveys were conducted from June through August 2010 (BKS 2014b). Habitat and species surveys for Ute ladies'-tresses were conducted on August 1, 2012, in the vicinity of the Demonstration Plant site. Habitat suitability was evaluated based on the presence of the following characteristics: late

season perennial water source, associated vegetation species, sandy or loamy textured soils, gradual transitions between uplands and water body or drainages, vegetation density of 75 to 90%, vegetation height less than 18 inches, and non-alkaline soils. Late season perennial water sources were present, according to field observations made in August 2010. However, where late season perennial water sources were present, associated vegetation species, appropriate soil textures, gradual transitions, vegetation cover and density, and non-alkaline sandy or loamy textured soils were either not present or not present in sufficient combination to provide suitable habitat for Ute ladies'-tresses. No individuals or populations of Ute ladies'-tresses were found during field surveys, and based on the lack of suitable habitat characteristics, local habitats in the project area were confirmed as unsuitable for Ute ladies'-tresses (BKS 2014b).

There were no requisite updates to the size and mapping of the vegetation community in a supplemental assessment of baseline vegetation completed in 2018 (RER 2019).

Northern Long-eared Bat

The FWS proposed the northern long-eared bat for listing as endangered under the ESA in October 2013 (FWS 2013). The northern long-eared bat was still listed under the ESA for Weston County during the 2018 wildlife baseline update (RER 2019).

The northern long-eared bat primarily inhabits forested regions. In Wyoming, it can be found in wooded riparian zones in badlands and prairies to conifer and deciduous woodlands at higher elevations, using the habitat in a variety of ways by foraging above, within, and below the canopy; within forest openings, over water, along forest trails, roads, and riparian areas; and at the forest edge (Hester and Grenier 2005). Although Wyoming is considered at the extreme western edge of its distributional range, the northern long-eared bat is considered abundant in the Black Hills National Forest in South Dakota (FWS 2014) where it uses abandoned mines and caves as hibernacula (Tigner and Stukel 2003).

WGFD conducted mist-net surveys for forest bats in northern and northeastern Wyoming during the summer of 2019 (WGFD 2021b). They captured 74 adult northern long-eared bats during the survey. In 2020, bat activity was recorded at five of eight roosting trees with the use of passive infrared camera observation (WGFD 2021b). The patterns observed suggest that the bats will continue to frequent these trees as maternity roosts throughout the year.

Previous surveys conducted by the WGFD captured female northern long-eared bats showing evidence of lactation or post-lactation (Cudworth, Johnson, and Grenier 2011). All were captured in Weston and Crook counties approximately 25 to 30 miles from the project area. There were no records of northern long-eared bats in the immediate vicinity of the (Cudworth, Johnson, and Grenier 2011) Demonstration Plant site reported by the Wyoming Natural Diversity Database (WNDD 2022).

Given these observations, the distributional range of the northern long-eared in the region encompasses the project area. However, no substantial amounts of woodlands and prominent rocky features are present within the project area; therefore, no surveys for bats were conducted (ICF 2014). The species' presence is unlikely based on the absence of suitable habitat in the project area and distances of known occurrences from the project area.

Greater Sage Grouse

The Greater Sage-Grouse Core Area Protection (Wyoming Executive Order [EO] 2008-2) was first implemented by Wyoming Governor Freudenthal in 2008. It has been renewed and revised several

times from 2008 to 2019 (EO 2010-4; 2011-5; 2013-3; 2015-4; 2017-2; 2019-3). The original EO established Core Population Areas ("Core Area") with which new developments are managed to prevent declines in greater sage-grouse populations across the state. The most recent EO (2019-3) designates sage-grouse core population area in the vicinity of the site, but the proposed Project area remains outside of any defined sage-grouse core population areas or connectivity corridors (WGFD 2019). At its closest point, the western border of the project area is approximately 1 mile away from the Thunder Basin greater sage-grouse core area (see Map 23).

Surveys for the presence of sage-grouse and use of the project area were conducted in the winter of 2011/2012 and summer of 2013 using accepted techniques (ICF 2014). The two known sage-grouse leks (communal mating sites; Upton 3 and Stellwagon) within 4 miles of the project area had been active since 2011. A previously undocumented lek (the McCrady lek) was found in spring 2012, approximately 2.1 miles west of the project area. The McCrady lek was active in 2013 and 2014 with peak counts of 17 and 7 attending males, respectively.

In 2014, WGFD identified six active leks, two inactive leks, and three leks with unknown status within a 10-mile radius of the project area. In 2001, there was only one known active lek within that distance (active leks have been attended by male sage-grouse during specific strutting seasons). Peak counts of males attending leks during spring are used as a population index to evaluate trends in greater sage-grouse populations (Connelly et al. 2004).

In addition to breeding habitat, areas with high sagebrush density west of the project area may provide habitat for nesting or wintering sage-grouse. Several flocks of sage-grouse were observed among the dense sagebrush stands in the western extent of the on-site wildlife survey area during winter aerial surveys in 2012 and 2013. A total of 123 sage-grouse were recorded within or near the Upton survey area during those efforts (ICF 2014).

As described in the 2018 wildlife baseline update in (RER 2019), surveys completed between 2016 and 2018 recorded no sage-grouse at the Upton 3 lek, and a peak of 38 males at the Stellwagon lek. The peak count of sage-grouse at the McCrady lek during these surveys was 13 males. No additional leks were found during these surveys.

3.5.3.3 Wyoming Species of Greatest Conservation Need

The State Wildlife Action Plan (SWAP) identifies challenges to wildlife conservation along with effects to individual wildlife species associated with alterations of habitat in the state. The SWAP identifies Wyoming Species of Greatest Conservation Need (SGCN) and assigns each species at risk of population decline and/or habitat threats/loss a Native Species Status number, 1 through 4. This SGCN list was updated in 2017 to include a total of 229 designated species in Wyoming. Many of these species are unlikely to occur in the vicinity of the Demonstration Plant site due to the absence of suitable habitat or limits to their geographical range (RER 2019).

Previous baseline surveys conducted by ICF documented species from this list on-site in the winter of 2011/2012 and summer 2013 using accepted techniques (ICF 2014). Other species were documented in the vicinity of the area through records provided by the WNDD (2014) or from surveys completed by other sources (Sauer et al. 2014; WNDD 2014). The 2018 Baseline update provided an updated potential and documented species list for the area near the Demonstration Plant site. All potential or documented species within this area are identified in Table 3-9. The presence of suitable habitats onsite contributed to other possible listed species though there were no specific observations.

The geographic distribution of each species in Table 3-9 overlaps the project area, based on their ranges and habitat associations in the Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (WGFD 2009).

Table 3-9. Wyoming species of greatest conservation that could potentially occur in the vicinity of the Demonstration Plant site

Common Name Scientific Name	Habitat [a]	Potential Occurrence (Prior to 2015) [b,c]	Reported in Survey Area in Wildlife Update (2018) [d]	State SGCN [f]
Mammals				
Western Small-footed Myotis *Myotis ciliolabrium*	Sagebrush-grasslands; eastern great plains, Buildings used for roosts, nurseries; Hibernates in caves, mines. Feeds on flying insects.	Possible	No	NSS3
Long-eared Myotis *Myotis evotis*	Ponderosa pine, juniper, cottonwood riparian; roosts in caves, buildings mines. Forages over water	Possible	No	NSS2
Little Brown Myotis *Myotis lucifugus*	Coniferous and deciduous forests, sagebrush-grasslands, riparian shrub, urban areas. Roosts in caves, buildings. Forages over water	Documented in vicinity	No	NSS3
Long-legged Myotis *Myotis volans*	Coniferous and deciduous forests, basin-prairie, and mountain-foothills shrublands, riparian areas.	Possible	No	NSS2
Hoary Bat *Lasiurus cinereus*	Coniferous and deciduous forests, aspen, basin-prairie shrublands, Roosts in deciduous trees; rarely uses buildings. Feeds on flying insects	Possible	No	NSS4
Silver-haired Bat *Lasionycteris noctivagans*	Coniferous and deciduous forests, often near water. Forages over water	Documented in vicinity	No	NSS4
Big Brown Bat *Eptesicus fuscus*	Coniferous and deciduous forests, basin-prairie, and mountain-foothills. Roosts and hibernates in buildings, occasionally in rock crevices,	Possible	No	NSS3
Black-tailed Prairie Dog *Cynomys ludovicianus*	Shortgrass and midgrass grasslands, constructs burrow system to support colony	Documented in vicinity	Yes	NSS3
Olive-backed Pocket Mouse *Perognathus fasciatus*	Basin-prairie shrublands, sagebrush/grasslands, eastern great plains	Possible	No	NSS3
Hispid Pocket Mouse *Chaetodipus hispidus*	Sagebrush-grasslands, eastern great plains grasslands.	Possible	No	NSS3
Plains Harvest Mouse *Reithrodontomys montanus*	Eastern great plains grasslands, most frequently grama grasslands.	Possible	No	NSS3
Prairie Vole *Microtus ochrogaster*	Basin-prairie shrublands, grasslands, eastern great plains grasslands,	Possible	No	NSS3
Swift Fox *Vulpes velox*	Eastern great plains grasslands, occasionally agricultural areas.	Documented in vicinity	No	NSS4
Greater sage-grouse *Centrocercus urophasianus*		---[e]	Yes	
Birds				
Northern Pintail *Anas acuta*	Marshes and lakes in association with most habitats below 8,000 feet. Present on BBS routes within 50 miles.	Documented in vicinity	Yes	NSS3
Canvasback *Aythya valisineria*	Marshes, lakes, rivers.	Documented in vicinity	Yes	NSS3
Redhead *Aythya americana*	Marshes, lakes, rivers. Present on BBS routes within 50 miles.	Documented in vicinity	Yes	NSS3
Lesser Scaup *Aythya affinis*	Marshes, lakes, rivers.	Possible	No	NSS3
Western Grebe *Aechmophorus occidentalis*	Marshes, lakes; Nest is a floating platform of reeds in shallow water	Possible	No	NSS4

Common Name Scientific Name	Habitat [a]	Potential Occurrence (Prior to 2015) [b,c]	Reported in Survey Area in Wildlife Update (2018) [d]	State SGCN [f]
American White Pelican *Pelecanus erythrorhynchos*	Rivers, lakes, ponds. Usually nests in colonies on islands	Documented in vicinity	No	NSS3
American Bittern *Botaurus lentiginosus*	Marshes; Nests on dry ground above the water or mud in emergent vegetation.	Possible	No	NSS3
Great Blue Heron *Ardea herodias*	Cottonwood-riparian, lakes, rivers; Nests in a tree, usually deciduous, colonial rookery	Documented in vicinity	Yes	NSS4
Snowy Egret *Egretta thula*	Marshes, lakes, rivers. Nests in bulrushes or cattails, or in a shrub on an island.	Possible	---[e]	NSS3
Black-crowned Night-Heron *Nycticorax nycticorax*	Marshes, lakes. Nests in a low shrub or on the ground on an island or in bulrushes or cattails.	Possible	No	NSS3
White-faced Ibis *Plegadis chihi*	Marshes, wet-moist meadows, lakes, irrigated meadows. Nests in bulrushes or cattails	Possible	No	NSS3
Bald Eagle *Haliaeetus leucocephalus*	coniferous forests, cottonwood-riparian near large lakes and rivers. Forages in open habitats during the winter	Documented in vicinity	Yes	NSS2
Swainson's Hawk *Buteo swainsoni*	Most habitats below 9,000 feet with open areas for foraging. Nests in an old nest, usually magpie, in a coniferous or deciduous tree.	Possible	No	NSS4
Ferruginous Hawk *Buteo regalis*	Basin-prairie shrublands; eastern great plains. Nests on a rock outcrop, the ground, a bank, or in a tree	Documented in vicinity	Yes	NSS3
Merlin *Falco columbarius*	Most habitats below 8,500 feet. Nests in an old nest, usually magpie, in a coniferous or deciduous tree. Present on BBS routes within 50 miles	Possible	No	NSS3
Virginia Rail *Rallus limicola*	Marshes, nests on the Nests on the ground, occasionally over water or mud. Present on BBS routes within 50 miles	Possible	No	NSS3
Sandhill Crane *Grus canadensis*	Wet-moist meadow grasslands, sedge meadows, irrigated native and introduced meadows, small grains, marshes.	Documented in vicinity	No	NSS3
Mountain Plover *Charadrius montanus*	Shortgrass, mixed grass prairies, sagebrush-grasslands. Often associated with prairie dog towns. Present on BBS routes within 50 miles	Possible	No	NSS4
Upland Sandpiper *Bartramia longicauda*	Eastern great plains grasslands, dryland grass pastures. Present on BBS routes within 50 miles	Documented in vicinity	Yes	NSS4
Long-billed Curlew *Numenius americanus*	Sagebrush-grasslands; eastern great plains, wet-moist meadow grasslands; irrigated native meadows. Present on BBS routes within 50 miles	Possible	No	NSS3
Burrowing Owl *Athene cunicularia*	Grasslands, basin-prairie shrublands, agricultural areas. Nests in mammal burrow, especially prairie dogs. Present on BBS routes within 50 miles	Documented in vicinity	Yes	NSS4
Short-eared Owl *Asio flammeus*	Basin-prairie shrublands, grasslands, marshes, irrigated native meadows, Nests on the ground, Present on BBS routes within 50 miles	Documented in vicinity	Yes	NSS4
Willow Flycatcher *Empidonax traillii*	Riparian shrub including willow, hawthorn, water birch, alder; below 9,000 feet. Present on BBS routes within 50 miles	Possible	---[e]	NSS3
Sage Thrasher *Oreoscoptes montanus*	Basin-prairie and mountain-foothills shrublands. Nest is concealed in or beneath a sagebrush shrub. Present on BBS routes within 50 miles	Documented in vicinity	Yes	NSS4
Brewer's Sparrow *Spizella breweri*	Basin-prairie and mountain-foothills shrublands, especially sagebrush. Present on BBS routes within 50 miles	Documented in vicinity	Yes	NSS4
Sage Sparrow *Amphispiza belli*	Basin-prairie and mountain-foothills shrublands Usually nests in or under a sagebrush. Present on BBS routes within 50 miles	Possible	No	NSS4

Common Name Scientific Name	Habitat [a]	Potential Occurrence (Prior to 2015) [b,c]	Reported in Survey Area in Wildlife Update (2018) [d]	State SGCN [f]
Grasshopper Sparrow *Ammodramus savannarum*	Eastern great plains grasslands, wet-moist meadow grasslands, agricultural areas. Nests on ground.	Documented in vicinity	Yes	NSS4
McCown's Longspur *Calcarius mccownii*	Eastern great plains foothills grasslands, basin-prairie shrublands, agricultural areas. Present on BBS routes within 50 miles	Documented in vicinity	No	NSS4
Chestnut-collared Longspur *Calcarius ornatus*	Eastern great plains foothills grasslands, basin-prairie shrublands, agricultural areas. Present on BBS routes within 50 miles	Possible	No	NSS4
Dickcissel *Spiza americana*	Eastern great plains grasslands; nests on the ground. Present on BBS routes within 50 miles	Possible	Yes	NSS4
Bobolink *Dolichonyx oryzivorus*	Eastern great plains grasslands; nests on the ground. Present on BBS routes within 50 miles	Possible	No	NSS4
Loggerhead Shrike *Lanius ludovicianus*		---[e]	Yes	
Golden Eagle *Aquila chrysaetos*		---[e]	Yes	
Reptiles				
Western Spiny Softshell *Apalone spinifera hartwegi*	Permanent lakes, ponds, and large streams in association with sandbars and other sandy aquatic substrates, below 6,000 feet.	Possible	---[e]	NSS4
Eastern Yellow-bellied Racer *Coluber constrictor flaviventris*	Woodlands and scarp woodlands within the plains and foothills zones, often near water.	Documented in vicinity	No	NSS4
Amphibians				
Great Plains Toad *Anaxyrus cognatus*	Deposits eggs in ponds and flooded areas formed by heavy rains. Plains grasslands, sandhills, agricultural areas	Possible	No	NSS4
Northern Leopard Frog *Lithobates pipiens*	Margins, banks of marshes, ponds, streams, other permanent water	Documented in vicinity	No	NSS4
Boreal Chorus Frog *Pseudacris maculata*	Moist margins of marshes, ponds, small lakes, creeks, up to 12,000 feet.	Documented in vicinity	Yes	NSS4
Fish				
Plains Minnow *Hybognathus placitus*	Prefers slow moving, turbid streams, and side pools where it feeds on stream-bottom vegetation. In Upper Beaver Creek HUC10	Possible	---[e]	NSS3

[a] Source: WGFD, 2009; WNDD, 2014; WNDD, 2012.
[b] Potential Occurrence:
Unlikely: May or may not occur in Weston County but no suitable habitat is present.
Possible: Occurs in Weston County, suitable habitat is present, may have been observed in the region but not observed at the Site.
[c] Records of species provided by (WNDD 2014) and observations reported by (ICF 2014).
[d] (RER 2019)
[e] Not included in list of potential and documented species at the time
[f] State Species of Greatest Conservation Need identified in the State Wildlife Action Plan (WGFD, 2010): Native Species Status: NSS2, population or distribution is restricted, declining with possible extirpation; severe limiting factors may or may not be increasing. NSS3, population or distribution is restricted, declining but extirpation not imminent; severe limiting factors are not increasing. NSS4, population or distribution may be declining or stable; severe limiting factors are not increasing or are moderate and may increase in severity.

3.5.4 Migratory Birds

The MBTA of 1918, as amended, prohibits hunting, taking, capturing, killing, possessing, selling, purchasing, shipping, transporting, or exporting migratory birds, parts, nests, and eggs covered by the MBTA. Non-native birds are not covered by the MBTA. Conservation efforts typically focus on migratory species that are listed as Birds of Conservation Concern (BCC). BCC have been identified by the FWS (2008) for different Bird Conservation Regions (BCR) in the US. The entire project area is in BCR 17, the Badlands and Prairies region.

Seventeen BCC species could occur within the project area based on their known distributions and habitat associations in western Wyoming (WGFD 2009). Included in Table 3-10 is the Conservation Priority for species identified by Wyoming Partners in Flight (Nicholoff 2003). Eight BCC species were observed on-site during baseline wildlife surveys conducted by ICF (2014). They include the ferruginous hawk, golden eagle, upland sandpiper, burrowing owl, loggerhead shrike, sage thrasher, Brewer's sparrow, and grasshopper sparrow. Short-eared owls and McCown's longspurs also were reported on the Upton BBS route (number 92049) that borders a portion of the project area on a BBS survey conducted by the National Biological Survey (Sauer et al. 2014).

Long-term (1993 to 2012) population trends within BCR 17 are available for most of the 17 BCC species (Sauer et al. 2014) and are included in Table 3-10. The compiled data and analyses show that populations of upland sandpiper, sage sparrow, and dickcissel are increasing but populations of black-billed cuckoo, loggerhead shrike, and Brewer's sparrow have been decreasing within the Badlands and Prairies BCR 17. Upland sandpiper, loggerhead shrike, and Brewer's sparrow have been documented near the Demonstration Plant site (ICF 2014).

Data compiled for 17 BBS routes within a 50-mile radius surrounding the project area (9 routes in Wyoming and 8 in South Dakota) also indicate that local populations of upland sandpipers have increased between 1994 and 2013 and populations of grasshopper sparrows have increased during the past 10 years (Table 3-10). There is insufficient data to estimate population trends for other sagebrush obligate BCC species (Brewer's sparrows, vesper sparrow, sage sparrows, and sage thrashers).

A total of 167 bird species listed as Nearctic and Neotropical migratory birds by the USFWS, Division of Bird Habitat Conservation, and protected under the MBTA (FWS 2010) have been observed within 50 miles from the project area between 1994 and 2013. Of these 167 bird species, 83 are known to occur or might occur in habitats on or adjacent to the project area. Trends for four species in the local surrounding area indicate their populations had been decreasing during those years, while populations for 19 species appear to have been increasing. Data for 43 other species indicate their populations have been relatively stable.

Raptor species observed (not nesting) in the project area include the bald eagle (*Haliaeetus leucocephalus*), northern harrier (*Circus cyaneus*), golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (Buteo regalis), American kestrel (*Falco sparverius*), and burrowing owl (*Athene cunicularia*). Rough-legged hawks (*Buteo lagopus*) were also observed but are present only during winter. Nesting within the wildlife survey area was confirmed for the golden eagle, red-tailed hawk, and burrowing owl (ICF 2014). None of the active raptor nests were within the vicinity of the Demonstration Plan Project area.

Based on additional monitoring as described in the 2018 baseline update, four species of raptors (the golden eagle, red-tailed hawk, ferruginous hawk, burrowing owl) have documented nests within the survey area (RER 2019).

The 2018 baseline update also reported five avian species (golden eagle, Brewer's sparrow, lark bunting, sage thrasher, willet) protected under the MBTA that have been recorded during monitoring efforts after 2014 (RER 2019). The Brewer's sparrow and lark bunting have been documented in Weston County and were documented within the survey area during each year of wildlife monitoring after 2014. The sage thrasher has been recorded in localized areas within the survey area corresponding to their preferred habitats but was not recorded past 2015. The willet was recorded in 2018 due to favorable habitat conditions that year.

Table 3-10. Birds of conservation concern that occur or may occur in the Demonstration Plant site

Common Name Scientific Name [a]	**Habitat** [b]	**PIF Conservation Priority** [c]	**Observed On-site (Prior to 2015)** [d]	**Reported in Survey Area in Wildlife Update (2018)**[e]	**BCR 17 Trend** [f] **1993 to 2012**	**Local Trend** [g] **1994 to 2013**
Ferruginous Hawk *Buteo regalis*	Nests in isolated trees, rock outcrops, artificial structures, ground near prey base.	Level I	Yes	Yes	No Trend	Insufficient Data
Golden Eagle *Aquila chrysaetos*	Nests in a tree or on a cliff face in most open habitats.	Level III	Yes	Yes	No Trend	Insufficient Data
Prairie Falcon *Falco mexicanus*	Nests in a rock cavity or on a ledge on a cliff or rock outcrop.	Level III	No	No	No Trend	Insufficient Data
Mountain Plover *Charadrius montanus*	In shortgrass and mixed grass prairie, nests on the ground.	Level I	No	No	Insufficient Data	Insufficient Data
Upland Sandpiper *Bartramia longicauda*	Eastern great plains grasslands, dryland grass pastures; nest on the ground.	Level I	Yes	Yes	Increasing	Increasing*
Long-billed Curlew *Numenius americanus*	Nests on the ground; often in wet-moist meadow grasslands or irrigated native meadows with aquatic areas nearby.	Level I	No	No	No Trend	Insufficient Data
Black-billed Cuckoo *Coccyzus erythropthalmus*	Deciduous, mixed coniferous woodlands, cottonwood riparian.	Level II	No	--	Decreasing	Insufficient Data
Burrowing Owl *Athene cunicularia*	Grasslands and agricultural areas; nests in mammal burrow, often a prairie dog burrow.	Level I	Yes	Yes	No Trend	Insufficient Data
Short-eared Owl *Asio flammeus*	Prairie shrublands, grasslands, marshes, native meadows; nests on the ground.	Level I	No	Yes	No Trend	Insufficient Data
Loggerhead Shrike *Lanius ludovicianus*	Nest is usually in deciduous tree or shrub in pine-juniper woodland or basin-prairie shrublands.	Level II	Yes	Yes	Decreasing	Insufficient Data
Pinyon Jay *Gymnorhinus cyanocephalus*	Ponderosa pine and pine-juniper woodland;	Not determined	No	No	No Trend	Insufficient Data

	nests in juniper or pine tree.					
Sage Thrasher *Oreoscoptes montanus*	Nest is concealed in or beneath a sagebrush shrub in sagebrush shrublands.	Level II	Yes	Yes	No Trend	Insufficient Data
Brewer's Sparrow *Spizella breweri*	Nests in sagebrush, occasionally greasewood, rabbitbrush in shrublands.	Level I	Yes	Yes	Decreasing	Insufficient Data
Sage Sparrow *Amphispiza belli*	Usually nests in or under sagebrush shrub in sagebrush shrublands.	Level I	No	No	Increasing	Insufficient Data
Grasshopper Sparrow *Ammodramus savannarum*	Nests in depression on ground in eastern great plains grasslands, wet-moist meadow grassland.	Level II	Yes	Yes	No Trend	Increasing**
Baird's Sparrow *Ammodramus bairdii*	Nests in depression on ground in eastern great plains grasslands, short-grass prairie.	Level I	No	No	No Trend	Insufficient Data
Chestnut-collared Longspur *Calcarius ornatus*	Nests in depression on ground in eastern great plains grasslands, agricultural areas.	Level II	No	No	No Trend	Insufficient Data
McCown's Longspur *Rhynchophanes mccownii*	Nests in depression on ground in eastern great plains grasslands, agricultural areas.	Level I	No	No	No Trend	Insufficient Data
Dickcissel *Spiza americana*	Nests on ground in eastern great plains grasslands.	Level II	No	Yes	Increasing	Insufficient Data

[a] Species observed on-site and/or reported on one or more of 17 BBS routes within 50 miles surrounding the project area between 1994 and 2013.
[b] (WGFD 2009)
[c] Conservation Priorities from the Wyoming Partners in Flight Bird Conservation Plan (Nicholoff 2003).
Level I: Species needs conservation action.
Level II: Species' status requires monitoring.
Level III: Species of local interest.
[d] (ICF 2014)
[e] (RER 2019)
[f] (Sauer et al. 2014)
[g] Linear trends of birds counted per route averaged for data available on 17 BBS routes within 50 miles surrounding the project area in Crook, Weston, Campbell, Converse, and Niobrara counties. Wyoming and Butte, Lawrence, Pennington, and Custer counties, South Dakota between 1994 and 2013.

3.5.5 Terrestrial Wildlife Species

The following sections focus on important species that are managed by the state wildlife agency for harvest, recreation, and revenue within the state.

Wildlife baseline surveys (ICF 2014) followed the survey requirements and protocols used and approved by the USFWS, USFS, WGFD, and WDEQ. Survey protocols for Threatened and Endangered (T&E) species (including petitioned, candidate, and proposed species) followed current federal (FWS and USFS) guidelines. All other survey methods were consistent with the procedures and schedules recommended in the Handbook of Biological Techniques (WGFD 2007) and WDEQ-Land Quality Division (LQD) Guideline No. 5 for Wildlife (WDEQ-LQD 1994).

Updated wildlife baselines were completed in 2018 following all appropriate guidelines (RER 2019).

3.5.5.1 Big Game

The project area coincides with the seasonal ranges of pronghorn (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*). Big game populations, also known as Herd Units (HU), extend over large areas within which animals utilize seasonal ranges. Pronghorn in the project area are within the Cheyenne River HU (HU 740) which covers approximately 7,466 mi^2 in northeastern Wyoming; 6,443 mi^2 (or 86%) in the HU are occupied by pronghorn on a seasonal or year-round basis, the remaining areas are not occupied. The project area coincides with winter-yearlong range, used year-round with an influx of animals during winter. Pronghorns (157 in January, 16 in February) were observed west of the project area during winter 2013. None were observed during winter 2012 (ICF 2014).

The Cheyenne River pronghorn population increased through 2007 with an estimated 55,240 animals but declined steadily with 29,560 animals in the 2013 population. Productivity of fawns declined between 2003 and 2013. The population declined since 2007 as WGFD management focused on increased female harvest to control population growth intended to achieve the population objective of 38,000 animals (Sandrini 2014). The population is not evenly distributed, becoming more clumped during winter with animals moving on winter-yearlong range and during summer as does with fawns concentrate in habitats with more succulent vegetation and water.

Pronghorn harvest in the vicinity of the Demonstration Plant site is indicative of a declining population, and hunter success declined from 2002 to 2013. Hunter success of pronghorn antelope also declined from 2017 to 2020 (WGFD 2020).

Mule deer on the project area are within the Cheyenne River HU (HU 740) which covers approximately 6,350 square miles in northeastern Wyoming; 5,485 square miles (or 86%) in the HU are occupied by mule deer on a seasonal or year-round basis. The project area is part of the yearlong range. Mule deer were observed (11 in winter 2012 and winter 2013) southeast of the project area in the vicinity of Iron Creek (ICF 2014).

The Cheyenne River mule deer population increased through 2000 with a peak estimated at 41,100 deer but declined to 18,180 animals in 2013. Fawn production significantly declined overall from 2003 to 2013 caused in part by poor range conditions (especially big sagebrush vegetation) and drought, particularly during 2012. Mule deer harvest, especially harvest of does, declined dramatically through 2013, in part due to hunter restrictions imposed by private landowners forcing intense hunting pressure on public lands. The population is not evenly distributed, gathering in winter as animals move on winter-yearlong range and summer as animals concentrate in habitats with more succulent vegetation.

The project area is within Hunt Area 8 for mule deer. Hunter success of mule deer within the hunt area declined from 2002 to 2013. It also rapidly decreased between 2017 and 2020 from 64.8% to 33.9% (WGFD 2020).

There are no population estimates available for mountain lions (Puma concolor) and very few are harvested annually within an area that includes the project area. No mountain lions nor their sign were reported during baseline wildlife surveys or during subsequent wildlife surveys (ICF 2014; RER 2019).

3.5.5.2 Upland Game Birds and Turkeys

Three upland game bird species were documented in the vicinity of the Demonstration Plant site during wildlife baseline surveys from winter 2012 through summer 2013 (ICF 2014). They include the greater sage-grouse, sharp-tailed grouse (*Tympanuchus phasianellus*), and wild turkey (*Meleagris gallopavo*).

Turkeys were seen in ponderosa pine habitat approximately 2 miles north of the project area during baseline surveys in winter 2012. Sharp-tailed grouse were seen in the same vicinity during March 2012; a hen and two juvenile sharp-tailed grouse were also seen south of the project area during June 2012 (ICF 2014). Greater sage-grouse, sharp-tailed grouse, and wild turkey were also reported in the vicinity of the Demonstration Plant site during subsequent wildlife surveys as described in the 2018 baseline update (RER 2019).

3.5.5.3 Migratory Game Birds

Migratory waterfowl and mourning doves are classified as migratory birds but are harvested annually. Mourning doves were observed in upland shrub habitat during wildlife baseline surveys (ICF 2014). Mourning doves were also observed in the vicinity of the Demonstration Plant site during subsequent wildlife surveys (RER 2019). Mourning doves also occur throughout the region surrounding the project area. Analysis of BBS data compiled for routes within 50 miles of the project indicated that the mourning dove population has significantly ($P<0.01$) increased between 1994 and 2013.

Thirteen species of waterfowl (ducks, geese) were observed on or near the project area during spring migration, 2013. Several small ponds and livestock impoundments on drainage near the Demonstration Plant site provide migration, feeding and refuge habitat. In addition, nesting and brood rearing was documented for nine waterfowl species including American wigeon (*Anas americana*), mallard (*Anas platyhynchos*), blue-winged teal (*Anas discors*), gadwall (*Anas strepera*), green-winged teal (*Anas carolinensis*), northern shoveler (*Anas clypeata*), northern pintail (*Anas acuta*), ruddy duck (*Oxyura jamaicensis*), ring-necked duck (*Aythya collaris*), and Canada goose (*Branta canadensis*).

Eighteen species of waterfowl were recorded in the vicinity of the Demonstration Plant site during the 2018 wildlife baseline update (RER 2019).

3.5.5.4 Small Game

Only one small game species, cottontail rabbit (most likely desert cottontails, *Sylvilagus audubonii*) occurs in the vicinity of the Demonstration Plant site. One individual cottontail was observed during two nights of spotlight surveys conducted in the vicinity of the Demonstration Plant site during early fall 2012 (ICF 2014). Within the area surrounding the Project area, the number of cottontails harvested per hunter day increased from 2010 to 2013. Cottontails can be an important prey species used by raptors and mammalian predators.

Cottontail species were also recorded in the vicinity of the Demonstration Plant site during the 2018 wildlife baseline update (RER 2019).

3.5.5.5 Furbearing Mammals

WGFD reports that seven species of furbearers have been harvested within the management area around the Demonstration Plant site. They include bobcat (*Lynx rufus*), badger (*Taxidea taxus*), beaver (*Castor canadensis*), marten (*Martes americana*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), and weasel (*Mustela* spp.). It is unlikely that marten or beaver are present in the project area. The swift fox (*Vulpes velox*) is classified as a non-game Species of Greatest Conservation Need but does occur in the project vicinity. Muskrats were observed swimming, grooming, and carrying nesting material in and around many of the ponds and impoundments near the Project area during spring and summer 2012 (ICF 2014). At one time, coyotes (*Canis latrans*), red fox (*Vulpes vulpes*), and raccoons (*Procyon lotor*) had been harvested as furbearers in the region; all three were documented within the wildlife survey area along with one badger seen in 2012 (ICF 2014).

Furbearers recorded as being in the vicinity of the Demonstration Plant site during the 2018 wildlife baseline update include coyote (*Canis latrans*), red fox (*Vulpes vulpes*), northern racoon (*Procyon lotor*),and American badger (*Taxidea taxus*) (RER 2019).

3.5.6 Aquatic Species

Vocalizations attributed to boreal chorus frogs (*Pseudacris triseriata*) were noted during mid-spring, 2012. Chorus frogs could inhabit impoundments and ponds, particularly those along Beaver Creek (ICF 2014). Boreal chorus frogs were recorded in the vicinity of the Demonstration Plant site during the 2018 wildlife baseline update (RER 2019). The boreal chorus frog is a SGCN. Another SGCN amphibian species is the northern leopard frog (*Lithobates pipiens*) which was documented at several locations in the project vicinity by the Wyoming Natural Diversity Database Data Explorer (WNDD) in 2014 but not during the 2018 wildlife baseline update. WGFD fisheries database shows that plains minnow (*Hybognathus placitus*) occurs in the Upper Beaver Creek Watershed which is near the Project area. The plains minnow is a SGCN and could occur within any of the tributary drainages to Beaver Creek, including Coyote Creek, as long as there is aquatic connectivity with other occupied stream reaches. However, no additional information about the species' local occurrence has been found.

3.6 Meteorology, Climate, and Air Quality

3.6.1 Regional Meteorology and Climate

The climate of the region is characterized broadly as interior continental with hot summers and cold winters. Table 3-11 lists the monthly average minimum and maximum temperatures, average precipitation, average snowfall, and average depth of snow from September 1, 1948 through February 28, 2005 at Upton NOAA/National Weather Service Cooperative Observer Network Weather Station 489205 (WRCC 2022).

The mean monthly temperature is highest for July (72 ºF) and lowest for January (22 ºF). Winds are common to the region and frequently strong, ranging from an average of 10 miles per hour during July and August to 16 miles per hour during November through April. Total annual precipitation is highly variable, with an average annual precipitation of 14 inches. Average annual snowfall is 43 inches. Approximately 80% of the precipitation each year falls between April and October and occurs primarily as rain. Most of the precipitation between November and April occurs as snow. The growing season extends between April and September (WRCC 2022).

Regional tornadoes, lightning strikes, thunderstorms, and hailstorms were reviewed in Weston County. There were 23 F0 through F2 tornadoes recorded in Weston County from 1950 to 2021 (NOAA 2022). There were three F2 tornadoes recorded west of Newcastle in 1953, 1958, and 1964 with no fatalities or injuries. Two injuries occurred during an F0 tornado on June 9, 2001, which occurred in Newcastle (NOAA 2022). From 1950 to 2021, there was one recorded lightning event, 151 hail events, and 17 blizzards recorded in Weston County (NOAA 2022).

Table 3-11. Monthly climate summary for Upton, Wyoming, 1948-2005 (WRCC 2022)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max Temperature (ºF)	31	36	45	57	68	78	87	86	75	61	43	33	58

Average Min Temperature (ºF)	7	11	20	29	40	49	56	54	43	31	19	9	30
Average Total Precipitation(in)	0	0	1	2	2	3	2	1	1	1	1	1	14
Average Total Snowfall (in)	7	7	7	5	0	0	0	0	0	2	6	8	43
Average Snow Depth (in)	4	4	1	0	0	0	0	0	0	0	1	3	1
ºF – degrees Fahrenheit in - inches													

3.6.2 Local Meteorology and Climate

RER installed a meteorological station in Upton in 2012 to continuously monitor local weather conditions. The meteorological station (Map 5) measures air temperatures, precipitation, wind speed, and wind direction. Figure 10 presents a wind rose compiled using wind speed and direction measurements made at the meteorological station from June 8, 2020 to June 7, 2021 (IML 2021). Winds are predominantly from the south-southeast (spring and summer; and at night) and north-northwest (winter and during the day). The average recorded wind speed was 9 miles per hour, and total annual precipitation was 11 inches.

3.6.3 Air Quality

RER installed five high-volume air samplers with particle size adapters in June 2012 to monitor background radionuclide, lanthanide, and particulate matter concentrations in ambient air. The results were reported in the *Baseline Radiological Investigation Report* (ERG 2015a) and are summarized in section 3.12 and Table 3-32.

The Demonstration Plant site and surrounding area are designated as Class II under the Clean Air Act. There are no Class I areas within 50 km (31 miles) of the Demonstration Plant site. The nearest Class I area is Wind Cave National Park, approximately 107 km (67 miles) southeast of the Demonstration Plant site. The second nearest is Badlands National Park, 181 km (113 miles) to the east. The Northern Cheyenne Indian Reservation is approximately 225 km (140 miles) to the northwest. Sensitive Class II areas within 100 km of the Demonstration Plant site include Devils Tower National Monument, Jewell Cave National Monument, Black Elk Wilderness Area, and Mount Rushmore National Memorial. Associated impacts at Badlands National Park are presumed to be less than those at Wind Cave since it lies farther to the east as reported in *Ambient Air Quality Modeling Protocol and Results Bear Lodge Project* (IML 2014b, 2014a).

Weston County is designated as attainment or unclassifiable for all criteria pollutants, indicating that ambient air concentrations are less than the National Ambient Air Quality Standards (NAAQS). Table 3-12 identifies NAAQS and Wyoming Ambient Air Quality Standards (WAAQS) for criteria pollutants. The WAAQS and NAAQS are health-based standards which define the maximum concentration of air pollutants allowed at all locations to which the public has access.

Representative background air pollutant concentrations of particulate matter (PM_{10} and $PM_{2.5}$), NO_2, SO_2, and CO for the Demonstration Plant site are provided in Table 3-13.

Table 3-12. National and Wyoming air quality standards for criteria pollutants

Parameter	Averaging Time	NAAQS	WAAQS	Form
Particulate matter (PM_{10})	24 hour	150 µg m^{-3}	150 µg m^{-3}	Not to be exceeded more than once per year on average over 3 years
	Annual	-	50 µg m^{-3}	Annual Mean
Fine particulate matter ($PM_{2.5}$)	24	35 µg m^{-3}	35 µg m^{-3}	98th percentile, averaged over 3 years
	Annual	12 µg m^{-3}	15 µg m^{-3}	Annual Mean
Nitrogen dioxide (NO_2)	1 hour	100 ppb	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	Annual	53 ppb	53 ppb	Annual Mean
Carbon monoxide (CO)	1 hour	35 ppm	35 ppm	Not to be exceeded more than once per year
	8 hour	9 ppm	9 ppm	
Sulfur dioxide (SO_2)	1 hour	75 ppb	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	3 hour	0.5 ppm	0.5 ppm	Not to be exceeded more than one per year
	8 hour	0.075 ppm	0.075 ppm	Annual 4th highest daily maximum 8-hour concentration, averaged over 3 years
Lead in total suspended particulates	Rolling 3 month average	0.15 µg m^{-3}	0.15 µg m^{-3}	Not to be exceeded

µg m^{-3} – micrograms per cubic meter
NAAQS - National Ambient Air Quality Standards
ppb – parts per billion
$PM_{2.5}$ and PM_{10} -particulate matter 2.5 and 10 microns
ppm – parts per million
WAAQS - Wyoming Ambient Air Quality Standards

Table 3-13. Background air pollutant concentrations

Pollutant	Background Concentration	Averaging Interval and Statistic	Source
Air quality index	40 to 47	Weston County average, 1999 to 2009	EPA [b]
Total suspended particulates	54 to 110 µg m^{-3}	Weston County average, 1999 to 2009	EPA [b]
Lead in total suspended particulates	0.02 to 0.06 µg m^{-3}	Weston County average, 1999 to 2009	EPA [b]
Ozone	0.047 to 0.055 ppm	Weston County average, 1999 to 2009	EPA [b]
Particulate matter (PM_{10})	15 µg m^{-3} 40 µg m^{-3}	Annual average concentration Maximum 4th highest 24-hour value	Antelope Coal Mine background monitor [a]
	23 to 34 µg m^{-3}	Weston County average, 1999 to 2009	EPA [b]
Fine particulate matter ($PM_{2.5}$)	3 µg m^{-3} 8 µg m^{-3}	Annual average concentration	Newcastle Refining air quality permit modeling [a]
	5 to 7 µg m^{-3}	Weston County average, 1999 to 2009	EPA [b]
Nitrogen dioxide (NO_2)	6 µg m^{-3} 21 µg m^{-3}	Annual average concentration 98th percentile of daily maximum hourly highs	Newcastle Refining air quality permit modeling [a]
	0.002 to 0.005 ppm	Weston County average, 1999 to 2009	EPA [b]
Carbon monoxide (CO)	378 µg m^{-3} 680 µg m^{-3}	8-hour highest concentration 1-hour highest concentration	Newcastle Refining air quality permit modeling [a]
	0.3 to 0.8 ppm	Weston County average, 1999 to 2009	EPA [b]
Sulfur dioxide (SO_2)	1 µg m^{-3} 16 µg m^{-3} 125 µg m^{-3} 43 µg m^{-3}	Annual average concentration 24-hour highest concentration 3-hour highest concentration 99th Percentile of daily maximum hourly highs	Newcastle Refining air quality permit modeling [a]
	0.001 to 0.003 ppm	Weston County average, 1999 to 2009	EPA [b]

[a] Recommended by the Wyoming Department of Environmental Quality - Air Quality Division
[b] From a compilation for Weston County monitoring stations, (USA.com 2022)
EPA – US Environmental Protection Agency
µg m^{-3} – micrograms per cubic meter
$PM_{2.5}$ and PM_{10} -particulate matter 2.5 and 10 microns
ppm – parts per million

3.7 Noise

A noise evaluation study was conducted in October 2012 to record the ambient sound levels for a total of 24 consecutive hours near the Demonstration Plant site at the four locations shown in Figure 3-1 of the *Noise Impact Study* (Behrens 2014). The 24-hour average decibel measurements were: 57.8, 53.0, 37.4, and 37.4 A-weighted decibels (dBA). The range of measurements at all locations was 23.5 to 63 dBA (Behrens 2014). No change is anticipated to these levels since the study took place.

Table 3-14 lists common outdoor sound pressure levels in rural and urban environments at different octave bands. In residential areas most noise comes from transportation, construction, industrial, and human and animal sources. Road traffic noise is the major source of noise. The noise can be highly variable. It is common that day-night levels of sound in different areas may vary over a range of 50 dB. The outdoor level in wilderness areas may occur as low as 30-40 dBA compared to 85-90 dBA in urban areas. Most urban dwellers live in areas of day-night levels of sound exceeding 48 dBA (Engineering Toolbox 2003).

Table 3-14. Common outdoor sound pressure levels in rural and urban environments at different octave bands (Engineering Toolbox 2003)

Time of Day	Conditions	Outdoor Sound Pressure (dB)							
		Octave Band Frequency (Hz)							
		63	125	250	500	1000	2000	4000	8000
Nighttime	Rural, no nearby traffic of concern	42	37	32	27	22	18	14	12
	Suburban, no nearby traffic of concern	47	42	37	32	27	23	19	17
	Urban, no nearby traffic of concern	52	47	42	37	32	28	24	22
	Urban, no nearby traffic of concern	57	52	47	42	37	33	29	27
Daytime	Business or commercial area	62	57	52	47	42	38	34	32
	Industrial or manufacturing area	67	62	57	52	47	43	39	37
	Within 300 ft (91 m) of continuous heavy traffic	72	67	62	57	52	48	44	42

dB – decibels
ft – feet
Hz - Hertz
m – meters

3.8 Historic and Cultural Resources

The western edge of the Black Hills within which sits the Demonstration Plant site is characterized by undulating plains. This region of plains is considered to have been continuously occupied by humans for the past 13,000 years (WCRM 2013) and is the ancestral home of Očhéthi Šakówiŋ (Assiniboine and Sioux), Tséstho'e (Cheyenne), and Apsaalooké (Crow) peoples (Native Digital Land 2021). After a period of conflict resulting in the forced removal of tribal members in the 1870s, the town of Upton (originally called Merino) grew from a ranching rest stop in the 1880s and construction of the Burlington and Missouri Railroad in 1890. Bentonite mining, including the American Colloid Company bentonite plant construction in 1928, led to growth in the 1900s, however Upton has remained a small town of under 1,000 ranchers and miners and serves as a rest stop for travelers into the Black Hills (WCRM 2013).

In November 2013, the Fort Peck Assiniboine and Sioux Tribe, Northern Arapaho Tribe, Crow Creek Sioux Tribe, and Northern Cheyenne Tribe conducted a tribal cultural preservation survey for the nearby Bear Lodge Project. The results of the survey were documented in a combined tribal report

(Fort Peck, Northern Arapaho, and Crow Creek) and a separate report from the Northern Cheyenne, previously transmitted to the NRC, the USFS, and Wyoming State Historic Preservation Office (SHPO).

In November 2018, the Demonstration Plant site landowner (Tiger Transfer, LLC) consulted the Wyoming SHPO regarding disturbed areas within the Upton Industrial Park. At this time, the SHPO found that the area "is an area of previous disturbance and has a low probability of containing historic properties" (Wyoming 2018).

A Class III cultural survey was conducted by Antiquus in March 2022 and transmitted to the NRC and Wyoming SHPO (Antiquus 2022). The survey encompassed the Demonstration Plant site consisting of just over 8 acres of land in the SE/NW of Section 34 of T48N R65W. The survey revealed no cultural resources in the area. A files search was also completed through the Wyoming SHPO which revealed 11 previous inventories in this section (Antiquus 2022). These previous inventories report three historic (48WE100, 48WE927, 48WE1446) and four prehistoric sites (48WE546, 48WE547, 48WE601, 48WE602) in the section. The four prehistoric sites consist of scatters of debitage, chipped stone tools and delated hearths. These four sites are described as badly deflated and have been throughout picked over. Sites 48WE100 and 48WE1446 are considered eligible for listing to the National Register of Historic Places (NRHP) but are both located outside of the surveyed area and will not be physically impacted by construction associated with the Demonstration Project. There will also be no additional visual impacts caused by construction associated with the Demonstration Project.

3.9 Visual/Scenic Resources

Visual resources are the visible physical features of a landscape that convey scenic value and are often the dominant resource value involved in providing recreational opportunities. The proposed Demonstration Plant will be located on private land within the Upton Industrial Park and near the Thunder Basin National Grassland (TBNG), both near the town of Upton, Wyoming (Map 7). There are no visual/scenic resource management guidelines for activities on private land in this area. The adjacent public USFS land is managed for scenic resources under its Scenery Management System (USDA 1995). The scenic integrity of these adjacent public lands is rated moderate and they do not contain popular recreational use attractions. This classification of scenic integrity refers to landscapes having slightly altered character. Alterations to the landscape must remain visually subordinate to the observable scenery.

Generally, the Demonstration Plant site is in an area with viewsheds and landscape characteristics common to the windswept, short-grass prairie of the region (Figure 11). There are some gently rolling hills on the western horizon, easterly views of Upton and its forested setting, and faint views of the Black Hills to the far northeast. Views of key site areas are provided on Figure 12, Figure 13, Figure 14, and Figure 15. Repairs to the exteriors of the existing buildings (Figure 16) by the current landowner have improved the overall appearance of the site. There are numerous existing paved, gravel, and dirt roads in the vicinity that are associated with agriculture and energy development. Highways US 16 and WY 116 are the major access roads nearby. Several power lines, a rail line, and high-pressure natural gas transmission line are additional linear features in the nearby landscape.

3.10 Socioeconomic

This section reviews baseline conditions of the socioeconomic resources study area, population, income and employment, housing, community services, and government revenues.

3.10.1 Socioeconomic Resources Study Area

To identify the study area of socioeconomic resources for the Demonstration Plant, commuting patterns were analyzed to identify linkages between Weston County and its neighbors. Commuter flows relate directly to the number of job opportunities at a specific destination and the driving time required for travel to that destination from a place of residence. Table 3-15 shows the occurrence of inter-county commuting in Weston and surrounding counties for one quarter. According to commuting data compiled by the Wyoming Department of Workforce Services (WDWS), most Weston County residents who work outside the county commute to Campbell County. Most workers who commute into Weston County are not Wyoming residents (WDWS 2016).

In rural areas such as northeast Wyoming, a 1-hour commute, or approximately 65 miles, is generally considered to be a reasonable one-way commuting distance. Towns within 65 miles of the Demonstration Plant site include Upton, Osage (an unincorporated Census Designated Place), and Newcastle in Weston County (2, 14, and 28 miles away, respectively); Moorcroft, Sundance, and Pine Haven in Crook County (20, 30, and 32 miles away, respectively); and Gillette in Campbell County (49 miles away). No towns in Converse and Niobrara counties, Wyoming, or Custer and Lawrence counties, South Dakota are within 65 miles of the Demonstration Plant site.

Based on regional commuting patterns and distances between population centers, the study area over which the socioeconomic impacts of the Demonstration Plant are analyzed includes Campbell, Crook, and Weston counties and communities within 65 miles of the Demonstration Plant site. This area is expected to provide most of the workforce for the Demonstration Plant and temporary housing for workers who may relocate to the area to supplement the local workforce. Although some goods and services may be purchased from vendors located outside the study area and a few workers who reside outside the study area may commute to work at the Demonstration Plant, the effects of such purchases and commuting are likely to be minimal.

Table 3-15. Inter-county commuter flows for nearby counties, 2018Q1 (WDWS 2019)

County, State	Total Workers	Worked in State of Residence		Worked Outside State of Residence
		In County of Residence	Outside County of Residence	
Wyoming				
Campbell County	24,821	21,596 (87%)	1,798 (7%)	1,326 (5%)
Converse County	6,643	4,424 (67%)	1,923 (29%)	296 (5%)
Crook County	2,716	1,436 (53%)	1,003 (37%)	277 (10%)
Niobrara County	808	584 (72%)	165 (20%)	59 (7%)
Weston County	3,079	1,930 (63%)	942 (31%)	207 (7%)

3.10.2 Population

Population characteristics and trends influence the availability of the local labor force. Table 3-16 provides population trends and forecasts in the study area and Wyoming between 1980 and 2040.

Campbell County is the dominant population center in the study area, with 47,026 residents in 2020. In 2020, Crook and Weston counties had 7,181 and 6,838 residents, respectively (Census Bureau 2020).

Since 1980, population growth in Campbell County has outpaced that of the state, due in large part to active energy development there. Population growth in Crook County has generally followed statewide trends, and population growth in Weston County has lagged the statewide population growth rate (Table 3-16). Between 2000 and 2010, population growth averaged 14.1% across Wyoming, 36.9% in Campbell County, 20.3% in Crook County, and 8.5% in Weston County (Census Bureau 2011; WDAI 2019). Between 2010 and 2020, population growth averaged 2.3% across Wyoming, 1.9% in Campbell County, and 1.4% in Crook County (Census Bureau 2020). Population decreased by 5.1% in Weston County during this time (Census Bureau 2020).

Among the cities and towns within the study area, Gillette has experienced the greatest population growth over the past 20 years. Gillette's population increased 48 and 15% in 2000-2010 and 2010-2020, respectively. Other towns experienced population decline. Between 2000 and 2020, the populations of Upton, Sundance, Moorcroft, Osage, and Newcastle decreased between 6 and 27%. The population of Pine Haven at that time increased by 0.6%.

The age distribution of the population is an important factor in assessing the size of the local labor force. Table 3-17 compares county populations by age. The age cohorts from 18 to 64 years offer the greatest potential contribution to the expected labor force. Their percentages are listed in Table 3-17.

Table 3-16. Population trends and growth rates in Wyoming and nearby counties, 1980 - 2040

Area	Population Levels						
	1980 [a]	**1990 [a]**	**2000 [a]**	**2010 [b]**	**2020[c]**	**2030 Forecast [b]**	**2040 Forecast [b]**
Wyoming	469,557	453,588	493,782	563,626	576,851	597,260	614,820
Campbell County	24,367	29,370	33,698	46,133	47,026	45,090	47,710
Gillette	12,134	17,545	19,646	29,087	33,403	31,141	32,590
Crook County	5,308	5,294	5,887	7,083	7,181	8,110	8,420
Moorcroft	1,014	768	807	1,009	946	1,156	1,200
Pine Haven	NA [d]	141	222	490	493	567	589
Sundance	1,087	1,139	1,161	1,182	1,032	1,380	1,433
Weston County	7,106	6,518	6,644	7,208	6,838	6,900	6,840
Newcastle	3,596	3,003	3,065	3,532	3,374	3,369	3,340
Osage	NA [e]	NA [e]	215	208	151	NA [e]	NA [e]
Upton	1,193	980	872	1,100	898	1,056	1,047

[a](WDAI 2014)
[b] (WDAI 2019)
[c] (Census Bureau 2020)
[d] Not Available. The Town of Pine Haven was incorporated in 1987 and the first census was recorded in 1990.
[e] Not Available. The first census for the Osage CDP was recorded in 2000, and the WDAI does not forecast populations for unincorporated communities.
CDP – Census Designated Place
NA – not applicable
WDAI – Wyoming Department of Administration & Information

Table 3-17. Population by age in Wyoming and nearby counties (Census Bureau 2011, 2020)

Age Range	Wyoming		Campbell County		Crook County		Weston County	
	Number of Persons	**Percent**	**Number of Persons**	**Percent**	**Number of Persons**	**Percent**	**Number of Persons**	**Percent**
Under 18 years	134,189	23.2	12,084	26.1	1,840	24.0	1,482	21.0
18 to 24 years	54,723	9.5	4,001	8.6	439	5.7	480	6.8
25 to 34 years	76,649	13.2	7,408	16.0	830	10.8	834	11.8
35 to 44 years	73,671	12.7	6,492	14.0	737	9.6	855	12.1
45 to 54 years	63,810	11.0	5,165	11.1	946	12.3	852	12.1
55 to 64 years	76,928	13.3	6,140	13.2	1,250	16.3	1,176	16.7
65 years and over	98,789	17.1	5,051	10.9	1,430	18.6	1370	19.4
Total	**578,759**	**100.0**	46,341	**100.0**	**7,472**	**100.0**	**7,049**	**100.0**

3.10.3 Income and Employment

3.10.3.1 Income and Earnings

Total personal income includes net earnings, dividends, interest, rent, and personal current transfer receipts. Net earnings consist of total earnings less contributions for government social insurance. Income from dividends, interest, and rent is also referred to as investment income. Transfer receipts include retirement, disability and unemployment insurance and other benefits as described in the table below. Per capita income measures the total income in an area by the area's population. Between 2019 and 2020, per capita income grew more rapidly in the study area than it did in the state. Per capita income (unadjusted for inflation) at that time increased 1.3% in Wyoming, 3.8% in Crook County, and 1.98% in Weston County while it decreased 0.4% in Campbell County (Table 3-18).

3.10.3.2 Total Employment

Table 3-19 shows total employment levels, including the number of farming and proprietor (self-employment) jobs, in Wyoming and the study area between 2015 and 2020. At that time, employment in Wyoming, as measured by the number of full- and part-time jobs, decreased 5.1%. Employment in Wyoming was increasing in 2018 and 2019, but dropped off in 2020, likely due to the COVID-19 pandemic. Most of the jobs in the study area are in Campbell County. Between 2015 and 2020, employment decreased 17.9% in Campbell County and 8.7% in Weston County but increased 0.7% in Crook County.

3.10.3.3 Employment and Income by Industry

Wage and Salary (Covered Employment) Data

Covered employment differs from full and part-time employment in that the former excludes farming and self-employed workers. By sector and based on available data, mining is the largest source of employment in Campbell County. Government (including public education) is the largest source of employment in Crook and Weston counties. The Retail Trade, Accommodations and Food Services, and Health Care sectors are also important sources of employment in the study area. The highest average annual wages are typically earned in the Mining and Construction sectors, and the lowest average annual wages are typically earned in the Accommodations and Food Services and Arts, Entertainment and Recreation sectors (Table 3-20).

Between 2015 and 2020, covered employment decreased from 37,496 to 31,806 workers in Campbell County (a 17.9% decrease) and from 4.090 to 3,763 (an 8.7% decrease) in Weston County. It increased from 4,545 to 4,559 (a 0.7% increase) in Crook County. Based on available data, nominal average annual wages at that time increased wages decreased 16.2% in Campbell County while it increased 20.3% in Crook County and 12.2% in Weston County. In 2020, annual wages averaged $117,632 in Campbell County, $10,503 in Crook County, and $10,645 in Weston County.

Projected Employment Growth

Although projections of county-level employment by industry are not available, the Wyoming Department of Workforce Services projects that employment in Wyoming will increase from 274,352 to 193,384 from 2018 to 2028. The greatest employment gains are projected to be in arts, entertainment, and recreation; professional, scientific, and technical services; and accommodation and food services (WDWS 2020).

Table 3-21 lists the major employers in the study area in 2014. Businesses and local service providers associated with mining, education, and health care are important employers in the study area (Table

3-21). The region's largest employers were in Campbell County. The largest employers in Crook and Weston counties were local government service providers.

3.10.3.4 Economic Base

Several industries that are substantial sources of employment in the study area, *e.g.*, local government, retail trade, health care, circulate money within the regional economy to provide local goods and services. While they provide jobs, these industries do not inject investment from outside the region into the regional economy to create industries that will export goods and services outside the region and support ancillary industries. Industries that fall into this latter category are known as basic industries and are the types of industries that drive an economy.

Basic industries have a higher concentration of employment within the local economy compared to a reference economy and are identified through location quotients. Location quotients are calculated by dividing the percent of employment in an industry sector within the local economy (here, Campbell, Crook, and Weston counties) by the percent of employment in the same industry sector in the reference region (Wyoming). Location quotients greater, equal to, or less than 1.0 indicate that there is a greater, equal, or lesser concentration of employment in an industry sector within a local economy as compared to the reference region. Basic industries are identified as having a location quotient greater than 1.0.

Location quotients for industry sectors in Campbell, Crook, and Weston counties in 2017 and 2020 compared to Wyoming are shown in Table 3-22. The location quotients indicate several industries in the study area that employ a greater portion of each county's workforce than the statewide average. The mining industry had the largest location quotient in Campbell, Crook, and Weston counties. This was followed by utilities in Campbell County and agriculture, forestry, fishing and hunting in Crook and Weston counties.

3.10.3.5 Unemployment

Annual unemployment rates across Wyoming have been around the national average for the past several years. Within the study area, unemployment rates in Campbell County have been lower than the statewide average, while unemployment rates in Crook and Weston counties have been slightly lower than or comparable to the statewide unemployment rate (US Bureau of Labor Statistics (BLS 2014).

Table 3-18. Per-capita personal income in Wyoming and local counties, 2000, 2012 (BEA 2014) and 2019, 2020 (BEA 2020a)

Per Capita Personal Income Components (2000, 2012)	Wyoming		Campbell County		Crook County		Weston County	
	2000	2012	2000	2012	2000	2012	2000	2012
Net Earnings [a]	$17,541	$31,130	$20,798	$36,439	$16,674	$27,682	$17,802	$36,910
Transfer Receipts [b]	$3,457	$6,343	$2,247	$3,964	$3,170	$5,930	$4,047	$6,656
Dividends, Interest & Rent [c]	$7,933	$13.093	$4,393	$8,469	$6,118	$14,490	$5,571	$10,502
Total Personal Income	$28,930	$50,567	$27,439	$48,872	$25,962	$48,102	$27,420	$54,068
Per Capita Personal Income (2019, 2020)	**Wyoming**		**Campbell County**		**Crook County**		**Weston County**	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Total Personal Income	$61,065	$61,855	$54,143	$53,932	$45,957	$47,752	$46,658	$47,599

[a] Total earnings less deductions for government social insurance.
[b] Includes retirement and pension benefits, disability insurance benefits, medical payments, income maintenance benefits, unemployment insurance benefits, and veterans benefits.
[c] Also referred to as investment income.
BEA – US Bureau of Economic Analysis

Table 3-19. Total full- and part-time employment in Wyoming and local counties, 2015-2020 (BEA 2020b)

Year	Wyoming	Campbell County	Crook County	Weston County
2015	406,033	37,496	4,525	4,090
2016	398,130	34,497	4,635	4,046
2017	398,940	33,624	4,716	3,942
2018	404,530	33,975	4,698	3,886
2019	408,143	34,147	4,633	3,918
2020	386,291	31,806	4,559	3,763

Note: includes proprietors and farm employment and earnings

Table 3-20. Employment by industrial sector in local counties, 2015 and 2020 (BEA 2020a, 2020b)

Industrial Sector	Campbell County				Crook County				Weston County			
	Average Annual Employment		Average Annual Wages		Average Annual Employment		Average Annual Wages		Average Annual Employment		Average Annual Wages	
	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020
Ag/Forestry/Fishing/Hunting	ND	ND	ND	ND	142	166	$2,791	$3,889	54	68	$1,362	$1,671
Mining	8,884	5,760	$99,7421	$635,029	472	405	$23,425	$27,509	428	352	$13,796	$17,154
Utilities	381	342	$48,239	$51,662	ND	ND	ND	ND	ND	13	ND	$1,002
Construction	1,392	2,466	$212,390	$171,979	398	395	$23,686	$22,043	303	ND	$17,338	ND
Manufacturing	733	639	$51,854	$51,341	220	272	$12,447	$17,704	183	ND	$17,515	ND
Wholesale Trade	1,915	1,447	$158,899	$132,031	85		$4,394	(D)	ND	35	ND	$2,453
Retail Trade	3,344	3,218	$123,377	$120,939	379	371	$8,023	$7,806	419	373	$8,211	$8,714
Transportation & Warehousing	1,563	1,390	$142,691	$137,061	ND	132	ND	$6,529	230	194	$34,059	$16,363
Information	237	272	$11,211	$15,793	ND		ND	ND	38	30	$1,291	$1,348

Industrial Sector	Campbell County				Crook County				Weston County			
	Average Annual Employment		Average Annual Wages		Average Annual Employment		Average Annual Wages		Average Annual Employment		Average Annual Wages	
	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020	2015	2020
Finance & Insurance	749	819	$34,566	$40,676	143	143	$3,985	-$1,158	144	112	$3,809	$4,135
Real Estate/Rental/ Leasing	1,700	1,543	$55,126	$49,523	221	213	$1,795	$1,281	129	145	$4,105	$4,233
Professional/Technical Svcs	1,148	1,069	$64,515	$59,394	136	168	$6,227	$10,656	109	97	$3,417	$3,130
Management of Companies/Enterprises	395	131	$37,481	$12,154	ND	29	ND	-$172	5	3	$1,095	$1,610
Admin & Waste Svcs	1,091	1,112	$39,506	$41,267	ND	86	ND	$2,469	67	96	$742	$1,050
Educational Services [a]	211	233	$5,562	$8,205	ND	ND	ND	ND	ND	ND	ND	ND
Health Care [a]	1,357	1,395	$71,289	$69,129	ND	ND	ND	ND	ND	ND	ND	ND
Arts, Entertainment, Recreation	ND	ND	ND	ND	66	87	$1,295	$1,906	ND	ND	ND	ND
Accommodation/Food Svcs	2,432	2,211	$52,895	$51,050	311	263	$5,132	$5,920	ND	ND	ND	ND
Other Services [b]	1,492	1,479	$66,210	$75,993		185	ND	$6,787	193	179	$3,899	$4,497
Total Government	5,332	4,865	$380,017	$377,859	746	721	$45,504	$48,516	830	826	$51,888	$57,413
Federal Government	4,985	97	$7,535	$9,649	88	75	$6,352	$6,364	49	54	$3,726	$4,786
State Government [c]	182	190	$14,645	$14,952	39	39	ND	ND	150	33	$11,186	$12,581
Local Government [c]	4,803	4,329	$350,317	$344,593	ND	ND	ND	ND	595	141	$35,924	$38,839
Total Employment by Industry	**37,496**	**31,806**	**$1,746,285**	**$1,503,382**	**4,525**	**4,559**	**$105,750**	**$132,736**	**4,090**	**3,763**	**$101,568**	**$115,624**

[a] Includes private education and health care services only.
[b] Except Public Administration.
[c] Includes public education and state and local government health care services.
ND - Not disclosed to avoid disclosure of confidential information.

Table 3-21. Major employers (RER 2014; Northeast Wyoming Economic Development Coalition 2014)

Employer	County	Number of Employees
Campbell County Schools	Campbell	1,771
Powder River Coal Company	Campbell	1,576
Rio Tinto Energy America	Campbell	1,209
Thunder Basin Coal Company	Campbell	1,205
Campbell County Memorial Hospital	Campbell	990
Foundation Coal West	Campbell	555
Campbell County Government	Campbell	538
Weston County Schools	Weston	286
Crook County Schools	Crook	237
Weston County Health Services	Weston	138
Powder River Energy Corporation	Campbell, Crook, Weston	124
Arch Coal	Weston	130
Crook County Medical Services	Crook	101
Wyoming Refining Company	Weston	75

Employer	County	Number of Employees
Weston County Government	Weston	58
Crook County Government	Crook	53

Table 3-22. Location quotients by industry, 2017 and 2020 (BLS 2020)

Industrial Sector	Campbell County		Crook County		Weston County	
	2017	2020	2017	2020	2017	2020
Ag, Forestry, Fishing & Hunting	0.33	0.34	2.73	2.75	1.95	2.42
Mining	55.15	55.27	24.71	32.86	14.41	23.47
Utilities	3.77	3.68	NR [a]	NR [a]	NR [a]	0.79
Construction	1.59	1.52	1.64	1.88	1.20	NR [a]
Manufacturing	0.20	0.26	0.94	1.02	0.78	NR [a]
Wholesale Trade	1.36	1.42	NR [a]	NR [a]	NR [a]	0.23
Retail Trade	0.86	0.99	0.79	0.80	1.02	1.10
Transportation & Warehousing	0.92	0.84	1.37	0.71	1.86	1.46
Information	0.47	0.51	0.26	NR [a]	0.67	0.52
Finance & Insurance	0.43	0.41	0.61	0.53	0.62	0.58
Real Estate, Rental & Leasing	0.79	0.80	0.17	0.08	0.33	0.17
Professional & Technical Services	0.42	0.41	0.31	0.52	0.24	0.21
Mgmt of Companies & Enterprises	0.54	0.25	NR [a]	0.07	NR [a]	0.08
Administrative & Waste Services	0.51	0.51	NR [a]	0.18	NR [a]	0.12
Educational Services [b]	0.13	0.17	NR [a]	NR [a]	NR [a]	NR [a]
Health Care & Social Assistance [b]	0.31	0.32	NR [a]	NR [a]	NR [a]	NR [a]
Arts, Entertainment, Recreation	0.35	0.45	1.02	1.65	NR [a]	NR [a]
Accommodation & Food Services	0.92	1.12	1.08	0.94	NR [a]	NR [a]
Other Services [c]	0.83	1.05	0.35	0.34	0.48	0.45

[a] NR – Not reported – unreported data at the county level do not allow a location quotient to be calculated.
[b] Includes private education and health care services only.
[c] Except Public Administration.

3.10.4 Housing

The 2019 American Community Survey (ACS) reported a total of 19,816 housing units in Campbell County, 3,672 housing units in Crook County, and 3,406 housing units in Weston County (Table 3-23). Single-family homes accounted for 66% of the housing units in Campbell County, 79% of the housing units in Crook County, and 75% of the housing units in Weston County. Most multi-family units in the study area are in Campbell County, where multi-family units comprised14% of the housing units, compared to 2% in Crook County and 5% in Weston County.

Owners occupy most housing units in the study area. Owner-occupied units accounted for approximately 73% of the occupied housing units in Campbell County, 82% in Crook County, and 83% in Weston County (see Table 3-23). Most of the housing units available for rent in the study area are in Gillette. In Crook County, most of the rental housing units are in Sundance, and most of Weston County's rental housing units are in Newcastle. Communities with the highest rates of renter occupancy are Moorcroft (27%), Upton (33%), and Gillette (30%). Communities with the lowest rates of renter occupancy are Sundance (17%), Pine Haven (6%), and Osage (0%).

According to the 2019 ACS, most of the vacant housing units in the study area were for rent, for sale, used seasonally or recreationally, or vacant due to other reasons. In Campbell County, 48% of vacant units were for rent, 19% were used seasonally, and 11% were for sale. "Other vacancies" accounted for 16% of all unoccupied housing units in Campbell County. In Crook County, seasonal or recreational use accounted for 42% of all vacant housing units and "other vacancies" accounted for 40%. In Weston County, 18% of vacant units were for sale, 7% of vacant housing units were used seasonally or recreationally, and 67% were attributed to "other vacancies" (Census Bureau 2019).

In general, a vacancy rate of 5% indicates a stable rental market, while lower vacancy rates indicate a tight rental market and higher vacancy rates indicate a weak rental market. In Campbell County, which has the study area's largest residential rental market, the vacancy rate between 2014 and 2019 was 10%. Between 2014 and 2019, vacancy rates averaged 20% in Crook County and 18% in Weston County.

Between 2000 and 2012, average residential sales prices for single family homes in the study area tended to be highest in Campbell County and lowest in Weston County. Average residential sale prices at that time increased from $151,615 to $236,978 in Campbell County, from $76,326 to $169,922 in Crook County, and from $74,379 to $137,564 in Weston County. Housing prices in the study area peaked in 2009, when the average residential sales price was $249,507 in Campbell County, $224,241 in Crook County, and $164,337 in Weston County. Average residential sales prices since then have fallen 5% in Campbell County, 24% in Crook County and 16% in Weston County (WHDP 2014).

Residential rental rates in the study area have been highest in Campbell County and lowest in Crook County. Reflecting regional economic trends, rents in the study area increased substantially between 2000 and 2009. Between June 2000 and December 2009, average rents in Campbell County increased from $434 to $774 for apartments, from $684 to $1,298 for mobile homes, and from $650 to $1,211 for houses. Average rents at that time in Weston County increased from $304 to $564 for apartments, from $418 to $551 for mobile homes, and from $367 to $636 for houses. Although comparable data are not available for mobile homes and houses in Crook County, average apartment rents increased from $319 to $459 (WHDP 2014).

Starting in December 2009, average rents for all types of rental units fell in Campbell County and increased moderately in Crook and Weston counties. In June 2013, rents averaged $686 for an apartment, $1,250 for a mobile home, and $1,082 for a house in Campbell County; $533 for an apartment and $573 for a house in Crook County; and $569 for an apartment, $609 for a mobile home, and $694 for a house in Weston County (WHDP, 2014a).

Several motels and RV parks have been available to provide short-term housing accommodations to business and leisure travelers, hunters, and other recreationists, and temporary workers in Campbell, Crook and Weston counties. Previous online searches for lodging accommodations within 65 miles of the Demonstration Plant site found approximately 2,091 motel rooms and 567 RV sites in the study area. Most of the motel accommodations are in Gillette, while RV facilities are relatively equally disbursed (Table 3-24). Because these estimates are based on lodging and RV facilities with an on-line presence, they are likely to underestimate the number of short-term housing accommodations in the study area because they do not include smaller establishments and privately let facilities that do not advertise on the internet.

Table 3-23. Selected housing characteristics in the study area, 2014-2019 (Census Bureau 2019)

Location	Total Housing Units	Occupancy Status				Housing Type		
		Occupied Units	Owner Occupied Units	Renter Occupied Units	Vacant Units	Single Family	Multi-Family	Mobile Homes and Other
Campbell County	19,816	17,822	13,081	4,741	1,994	12,999	2,695	4,122
Gillette	14,089	12,751	8,913	3,838	1,338	9,003	2,776	2,311
Crook County	3,672	2,943	2,407	668	729	2,908	81	683
Moorcroft	421	352	256	96	69	331	16	74
Pine Haven	259	204	192	12	55	180	0	79
Sundance	565	474	349	125	91	520	2	43
Weston County	3,406	2,796	2,320	475	610	2,561	160	685
Newcastle	1,578	1,290	1,049	241	288	1,201	147	229
Osage CDP	105	79	79	0	26	49	0	56
Upton	462	412	276	136	50	351	13	98

Table 3-24. Short-term housing accommodations (RER 2014)

Location	Hotels/Motels		RV Campgrounds	
	Establishments	Rooms	Campgrounds	Sites
Campbell County				
Gillette	21	1,663	2	150
Crook County				
Moorcroft	5	81	4	75
Pine Haven	1	9	2	37
Sundance	5	215	5	130
Weston County				
Newcastle	6	82	5	150
Upton	2	41	1	25
Total	**40**	**2,091**	**19**	**567**

3.10.5 Community Services

3.10.5.1 Schools

There are four school districts in the study area: Campbell County School District (SD) #1, Crook County SD #1, Weston County SD #1, and Weston County SD #7. Table 3-25 summarizes enrollments in these school districts between 2015 and 2021.

The Demonstration Plant site is in Weston County SD #7. The district has one elementary, one secondary, and one high school in Upton. Between 2015 and 2021, district-wide enrollments ranged from 222. Total 2013 enrollments of 260 were 11% below peak enrollments.

Table 3-25. School district enrollments, 2015-2021 (WDE 2022)

School Year Start	Campbell SD #1	Crook SD #1	Weston SD #1	Weston SD #7
Oct 2015	9,177	1,168	799	268
Oct 2016	8,726	1,149	768	258
Oct 2017	8,708	1,145	754	254
Oct 2018	8,721	1,184	792	223
Oct 2019	8,830	1,201	810	235
Oct 2020	8,567	1,164	777	222
Oct 2021	8,633	1,226	773	471

SD – school district

3.10.5.2 Medical Services

Residents and workers in the study area are served primarily by three hospitals: the Campbell County Memorial Hospital in Gillette, Crook County Medical Services District in Sundance, and Weston County Health Services in Newcastle. Campbell County Memorial Hospital has 142 beds and is designated as an area trauma hospital by the Wyoming Department of Health (WDH) Office of Emergency Medical Services. Crook County Medical Services District, with 56 beds, and Weston County Health Services, with 75 beds, are designated as trauma receiving facilities (WHA 2017). In addition to hospitals, there are two urgent care facilities in Gillette. Campbell County Memorial Hospital and Black Hills Urgent Care have walk-in clinics that are open 7 days per week, and offer a full range of health care services, including x-ray facilities and laboratory studies.

3.10.5.3 Law Enforcement

Sheriff's offices in Campbell, Crook, and Weston counties, and police departments in Gillette, Moorcroft, Newcastle, Sundance, and Upton provide law enforcement services. The jurisdiction of the Crook County Sheriff's Office includes the Town of Pine Haven, and the Weston County Sheriff's Office's jurisdiction includes Osage. Table 3-26 shows the levels of personnel for law enforcement agencies in 2010 and 2012 (RER 2014).

Between 2010 and 2012, the number of arrests increased in Campbell and Weston counties and decreased in Crook County. The greatest increase in arrests was by the Gillette Police Department (Table 3-27). According to arrest statistics compiled in historic Crime in Wyoming annual reports, larceny-theft accounts for most index crime arrests, and drug and alcohol offenses and other assaults account for the majority of other arrests (RER 2014).

Table 3-26. Law enforcement personnel, 2010 and 2012 (RER 2014)

County/ Agency	2010			2012		
	Total Staff Size [a]	Officers	Officers per 1,000 Population	Total Staff Size	Officers	Officers per 1,000 Population
Campbell County	143	98	2.1	145	100	2.2
Sheriff	60	45	2.6	60	45	2.6
Gillette PD	83	53	1.8	85	55	1.9
Crook County [b]	32	19	2.7	28	13	2.0
Sheriff	21	9	2.1	20	9	2.0
Moorcroft PD	5	4	4.0	4	3	2.9
Sundance PD	1	4	3.4	3	3	5.0
Weston County	26	16	8.1	23	13	2.1
Sheriff	10	8	1.4	8	6	2.3
Newcastle PD	16	8	14.8	15	7	2.0
Upton PD	NR	4	3	4	3	NR

[a] Civilian employees account for the difference between total staff and officers.
[b] Includes the Hulett Police Department
NR – not reported PD – police department

Table 3-27. Arrests by type of crime, 2010 and 2012 (RER 2014)

County/ Agency	2010				2012			
	Index Crime Arrests [a]	Drug Abuse Arrests	Other Arrests [b]	Total Arrests	Index Crime Arrests [a]	Drug Abuse Arrests	Other Arrests [b]	Total Arrests
Campbell County	262	297	3,672	4,321	436	442	3,460	4,338
Sheriff	72	120	1,228	1,420	57	83	1,083	1,223
Gillette PD	190	177	2,444	2,811	379	359	2,427	3,165
Crook County [c]	18	14	294	335	9	13	210	232
Sheriff	6	13	208	237	4	9	410	153
Moorcroft PD	5	1	34	39	2	0	0	2
Sundance PD	1	0	32	33	3	0	20	23
Weston County	17	9	87	113	12	13	145	170
Sheriff	2	1	11	14	2	3	20	25
Newcastle PD	15	8	76	99	10	10	125	145
Upton PD	NR	NR	NR	NR	NR	NR	NR	NR

[a] Includes murder and non-negligent manslaughter, forcible rape, robbery, aggravated assault, burglary, larceny, and motor vehicle theft
[b] Includes manslaughter by negligence; arson; other assault; forgery and counterfeiting; fraud; embezzlement; buying, receiving or possessing stolen property; vandalism; carrying or possessing weapons; prostitution and commercial vice; sex offenses (except rape and prostitution); drug abuse; gambling; offenses against family and children; driving under the influence; liquor laws; drunkenness; disorderly conduct; vagrancy; and all other offenses (excluding traffic).
[c] Includes the Hulett Police Department.
NR – not reported PD – Police Department

3.10.5.4 Fire and Emergency Services

Table 3-28 lists the fire suppression and accident response agencies in the study area, and information about agency staffing.

The Weston County Fire Protection District (FPD) and Upton Volunteer Fire Department (VFD) will provide first-response fire suppression services to the Demonstration Plant site. Technically, the Upton VFD provides first-response services to the Upton Industrial Center and the Weston County FPD

provides first-response services in adjacent unincorporated areas. However, given the county's small population base, both agencies respond to fires in the area. The Weston County FPD and Upton VFD share fire-fighting equipment, including three structural trucks, two water tenders, and three brush trucks. The Upton VFD will provide emergency medical and ambulance services to the Demonstration Plant site (RER 2014).

The towns of Moorcroft, Newcastle, and Pine Haven, and the Osage Census Designated Place (CDP), provide municipal ambulance services to residents of the respective communities and surrounding CDP areas. Pine Haven and Osage each have one ambulance, Moorcroft has two ambulances, and Newcastle has four ambulances, which also cover the Upton area upon request.

Those injured seriously at the Demonstration Plant or along the access route may be air evacuated via helicopter using Life Flight dispatched from the Wyoming Medical Center in Casper. Alternatively, Black Hills Life Flight, a privately-owned critical care transport service operated from Rapid City provides Life Flight service to Wyoming via fixed wing aircraft and helicopter.

Table 3-28. Fire protection agencies (RER 2014; "All the Fire Departments of the USA" 2019)

Fire Department	Square Miles Covered	Number of Stations	Personnel		Emergency Medical Services	
			Paid	Volunteer	EMS provided	EMT
Campbell County Fire Dept.	5,000	10 [a]	87	150	No	NR
Crook County Fire Dept.	2,871	6	3	300	No	0
Moorcroft Fire Dept.	2	1	1	19	Yes	9
Pine Haven Volunteer Fire Dept.	10	1	0	15	Yes	5
Sundance Volunteer Fire Dept.	NR	1	0	18	No	4
Weston Co Fire Protection District	2,400	3	2	85	No	0
Newcastle Volunteer Fire Dept.	NR	1	0	38	No	0
Osage Volunteer Fire Dept.	1,500	1	0	8	Yes	4
Upton Volunteer Fire Dept.	NR	1	0	27	Yes	8

[a] Includes 10 structural stations and 11 wildland support stations
Dept. – Department
EMS – emergency medical services
EMT – emergency medical technician
NR – not reported

3.10.6 Government Revenues

Potential fiscal impacts of the commercial-scale Bear Lodge Project were evaluated in *Bear Lodge Project Socioeconomic Impact Analysis* (RER 2014), and no separate analysis has been performed for the Demonstration Project. Baseline government revenues from the 2014 study are presented below.

Property tax is a major source of revenue to Weston County government. In recent years property taxes have made a decreasing contribution to the county's budget. Property tax revenues fell from $3.7 million (44% of total revenues) in Fiscal Year (FY, July-June) 2010 to $1.4 million (17% of county revenues) in FY 2011. In 2014, property tax accounted for 23% (nearly $1.9 million) of total county revenues (Table 3-29). Intergovernmental revenues, primarily transfers from the federal and state governments, have partially offset declining property tax revenues. In FY 2010, intergovernmental revenues of $3.5 million accounted for 43% of total county revenues. In FY 2014, intergovernmental revenues increased to $5.3 million and accounted for 64% of county revenues. Between FY 2010 and

FY 2014, revenue from sales tax accounted for between 5 and 10% of the county's total revenues, other tax revenues accounted for approximately 4%, and charges for services and miscellaneous revenues accounted for between 3 and 6% of county revenues.

Property tax is an ad valorem tax that is based on assessed valuations and local tax rates. Due largely to increasing mineral valuations, total assessed valuations across Wyoming have increased dramatically since 2000. The greatest increases have been in counties with active mineral production, such as Campbell County. Between FY 2000 and FY 2013, Campbell County's total assessed valuation increased from $1.6 billion to $5.6 billion. Total assessed valuations in Weston County at that time increased from $61 million to $155 million, and total assessed valuations in Crook County increased from $78 million to $237 million (RER 2014).

Minerals make the greatest contribution to assessed valuations in the study area. In Weston County, minerals account for 40% of assessed valuations, followed by residential property (24%), and utilities, railroads, and pipelines (19%). Due in part to Weston County's efforts to stimulate economic growth through endeavors such as the Upton Industrial Park, industrial property accounts for 11% of the county's total assessed valuation (RER 2014).

The State of Wyoming levies a 4% sales tax on taxable purchases made within the state and a 4% use tax on taxable purchases made outside the state for use in Wyoming. Local governments have the option to impose additional sales, use, and lodging taxes. Campbell County currently imposes a 1% general purpose tax rate, 1% specific purpose tax rate (designated for capital improvement projects), and 2% lodging tax rate, for effective tax rates of 6% on taxable purchases and 8% on lodging. Crook County imposes a 1% general purpose tax rate and 2% lodging tax rate, for effective tax rates of 5% on taxable purchases and 7% on lodging. Weston County imposes a 1% general purpose tax rate and a 4% lodging tax rate, for effective tax rates of 5% on taxable purchases and 9% on lodging (Wyoming 2013).

Reflecting its economic influence, Campbell County accounted for 92% of sales and use tax receipts in the study area between FY 2007 and FY 2013, compared to 4% for Crook and Weston counties (Table 3-30). Because total sales tax receipts are influenced by locally imposed optional taxes, which often change between years, comparing taxable sales over time is most accurately based only on the state's 4% sales tax. Between FY 2007 and FY 2009, state sales and use tax receipts increased 20% in Campbell County, 4% in Crook County, and 6% in Weston County. Impacted by the national economic recession, between FY 2009 and FY 2010 state-imposed sales and use tax receipts decreased in Campbell and Weston counties (24% and 17%, respectively), and increased 1.5% in Crook County. The region's more recent recovery is indicated by state sales and use tax receipts that increased 12% in Campbell County, 29% in Crook County, and 20% in Weston County between FY 2007 and FY 2013 (RER 2014).

Lodging tax applies to stays of less than 30 days at hotels, motels, RV parks, and private campgrounds and is used to promote tourism and travel within the state. Between FY 2007 and FY 2013, Campbell County accounted for 69% of the lodging tax collections in the study area, Crook County accounted for 14%, and Weston County accounted for 17% (Table 3-30). Lodging tax receipts at that time increased most rapidly in Campbell County (72%), followed by Crook (35%) and Weston (32%) counties (RER 2014).

Table 3-29. Weston County revenue sources, FY 2010 – FY 2014 (Price 2014)

Revenue Source	FY 2010	FY 2011	FY2012	FY 2013	FY 2014
Property Tax	$3,657,166	$1,406,971	$1,578,499	$1,892,088	$1,896,677
Sales and Use Tax [a]	$381,944	$809,876	$629,051	$434,730	$451,554
Other Taxes [b]	$363,633	$319,086	$316,206	$347,541	$334,266
Intergovernmental Revenues	$3,541,757	$5,223,227	$4,401,643	$3,661,894	$5,255,169
Charges for services	$183,212	$196,618	$188,186	$200,864	$227,271
Miscellaneous Revenues	$211,069	$111,146	$172,653	$199,593	$32,296
Total Revenues	**$8,338,781**	**$8,066,924**	**$7,286,238**	**$6,736,710**	**$8,199,233**

[a] Revenue from Weston County's 1% general purpose tax.
[b] Includes motor vehicle registration fees, business licenses and permits, and delinquent tax collections.

Table 3-30. Sales and use tax revenue, FY 2007 – FY 2013 (RER 2014)

Tax Type and Fiscal Year	Campbell County		Crook County		Weston County	
	Total Sales/ Use Taxes	State 4% Sales/ Use Tax	Total Sales/ Use Tax	State 4% Sales/ Use Tax	Total Sales/ Use Tax	State 4% Sales/ Use Tax
Sales Tax						
FY 2007	$137,822,376	$104,991,307	$5,011,478	$3,342,185	$4,660,348	$3,728,285
FY 2008	$153,037,064	$116,626,803	$5,526,730	$3,686,430	$4,624,664	$3,699,812
FY 2009	$163,087,080	$126,102,084	$5,421,838	$3,615,702	$4,889,516	$3,911,606
FY 2010	$121,409,187	$97,217,470	$5,400,751	$3,601,510	$4,041,082	$3,232,872
FY 2011	$141,129,143	$112,915,126	$5,551,909	$3,701,265	$4,479,936	$3,583,945
FY 2012	$179,606,535	$127,785,611	$6,294,818	$4,192,809	$4,779,432	$3,821,249
FY 2013	$172,265,894	$114,513,848	$6,620,999	$4,401,954	$4,913,259	$3,924,363
Use Tax						
FY 2007	$17,317,851	$13,195,132	$1,179,713	$78,6591	$1,141,330	$903,067
FY 2008	$20,783,856	$15,805,729	$1,261,553	$843,008	$1,491,530	$1,193,224
FY 2009	$20,354,359	$15,898,351	$988,683	$659,607	$1,266,220	$1,013,248
FY 2010	$14,091,426	$11,436,610	$1,111,777	$740,637	$1,049,192	$839,354
FY 2011	$18,200,156	$14,477,226	$967,483	$644,986	$6,731,116	$5,384,892
FY 2012	$14,628,998	$10,429,886	$1,218,116	$811,904	$3,697,418	$2,957,918
FY 2013	$10,823,347	$7,152,359	$1,808,068	$1,204,442	$1,176,210	$940,738
Lodging Tax						
FY 2007	NR[2]		$50,422		$64,559	
FY 2008	NR[2]		$57,899		$70,684	
FY 2009	$131,027		$58,306		$71,274	
FY 2010	$415,355		$57,836		$64,735	
FY 2011	$468,117		$57,279		$61,674	
FY 2012	$464,142		$57,216		$65,273	
FY 2013	$431,762		$57,633		$68,368	

FY – fiscal year NR – not reported

3.11 Environmental Justice

Under current NRC procedures, the area for potential environmental justice impacts associated with Office of Nuclear Material Safety and Safeguards programs is generally determined to be a 0.6-mile radius from the center of a proposed site in urban areas and a 4-mile radius in rural areas (NRC 2004). Upton is the primary population center within a 4-mile radius of the Demonstration Plant site and there are no housing structures within 0.6-mile of the site. The Demonstration Plant site is in Census Block Group 1 of Census Tract (CT) 9511, which includes Upton and its environs (Map 24).

Table 3-31 summarizes minority and low-income populations in Wyoming, Weston County, CT 9511, and CT 9511 Block Group 1. Based on 2019 and 2020 census data, racial minorities comprised 17.5% of the state's population, 10.9% of Weston County's population, and 11.4% of CT 9511's population. Persons of Hispanic origin, who may be of any race, at the time comprised 10.1% of Wyoming's population, 4.1% of Weston County's population, and 4.9% of CT 9511's population. Based on 2020 census data, low income populations comprised 9.2% of the state's population and 10.2% of Weston County's population (Census Bureau 2020).

The decennial census provides information on population characteristics at the census block group level. According to the 2019 ACS, racial minorities accounted for 16.10% of the population in CT 9511 Block Group 1 and persons of Hispanic origin comprised 9.9% (ACS 2019). The 2019 ACS did not report income and poverty data.

Table 3-31. Minority and low-income populations in Wyoming and the Demonstration Project area

Racial, Ethnic, and Poverty Characteristics	Wyoming [a]	Weston County [a]	CT 9511 [b]	Block Group 1, CT 9511 [c]
White	92.5%	93.2%	90.7%	97.4%
Total Racial Minorities	17.5%	10.9%	11.4%	16.1%
Black or African American	1.3%	0.7%	0.6%	0.2%
American Indian and Alaska Native	2.7%	1.9%	1.6%	2.4%
Asian	1.1%	1.7%	0.3%	0.8%
Native Hawaiian and other Pacific Islander	0.1%	0%	0.1%	0.1%
Two or more races	2.2%	2.5%	3.9%	2.7%
Hispanic origin [d]	10.1%	4.1%	4.9%	9.9%
Median household income	$64,049	$57,031	--	--
Percent of persons in poverty	9.2%	10.6%	--	--

[a] (Census Bureau 2020)
[b] (Census 2020)
[c] (ACS 2019)
[d] Hispanic origin is considered an ethnicity. Persons of Hispanic origin may be of any race.
CT – Census Tract

3.12 Public and Occupational Health

Public and occupational health for the site were evaluated in the context of potential harm from exposure to non-radiological and radiological constituents. Currently, the Demonstration Plant site is unoccupied. There are no current sources of exposure to chemicals or radioactive materials.

3.12.1 Non-radiological Exposures

The health effects of REE were reported in *A Literature Review of the Health and Ecological Effects of the Rare Earth Elements* (Damian 2014). The review of the literature focused on cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium-neodymium, praseodymium, samarium, terbium, thulium, ytterbium, and yttrium: considered to have the greatest potential for release as part of the Demonstration Project.

REEs share similar physicochemical properties, which results in common toxicological properties across the group. The properties, in elemental form unless otherwise stated, include:

- silvery-white, soft metals that tarnish when exposed to air;

- solubility increases with increasing atomic number;
- high melting and boiling points;
- react with water and dilute acids to form hydrogen gas;
- strongly paramagnetic;
- active reducing agents;
- ignite in air;
- soluble forms include chlorides, nitrates, and sulfates;
- insoluble forms include carbonates, phosphates, and hydroxides;
- fluoresce strongly under ultraviolet light; and
- dusts of these compounds may present fire and explosion hazards.

REE have no known role or requirement in living systems. REE are grouped into “light” (cerium, europium, gadolinium, lanthanum, neodymium, praseodymium-neodymium, praseodymium, and samarium) and “heavy” REE (dysprosium, erbium, holmium, lutetium, terbium, thulium, yttrium, and ytterbium) based on atomic weight. Light REE deposit mainly in the liver, while HREE tend to mimic calcium and deposit in the bone. In addition, light REE tend to be excreted primarily via the feces whereas HREE tend to be excreted mainly via the urine. The toxicity of REE is thought to generally decrease with increasing atomic weight.

A common feature of REE (particularly the heavy) that may underlie their toxicity is their ability to displace calcium from binding sites in key biomolecules (such as enzymes), leading to biochemical dysfunction. REE have low acute and chronic toxicity via the ingestion route of exposure. The target organ following ingestion exposure is the liver, whereas the lung is the target organ for inhalation exposure. Effects to the liver include fatty degeneration of the liver and necrosis. Those to the lung include pneumoconiosis and pulmonary fibrosis. REE typically show an anti-coagulative effect on the blood as well. REE are irritants to both the eye and skin and are poorly absorbed via either the gastrointestinal tract or the skin.

There are sparse publications regarding the mutagenicity and carcinogenicity of REE. Available data provide some evidence for a mutagenic effect of cerium and holmium and a carcinogenic effect of yttrium. However, the EPA at this time has not classified any of REE as carcinogens. Although REE have consistent effects on the lung, an occupational exposure limit has been established only for yttrium.

The REE as a group have oral lethal dose (LD_{50}) values generally well above 3,000 ppm. This level of acute toxicity is classified as “moderately” or “slightly” toxic. The REE oral LD_{50} values are in most cases higher than the LD_{50} of table salt (4,000 ppm).

Inhalation exposure to REE, primarily via occupational exposure, is associated in the short-term with acute irritative bronchitis and in the long-term by pneumoconiosis and progressive pulmonary fibrosis. Most cases of pneumoconiosis and pulmonary fibrosis have been observed in photoengravers or film projectionists because of long-term exposure to REE oxide fumes or smoke related to the use of carbon arc. These cases are often associated with high REE concentrations in the lungs and not necessarily related to the presence of any radioactive component. However, the evaluation of such cases is often confounded by simultaneous exposure to radioactive elements and/or silica dust. Despite the well-documented effects of REE on the lung, no occupational exposure limits have been established for any of REE except yttrium (American Conference of Governmental Industrial

Hygienists and National Institute of Occupational Safety and Health Threshold Limit Value (TLV) and recommended exposure limit, 8-hr time-weighted average of 1 milligram per cubic meter ([mg m^{-3}] respectively).

Reference doses for the oral and inhalation route of exposure, and reference concentrations for the inhalation route of exposure have been evaluated (IML 2014b). Reference doses and reference concentrations are benchmarks of safe levels of long-term chemical exposure via the ingestion and inhalation routes of exposure, respectively. There are no inhalation route references doses for any REE. In addition, none of the REE have been classified as carcinogens by the EPA, thus, none have associated cancer slope factors.

As measured in a 2015 baseline investigation (ERG 2015a), site-wide average cerium and lanthanum particulate concentrations in air are 9.0×10^{-4} micrograms per cubic meter (µg m^{-3}) and 4.5×10^{-4} µg m^{-3}, respectively. The range of cerium concentrations is 6.5×10^{-6} µg m^{-3} to 4.0×10^{-3} µg m^{-3}. The range of lanthanum concentrations is 3.6×10^{-6} µg m^{-3} to 2.0×10^{-3} µg m^{-3}.

3.12.2 Radiological Exposures

3.12.2.1 Background Radiation Dose

Background radiation doses from natural sources, while variable, always occur to some degree. Sources of background radiation dose include:

- Cosmic radiation from the sun and other celestial sources;
- Terrestrial radiation from radionuclides in soils and rocks;
- Radon and its short-lived decay products in indoor and outdoor air; and
- Radionuclides in the body, acquired from the inhalation of air, and ingestion of food and water.

The US average background dose rate from naturally occurring sources is approximately 320 millirem per year (mrem y^{-1}) (NCRP 2009). Some places in the world have dose rates of up to 1,000 mrem y^{-1} [United Nationals Scientific Committee on the Effects of Atomic Radiation (UNSCEAR 2000)]. Background dose rates vary according to factors such as elevation, radionuclide concentrations in soil and rock, construction materials in residential buildings, and lifestyle. Background radiation doses in the Mountain West states, including Wyoming, are higher than the background radiation doses in the west, east and Gulf Coast states.

3.12.2.2 Radiological Concentrations at Rare Earth Facilities

Many ores processed for their mineral content, including REE, contain naturally occurring radioactive material (NORM) such as potassium-40 and the uranium and thorium decay series radionuclides (UNSCEAR 2000). The minerals used for commercial sources of REE contain elevated concentrations of radionuclides in the thorium decay series and, to a lesser degree, the uranium decay series. These minerals include monazite and bastnasite ores (IAEA 2007). Radionuclides can mobilize during processing and migrate to dust, scales, and other process residues, therefore potentially having relatively higher concentrations of radionuclides than feedstock. This potential increase in the concentrations of radionuclides can change the magnitude of radiological hazards to the public living near the REE processing facility. An environmental monitoring program designed to evaluate potential impacts from REE recovery operations, including public doses, is typically in place prior to the operation of such facilities.

3.12.2.3 Demonstration Plant Exposures

A baseline radiological investigation conducted in 2015 (ERG 2015a)(Appendix H) included a gamma survey, soil sampling, exposure rate monitoring, radon flux measurements, radon measurements in air (Map 5), and airborne particulate measurements (Map 5). The spatial scope of the baseline investigations focused on the proposed site of the commercial-scale Bear Lodge Project (RER 2015a, 2015b), which would have been located to the northwest (1.4 miles via road, 0.8 miles directly) of the Demonstration Plant site. Results of this baseline radiological investigation are considered representative of the Demonstration Project site due to its physical proximity to the proposed Bear Lodge Project Upton Plant site and no indication that conditions would have changed in intervening years. A summary of the results is reported in Table 3-32.

Soil sampling was conducted in 2022 at the six locations in Map 4 to inform a site-specific background estimate. This study composited samples for each borehole across three sample depths, 0-18 inches, 18-30 inches, and 30-60 inches. Soil sampling results for radionuclides are summarized in Table 3-32. Soil sampling analytical results are presented in Appendix H.

A site visit in November 2021 also included scoping gamma count rate measurements with a 2-inch by 2-inch thallium-doped sodium iodide detector at the location indicated on Map 4 and a scoping walkover scan of the Demonstration Plant site; no areas of noticeably elevated gamma count rates were recorded.

Table 3-32. Summary of baseline radiological investigations

Parameter	Unit	Study	Min	Mean	Max	SD	Comparison Level	Percent of Comparison Level
External exposure rate	$\mu R\ hr^{-1}$	(ERG 2015a)	10.1	13.8	19.3	--	--	--
External dose rate [a]	$mrem\ y^{-1}$	(ERG 2015a)	96	103	118	--	100	--
Soil concentrations								
Natural thorium	$pCi\ g^{-1}$	2022	3.6	4.5	5.7	0.4	--	--
Natural uranium	$pCi\ g^{-1}$	2022	1.7	1.8	2.0	0.1	--	--
Radium-226 [b]	$pCi\ g^{-1}$	2022	0.6	1.0	1.4	0.2	5	--
Radium-228	$pCi\ g^{-1}$	2022	0.3	0.9	1.7	0.4	--	--
Particulate air concentrations [c]								
Natural thorium [d]	$\mu Ci\ mL^{-1}$	(ERG 2015a)	ND	4.1E-17	2.4E-16	--	7E-15	3% max
Natural uranium	$\mu Ci\ mL^{-1}$	(ERG 2015a)	ND	3.6E-17	1.2E-16	--	3E-12	0.004% max
Thorium-230	$\mu Ci\ mL^{-1}$	(ERG 2015a)	ND	2.6E-17	1.7E-16	--	2E-14	0.8% max
Radium-226	$\mu Ci\ mL^{-1}$	(ERG 2015a)	ND	1.0E-16	3.5E-15	--	9E-13	0.4% max
Radon [e]								
Radon air concentration	$\mu Ci\ mL^{-1}$	(ERG 2015a)	7E-10	--	1.6E-9	--	1E-10	Max 16 times limit (limit is 6% of background)
Radon flux [b]	$pCi\ m^{-2}\ s^{-1}$	(ERG 2015a)	0.2	0.69	1.22	--	20	--

[a] External dose rate measured using environmental badge dosimeters deployed between February 2013 and March 2014 are compared to the 10 CFR 20.1301 limit for above background total effective dose equivalent to a member of the public.
[b] Radium-226 concentration and radon flux are compared to the limits specified in 10 CFR 40, Appendix A, Criterion 6, although this standard applies to uranium mill tailings and thus is not directly germane to this characterization.
[c] Particulate and radon air concentrations were compared to their effluent concentration limits in 10 CFR 20 Appendix B.
[d] The comparison level for natural thorium is calculated from the limits for thorium-228 (3E-14 µCi mL^{-1}) and thorium-232 (4E-15 µCi mL^{-1}) based on equal activity contributions from these two isotopes as 1/(0.5/3E-14 + 0.5/4E-15) as indicated in footnote 4 to 10 CFR 20 Appendix B.
[e] All measured radon was assumed to be radon-222.
[f] Total soil sampling analytical results can be found in Appendix H.
µCi mL^{-1} – microcuries per milliliter
µR hr^{-1} – microroentgen per hour
mrem y^{-1} – millirem per year
ND – not detected
pCi g^{-1} – picocuries per gram
pCi m^{-2} s^{-1} – picocuries per square meter per second
SD – standard deviation

3.13 Waste Management

No known large-scale hazardous or other solid wastes are generated or stored on the lands included in the Demonstration Plant site. A site visit in April 2021 identified materials left by a former facility tenant including several non-hydrocarbon chemical drums containing sulfuric acid, sulfamic acid, hydrogen peroxide, and sodium hydroxide, several scattered drums of hydrocarbon material, and several five-gallon buckets of various chemicals (BKS 2021). Cleanup and disposal of these materials was conducted by the landowner (Figure 17) as part of the lease agreement for the Demonstration Project, and no waste materials are expected to remain onsite at the initiation of Demonstration Project activities.

4 Environmental Impacts

This section addresses the impacts for each resource described in section 3 and proposes project design features and monitoring, if needed, in response to impacts.

4.1 Land Use Impacts

4.1.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to land use.

4.1.2 Proposed Action

Construction of the Demonstration Plant does not conflict with current land uses in Weston County, which does not have zoning, nor will it impact existing land uses. Commercial crops are not grown on or in the vicinity of the Demonstration Plant site and the proposed action will not affect the use of land to grow crops elsewhere in the county. There is currently no grazing or hunting on the Demonstration Plant site, and RER's use of the site for mineral processing will not impact grazing or recreational activities elsewhere in the county. The project will not affect mineral development, including natural gas and oil production, or mining in the county.

Construction of the Demonstration Plant will not affect short-term land use patterns in Weston County, and operation will not affect long-term land use patterns in the county. Following the completion of REE processing, the Demonstration Plant site will be reclaimed to conform with surrounding topographic and vegetation conditions, including the clayey upland site habitat present on the TBNG. Site reclamation will be implemented to reestablish a suitable post-mining land use, such as industrial use or grazing. If objectives for the use of the land change given regulatory review or ongoing community and stakeholder processes, the Demonstration Plant decommissioning plan will be adjusted accordingly and in compliance with state and local requirements.

4.1.3 Project Design Features and Monitoring

RER is proposing the following project design features to reduce impacts to land use:

- During operation, the Demonstration Plant will have access controls including fencing as described in section 2.1.2.2.
- Upon closure of the Demonstration Plant, facilities will be decommissioned to accommodate future industrial use.

No monitoring is planned for potential effects to land use.

4.2 Transportation Impacts

4.2.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to transportation.

4.2.2 Proposed Action

Section 2.1.2.6 describes the vehicles required during construction, operations, and closure of the Demonstration Plant and the assumptions behind the numbers of estimated vehicles. Due to its small scale and short duration, the Demonstration Project poses no anticipated impacts to roadway systems, traffic patterns, traffic crashes, or railroads.

A USFS permit (Appendix G) was received for improvements to a segment of road which will be used to transport the exploration sample to the Demonstration Plant site. The exploration sample will be initially transported via USFS roads FS851, FS879, and FS 838.1 to Warren Peak Road, as indicated in Appendix G, and delivered to Upton through Sundance using US 14, WY 116, and Buffalo Creek Road (approximately 43 miles).

Map 9 shows the primary roads that will be used by workers and deliveries to access the Demonstration Plant, including Interstate 90, WY 116, and US 16. Secondary access for workers commuting from the Pine Haven area will include US 14 and WY 113.

Radioactive waste products will be transported to the Waste Control Specialists, LLC (WCS) disposal facility in Andrews, Texas via rail.

4.2.3 Project Design Features and Monitoring

RER is proposing the following project design features to mitigate potential effects to transportation:

- Access improvements to the Demonstration Plant off Buffalo Creek Road including grading and improvements to the gravel driveways and parking area

No monitoring is planned for potential effects to transportation.

4.3 Topography, Soils, and Geology Impacts

4.3.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to topography, soils, or geology.

4.3.2 Proposed Action

Potential impacts to topography, soils, and geology may occur during construction, operation, and decommissioning of the Demonstration Plant from activities including clearing vegetation, topsoil stripping, excavation, backfill, compaction, grading, and utility and pipeline trenching. There is limited potential impact to geology due to the minor depth of disturbance.

Based on the total anticipated disturbance area of approximately 8 acres (section 2.1.2.2) and an average topsoil depth of 1 foot (section 3.3.2), the volume of topsoil disturbed during the life of the project is estimated to be up to about 13,000 cubic yards. This estimate is conservatively high given that topsoil will not generally be removed and much of it will be replaced promptly after removal, such as during pipeline and utility trenching.

Due to the relatively minor nature of disturbance associated the proposed Demonstration Plant, there will be few areas of subsoil disturbance. The subsoil will be disturbed by cut, fill, and grading operations necessary to construct a level laydown yard and by excavation of the perimeter containment berm, flood control diversion channels, and a stormwater retention and sediment control pond. This material may be used to provide a slightly elevated and relatively level primary access road, or it may be stored in a stockpile separate from the topsoil stockpiles. During decommissioning, the area will be contoured to approximate the pre-construction topography.

Potential soil impacts may include soil loss, compaction, and soil contamination.

Wind and water erosion are the two salient sources of potential soil loss. As described in section 3.3.2, the soils within the project area have a moderate potential to be affected by wind and water erosion. The soils are more susceptible to erosion from water than wind due to the clayey nature of surface horizons throughout the site. Surface disturbance activities will expose soil and subsoil and temporarily increase the potential for soil loss due to wind and water erosion.

Soils within the project area have the potential to be compacted, particularly during construction, when heavy equipment activities will be at their highest. Soil compaction could result in a decrease in infiltration, thereby increasing runoff.

Potential soil contamination by radioactive materials could occur from the deposition of airborne particulates (dust) or spills of exploration sample during transport, physical upgrading, transfer between buildings, or shipping of waste. Spills will be cleaned up immediately and residual materials assessed during facility decommissioning by way of surveys and soil sampling.

Potential soil contamination could also occur from leaking fuel or oil from heavy construction equipment and passenger vehicles operated during construction. The volumes of the leaks are expected to be low and result in only localized impacts. Spills or leaks will be stopped and collected.

A geotechnical investigation was conducted for the Demonstration Plant site in 2022 (locations identified in Map 4) (Inberg-Miller Engineers 2022), and recommendations were provided for site preparations and earthwork, ground improvements, and modifications to foundations, slabs, and site drainage.

4.3.3 Project Design Features and Monitoring

RER is proposing the following project design features to reduce effects to topography, soils, and geology:

- To minimize soil loss, the site will be appropriately graded to limit erosion (see Map 25)
- Promptly address spills and leaks with the potential for soil contamination.

No monitoring is planned for the potential effects to topography, soils, and geology other than surveys and sampling associated with decommissioning (RER 2022b).

4.4 Water Resources Impacts

4.4.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to water resources.

4.4.2 Proposed Action

The Demonstration Plant is expected to use approximately 1-5 gpm of water from the City of Upton and most water used at the Demonstration Plant will be recycled.

The Demonstration Project has limited potential to impact surface water and groundwater to varying degrees. As discussed in section 3.4, surface water and groundwater within/adjacent to the project area are used for livestock, irrigation, and domestic needs.

4.4.2.1 Surface Water

Map 25 depicts the location of proposed facilities. During construction, potential surface water impacts could occur primarily from site disturbing activities such as access road, utility, and Demonstration Plant construction. The site disturbing activities will include vegetation removal, topsoil stockpiling, and limited periods of low impact drainage channel disturbance. These activities have the potential to result in minor hydrocarbon spills, primarily related to fuel and lubricants from heavy equipment operation. The primary potential impact from the removal of vegetation and disturbance of soil is water quality degradation.

As shown on Map 25, the proposed facilities will be constructed near an ephemeral stream channel, but surface water flow will be completely contained within the site boundary and will not have the potential to affect surface water quality and flow. Accidental spills and leaks (*e.g.*, equipment leaks) during construction, operations, and decommissioning will also be appropriately contained and remediated. Potential impacts from accidental spills and leaks will be small due to the small volume, rapid cleanup response and site grading.

Site grading will occur in three identified subbasins within the proposed Demonstration Project site. The 3 subbasins within the site include:

- Subbasin A, 3.92 acres, will collect and direct stormwater away from the restricted area into a retention pond. A 1.0-foot berm will be construction at the fence line.
- Subbasin B, 1.42 acres, will collect and direct water into an existing wetland.
- Subbasin C, 1.30 acres, will contain and direct water within the restricted area to a collection sump and waste disposal. A 0.5-foot berm will be constructed at the fence line.

4.4.2.2 Groundwater

Potential groundwater impacts during construction, operations, and closure of the Demonstration Plant are related primarily to accidental spills and leaks, which would primarily affect shallow hydrologic

units. The shallow groundwater (less than 20 ft) in the project area is limited to accumulations in perched and isolated zones within the alluvial Valley Fill and Weathered Shale portion of the surficial geologic formation (see section 3.4.2). The permeability of the Belle Fourche Shale is very low; therefore, the potential for groundwater contamination is minimal.

No groundwater wells will be used to supply water to the plant; therefore no groundwater rights will be affected.

4.4.2.3 Wetlands

The Demonstration Plant site includes a small area identified as a freshwater pond using National Wetland Inventory mapping (Map 16). A further aquatic survey is planned for summer 2022 which will be used to obtain an updated ACE jurisdictional determination for the Demonstration Plant site.

4.4.3 Project Design Features and Monitoring

RER is proposing the following project design features to reduce effects to water resources:

- Process controls, including level indicators and alarms will be used throughout the facility to monitor any unexpected release of liquids.
- Spills and leaks will be promptly controlled and remediated using the best technology currently available to reduce or eliminate contamination.
- Every building and its equipment will be contained, and any runoff material will be collected in a sump and disposed of properly.
- Sitewide grading will be used to collect stormwater for appropriate sampling and disposition.

Monitoring will include appropriate leak detection. No other monitoring is planned for the potential effects to water resources other than surveys and sampling associated with decommissioning (RER 2022b).

4.5 Ecological Resources Impacts

4.5.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to ecological resources.

4.5.2 Proposed Action

4.5.2.1 Vegetation

Direct effects to vegetation may occur during surface disturbance through removal of vegetation. Surface disturbance, increased vehicle traffic, equipment placement and operation, foot traffic and other activities associated with the proposed action could increase the distributions of established weed species (see Table 3-8) and/or could introduce new invasive species into areas that are not currently infested. Vehicles transport weed seeds embedded in dried mud or soils attached to bumpers, undercarriages, and wheel wells.

Vehicles and project-related activities would generate dust. Dust generation could occur during vegetation clearing, operation of earth-moving equipment, and increased traffic along roads during construction and operations.

The proposed action will remove a limited amount of vegetation during site grading. Impacts to plant species of special status (Ute ladies'-tresses) are not anticipated because none were found in the project area.

4.5.2.2 Wildlife

Potential impacts to animal species of special status are not anticipated. Although the project area is within the species' range for the northern long-eared bat (proposed for listing under the ESA) which encompasses a larger area than simply where the species is known to exist, its presence has been judged as unlikely (ICF 2014).

Most mammalian Species of Greatest Conservation Need except for some of the smaller rodents would not be able to penetrate the chain-link fence proposed to surround the site.

Increased vehicle-related mortality due to increased project-related traffic could directly impact big game. WGFD identified US 16 as a migration barrier to pronghorn but not to mule deer. However, there are no defined mule deer migration routes across US 16 (US 16 separates the Cheyenne River from the Black Hills Hunting Unit) and animal-vehicle collisions on US 16 west of Upton are expected to be minimal. Direct impacts could occur to small game and furbearers through mortalities from project-related traffic. Maintaining speed limits would minimize the potential for vehicle collisions with terrestrial wildlife.

Public access to the project area and vicinity would likely not change because of the proposed action; however, human presence would increase in the area.

4.5.3 Project Design Features and Monitoring

Due to the small scale and limited duration of the Demonstration Project, RER is not proposing any specific project design features to reduce effects to ecological resources.

No monitoring is planned for the potential effects to ecological resources.

4.6 Air Quality Impacts

4.6.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to air quality.

4.6.2 Proposed Action

Due to the small scale and limited duration of the Demonstration Project, no significant impacts to air quality are anticipated (TetraTech 2022). Potential impacts include emissions of particulates and vapors from open sources and/or building stacks. Air quality impacts may also occur during dust-generating site grading activities.

An inventory of air pollutant emissions was conducted to quantify air emissions from operation of the commercial facility in 2014. Air emissions of PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x., and Hazardous Air Pollutants are reported in *Ambient Air Quality Modeling Protocol and Results Bear Lodge Project - Upton Hydrometallurgical Plant* (IML 2014b, 2014a). Additional air modeling was conducted as part of the

approved air quality permitting application to the WDEQ-Air Quality Division (AQD), included as Appendix I.

4.6.3 Project Design Features and Monitoring

RER is proposing the following project design features to reduce effects to air quality:

- Emission controls on process equipment according to WDEQ- AQD permitting requirements.
- Dust control during grading activities
- Baghouses and installation of a temporary curtain on the PUG/Sample Storage Facility during PUG processing to minimize dust generation from material handling systems,
- High-efficiency particulate air filter and scrubber systems associated with Main Process Facility systems to eliminate particulate and vapor emissions from the process circuits.

The airborne release of radiological and non-radiological effluents from the Demonstration Plant are expected to be very small. RER intends to:

- Monitor airborne radionuclide emissions from the Demonstration Plant at or near release points (stacks and cooling tower) using continuous and/or grab sampling techniques to estimate license-related releases.
- Determine the airborne concentrations of radon -222, radon-220 and radioactive particulates, including natural uranium and thorium.
- Evaluate impacts from airborne releases to the nearest receptor and member of the public using an air dispersion computer code acceptable to the NRC.
- Develop implementing SOPs describing the locations, instruments and equipment, and methods for evaluating emissions and public dose prior to operations.
- Maintain the meteorological station installed as part of baseline surveys.

WYDEQ may also require an environmental monitoring program for the Demonstration Plant.

4.7 Noise Impacts

4.7.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to noise.

4.7.2 Proposed Action

Impacts from noise for the larger-scale commercial facility, in a similar location to the Demonstration Plant, were modeled in 2014 (Behrens 2014). This investigation concluded that impacts from operational noise posed by the commercial facility would increase the ambient level by less than 5 dB at the nearest residential receptor (Map 4), which is within a range of “barely perceptible” and not a significant impact to noise.

Sound power levels from noise-generating equipment included the following estimated levels (Behrens 2014), which have the potential to exceed occupational permissible exposure levels in 29 CFR 1926.52:

- PUG processing crusher – 111 dBA
- Air compressor – 117 dBA
- Calciner – 108 dBA
- Cooling tower – 110 dBA
- Heating, ventilation, and air conditioning system – 95 dBA
- Haul trucks unloading – 116 dBA

4.7.3 Project Design Features and Monitoring

RER is proposing the following project design features to reduce noise effects:

- Equipment will be maintained to meet standards for noise and worker safety.
- Protection for workers will be provided when the anticipated noise level exceeds permissible exposure levels in 29 CFR 1926.52

Noise monitoring is not planned during project operations.

4.8 Historic and Cultural Resources Impacts

4.8.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to historic and cultural resources.

4.8.2 Proposed Action

A cultural resources survey completed by Antiquus in March 2022 revealed no cultural resources within the approximately 8 acres encompassed by the Demonstration Plant site. Thus, project avoidance was not recommended.

4.8.3 Project Design Features and Monitoring

RER has not identified any project design features to further reduce effects to historic and cultural resources. No monitoring of historic and cultural resources is proposed.

4.9 Visual/Scenic Resources Impacts

4.9.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no impacts to visual/scenic resources.

4.9.2 Proposed Action

The profile of the facilities at the Demonstration Plant will be consistent with those in the adjacent Upton industrial areas. The Demonstration Plant would be noticeable to travelers using US 16 and WY 116, although it would only be visible locally and briefly. The building and connecting power line and buried natural gas pipeline are not expected to contrast significantly with landscape characteristics, given the past and present industrial use on the proposed site and in the area.

Therefore, there will be largely no changes to visual/scenic resources posed by the Demonstration Plant.

4.9.3 Project Design Features and Monitoring

RER has not identified any project design features to reduce effects to visual/scenic resources. Monitoring for visual/scenic resources is not proposed.

4.10 Socioeconomic Impacts

4.10.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no project related increases in local employment and tax revenues resulting in unrealized economic benefits to the local and regional economy. Similarly, the no action alternative would halt the progress toward demonstrating a new REE separation and processing technology and a path forward for commercial development. No action would increase the risk of Chinese influence over REE supply and technology.

4.10.2 Proposed Action

The primary drivers of the potential socioeconomic effects associated with construction, operation, and closure of the Demonstration Plant will be the direct employment and associated payroll, level of capital investment, and government revenues generated by the Demonstration Plant. These factors will support additional spending, or secondary effects, throughout the local economy. Due to the short-term nature of the Demonstration Project, socioeconomic effects will be temporary.

The Demonstration Project workforce is summarized in section 2.1.2.5 and Table 2-1. Based on the information about population, commuting patterns, and housing in section 3.10, this analysis assumes that: 80% of the construction, operations, and decommissioning workforce will come from the study area and that 20% will come from other counties.

RER has engaged with community leaders to discuss potential socioeconomic impacts of the proposed action, including a meeting with Weston County Commissioners on October 19, 2021.

4.10.3 Project Design Features and Monitoring

RER is not proposing project design features to reduce potential socioeconomic impacts. No monitoring is planned for potential socioeconomic impacts.

4.11 Environmental Justice Impacts

4.11.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no environmental justice impacts.

4.11.2 Proposed Action

The potential for adverse impacts to minority and low-income populations due to the Demonstration Project was evaluated by comparing the characteristics of racial, ethnic, and poverty in the population surrounding the Demonstration Plant site with comparable characteristics of the county- and state-wide populations. As discussed in section 3.11, Block Group 1 of CT 9511 includes a 4-mile radius around the Demonstration Plant site. Overall, this block group contains lower proportions of racial and Hispanic minority populations than Weston County and the state. Although poverty data are not available for census block groups, the percent of individuals in poverty within CT 9511 is lower than that the county and state. Construction, operation, and closure of the facility will not result in disproportionately high and adverse human health or environmental impacts on minority or low-income populations, because within 4 miles of the Demonstration Plant site these populations are lower than those within the county and state.

4.11.3 Project Design Features and Monitoring

RER is not proposing any project design features to reduce potential environmental justice impacts. No monitoring is planned for environmental justice impacts.

4.12 Public and Occupational Health Impacts

4.12.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no public or occupational health impacts.

4.12.2 Proposed Action

This section addresses the potential impacts to public and occupational health posed by the Demonstration Project.

4.12.2.1 Non-radiological Impacts

Occupational non-radiological impacts may occur by way of direct exposures to chemicals and localized fugitive emissions of gases and airborne particulates. Regulations in the 2021 International Fire Code (IFC) will apply to the occupational, non-radiological components of exposure. It is expected that inhalation will be the predominant exposure pathway. Workers will be at the Demonstration Plant for 2,000 hours per year, however various processes will be limited in duration to less than one year. The locations at which the maximum exposures to chemicals or airborne particulates are expected to occur are inside the process facilities. Potential occupational noise impacts and mitigation measures are identified in section 4.7.2.

Non-radiological impacts to the public, if any, would occur largely by way of air pathways. The pattern of off-site transport of lanthanides is expected to follow those for particulates.

4.12.2.2 Radiological Impacts

Pathway assessments for radiological exposure are addressed in Appendix F. While the Demonstration Project has the potential to result in occupational radiological doses exceeding NRC's limits for members of the public, doses are anticipated to be well below NRC's occupational dose limits and will be maintained as low as is reasonably achievable (ALARA) for the Demonstration Project.

Radiological impacts to the public, if any, would be limited to inhalation exposure pathways.

4.12.3 Project Design Features and Monitoring

RER has identified the following project design features to reduce public and occupational health impacts:

- A Hazard and Operability Analysis (HAZOP) will be performed early in the design process to identify potential hazards
- A Hazard Work Authorization (HWA), appropriate standard operating procedures (SOPs), and an Emergency Response Pan (ERP) will be developed prior to commencing operations
- A radiation protection program (RPP) and ALARA program consistent with NRC license requirements will be developed prior to commencing operations
- Engineering controls will be used to reduce airborne concentrations of hazardous constituents in the workplace where needed.
- Administrative controls, and personal protective equipment (PPE) to limit worker exposure to hazardous constituents for activities where risks are not adequately addressed by engineering controls.
- Scrubbers and bag houses will be used to reduce releases of gases and particulates from facility stacks.

The following monitoring is proposed for public and occupational health:

- Radiological monitoring will be performed in accordance with the NRC radioactive materials license and references therein.
- An asbestos survey will be performed as a component of air quality permitting.

4.13 Waste Management Impacts

4.13.1 No Action

Under the No Action alternative, the Demonstration Plant would not be developed, and there would be no waste management impacts.

4.13.2 Proposed Action

In the waste treatment process, described in the section 9 and Appendix C of the license application (RER 2022a), all radioactive waste and wastewater streams are combined and neutralized for disposal. There will be no discharge of wastewater.

The first precaution taken to avoid the generation of waste will be to use appropriate purchasing controls to restrict purchases to non- or least-toxic products, and to limit the volumes that are purchased to preclude excess.

If possible, waste materials will be re-used on site. Recycling will be a priority and options will be evaluated for the following waste materials: used oil and lubricants, spent solvents and paints, plant equipment; electronic equipment and components; office paper; lunch and break room waste s (beverage containers, newspapers, food containers, etc.); packaging wastes (pallets, cardboard and

bubble-wrap); and scrap metal (machine shop millings, empty barrels, excess wiring, unusable parts and equipment).

Finally, if disposal is the only remaining option, RER will follow an appropriate off-site disposal strategy, created in accordance with applicable state and federal requirements. Waste shipping is described in section 2.1.2.6 and further details are provided in the license application (RER 2022a).

4.13.3 Project Design Features and Monitoring

RER has identified the following project design features to reduce waste management impacts:

- Develop detailed SOPs regarding waste management at the Demonstration Plant prior to the receipt of licensed material.
- All waste generated by the process will be shipped off-site to licensed facilities for disposal: non-hazardous industrial waste will be taken to the Weston County transfer facility, and radiological waste will be transported by rail to the WCS disposal facility in Andrews, Texas at a rate of approximately one roll-off bin per week (approximately 30 short tons or 29 cubic yards per week).
- Waste management for specific waste streams will include:
    - Tailings will be placed into roll-off bins (approximately 30 short tons or 29 cubic yards) and temporarily stored on-site according to license requirements.
    - Other dry radioactive waste will be stored temporarily on-site in clearly marked containers, segregated from non-radioactive waste, prior to shipment to an off-site licensed disposal facility.
    - All sewage will be disposed of according to City regulations.
    - Waste laboratory chemicals will be containerized and stored within the laboratory for offsite disposal, if required.
    - All waste streams generated from the use of purchased materials will be evaluated for proper handling.
- RER will verify that waste shipping contractors have plans in place to meet DOT regulations for safe handling and emergency response.

No monitoring is proposed for waste management activities other than monitoring required to meet DOT regulations.

5 Mitigation Measures

A summary of the mitigation measures (project design features) is provided in Table 5-1.

Table 5-1. Summary of project design features serving as mitigation measures for environmental impacts

Potential Impact	Project Design Features
Land Use	• During operation, the Demonstration Plant will have access controls including fencing as described in section 2.1.2.2. • Upon closure of the Demonstration Plant, facilities will be decommissioned to accommodate future industrial use.
Transportation	• Access improvements to the Demonstration Plant off Buffalo Creek Road including grading and improvements to the gravel driveways and parking area
Topography, Soils and Geology	• To minimize soil loss, the site will be appropriately graded to limit erosion (see Map 25) • Promptly address spills and leaks with the potential for soil contamination.
Water Resources	• Process controls, including level indicators and alarms will be used throughout the facility to monitor any unexpected release of liquids. • Spills and leaks will be promptly controlled and remediated using the best technology currently available to reduce or eliminate contamination. • Every building and its equipment will be contained, and any runoff material will be collected in a sump and disposed of properly. • Sitewide grading will be used to collect stormwater for appropriate sampling and disposition.
Ecological Resources	None
Air Quality	• Emission controls on process equipment according to WDEQ-AQD permitting requirements. • Dust control during grading activities • Baghouses and installation of a temporary curtain on the PUG/Sample Storage Facility during PUG processing to minimize dust generation from material handling systems, • High-efficiency particulate air filter and scrubber systems associated with Main Process Facility systems to eliminate particulate and vapor emissions from the process circuits.
Noise	• Equipment will be maintained to meet standards for noise and worker safety. • Protection for workers will be provided when the anticipated noise level exceeds permissible exposure levels in 29 CFR 1926.52
Historic and Cultural Resources	None
Visual/Scenic Resources	None
Socioeconomic	None
Environmental Justice	None
Public and Occupational Health	• A Hazard and Operability Analysis (HAZOP) will be performed early in the design process to identify potential hazards • A Hazard Work Authorization (HWA), appropriate standard operating procedures (SOPs), and an Emergency Response Pan (ERP) will be developed prior to commencing operations • A radiation protection program (RPP) and ALARA program consistent with NRC license requirements will be developed prior to commencing operations • Engineering controls will be used to reduce airborne concentrations of hazardous constituents in the workplace where needed. • Administrative controls, and PPE to limit worker exposure to hazardous constituents for activities where risks are not adequately addressed by engineering controls.

Potential Impact	Project Design Features
	• Scrubbers and bag houses will be used to reduce releases of gases and particulates from facility stacks.

Waste Management	• Develop detailed SOPs regarding waste management at the Demonstration Plant prior to the receipt of licensed material.
	• All waste generated by the process will be shipped off-site to licensed facilities for disposal: non-hazardous industrial waste will be taken to the Weston County transfer facility, and radiological waste will be trucked to the WCS disposal facility in Andrews, Texas.
	• Waste management for specific waste streams will include:
	  ○ Tailings will be placed into containers and temporarily stored on-site according to license requirements.
	  ○ Other dry radioactive waste will be stored temporarily on-site in clearly marked containers, segregated from non-radioactive waste, prior to shipment to an off-site licensed disposal facility.
	  ○ All sewage will be disposed of according to City regulations.
	  ○ Waste laboratory chemicals will be containerized and stored within the laboratory for offsite disposal, if required.
	  ○ All waste streams generated from the use of purchased materials will be evaluated for proper handling.
	• RER will verify that waste shipping contractors have plans in place to meet DOT regulations for safe handling and emergency response.

ALARA – as low as is reasonably achievable
DOT – US Department of Transportation
PPE – personal protective equipment
RER – Rare Element Resources, Inc.
WCS – Waste Control Specialists, LLC
WDEQ-AQD – Wyoming Department of Environmental Quality – Air Quality Division

6 Environmental Monitoring Programs

A summary of monitoring programs is provided in Table 6-1. Map 5 identifies environmental monitoring locations.

Table 6-1. Summary of monitoring for environmental impacts

Potential Impact	Monitoring
Land Use	None
Transportation	None
Topography, Soils and Geology	• Surveys and sampling associated with decommissioning (RER 2022b)
Water Resources	• Surveys and sampling associated with decommissioning (RER 2022b)
Ecological Resources	• Surveys and sampling associated with decommissioning (RER 2022b)
Air Quality	• Monitor airborne radionuclide emissions from the Demonstration Plant at or near release points (stacks and cooling tower) using continuous and/or grab sampling techniques to estimate license-related releases. • Determine the airborne concentrations of radon-222, radon-220 and radioactive particulates, including natural uranium and thorium. • Evaluate impacts from airborne releases to the nearest receptor and member of the public using an air dispersion computer code acceptable to the NRC. • Develop implementing SOPs describing the locations, instruments and equipment, and methods for evaluating emissions and public dose prior to operations. • Maintain the meteorological station installed as part of baseline surveys.
Noise	None
Historic and Cultural Resources	None
Visual/Scenic Resources	None
Socioeconomic	None
Environmental Justice	None
Public and Occupational Health	• Radiological monitoring will be performed in accordance with the NRC radioactive materials license and references therein (RER 2022a). • An asbestos survey will be performed as a component of air quality permitting
Waste Management	• Monitoring as required to meet DOT regulations

DOT – US Department of Transportation
NRC – US Nuclear Regulatory Commission
RER – Rare Element Resources, Inc.

7 Cost Benefit Analysis

Because the Demonstration Project is a test facility intended to meet the objectives of a government directive and DOE contract award, a cost-benefit analysis was not performed.

8 Summary of Environmental Consequences

There are no environmental consequences expected from the proposed action, given the environmental setting and proposed mitigation measures summarized in section 1.

9 References

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- General Atomics – San Diego, CA (GA)
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Figures

TABLE 1. PROGRAM WBS SUMMARY		BP 1				BP 2				BP 3					
		Y1				Y2				Y3				Y4	
WBS	Task	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
1	REE Demonstration Plant														
1.1	REE Demonstration Plant Execution														
1.1.1	Design/Engineering														
1.1.2	Procurement/Contracting														
1.1.3	Construction														
1.1.4	Operations														
1.1.5	Program Support														
1.1.6	Subcontractor PM Activities														
1.1.7	Milestones														
1.1.7.1	Design														
1.1.7.2	Procurement & Construction														
1.1.7.3	Operations														
1.1.8	Go/No-Go Decisions				M12			M21							
3	Program Management														
3.1	Management & Coordination														
3.1.1	GA Program Management														

BP – budget period
GA – General Atomics
M - month
PM – project management
REE – rare earth element
Q – quarter
WBS – work breakdown schedule
Y - year

Figure 1. Anticipated Demonstration Project schedule

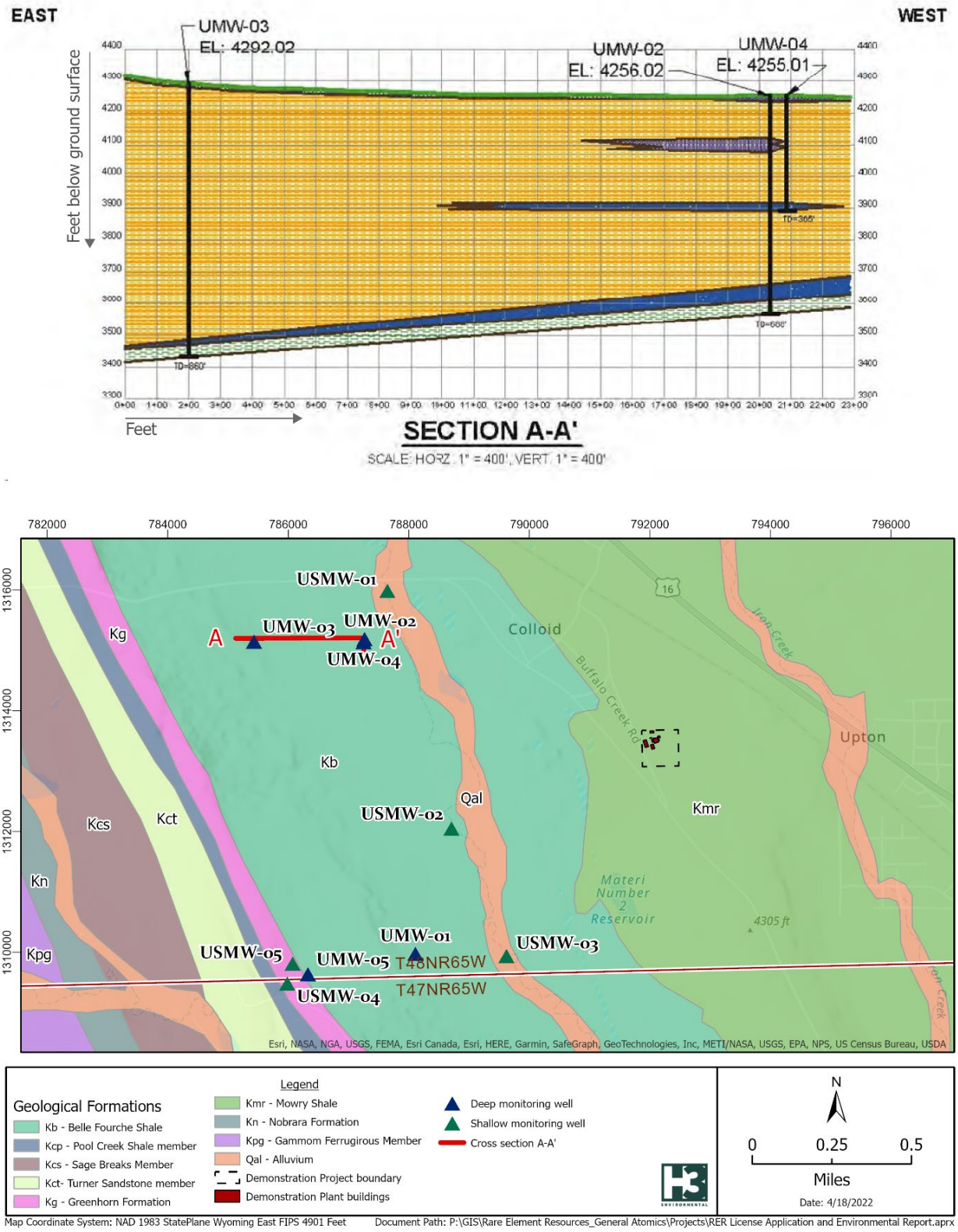


Figure 2. Geologic cross section A-A' (RER 2015a)

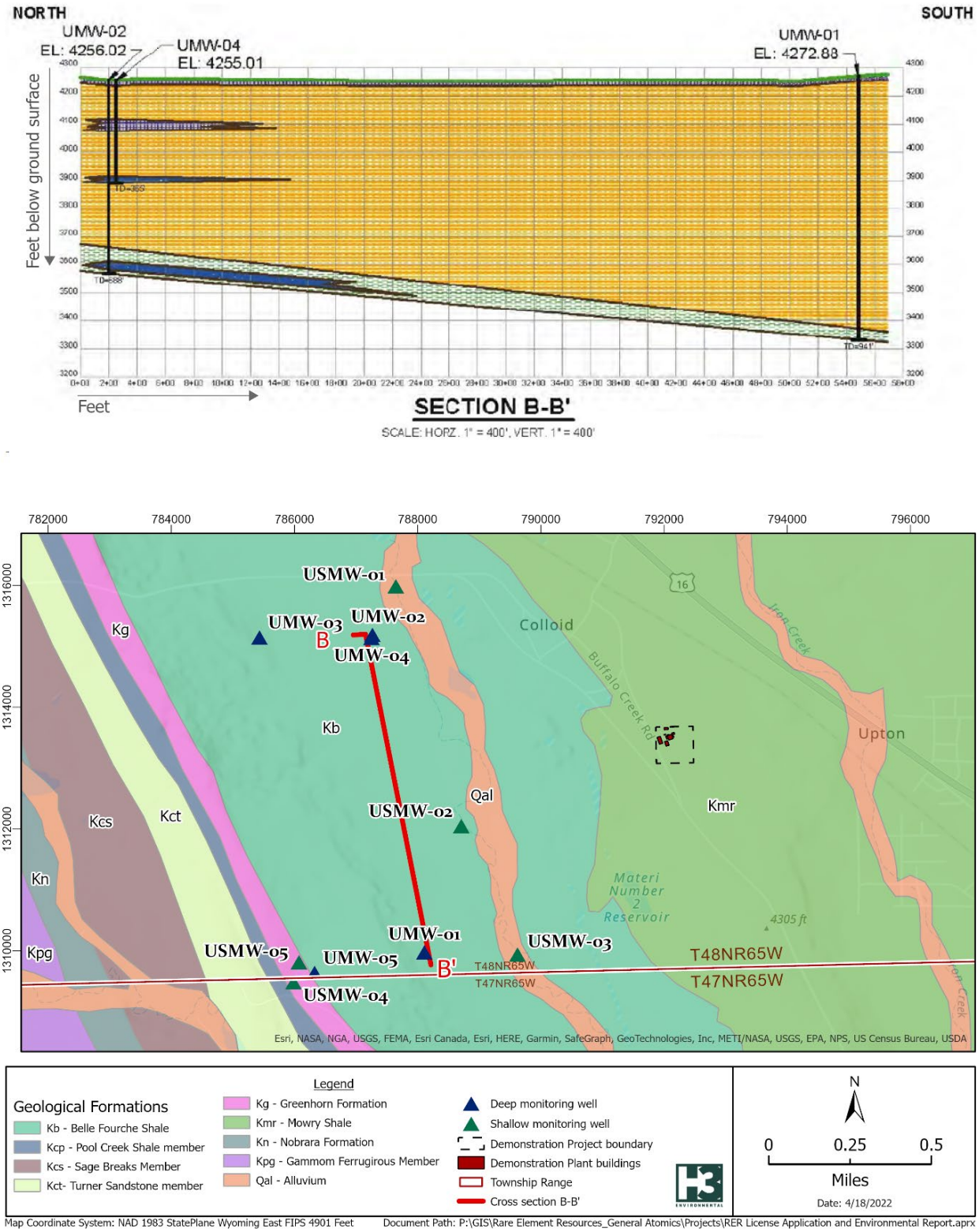


Figure 3. Geologic cross section B-B' (RER 2015a)

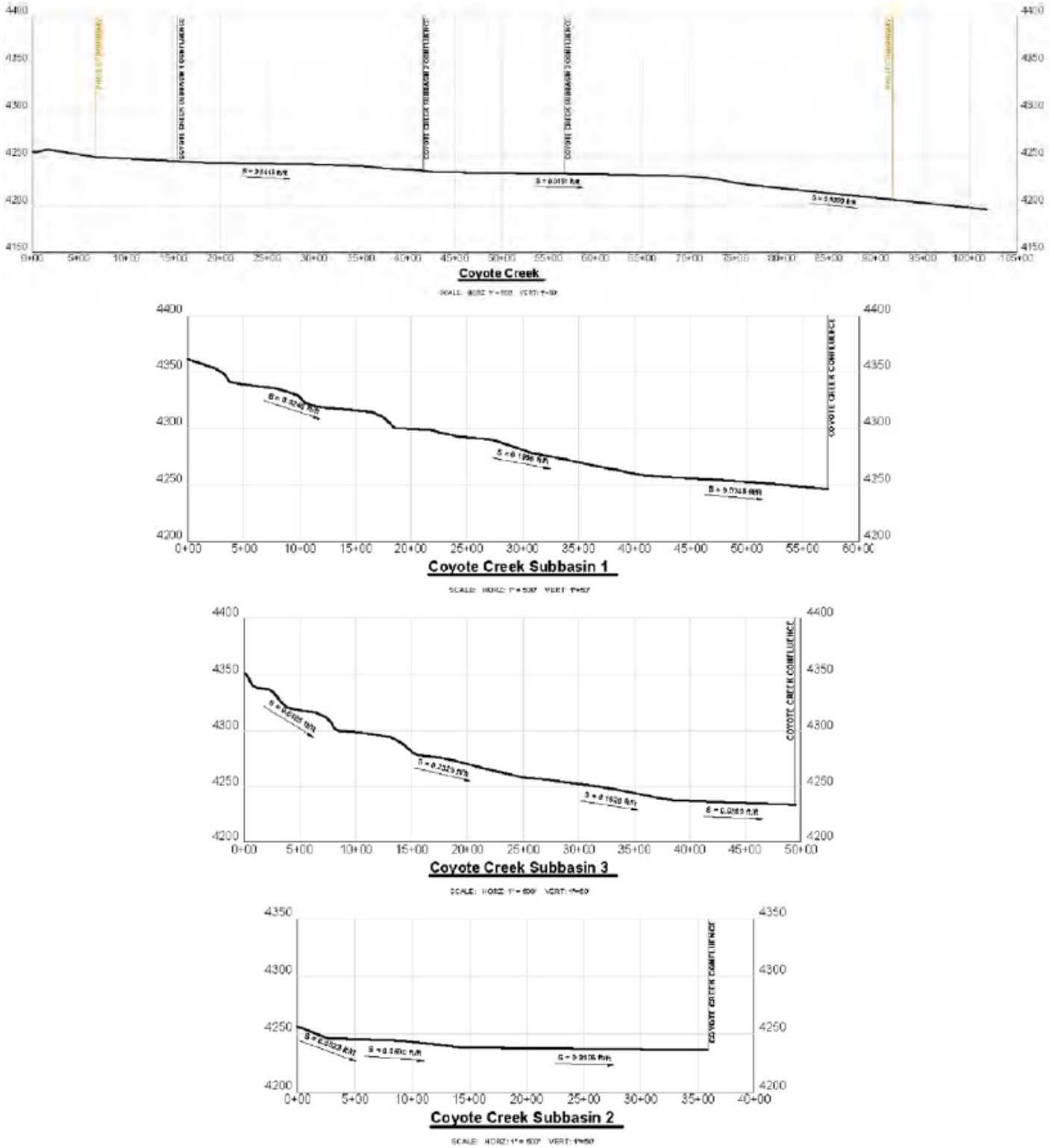


Figure 4. Stream profiles (RER 2015a)

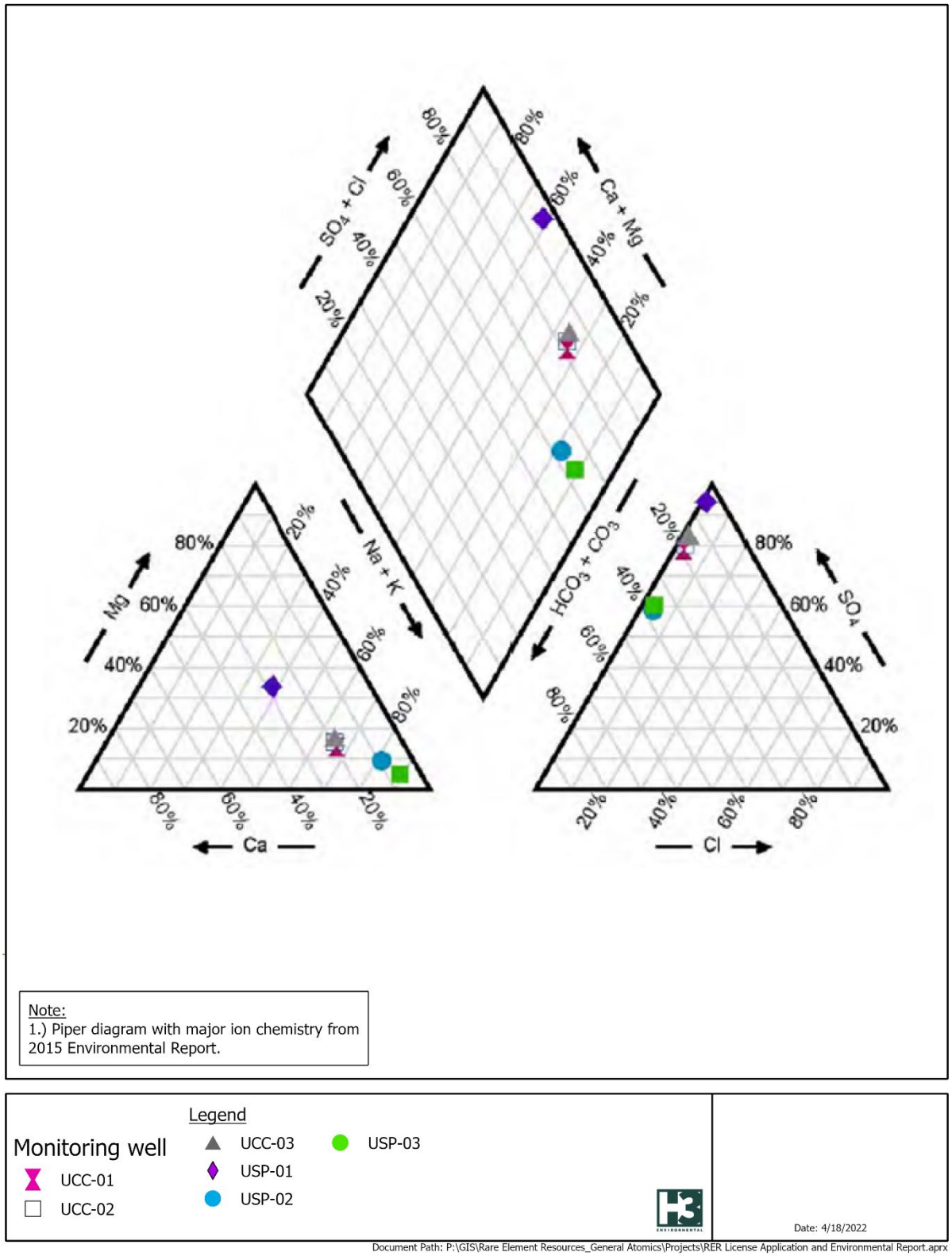
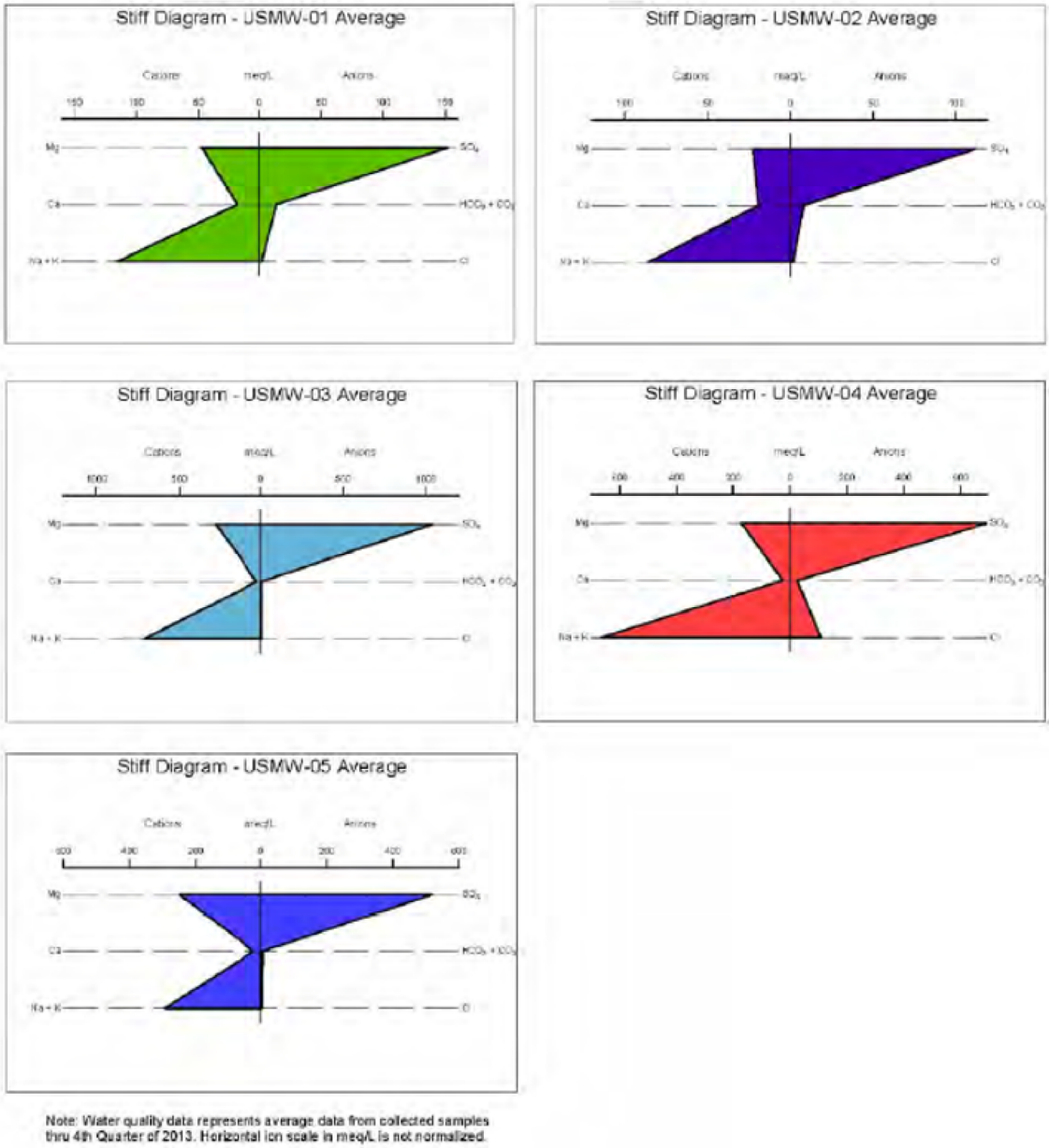


Figure 5. Piper diagram major ion chemistry (RER 2015a)



Note:
1.) Stiff diagrams from valley fill and weathered shale monitoring wells from 2015 Environmental Report.

Legend

Date: 4/18/2022

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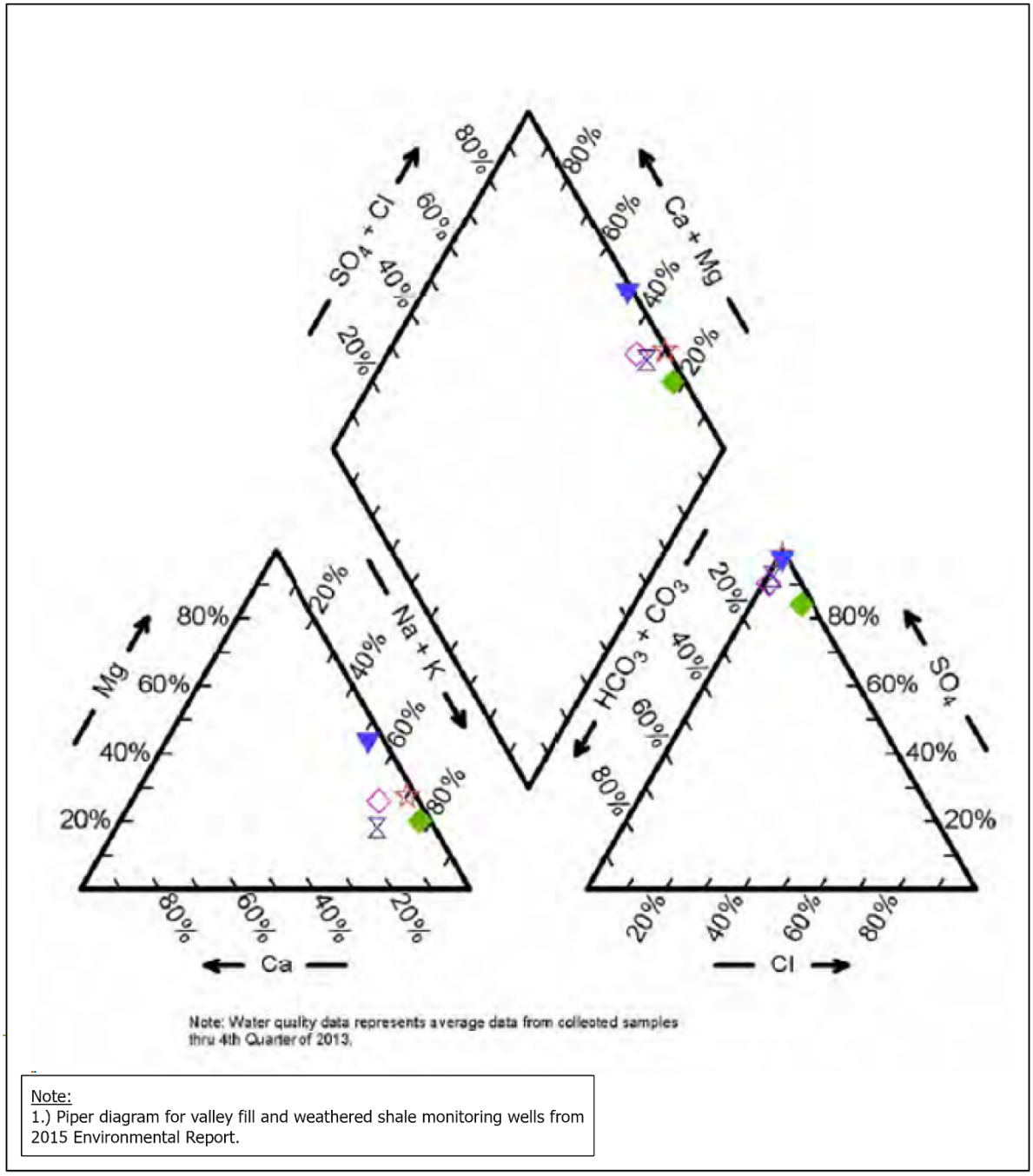
Figure 6. Stiff diagrams Valley Fill and Weathered Shale monitoring wells (RER 2015a)



Note:
1.) Piper diagram for valley fill and weathered shale monitoring wells from 2015 Environmental Report.

Legend

Monitoring well

- USMW-01
- USMW-02
- USMW-03
- USMW-04
- USMW-05

Date: 4/18/2022

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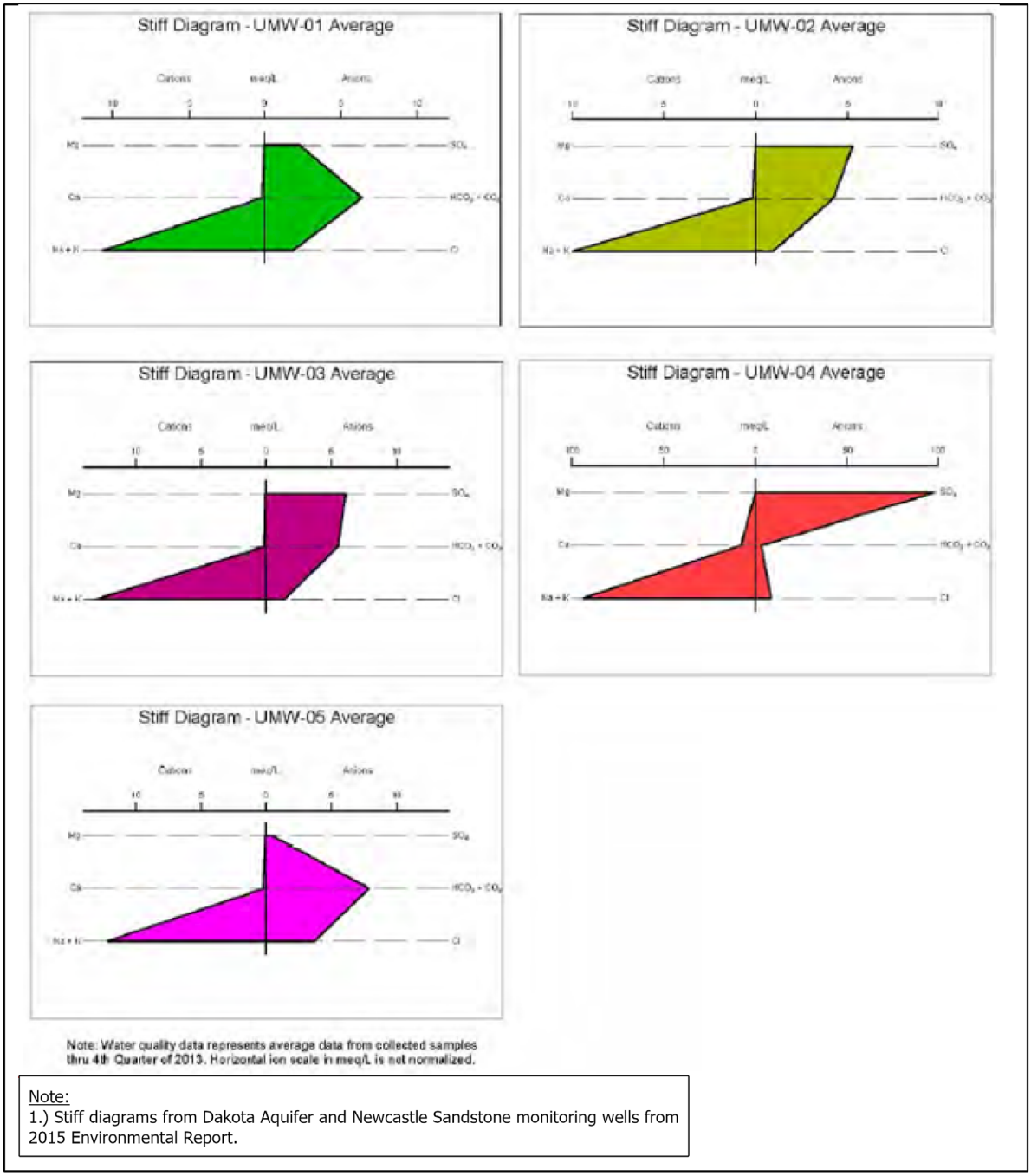
Figure 7. Piper diagram Valley Fill and Weathered Shale monitoring wells (RER 2015a)



Note:
1.) Stiff diagrams from Dakota Aquifer and Newcastle Sandstone monitoring wells from 2015 Environmental Report.

Legend

Date: 4/18/2022

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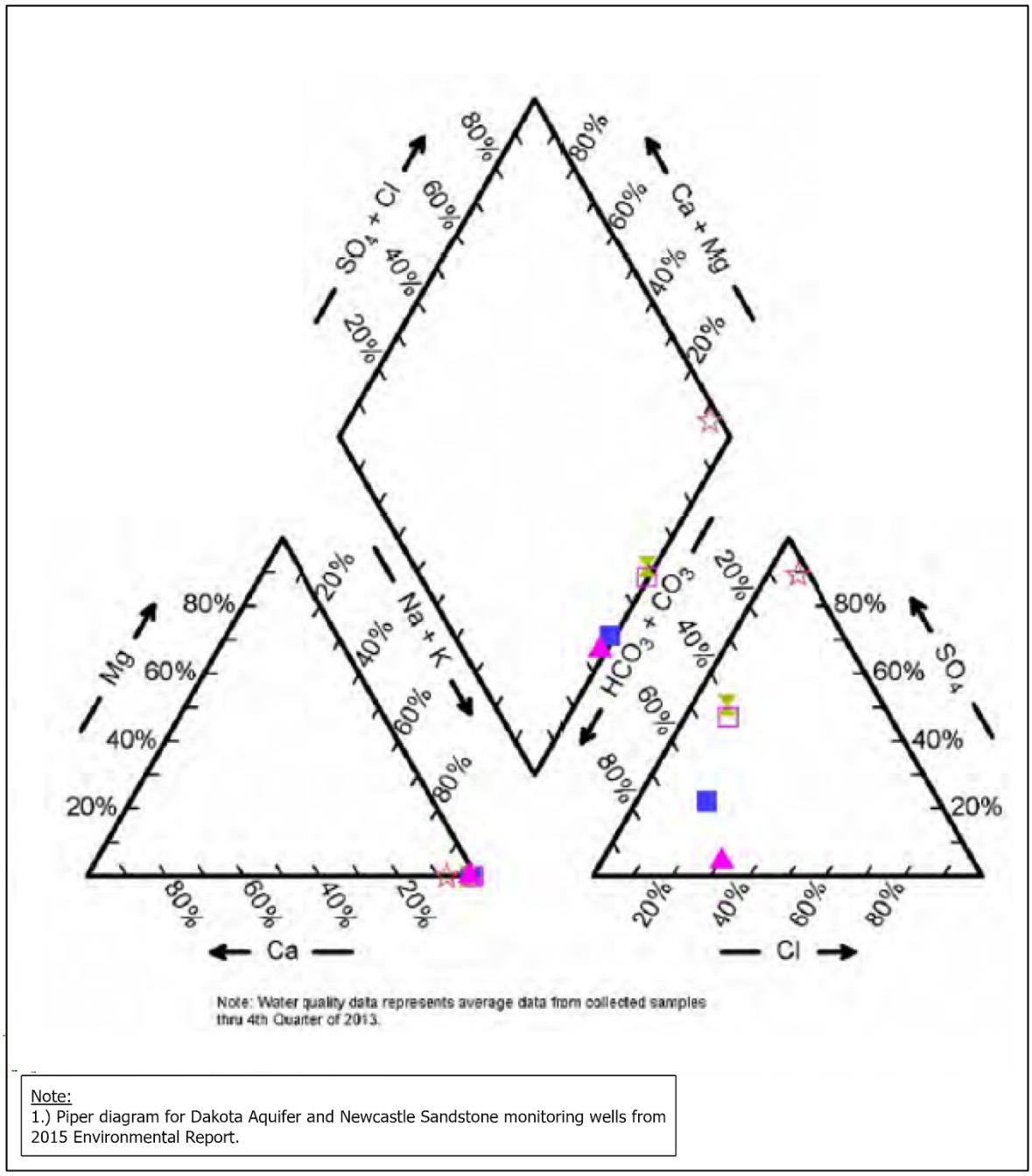
Figure 8. Stiff diagrams Dakota Aquifer and Newcastle Sandstone monitoring wells (RER 2015a)



Note:
1.) Piper diagram for Dakota Aquifer and Newcastle Sandstone monitoring wells from 2015 Environmental Report.

Legend

Monitoring well

- UMW-01
- UMW-02
- UMW-03
- UMW-04
- UMW-05

Date: 4/18/2022

Document Path: P:\GIS\Rare Element Resources_General Atomics\Projects\RER License Application and Environmental Report.aprx

Figure 9. Piper diagram Dakota Aquifer and Newcastle Sandstone monitoring wells (RER 2015a)

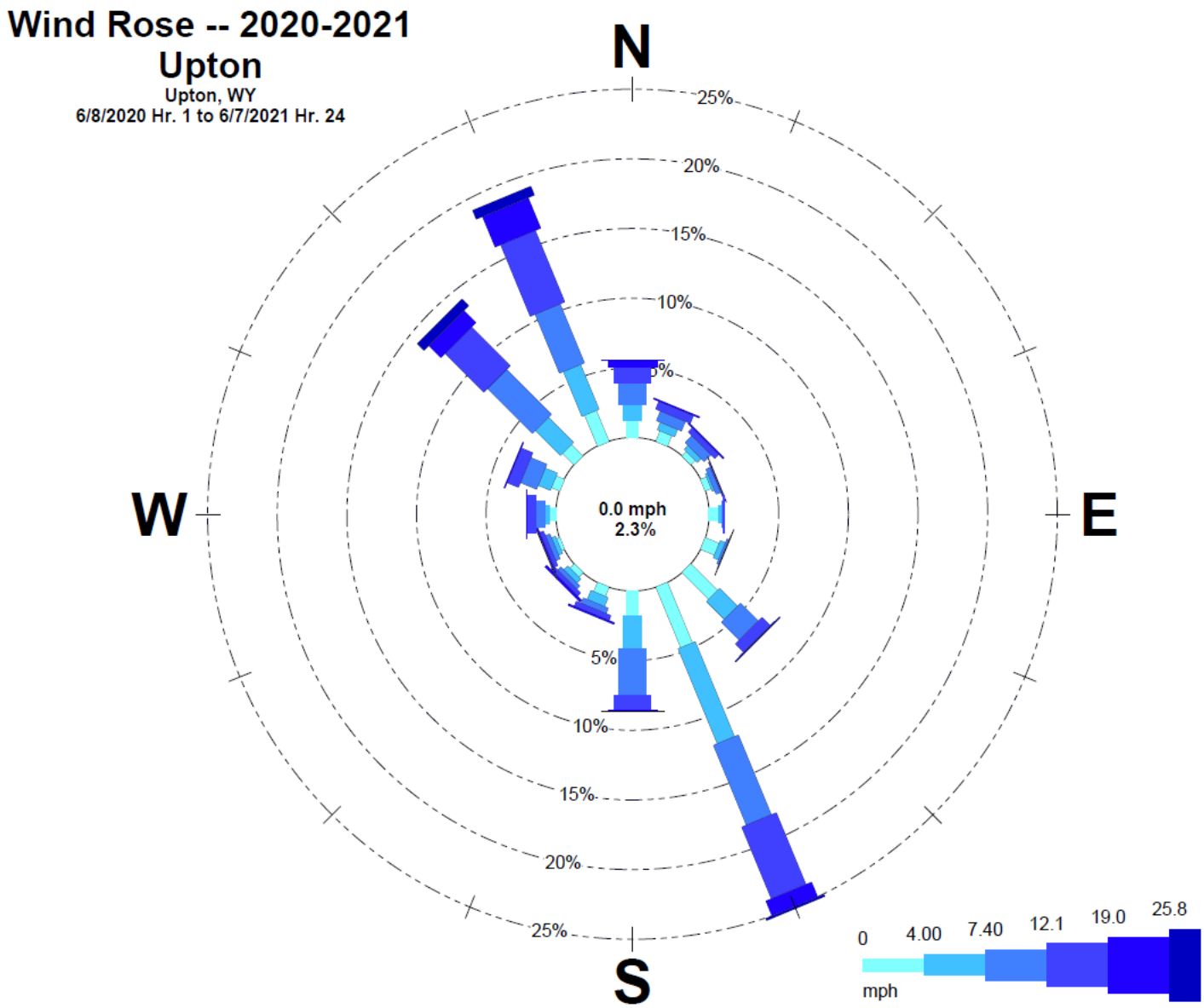


Figure 10. Demonstration Plant wind rose (IML 2021)

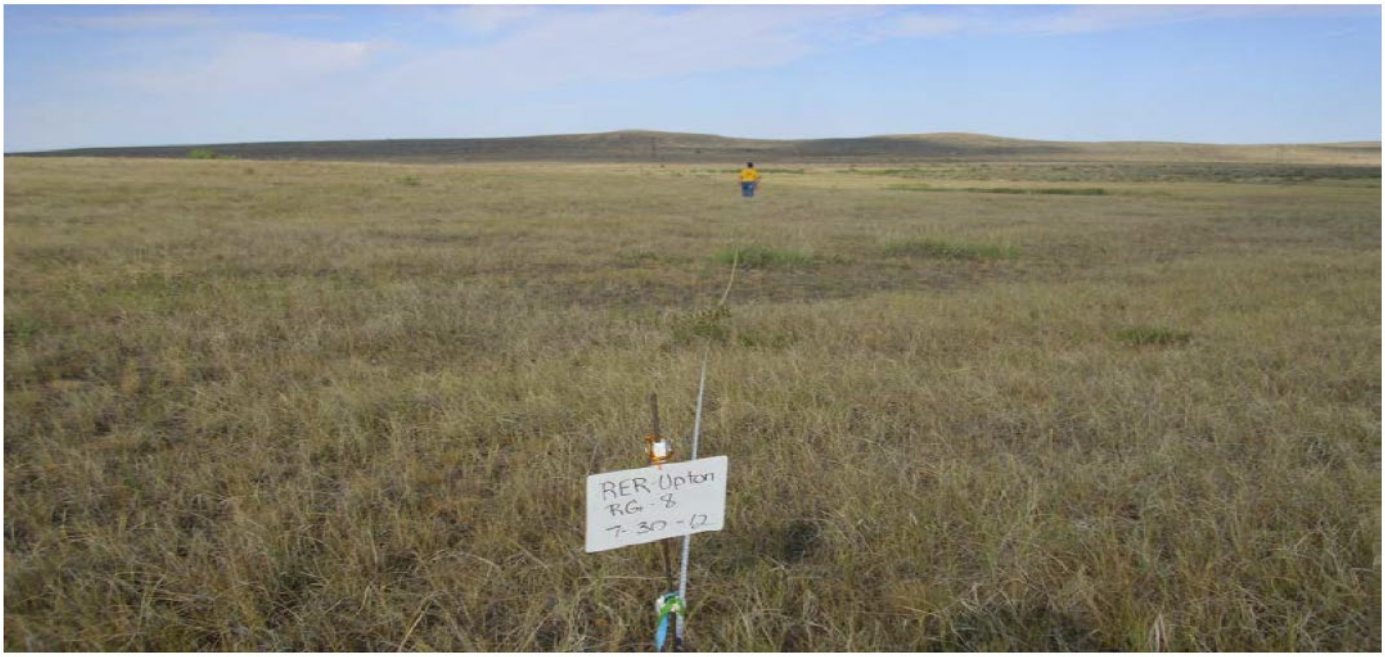


Figure 11. Photograph of representative grasslands and viewsheds taken near the Demonstration Plant site looking northwest (RER 2015a)

Figure 12. View from the proposed Demonstration Plant site facing West across Buffalo Creek Road (BKS 2021)

Figure 13. View from the southeast corner of the Demonstration Plant site facing West. Demonstration Plant site visible in top right of photo (BKS 2021)

Figure 14. View from the northeast corner of the Demonstration Plant site looking west toward existing structures (BKS 2021)

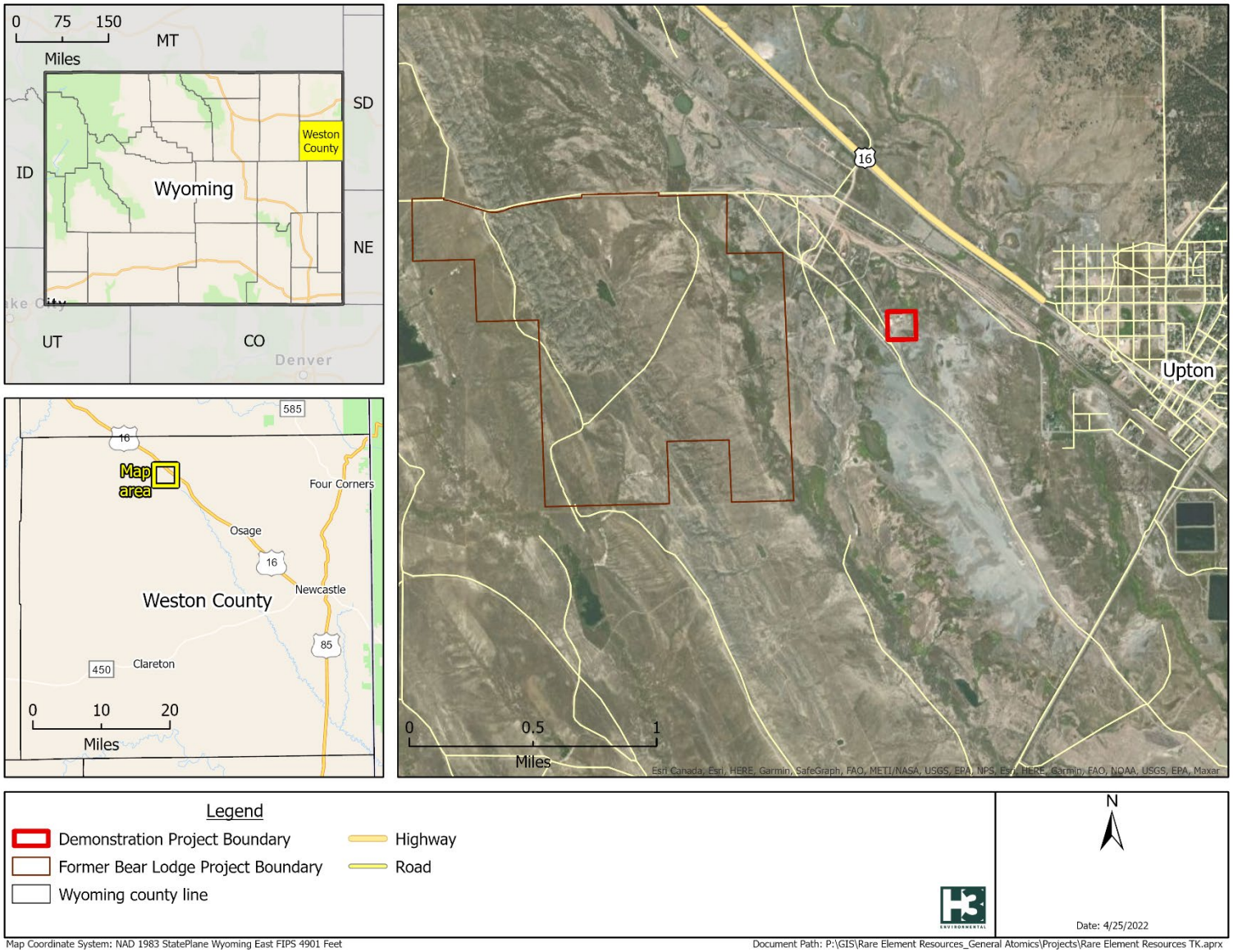
Figure 15. View from the northwest corner of the Demonstration Plant site looking southeast toward existing structures (BKS 2021)

Figure 16. View of the main process facility (East side) after repairs in 2021

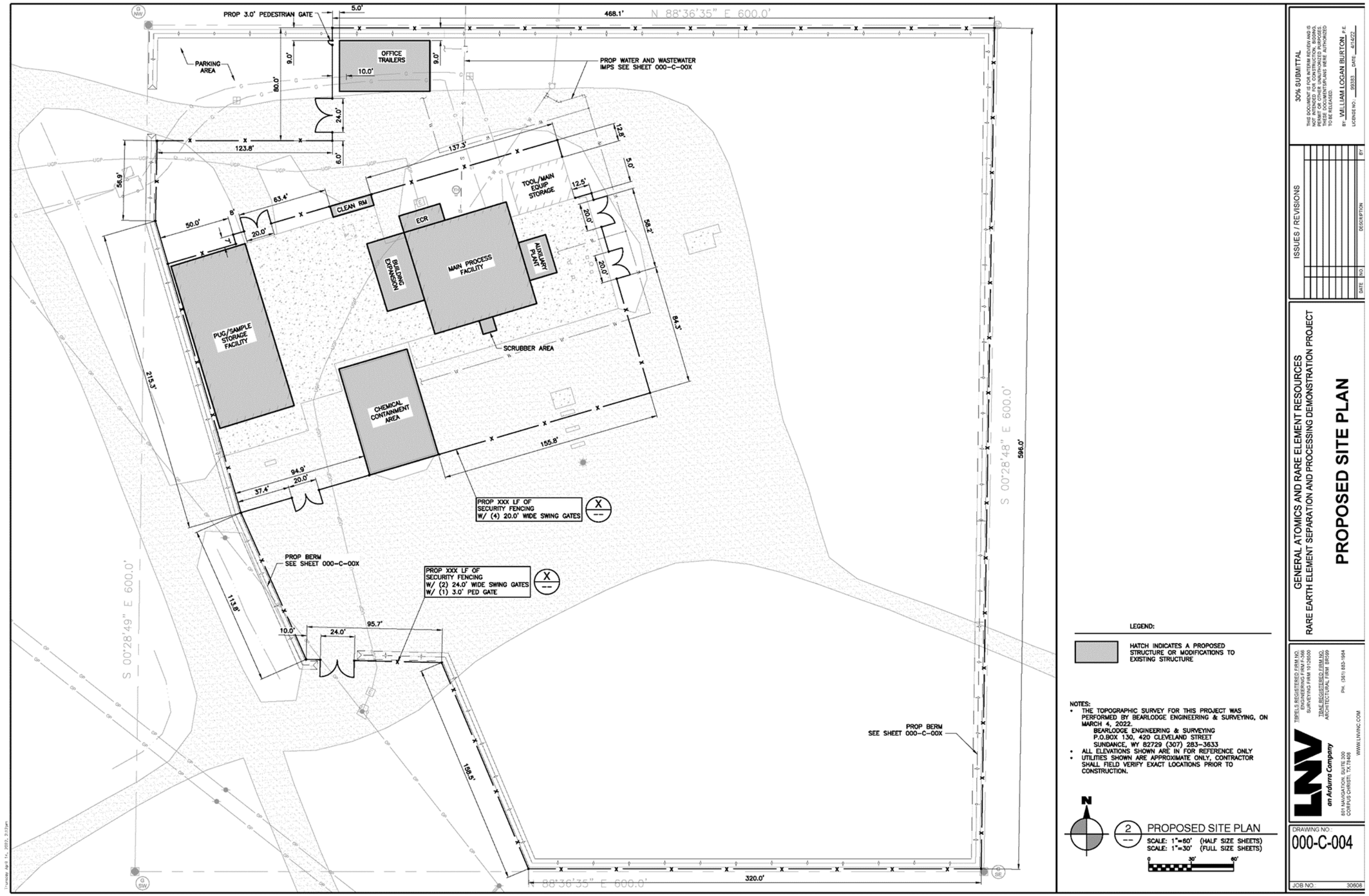
Figure 17. Aerial imagery of Demonstration Plant site (November 2021) after landowner cleanup of items identified in the *Environmental Site Assessment Phase 1 Report* (BKS 2021)

Maps

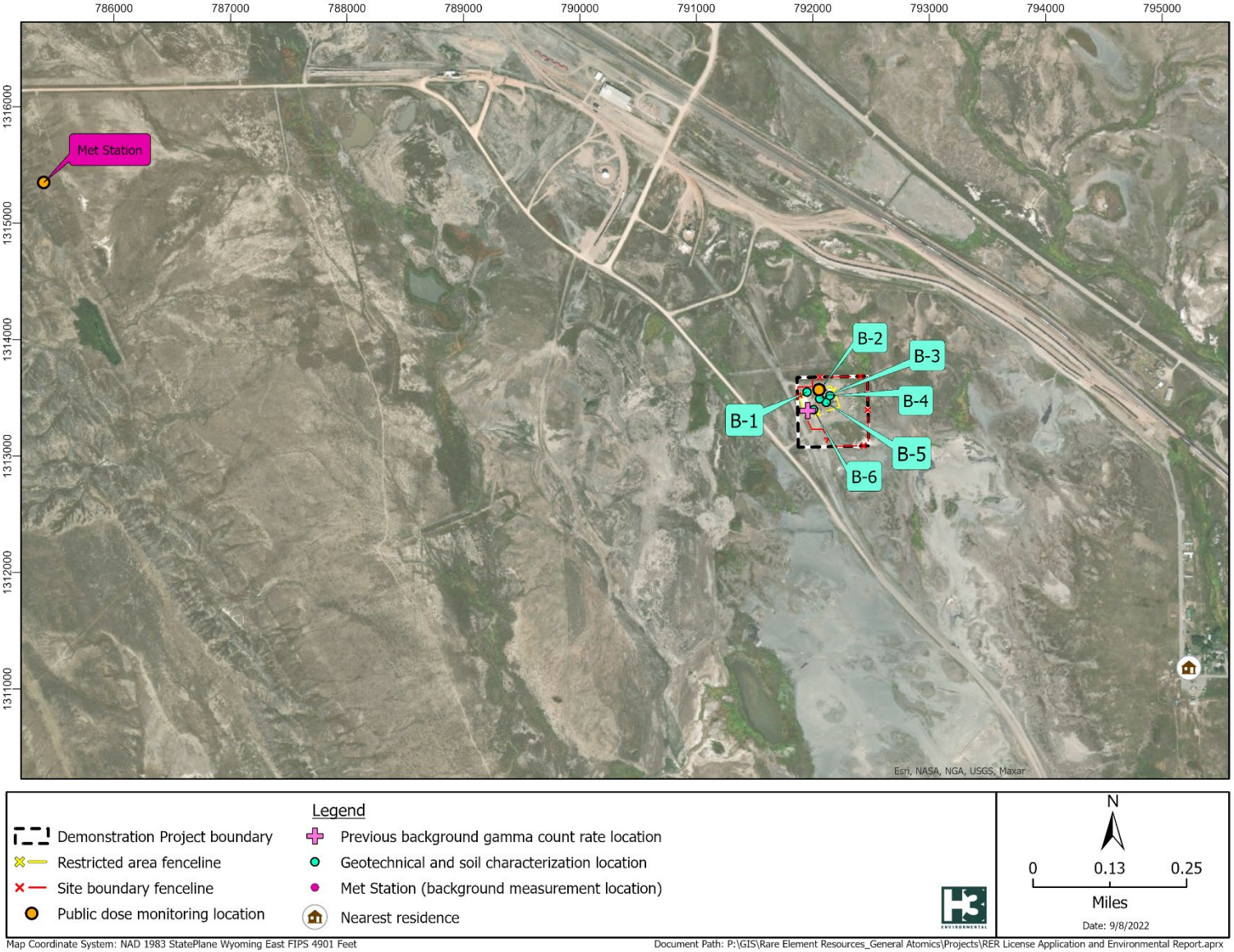
Map 1. Demonstration Project boundary near Upton, Wyoming



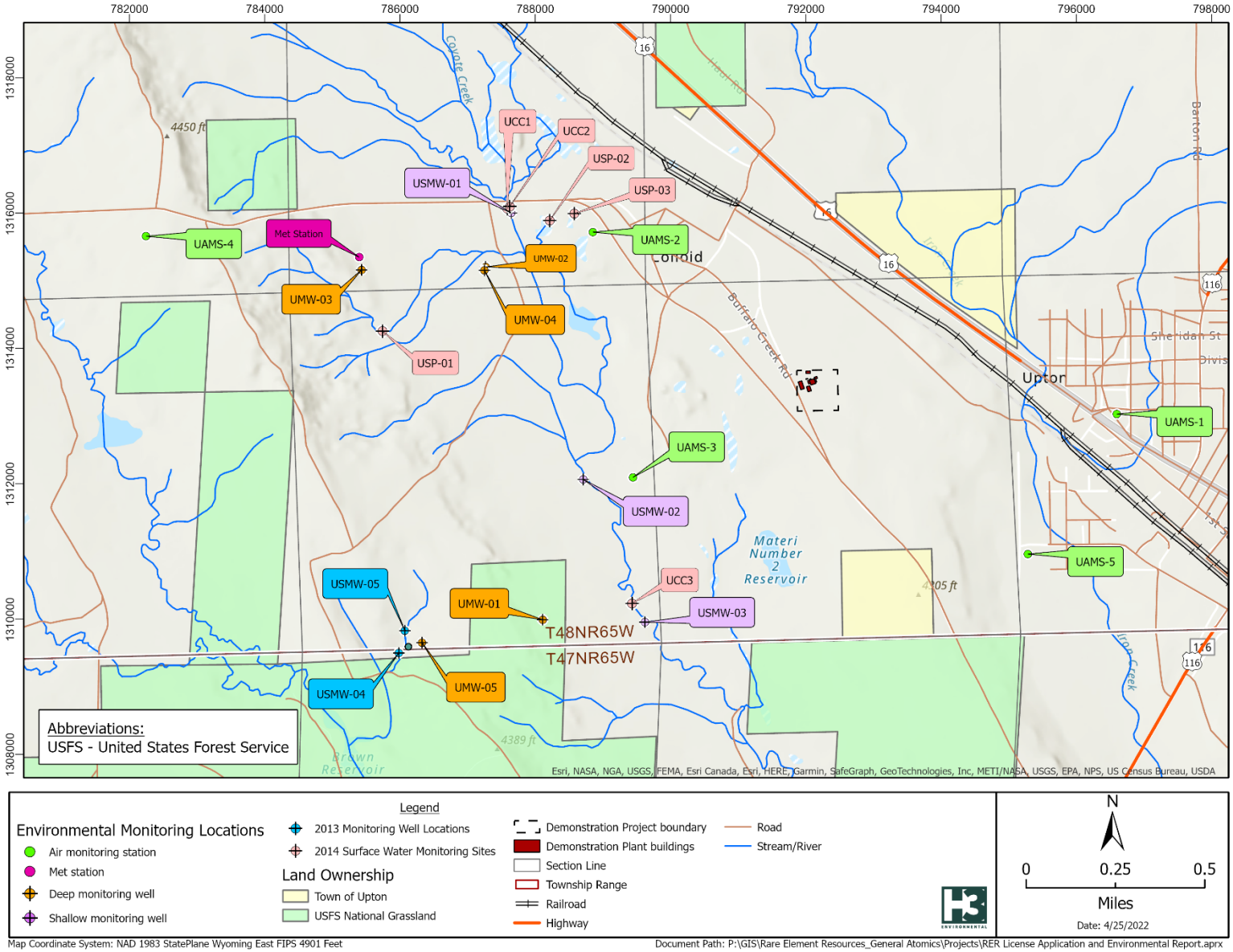
Map 2. Comparison of Demonstration Project and former Bear Lodge Project boundaries



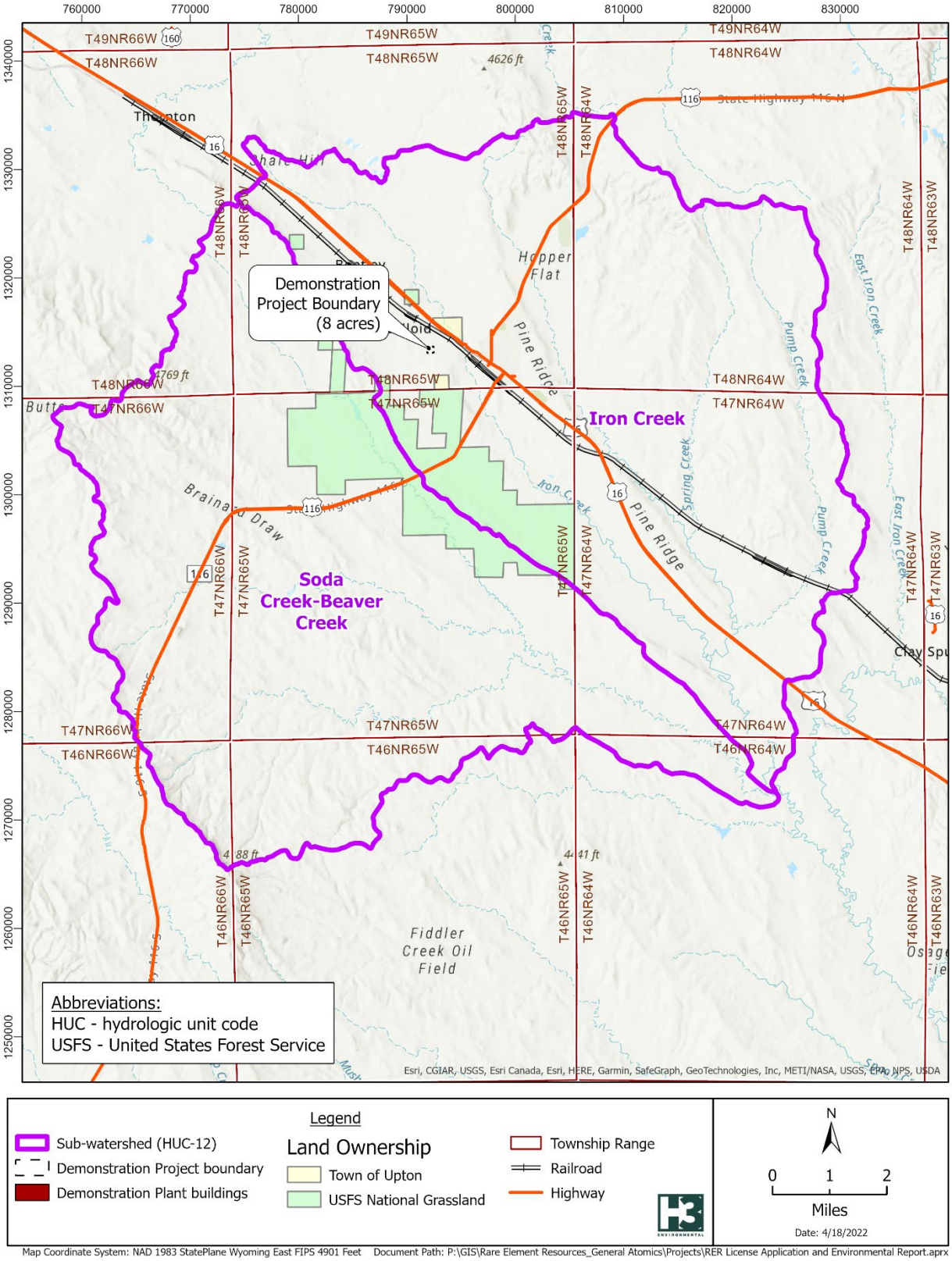
Map 3. Proposed Site Plan for the Demonstration Project



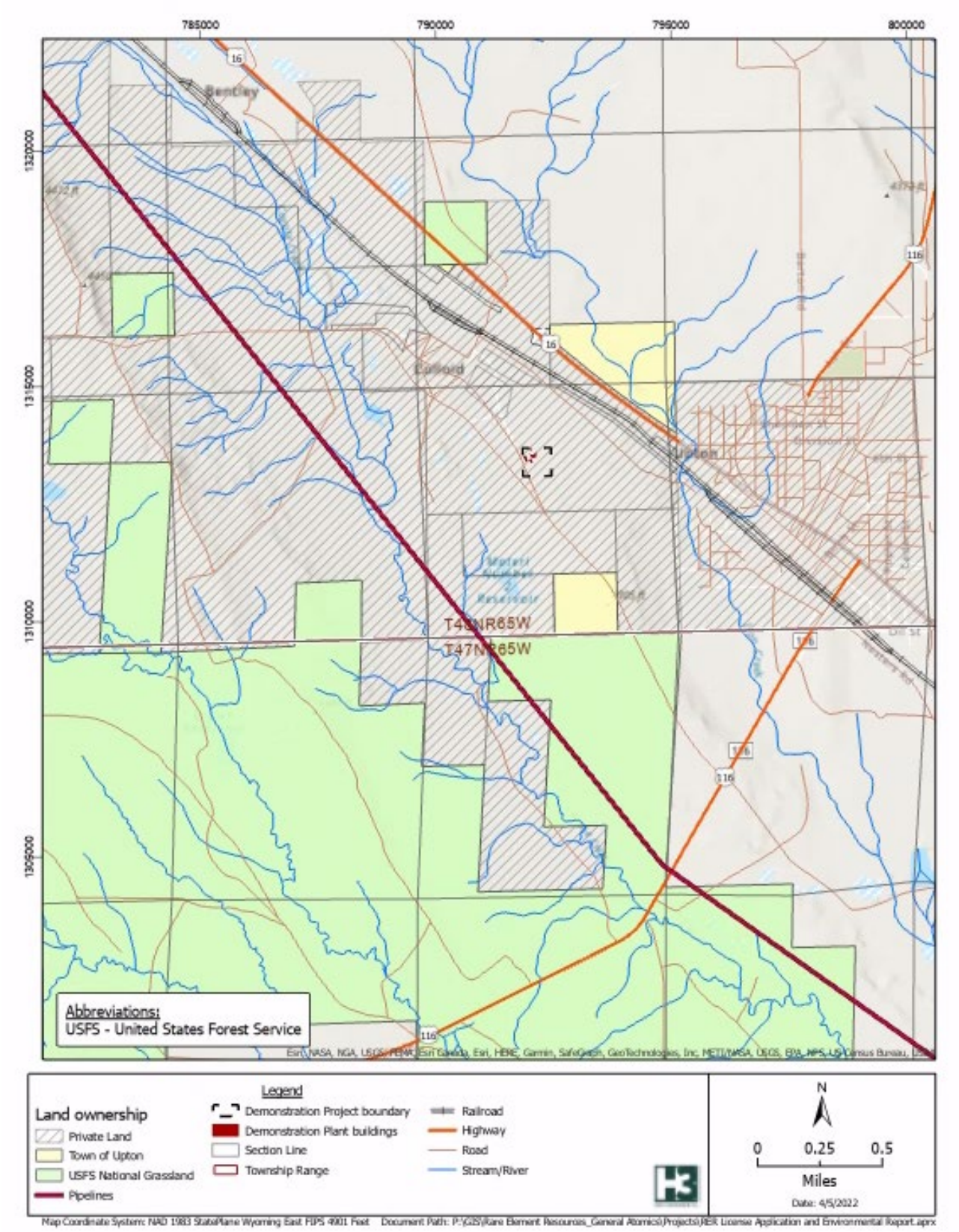
Map 4. Demonstration Project environmental monitoring map



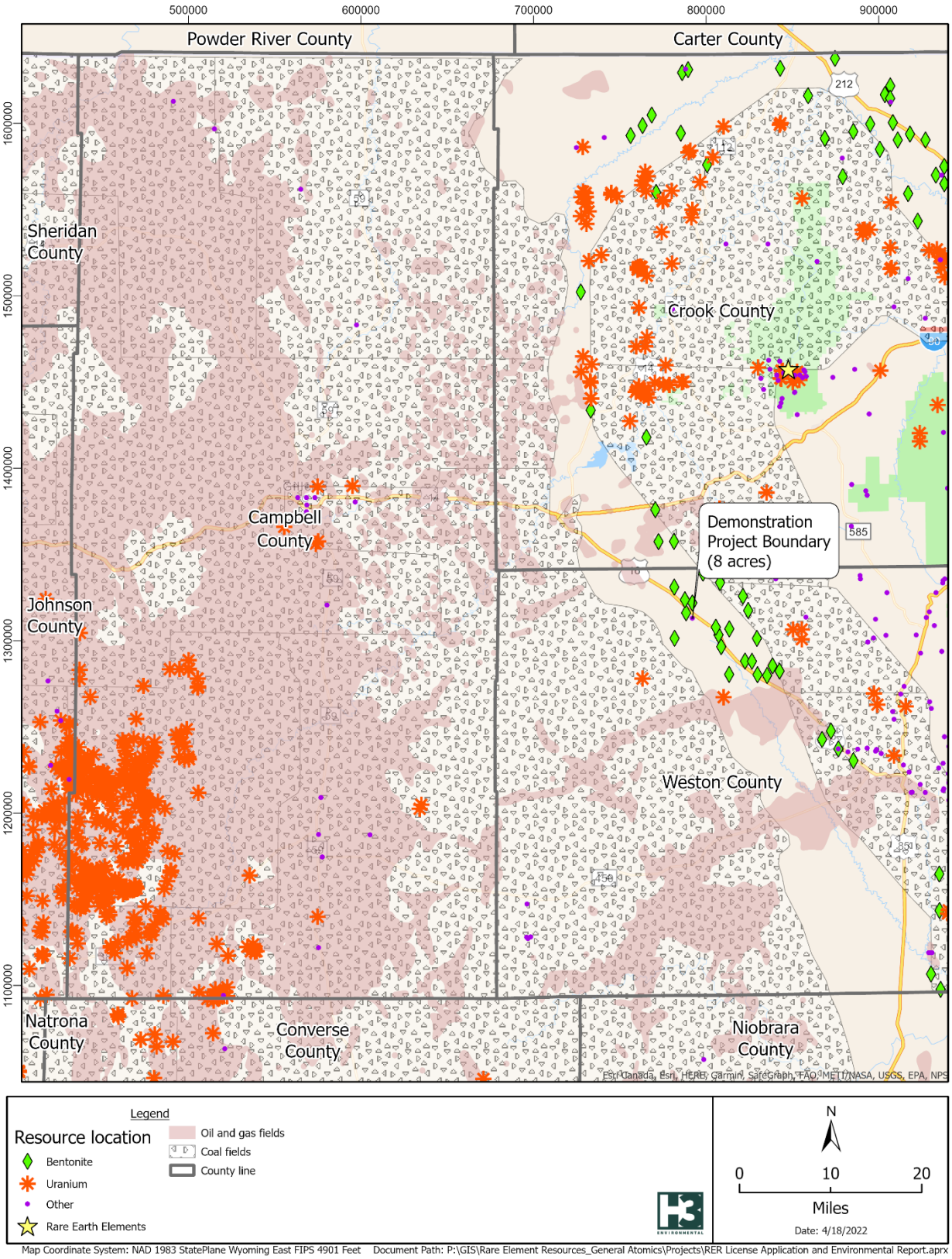
Map 5. Demonstration Project baseline monitoring map



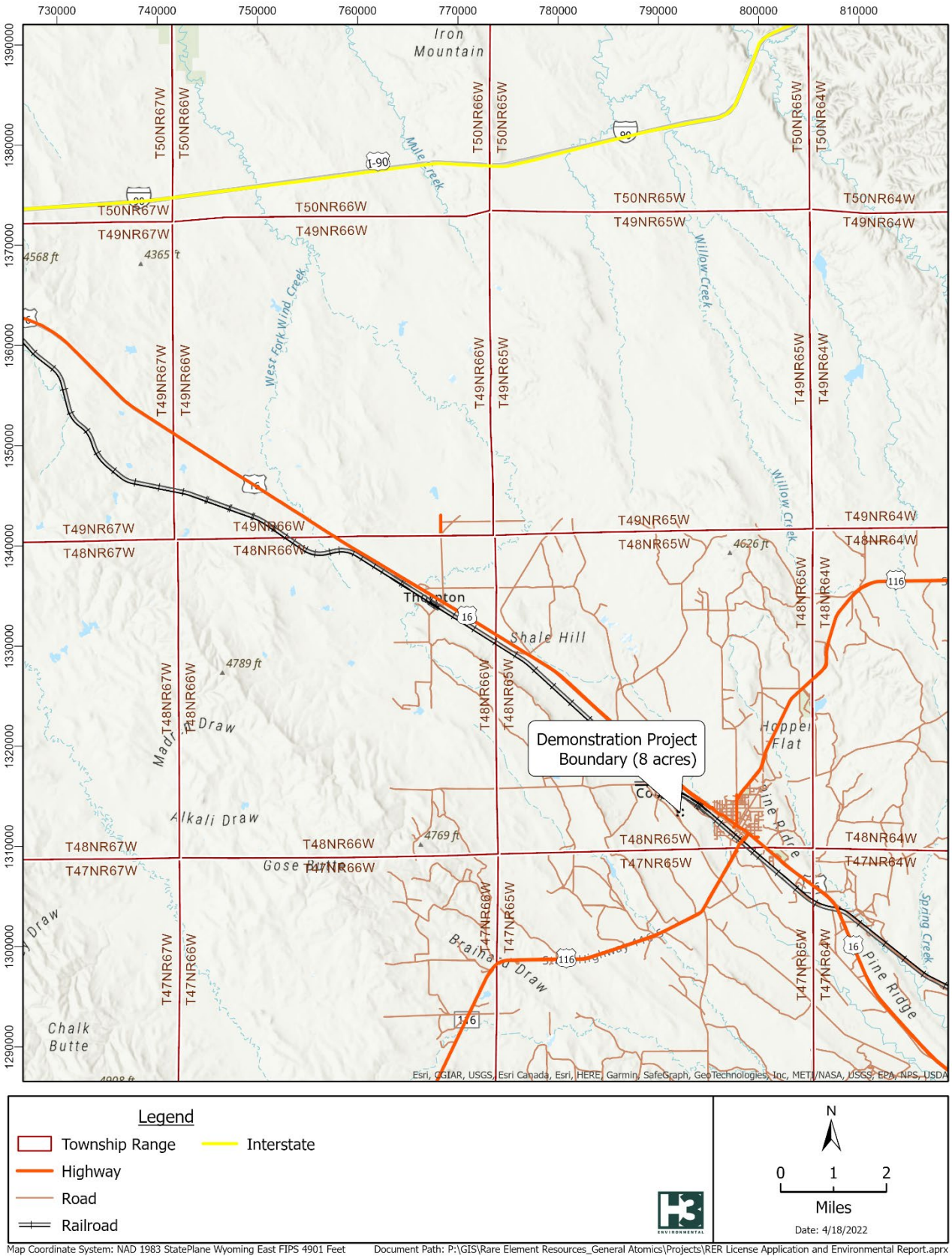
Map 6. Demonstration Project cumulative effects study area



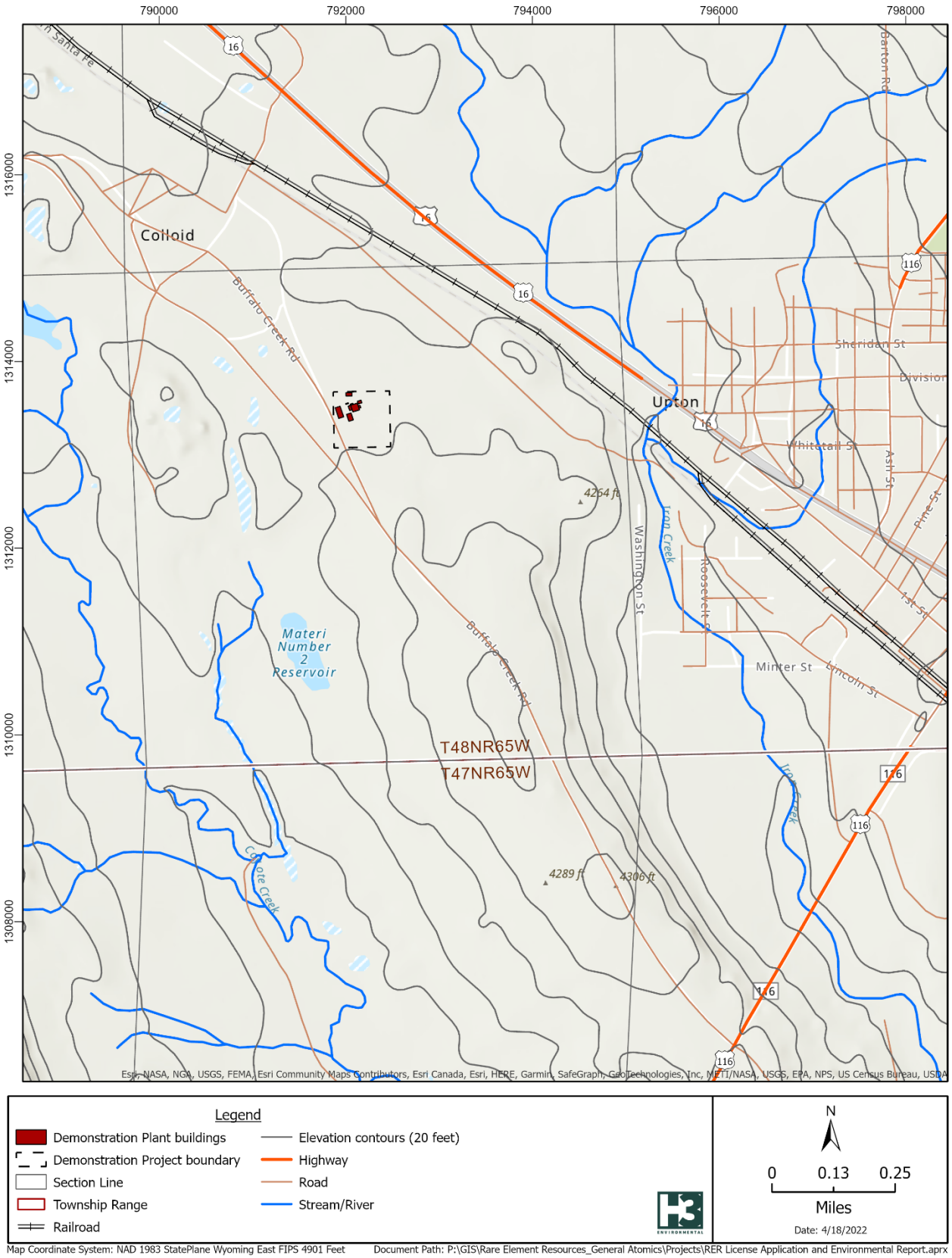
Map 7. Land ownership in the vicinity of the Demonstration Project



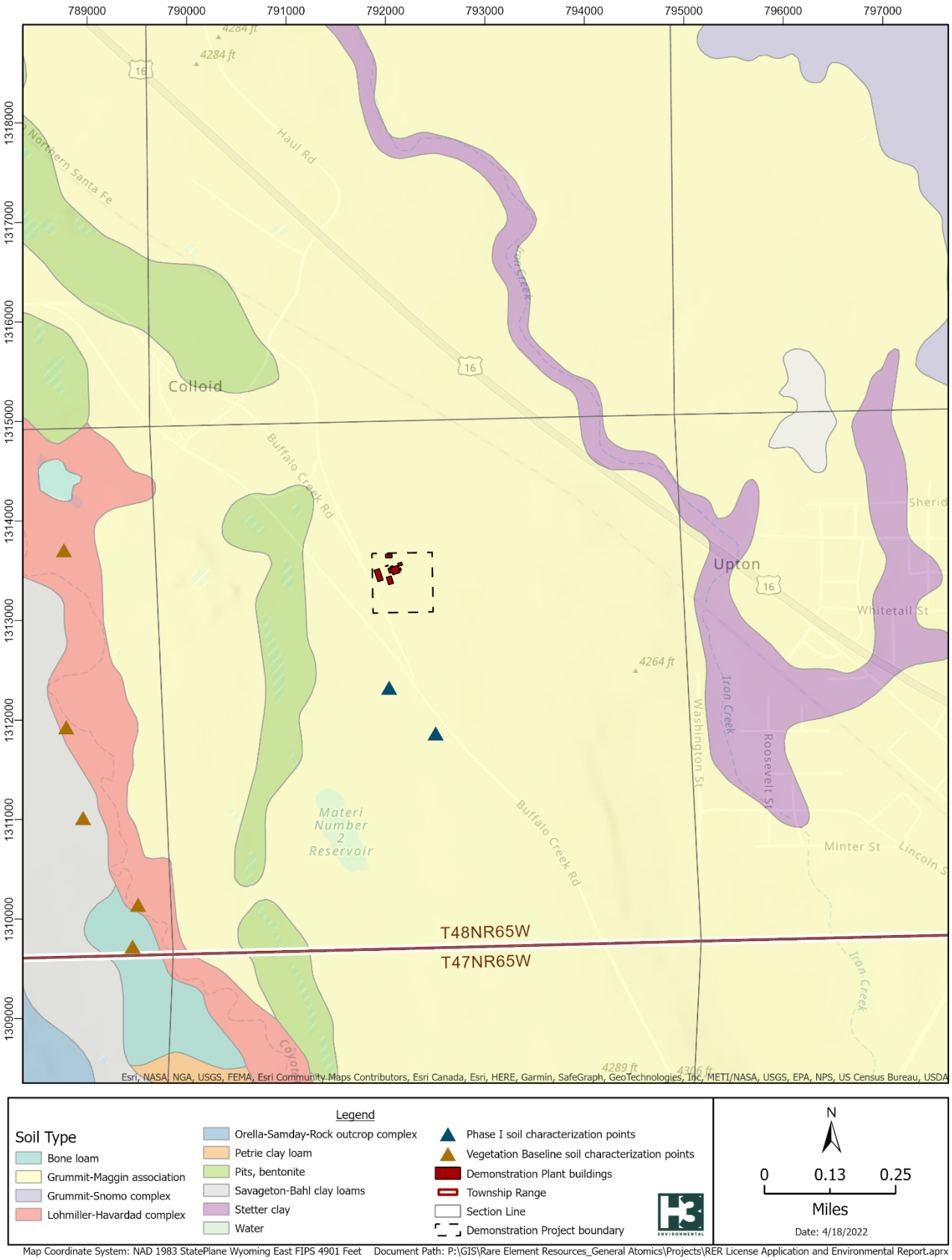
Map 8. Mineral resources in the vicinity of the Demonstration Project



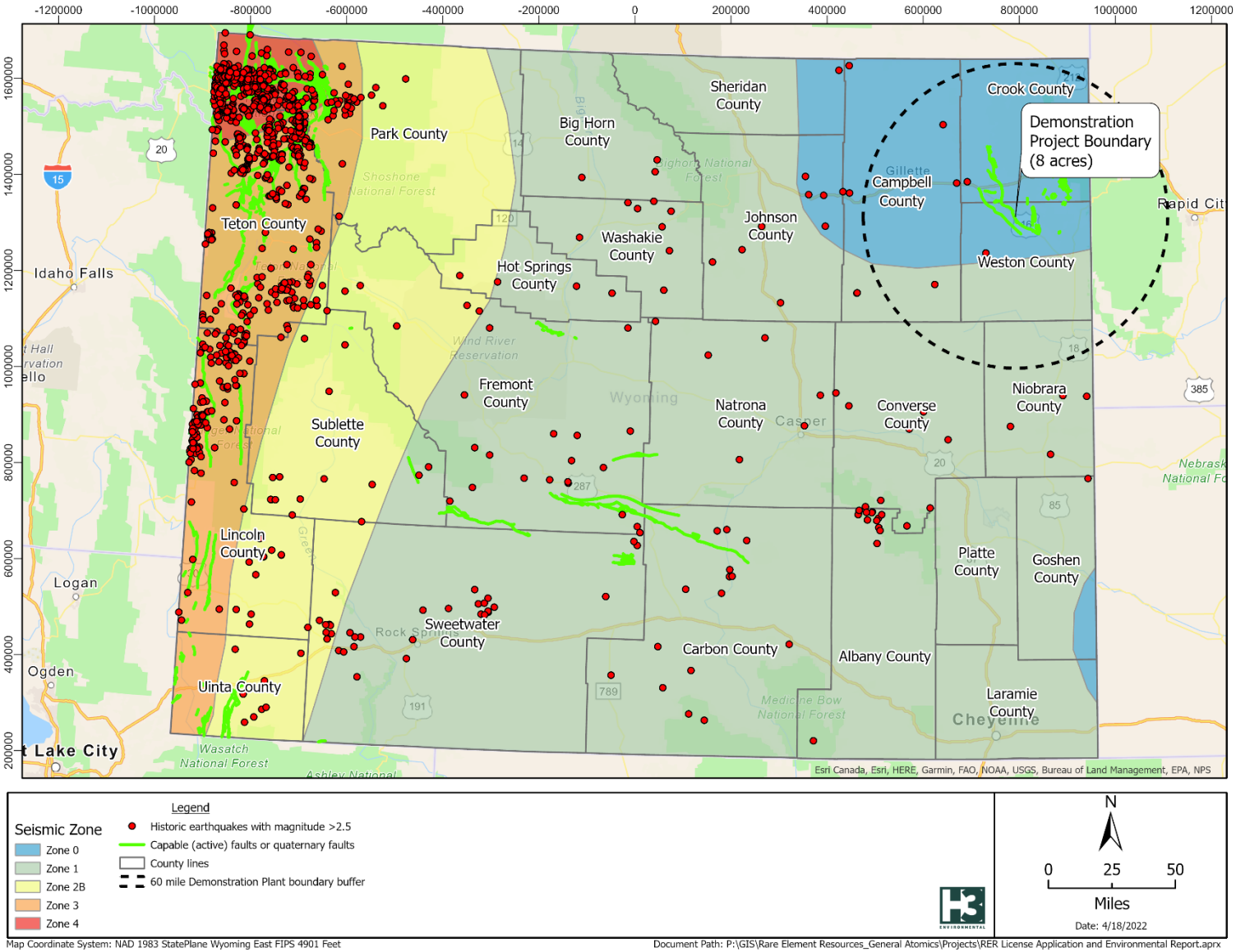
Map 9. Roads and railways in the vicinity of the Demonstration Project



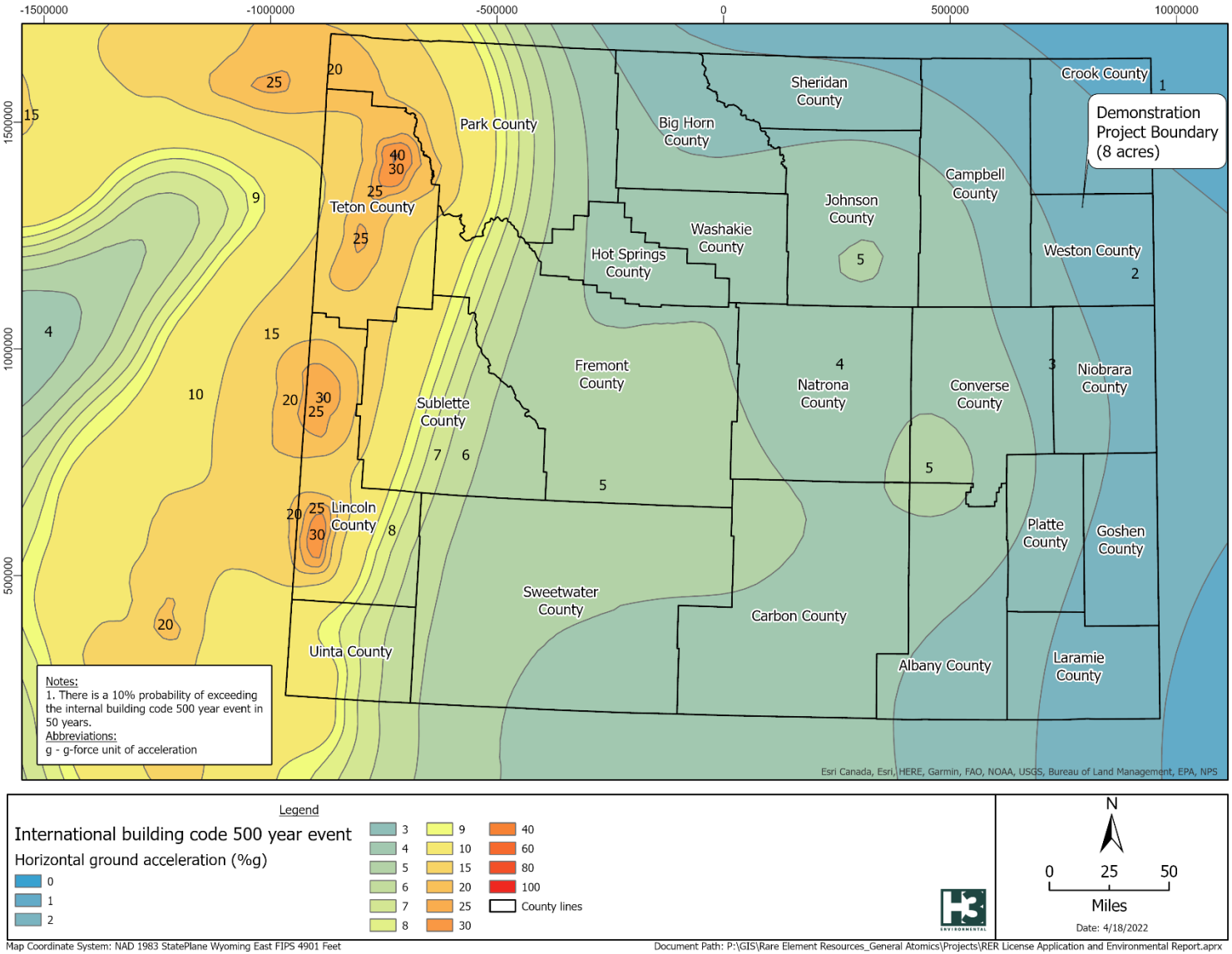
Map 10. Demonstration Project topography



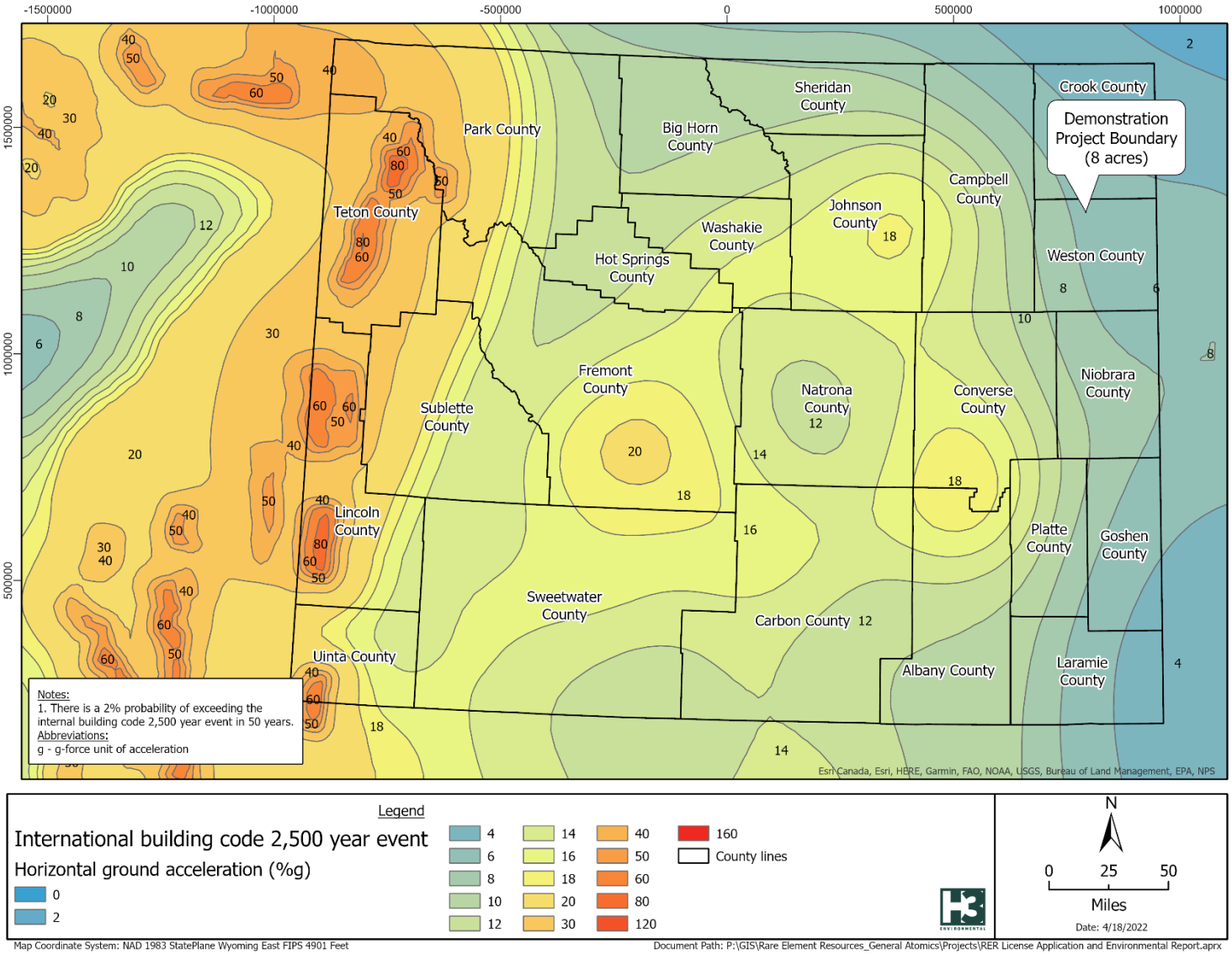
Map 11. Demonstration Project soil types



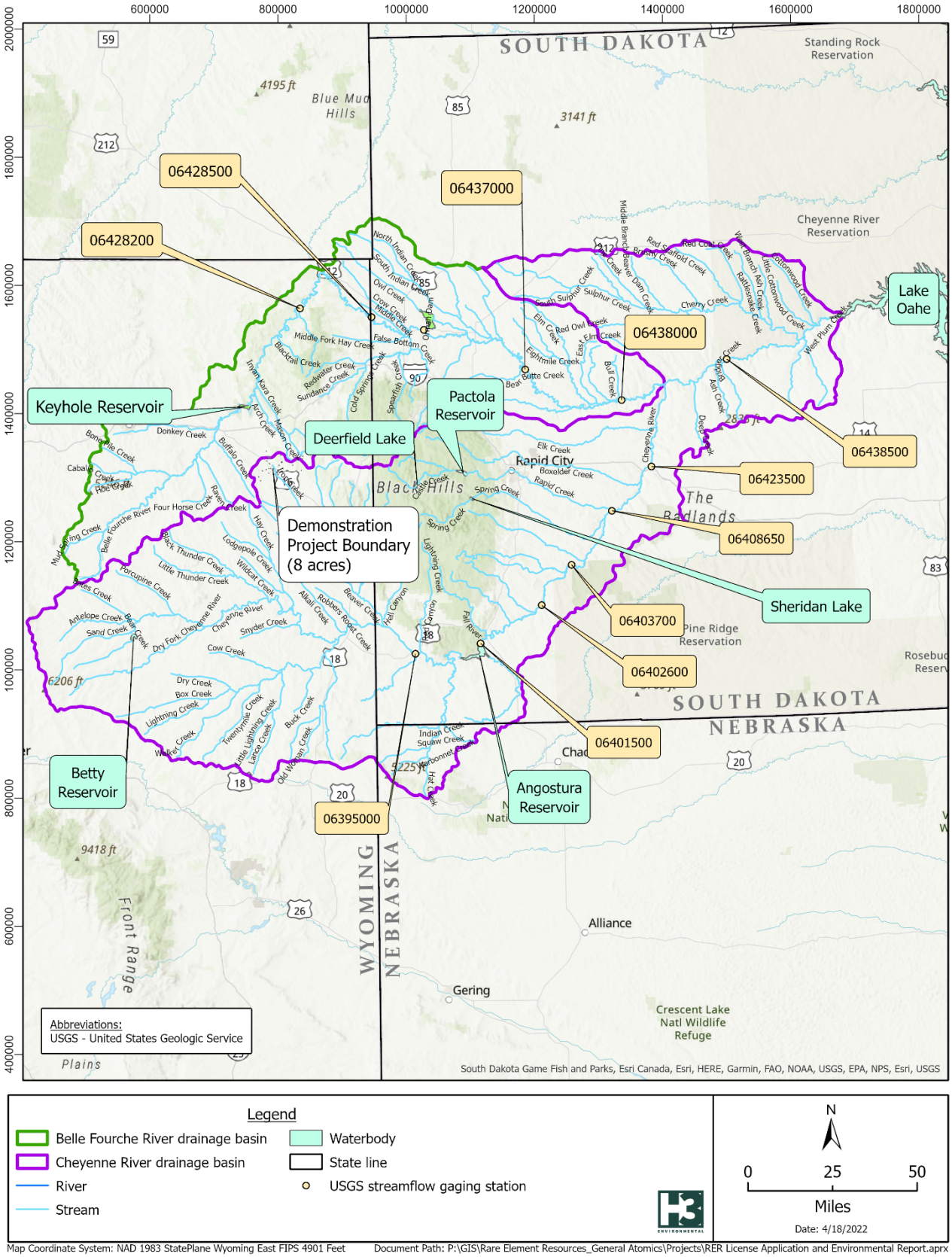
Map 12. Historic earthquakes and seismic zones in Wyoming



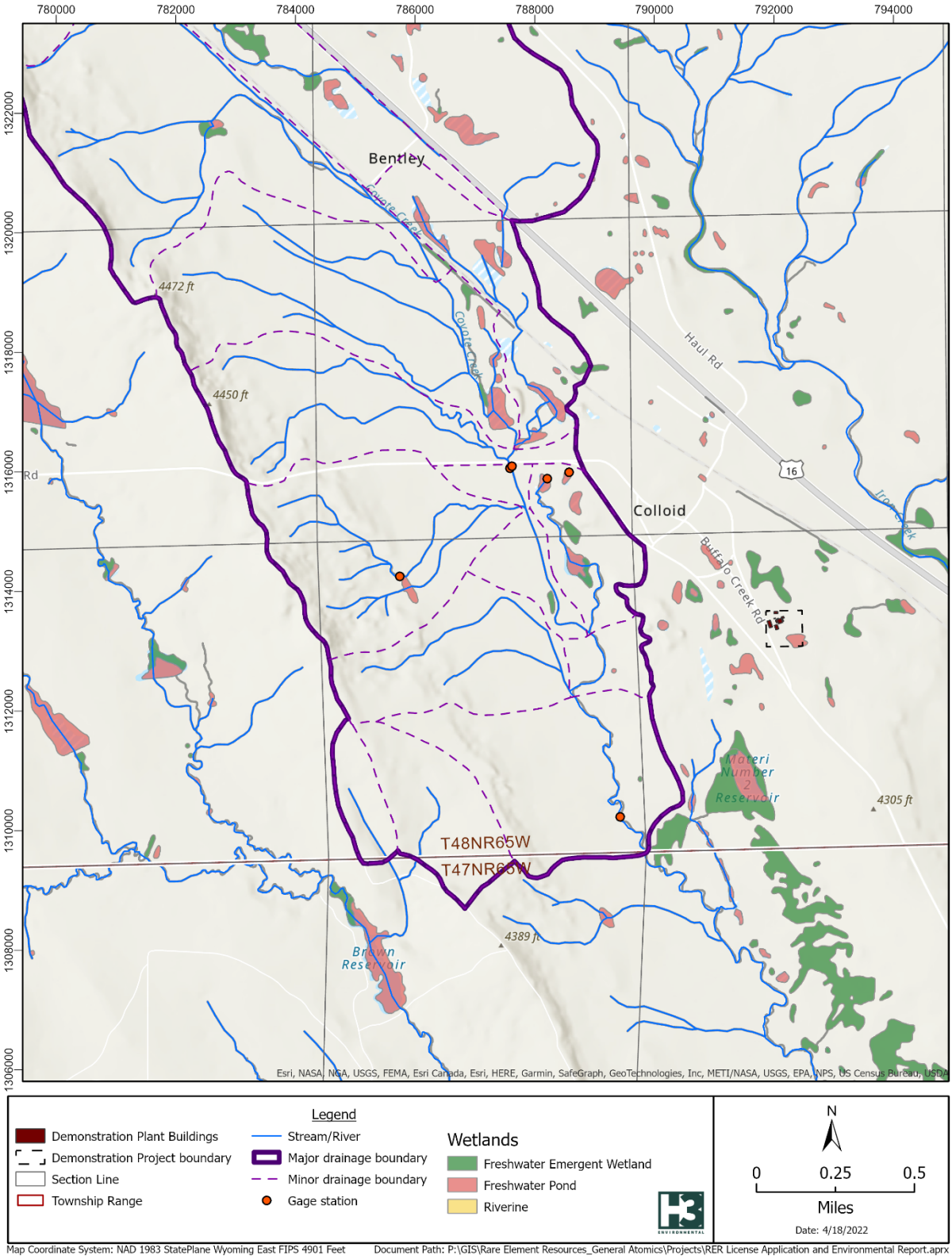
Map 13. International building code 500-year event



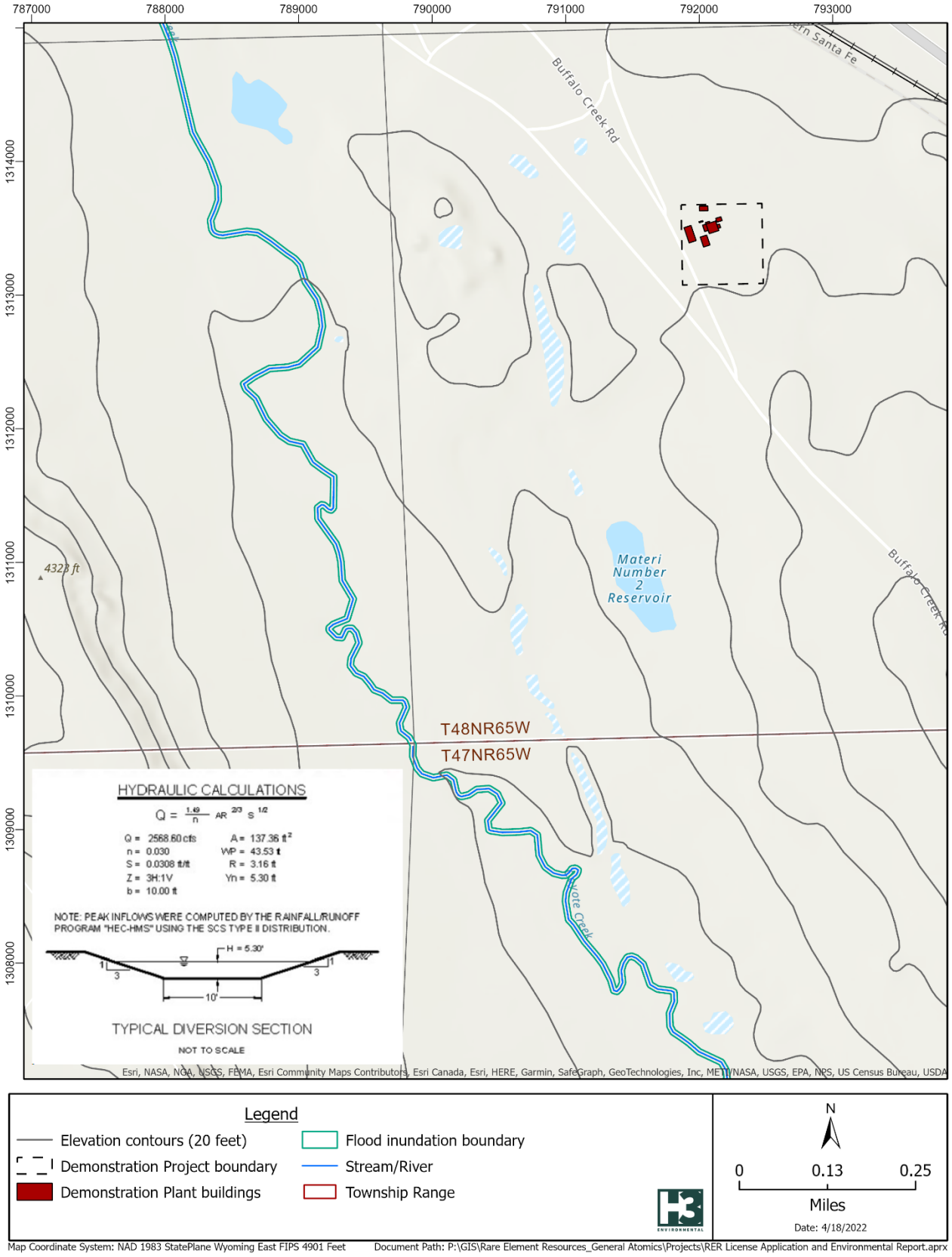
Map 14. International building code 2,500-year event



Map 15. Belle Fourche River and Cheyenne River Drainage Basin



Map 16. Drainage basins and wetlands in the vicinity of the Demonstration Project



Legend

- Elevation contours (20 feet)
- Demonstration Project boundary
- Demonstration Plant buildings
- Flood inundation boundary
- Stream/River
- Township Range

N

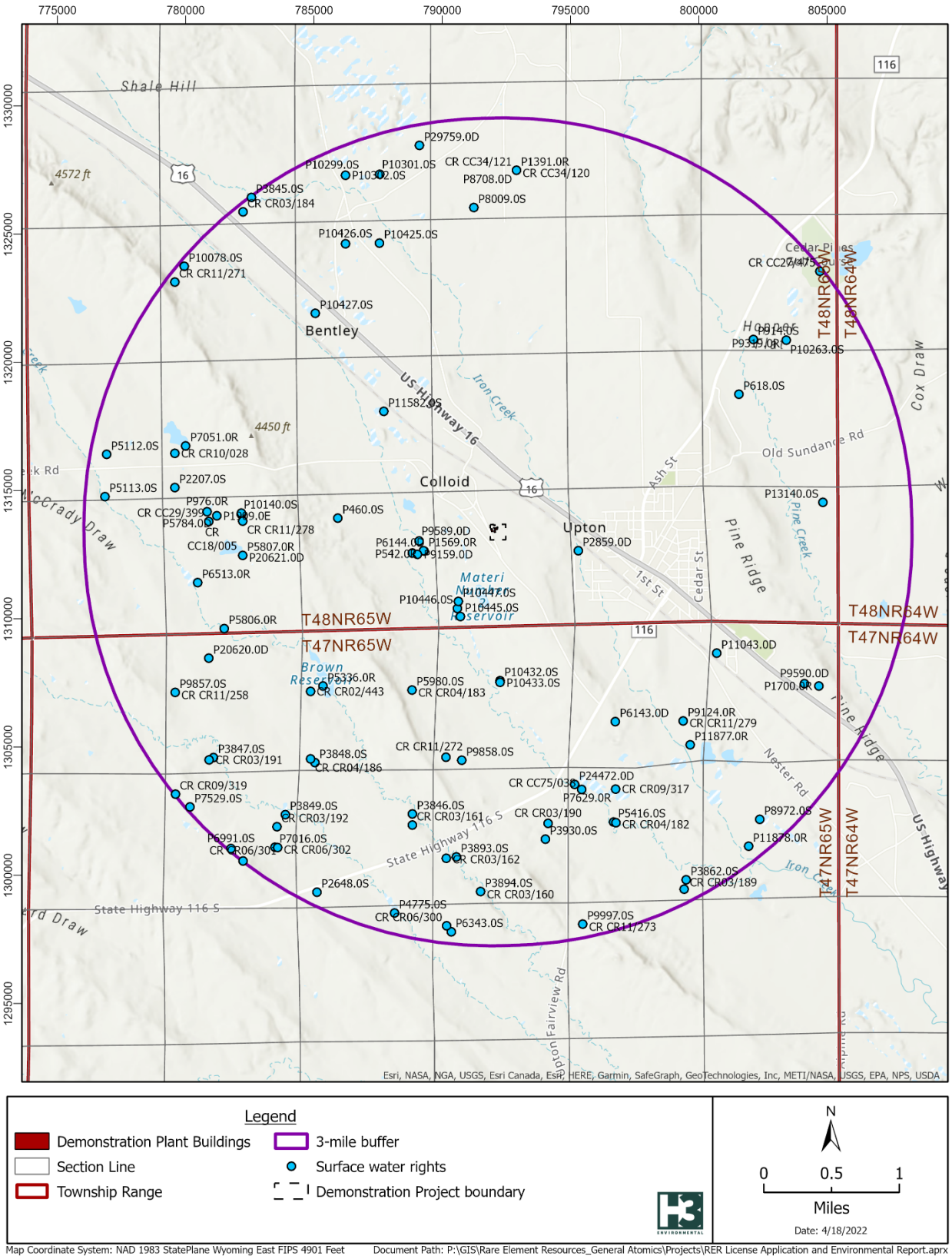
0 0.13 0.25

Miles

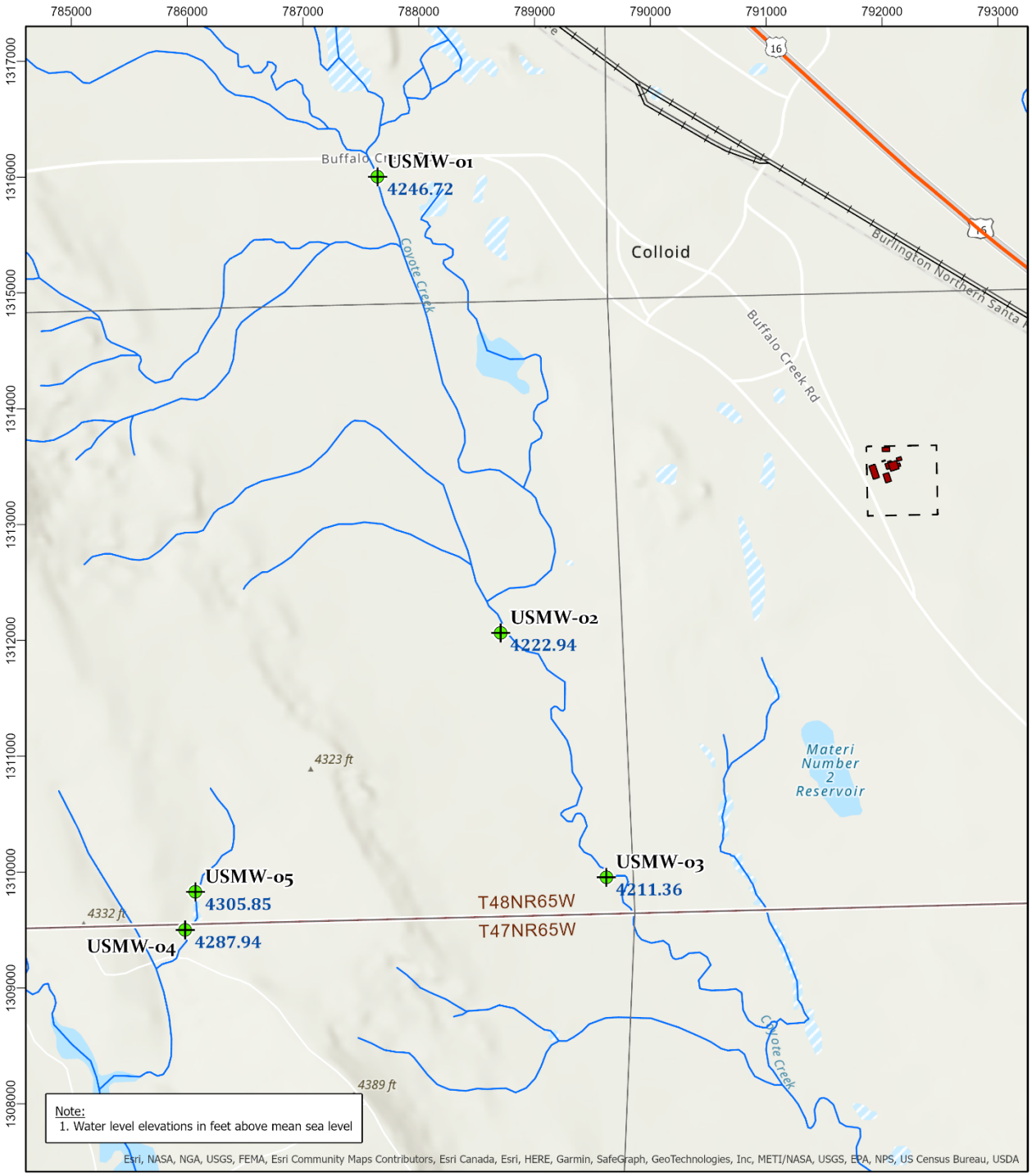
Date: 4/18/2022

Map Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet Document Path: P:\GIS\Rare Element Resources_General Atomics\Projects\RER License Application and Environmental Report.aprx

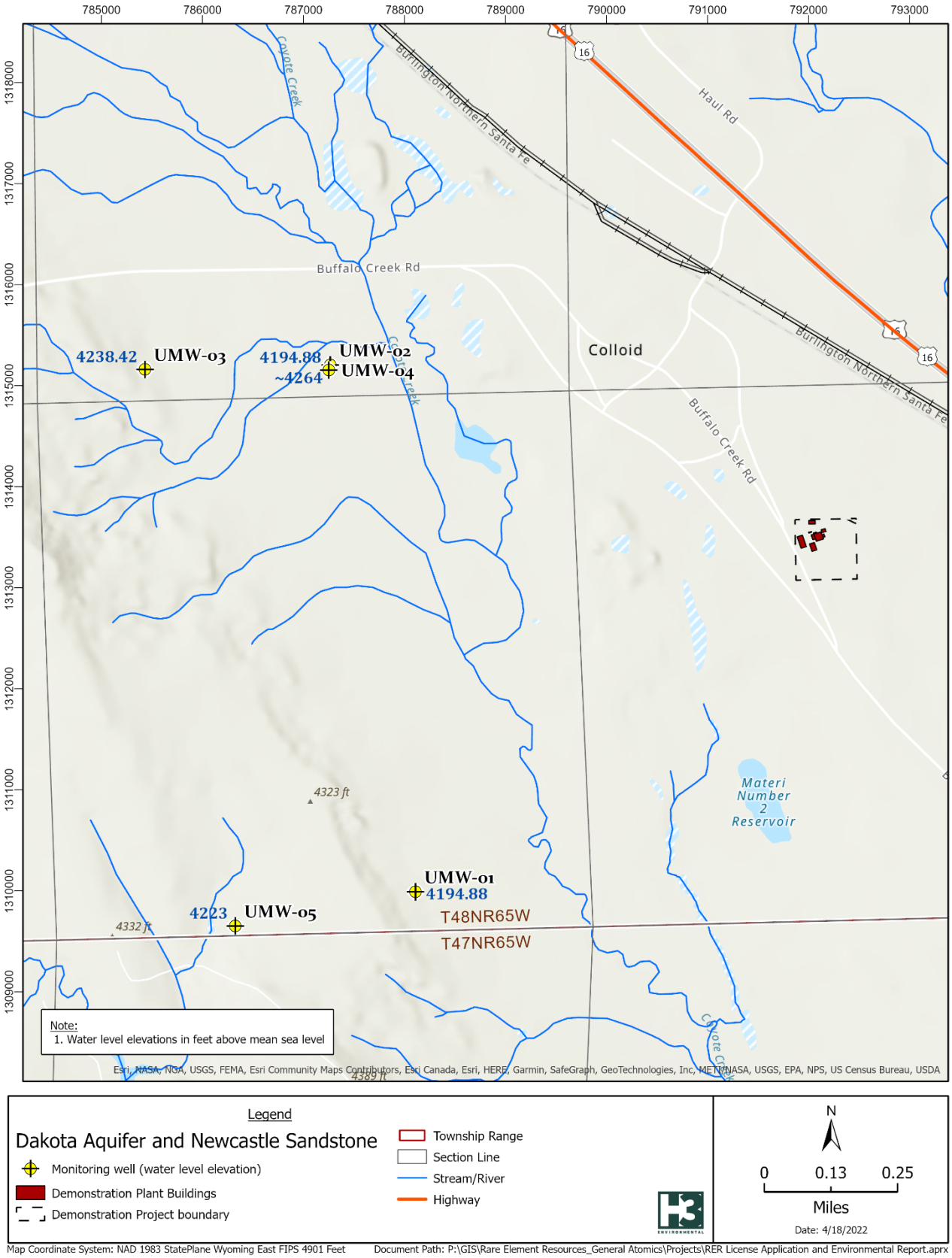
Map 17. 100-Year flood inundation boundaries



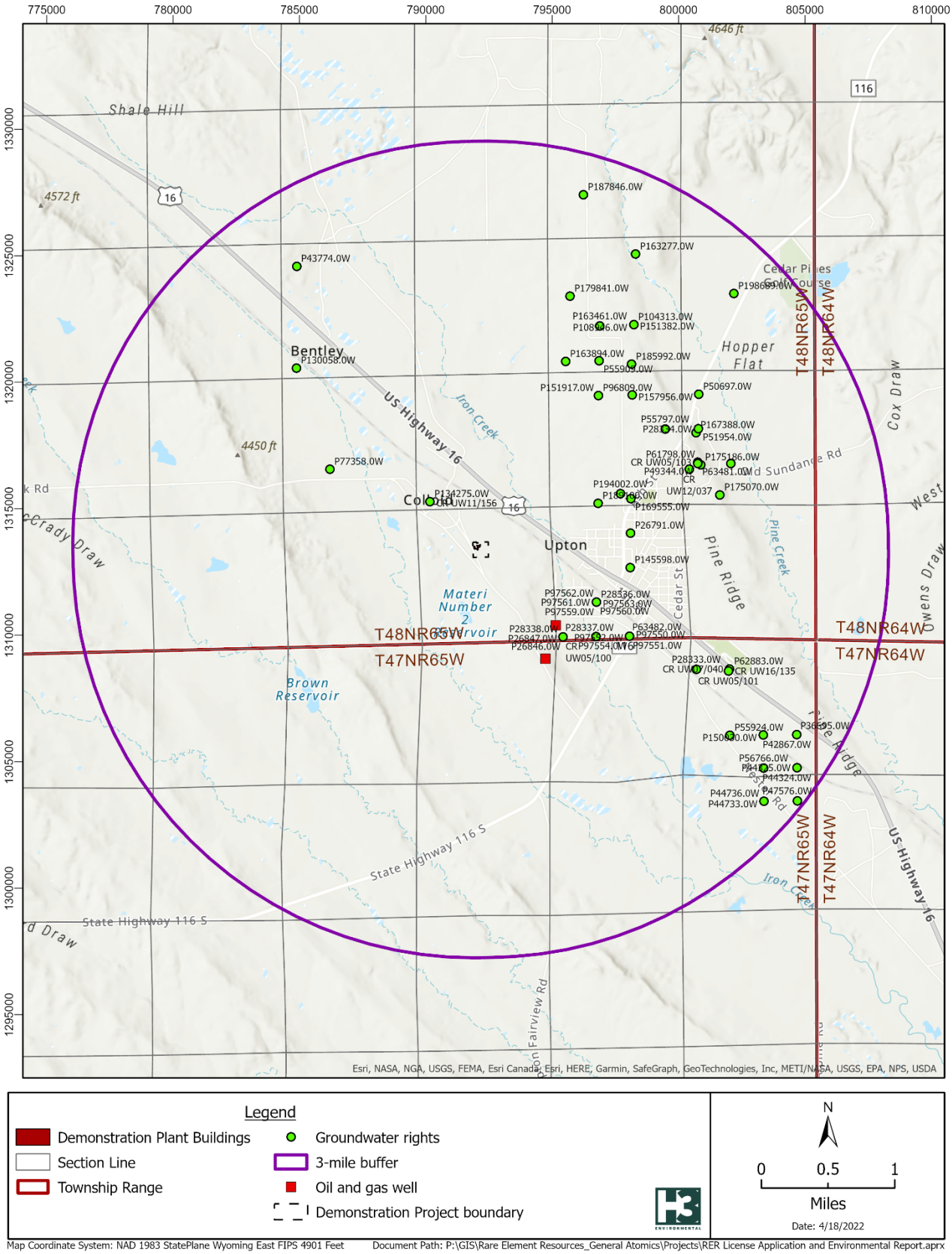
Map 18. Surface water rights within three miles of the Demonstration Project



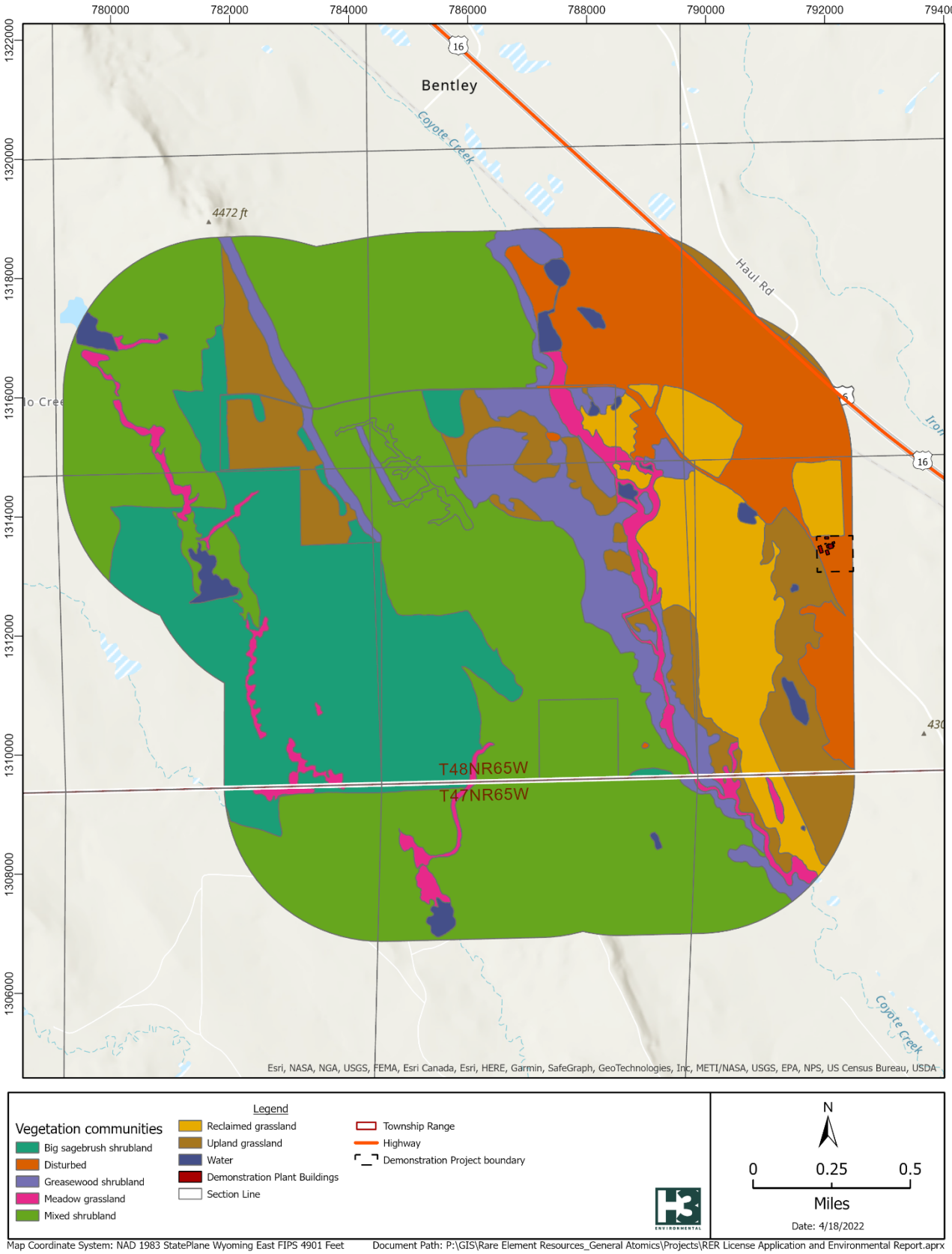
Map 19. Water level elevations valley fill and weathered shale



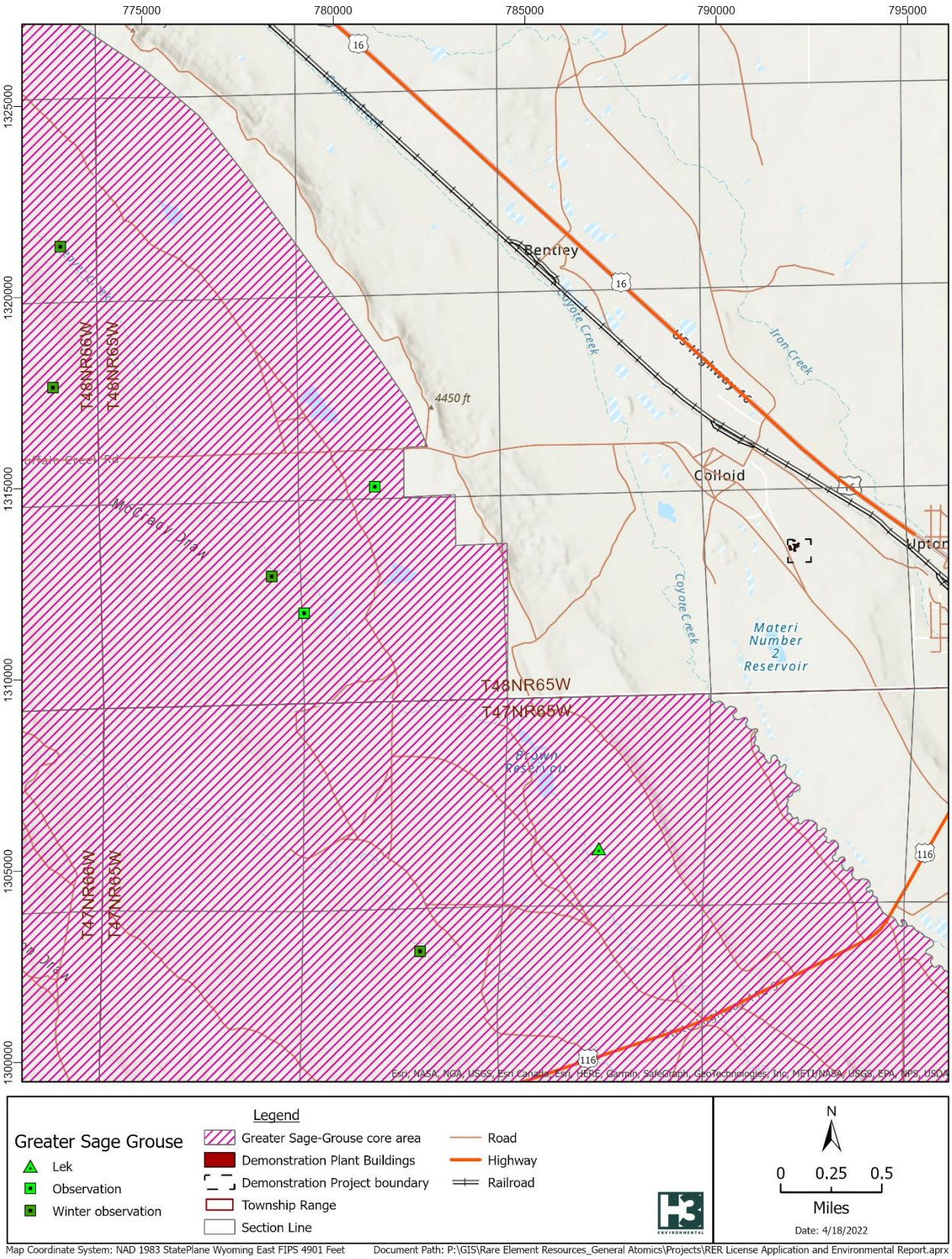
Map 20. Water level elevations Dakota aquifer and Newcastle sandstone



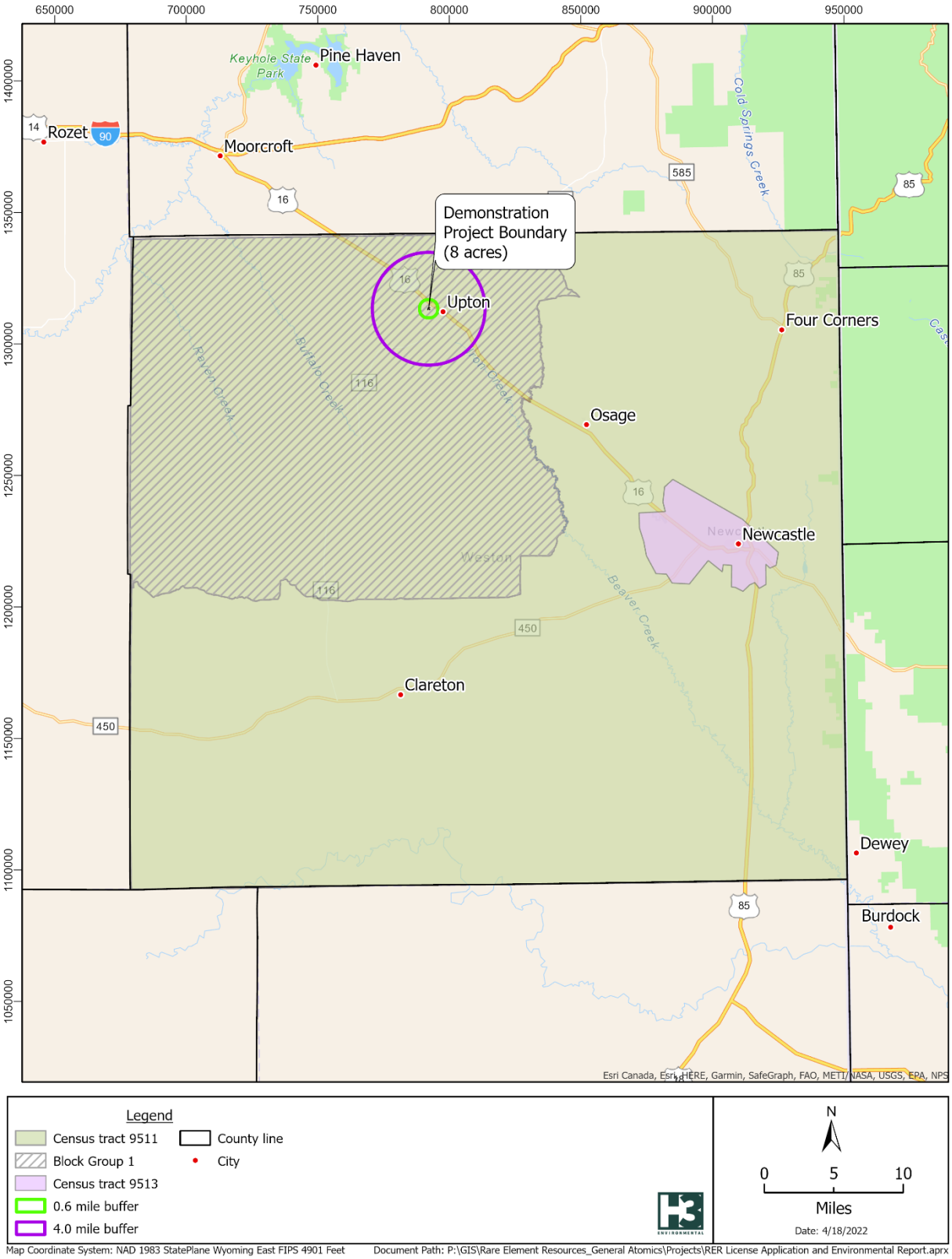
Map 21. Groundwater rights within three miles of the Demonstration Project



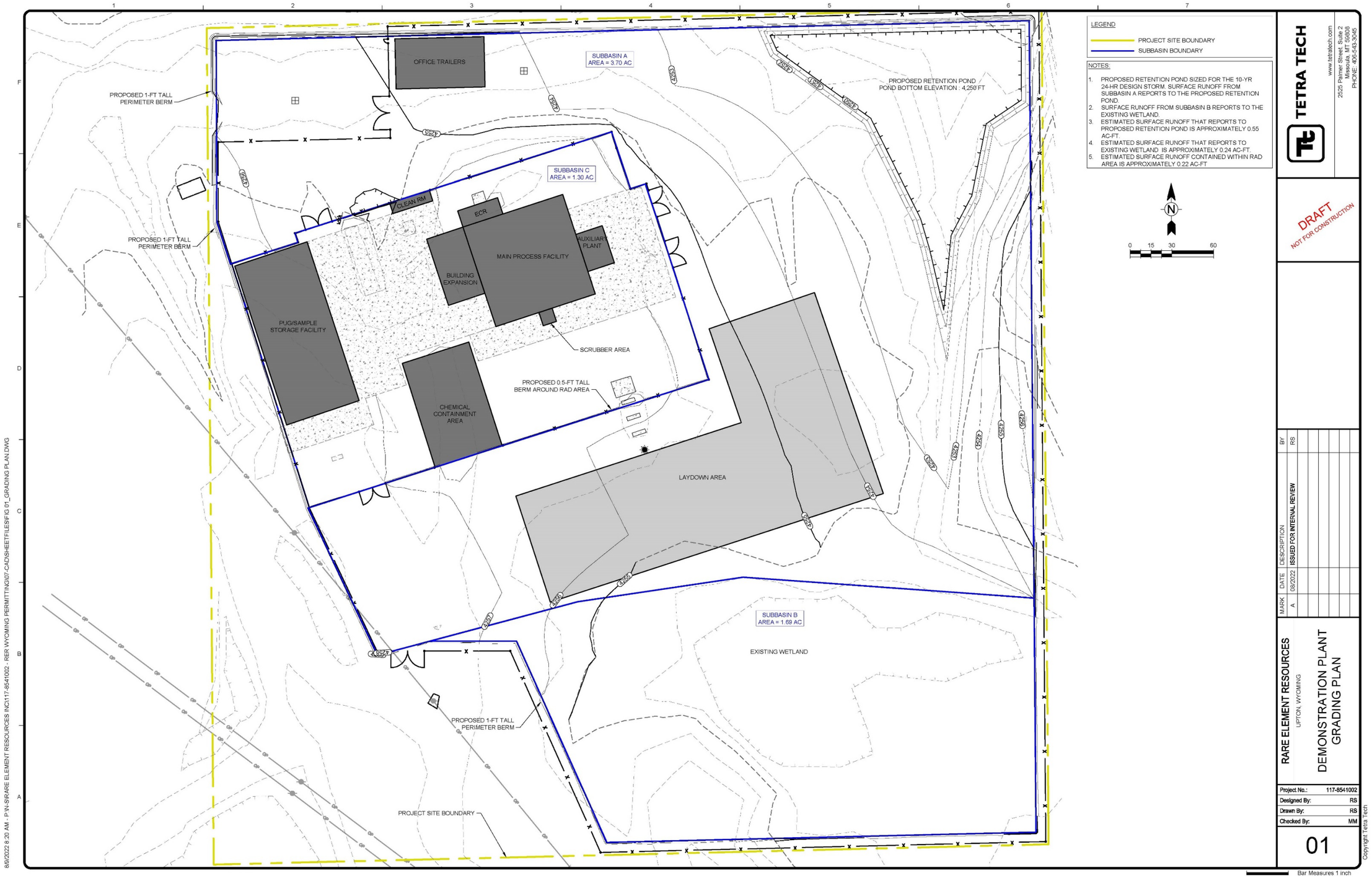
Map 22. Vegetation communities



Map 23. Greater sage-grouse core area and leks in the vicinity of the Demonstration Project



Map 24. Environmental justice affected area

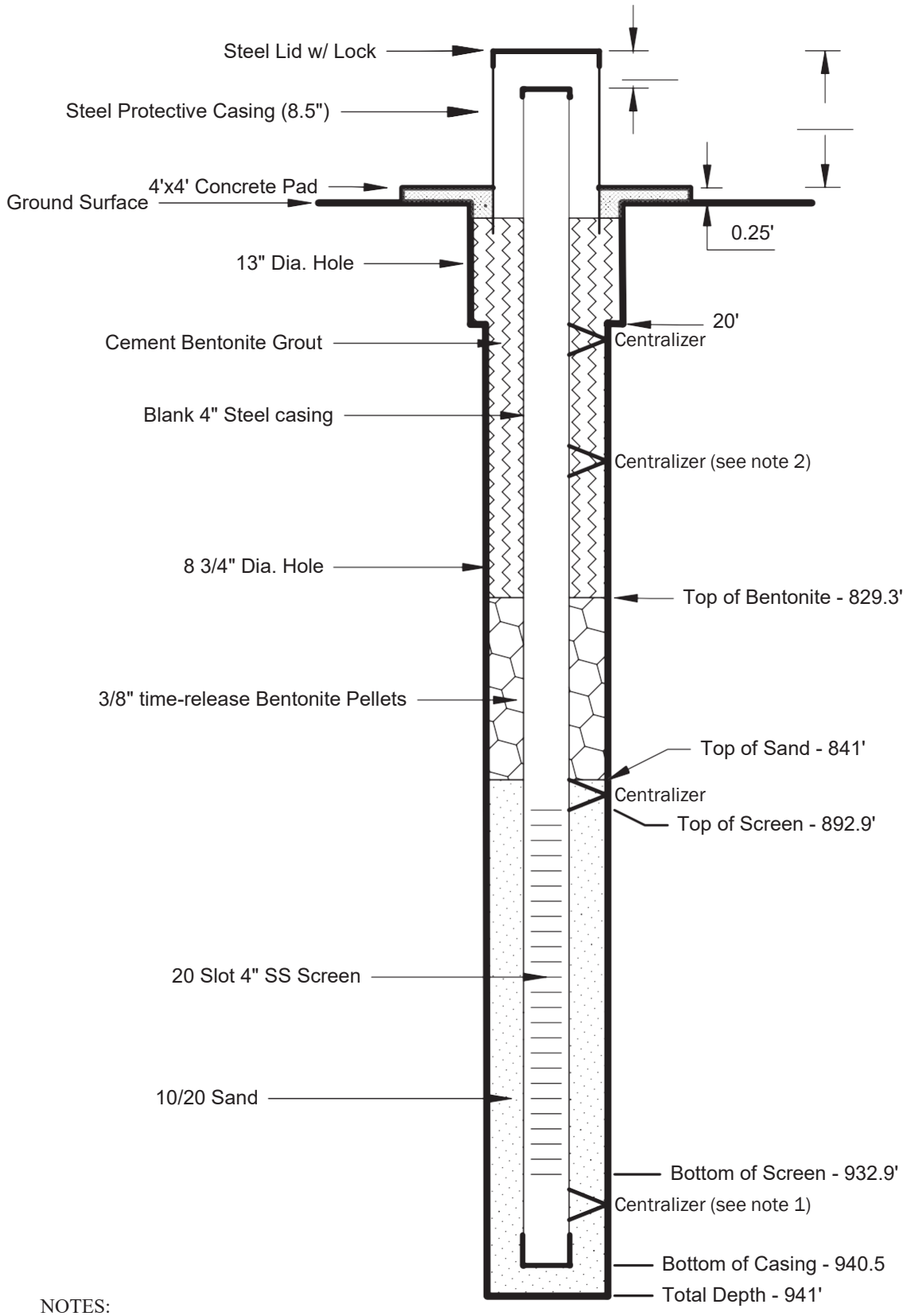


Map 25. Proposed site grading and stormwater control plan

Appendix A: Monitor Well Lithologic Log and Schematic

MONITOR WELL UMW-01

COMPLETED 04/23/12



NOTES:

1. Centralizers placed within 2 feet of top and bottom of screen.
2. Centralizers placed approximately every 40 feet after top screen centralizer.

All depths below ground surface

NOT TO SCALE

BD GeoEnvironmental Services

Prepared for: Rare Element Resources

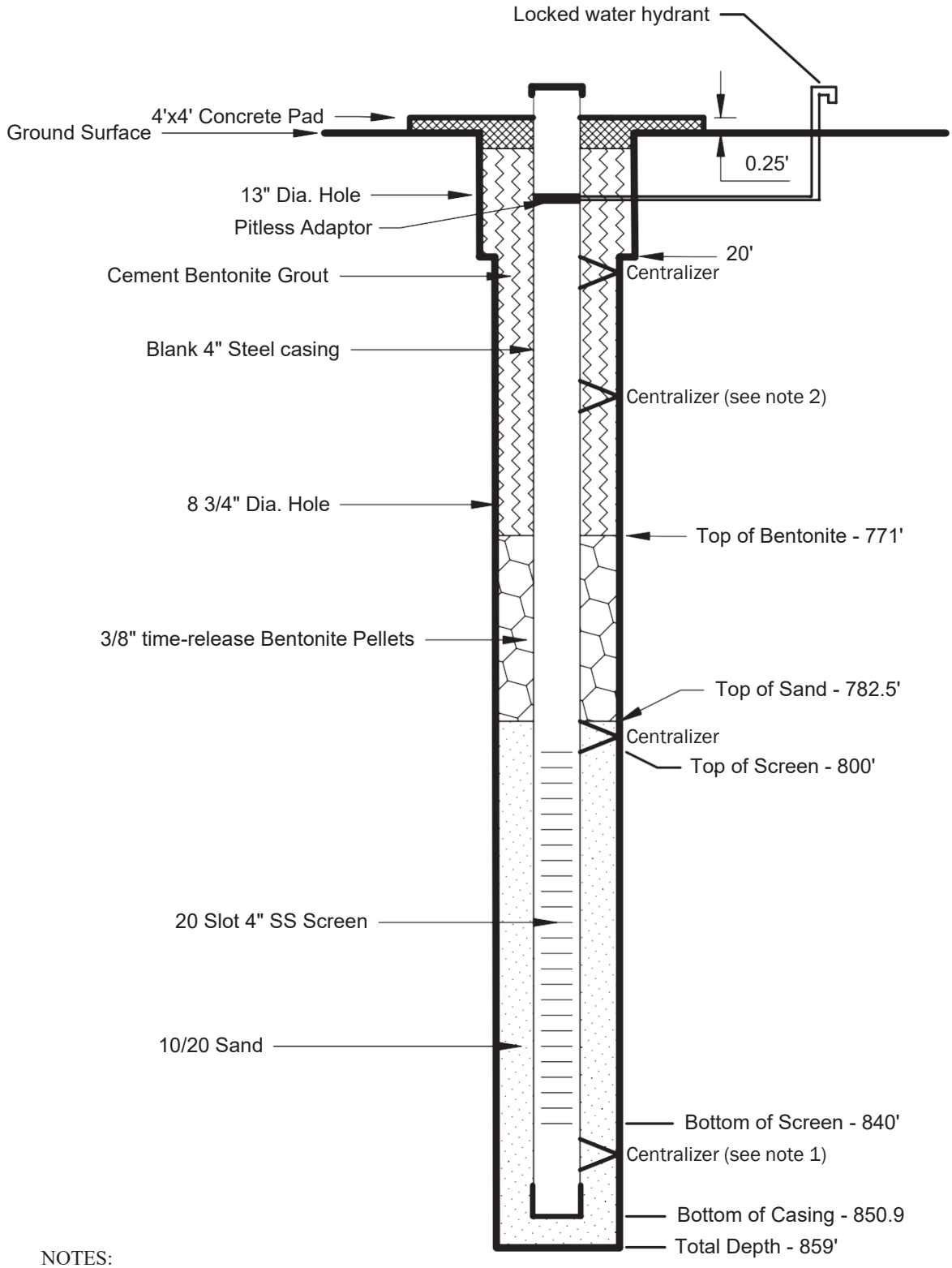
Brant A. Dennis, P.G., C.P.G.

Hole No. **UMW-01**

From	To	Lith	Descripton/Comments
0	10	CL	lt brown to lt brwn gry, weathered shale
10	20	CL/SH	brwn to lt gry brwn, weathered to sli. weathered
20	30	SH	gry with bentonite, gry white
30	900	SH	gry to dk med gry
900	941	STS/SH	lt med gry, sli. sndy, vfg,/gry

MONITOR WELL UMW-02

COMPLETED 3/17/12



NOTES:

1. Centralizers placed within 2 feet of top and bottom of screen.
2. Centralizers placed approximately every 40 feet after top screen centralizer.

All depths below ground surface

NOT TO SCALE

BD GeoEnvironmental Services

Prepared for: Rare Element Resources

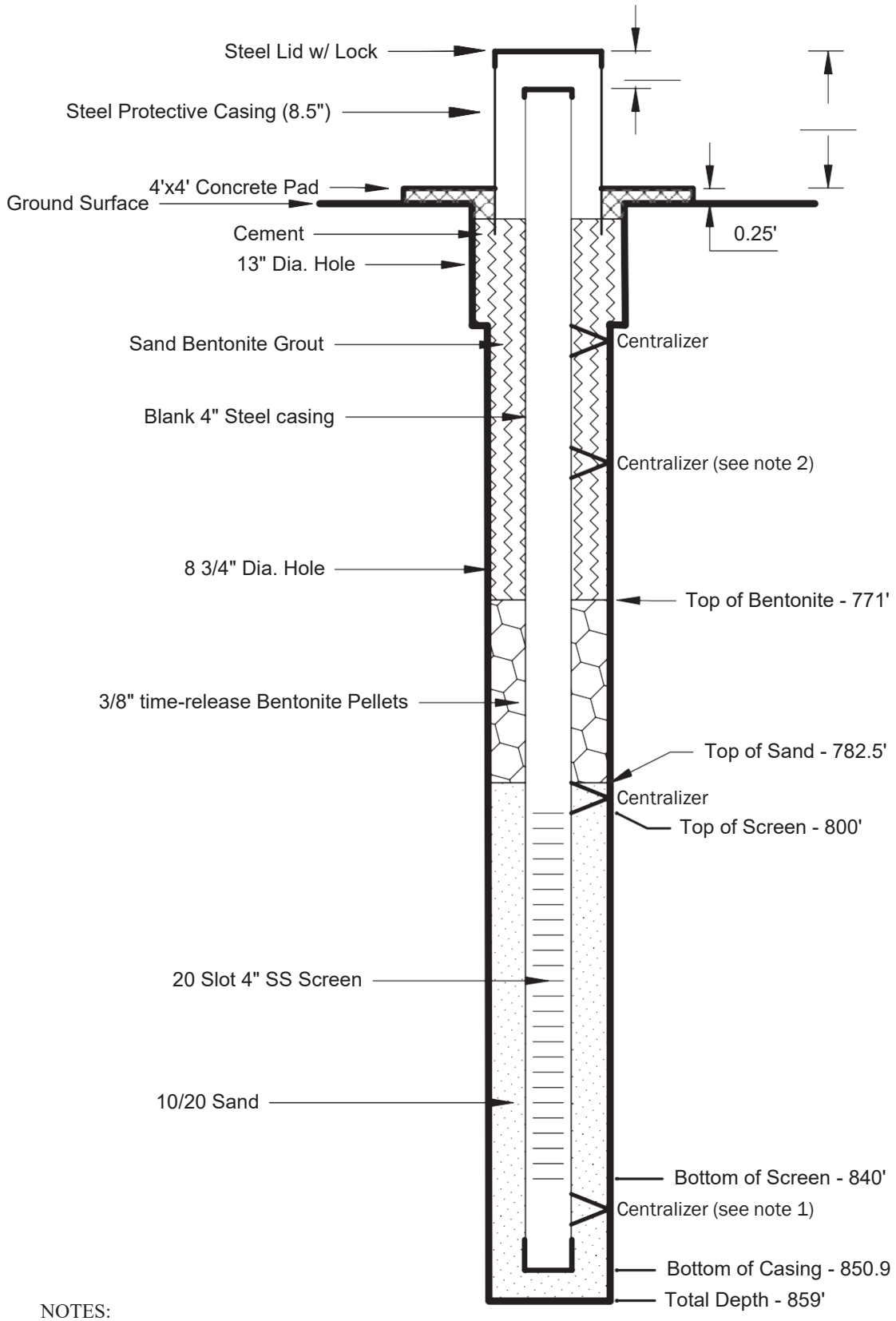
Brant A. Dennis, P.G., C.P.G.

Hole No. **UMW-02**

From	To	Lith	Descripton/Comments
0	20	CL	lt. gry brwn, soft
20	135	SH	lt brwn gry to med gry
135	180	SH	gry to dk med gry, occ. Gry white bentonite lenses
180	340	SH	gry to dk med gry
340	360	STS/SH	brwn gry to lt med gry, sli. sndy, vfg,
360	365	SH/STS	dk med gry/ly med gry, sli. Sndy, vfg
365	595	SH	dk med gry
595	645	SH	dk med gry, v. sli. silty to sli. silty, mnr SS, vfg, cemented
645	655	SS/STS	lt.brwn gry, vfg, vfg, inc. SH w/ depth, dk med gry
655	675	SH	dk med gry, w/ thin SS/STS lenses(<20%), lt. brwn
675	720	SS/SH	lt med gry, vfg, silty/dk med gry

MONITOR WELL UMW-03

INSTALLED 04/01/12



NOTES:

1. Centralizers placed within 2 feet of top and bottom of screen.
2. Centralizers placed approximately every 40 feet after top screen centralizer.

All depths below ground surface

NOT TO SCALE

BD GeoEnvironmental Services

Prepared for: Rare Element Resources

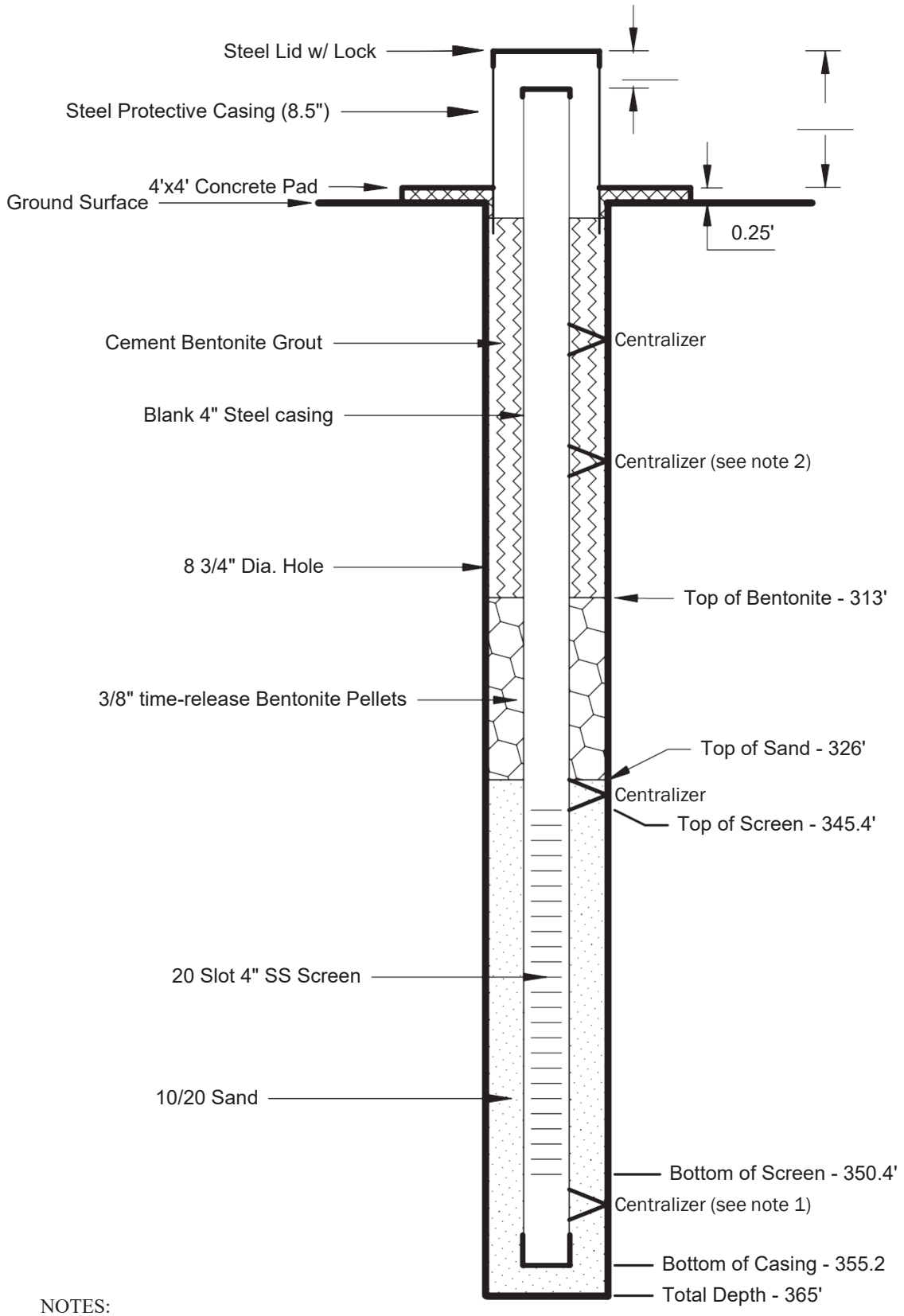
Brant A. Dennis, P.G., C.P.G.

Hole No. **UMW-03**

From	To	Lith	Descripton/Comments
0	12	CL/SH	weathered, lt. gry brwn, silty(<5%)
12	805	SH	gry to drk med. gry., occ. STS lenses, occ. bentonite lenses
805	820	SH/STS/SS	gry to lt med gry, vfg
820	860	STS/SS/H	lt. gry white, vfg, not well cemented; SH-gry

MONITOR WELL UMW-04

INSTALLED 03/16/13



NOTES:

1. Centralizers placed within 2 feet of top and bottom of screen.
2. Centralizers placed approximately every 40 feet after top screen centralizer.

All depths below ground surface

NOT TO SCALE

BD GeoEnvironmental Services

Prepared for: Rare Element Resources

Brant A. Dennis, P.G., C.P.G.

Hole No. **UMW-04**

From	To	Lith	Descripton/Comments
0	20	CL	Lt. gry-brwn, mnr sand/gravel
20	25	CL/SH	Lt. gry-brwn, sli. Weathered
25	240	SH	gey to dk med gry., occ. Bentonite, white
240	245	SH	gry, STS (<40%), lt grey brown
245	340	SH	gry to dk med gry
340	360	STS/SH	lt gry brwn, v. sli. Sndy, vfg/dk. med gry. No cementation
360	365	SH	dk med gry

Rare Element Resources
Targeting Rare Earth Elements and Gold

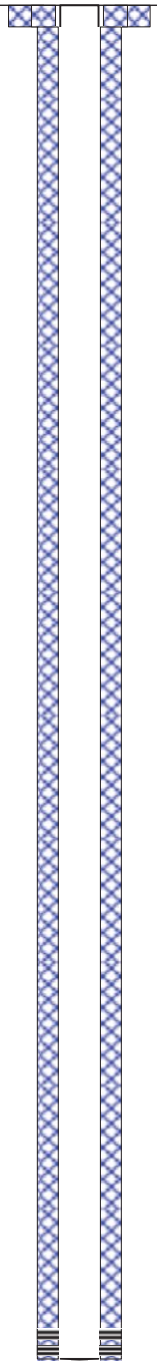
Monitor Well:UMW-05

Sheet 1 of 1

Project: Upton Site
County: Weston County, WY
Total Depth (ft): 1265
TOC Elevation (ft amsl): 4318 (est.)
Location: SE 1/4, NW 1/4, Sec 33, T48N, R65W

Date Drilled: 2/7/13
Date Installed: 2/26/13
Driller: TYVO Portadrill
Drilling Method: Rotary w/ Water/Gel
Surface Completion: 8.5" locking steel well box (3.0' ags)

Depth (ft bgs)	Static WL	Litholog	Lithologic Description	Depth (ft)	Well Completion
0					14 3/4" Borehole Diameter to 20' 10" Steel Surface Casing to 20', cemented in place
100					8 3/4" Borehole Diameter to TD
200					Cement annular seal 4" steel casing
300					
400					
500					
600			Shale: Gray to dark medium gray, occasional dark brown gray		
700					
800					
900					
1000					
1100					
1200				1225.0	Perforations from 1227-1237 ft and 1242-1252 ft
			Shale/siltstone: Gray to dark medium gray, light gray	1260.0	Casing Bottom = 1254.5' TD = 1265'
1300					



Note: Well Installation by B. Dennis (BD GeoEnvironmental Services). Completion information & field observations provided by BD.
Note: Lithologic logging by Brant Dennis, WY PG-2197 (BD GeoEnvironmental Services)
Note: Water level represents initial level after installation.

HoleName	From_Ft	To_Ft	LITH_CODE	LITHOLOGY	COMMENTS
UMW-05	0	1225	SH	Shale	gry to dk med gry, occ. Dk brwn gry
UMW-05	1225	1260	SH/STS	Shale/Siltstone	gry to dk med gry, lt gry

Appendix B: Geotechnical Permeability Test Results

CONSOLIDATION/SWELL TEST
ASTM D 4546

CLIENT BD Geo Environmental

JOB NO. 2823-01

BORING NO.	UCH-01	SAMPLED	
DEPTH	26.78-28.15'	TEST STARTED	06/11/12 DPM
SAMPLE NO.	#1	TEST FINISHED	06/13/12 DPM
SOIL DESCR.		SETUP NO.	ATT-17
LOCATION	RER - Upton		

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil & Ring(s) (g)	343.3	344.7
Wt. Ring(s) (g)	104.9	104.9
Wt. Soil (g)	238.4	239.8
Wet Density PCF	126.7	128.6
Sample Diameter (in)	3.021	3.021
Sample Height (in)	1.000	0.991
Wt. Wet Soil & Pan (g)	245.2	246.6
Wt. Dry Soil & Pan (g)	214.0	214.0
Wt. Lost Moisture (g)	31.2	32.6
Wt. of Pan Only (g)	6.8	6.8
Wt. of Dry Soil (g)	207.3	207.3
Moisture Content %	15.0	15.7
Dry Density PCF	110.2	111.2
Max. Dry Density PCF		
Percent Compaction		

LOAD (PSF)	CONSOL. (IN.)
64	0.0000
509	0.0032
509	-0.0015
1018	-0.0004
2036	0.0028
4073	0.0091

	LOAD (PSF)	LOG LOAD	CONSOL. (IN.)	DEFL. (IN.)
	64	1.806	0.0000	0.0000
	509	2.707	0.0032	-0.0032
Inundate	509	2.707	-0.0015	0.0015
	1018	3.008	-0.0004	0.0004
	2036	3.309	0.0028	-0.0028
	4073	3.610	0.0091	-0.0091

Data Entered By: DAW Date: 06/14/2012
Data Checked By: DPM Date: 6/14/12
Filename: BDSW2678

ADVANCED TERRA TESTING, INC. ATT

CONSOLIDATION/SWELL TEST
ASTM D 4546

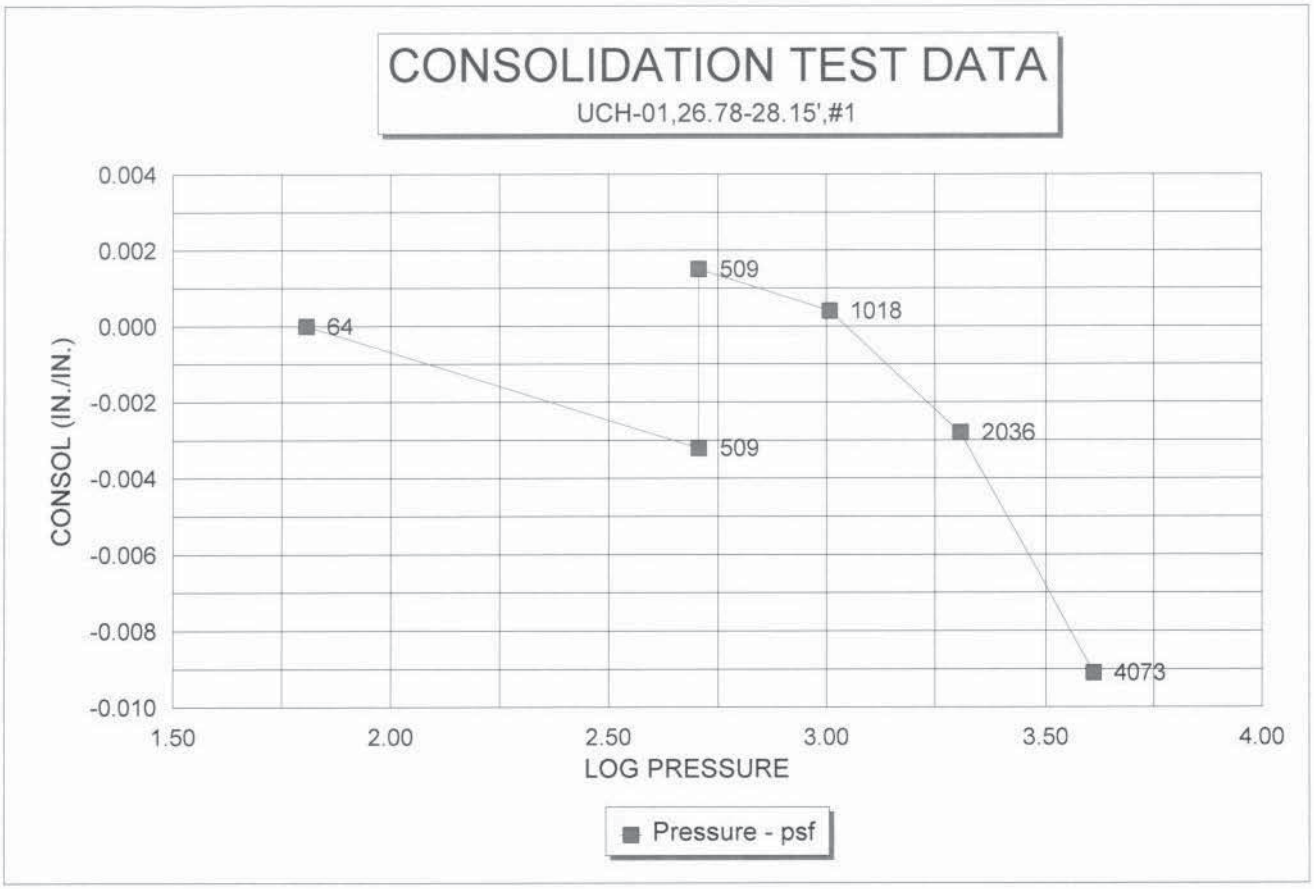
CLIENT	BD Geo Environmental	JOB NO.	2823-01
BORING NO.	UCH-01	SAMPLED	
DEPTH	26.78-28.15'	TEST STARTED	06/11/12 DPM
SAMPLE NO.	#1	TEST FINISHED	06/13/12 DPM
SOIL DESCR.		SETUP NO.	ATT-17

TIME READING DATA

509 wet psf load

Elapsed Time (min)	SQRT Time (min)	Dial Reading (in)	Defl. (in)
0.0	0.00	0.0050	0.0000
0.1	0.32	0.0050	0.0000
0.3	0.50	0.0049	0.0001
0.5	0.71	0.0047	0.0003
1.0	1.00	0.0042	0.0008
2.0	1.41	0.0038	0.0012
4.0	2.00	0.0033	0.0017
9.0	3.00	0.0025	0.0025
16.0	4.00	0.0020	0.0030
30.0	5.48	0.0016	0.0034
60.0	7.75	0.0011	0.0039
146.0	12.08	0.0007	0.0043
240.0	15.49	0.0006	0.0044
480.0	21.91	0.0005	0.0045

Data Entered By: DAW Date: 06/14/2012
Data Checked By: DPM Date: 6/14/12
Filename: BDSW2678


CONSOLIDATION TEST DATA
UCH-01,26.78-28.15',#1
CONSOL (IN./IN.)
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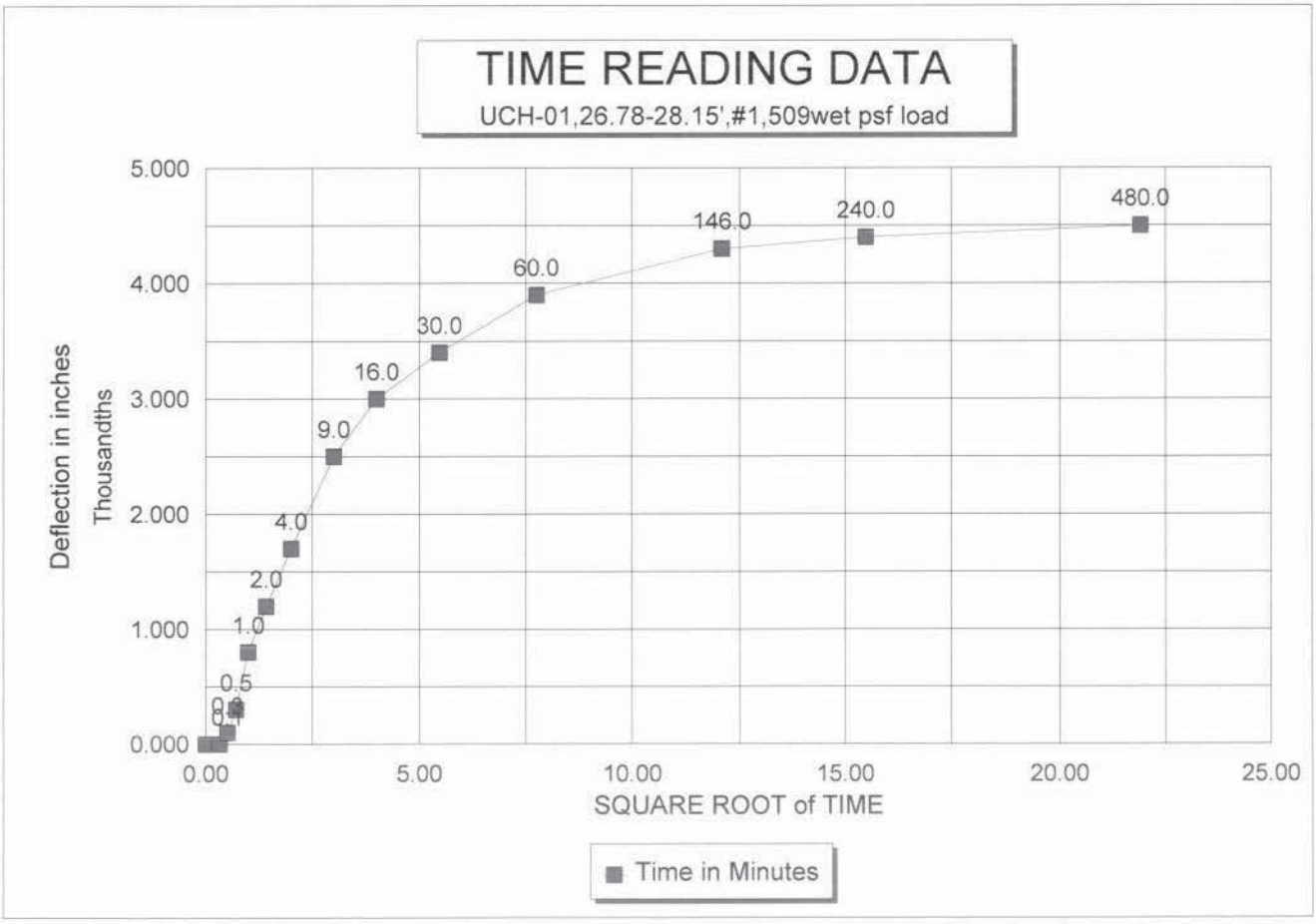
0.002
0.000
-0.002
-0.004
-0.006
-0.008
-0.010
1.50
2.00
2.50
3.00
3.50
4.00
LOG PRESSURE
64
509
509
1018
2036
4073
Pressure - psf


TIME READING DATA
UCH-01,26.78-28.15',#1,509wet psf load
Deflection in inches
Thousandths
5.000
4.000
3.000
2.000
1.000
0.000
0.00
5.00
10.00
15.00
20.00
25.00
SQUARE ROOT of TIME
0.5
1.0
2.0
4.0
9.0
16.0
30.0
60.0
146.0
240.0
480.0
Time in Minutes

CONSOLIDATION/SWELL TEST
ASTM D 4546/METHOD B

CLIENT	BD Geo Environmental	JOB NO.	2823-01
BORING NO.	UCH-01	SAMPLED	
DEPTH	49-58.25'	TEST STARTED	06/08/12 DPM
SAMPLE NO.	#2	TEST FINISHED	06/12/12 DPM
SOIL DESCR.		SETUP NO.	ATT-16
LOCATION	RER-Upton		

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil & Ring(s) (g)	343.9	346.2
Wt. Ring(s) (g)	98.9	98.9
Wt. Soil (g)	245.0	247.3
Wet Density PCF	146.9	149.5
Sample Diameter (in)	2.873	2.873
Sample Height (in)	0.980	0.972
Wt. Wet Soil & Pan (g)	251.7	254.0
Wt. Dry Soil & Pan (g)	233.4	233.4
Wt. Lost Moisture (g)	18.3	20.6
Wt. of Pan Only (g)	6.7	6.7
Wt. of Dry Soil (g)	226.7	226.7
Moisture Content %	8.1	9.1
Dry Density PCF	136.0	137.1
Max. Dry Density PCF		
Percent Compaction		

LOAD (PSF)	CONSOL. (IN.)	CONSOL. (IN./IN)
70	0.0000	0.0000
493	0.0026	0.0027
493	-0.0182	-0.0186
1126	-0.0178	-0.0182
2252	-0.0163	-0.0166
4503	-0.0123	-0.0126
9007	-0.0072	-0.0073
18014	-0.0010	-0.0010
36027	0.0081	0.0083

	LOAD (PSF)	LOG LOAD	CONSOL. (IN./IN.)	DEFL. (IN./IN.)
	70	1.8451	0.0000	0.0000
	493	2.6928	0.0027	-0.0027
Inundate	493	2.6928	-0.0186	0.0186
	1126	3.0515	-0.0182	0.0182
	2252	3.3526	-0.0166	0.0166
	4503	3.6535	-0.0126	0.0126
	9007	3.9546	-0.0073	0.0073
	18014	4.2556	-0.0010	0.0010
	36027	4.5566	0.0083	-0.0083

Data Entered By: DAW Date: 06/15/2012
Data Checked By: DPM Date: 6/15/12
Filename: BDC04958

CONSOLIDATION/SWELL TEST
ASTM D 4546

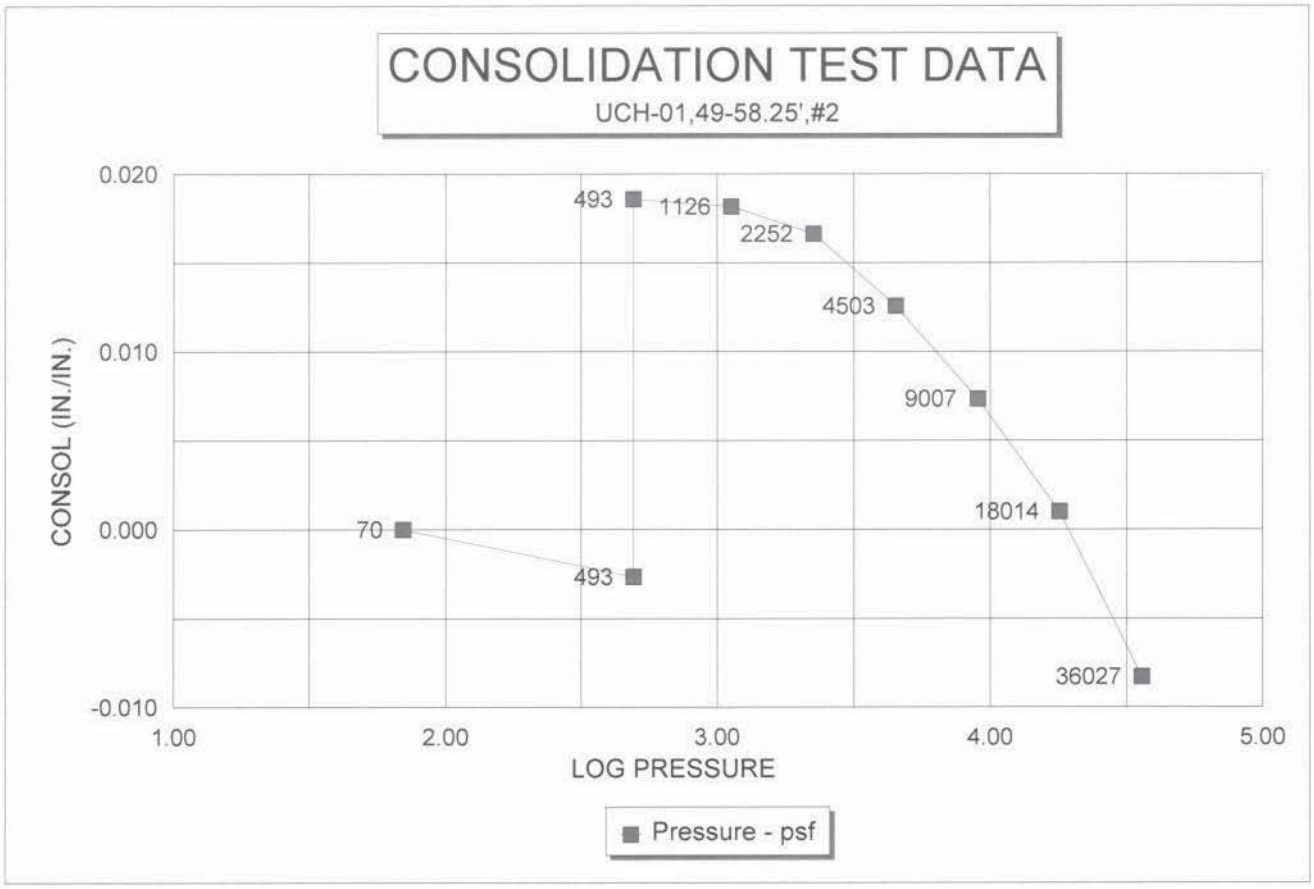
CLIENT	BD Geo Environmental	JOB NO.	2823-01
BORING NO.	UCH-01	SAMPLED	
DEPTH	49-58.25'	TEST STARTED	06/08/12 DPM
SAMPLE NO.	#2	TEST FINISHED	06/12/12 DPM
SOIL DESCR.		SETUP NO.	ATT-16

TIME READING DATA

493 wet psf load

Elapsed Time (min)	SQRT Time (min)	Dial Reading (in)	Defl. (in)
0.0	0.00	0.0041	0.0000
0.1	0.32	0.0041	0.0000
0.3	0.50	0.0036	0.0005
0.5	0.71	0.0032	0.0009
1.0	1.00	0.0025	0.0016
2.0	1.41	0.0012	0.0029
4.0	2.00	0.0002	0.0039
9.0	3.00	-0.0020	0.0061
16.0	4.00	-0.0038	0.0079
30.0	5.48	-0.0065	0.0106
60.0	7.75	-0.0096	0.0137
120.0	10.95	-0.0124	0.0165
240.0	15.49	-0.0143	0.0184
480.0	21.91	-0.0159	0.0200

Data Entered By: DAW Date: 06/15/2012
Data Checked By: _____ Date: _____
Filename: BDC04958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CONSOL (IN./IN.)
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-0.010
1.00
2.00
3.00
4.00
5.00
LOG PRESSURE
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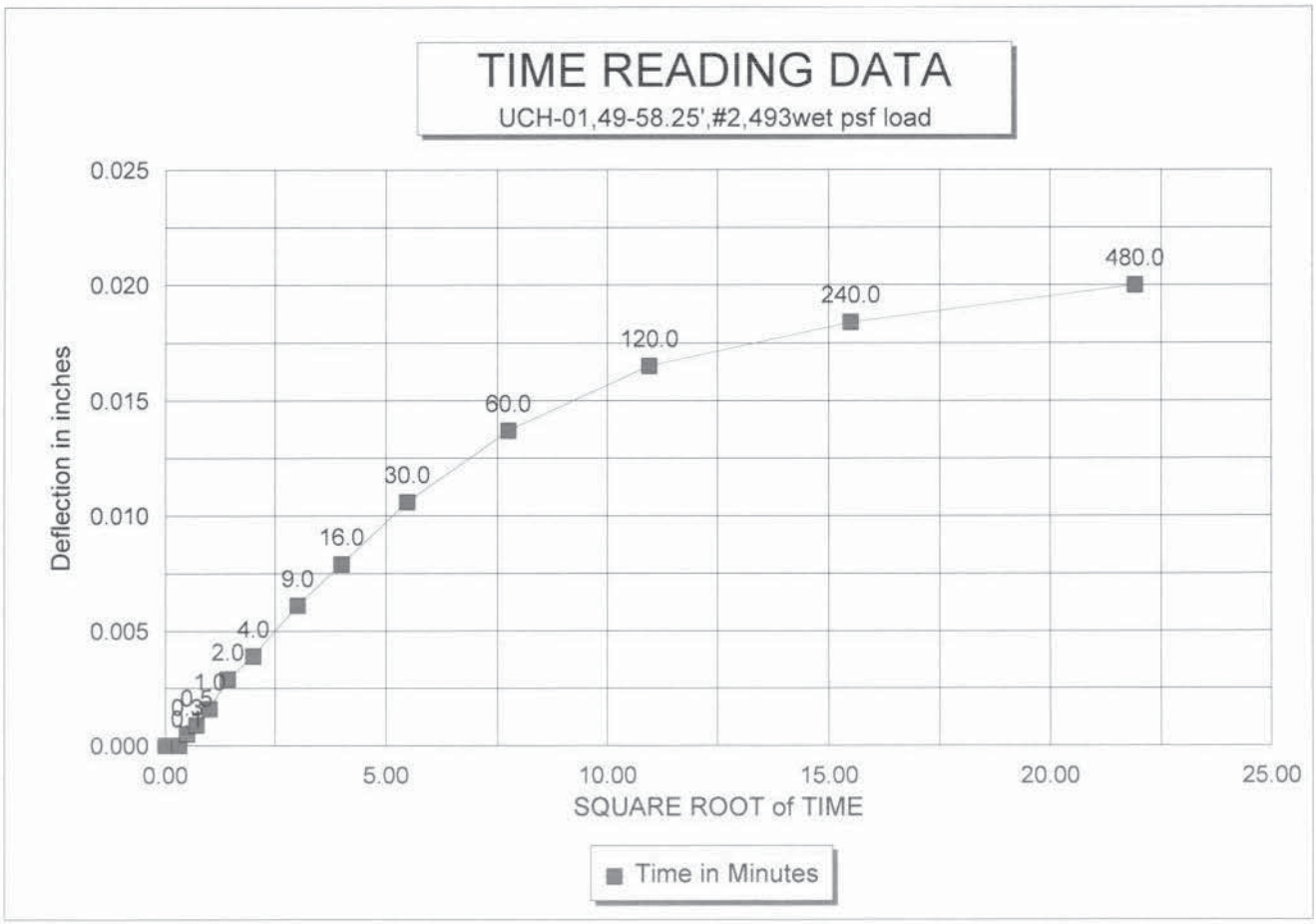
493
493
1126
2252
4503
9007
18014
36027
Pressure - psf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0.020
0.015
0.010
0.005
0.000
0.00
5.00
10.00
15.00
20.00
25.00
SQUARE ROOT of TIME
2.0
4.0
9.0
16.0
30.0
60.0
120.0
240.0
480.0
Time in Minutes

PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD
ASTM D 5084

CLIENT	BD GeoEnvironmental	JOB NO.	2823-01
BORING NO.	UCH-01	SAMPLED	
DEPTH	26.78-28.15'	TEST STARTED	06/09/12 CAL
SAMPLE NO.	1	TEST FINISHED	06/13/12 CAL
SOIL DESCR.		CELL NUMBER	8S
LOCATION	Core Samples UCH-01	SATURATED TEST	Yes
CONF. PRES. PSF	3586	TEST TYPE	TX/Pbp/Tap Water

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	566.1	570.9
Wt. Wet Soil & Pan (g)	572.7	577.5
Wt. Dry Soil & Pan (g)	496.3	496.3
Wt. Lost Moisture (g)	76.4	81.2
Wt. of Pan Only (g)	6.7	6.7
Wt. of Dry Soil (g)	489.7	489.7
Moisture Content %	15.6	16.6
Wet Density PCF	130.6	135.6
Dry Density PCF	113.0	116.3

Init. Diameter (in)	2.981	(cm)	7.572
Init. Area (sq in)	6.979	(sq cm)	45.031
Init. Height (in)	2.365	(cm)	6.007
Vol. Bef. Consol. (cu ft)	0.00955		
Vol. After Consol. (cu ft)	0.00928		
Porosity %	30.91		

FLOW PUMP CALCULATIONS

Pump Setting	9
Velocity CM/Sec	5.91E-05
Q (cc/s)	1.89E-06
Height	2.324
Diameter	2.964
Pressure (psi)	2.020
Area after consol. (cm*cm)	44.512
Gradient	24.059
Permeability k (cm/s)	1.8E-09
Permeability k (m/s)	**1.8E-11**
Back Pressure (psi)	38.0
Cell Pressure (psi)	62.9
Ave. Effective Stress (psi)	23.890

Average temperature degree C: 24.5
NOTE: Short sample.

Data entry by: DAW Date: 06/14/2012
Checked by: CH Date: 6/16/2012
FileName: BDP001S1

TRIAXAL COMPRESSION TEST DATA

CLIENT	BD GeoEnvironmental	JOB NO.	2823-01
BORING NO.	UCH-01	SAMPLED	
DEPTH	26.78-28.15'	TEST STARTED	06/09/12 CAL
SAMPLE NO.	1	TEST FINISHED	06/13/12 CAL
SOIL DESCR.		SETUP NO.	8S
LOCATION	Core Samples UCH-01	SATURATED TEST	Yes
CONF. PRES. PSF	3586	TEST TYPE	TX/Pbp/Tap Water

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
40.0	38.0	3.6	13.7				
50.0		13.8	13.8	39.5	49.2	9.7	0.97

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT Time (Min)	Burette Reading (CC)	Volume Defl. (cc)
0.00	0.00	13.50	0.00
0.25	0.50	18.85	-5.35
0.5	0.71	19.20	-5.70
1	1.00	19.50	-6.00
2	1.41	20.20	-6.70
4	2.00	20.40	-6.90
9	3.00	20.80	-7.30
16	4.00	21.10	-7.60
30	5.48	21.30	-7.80
60	7.75	21.60	-8.10
120	10.95	21.80	-8.30
240	15.49	22.00	-8.50
360	18.97	22.10	-8.60

Initial Height (in)	2.365	Init. Vol. (CC)	270.54
Height Change (in)	0.041	Vol. Change (CC)	19.20
Ht. After Cons. (in)	2.324	Cell Exp. (CC)	11.46
Initial Area (sq in)	6.979	Net Change (CC)	7.74
Area After Cons. (sq in)	6.899	Cons. Vol. (CC)	262.80

Data entry by: DAW Date: 06/14/2012
Checked by: CAN Date: 6/16/2012

ADVANCED TERRA TESTING, INC. ATT

Appendix C: Water Data Tables

Table 1
Cheyenne River Mean Annual Streamflow

Parameter	USGS Gaging Stations							
	06386500	06395000	06401500	06402600	06403700	06408650	06423500	06438500
	Near Spencer, WY	At Edgemont, SD	Below Angostura Dam, SD	Near Buffalo Gap, SD	At Red Shirt, SD	Near Scenic, SD	Near Wasta, SD	Near Plainview, SD
Latitude	43°25'15.68"	43°18'20"	43°20'42"	43°30'07.12"	43°40'20.7"	43°53'53"	44°04'52"	44°31'46"
Longitude	-104°07'53.13"	-103°49'14"	-103°26'12"	-103°04'26.17"	-102°53'30"	-102°38'37"	-102°24'03"	-101°55'47"
Elevation (ft)	3626.00	3414.56	3058.02	2811.45	2670	2455	2260.78	1848.76
Drainage Area (sq-mi)	5,350	7,204	9,135	9,833	10,300	11,252	12,725	21,425
Mean Annual Flowrate (cfs)	47.7	74.3	69.1	112.0	121.6	209.8	346.8	777.8
Mean Annual Discharge (ac-ft)	34,557	53,827	50,060	81,140	88,094	151,992	251,243	563,485
Period of Record	1949-2013	1947-2013	1951-1978	1969-2013	1999-2013	2008-2013	1964-2013	1951-2013

Source: USGS, 2014

Table 2
Annual Peak Streamflow for the Cheyenne River

USGS Gage 06395000 near Edgemont, SD		
Water Year	**Date**	**Gage Height (feet)**
1905	Jul. 30, 1905	10.50
1922	May 1, 1922	14.00
1929	Jun. 03, 1929	9.86
1930	Aug. 18, 1930	7.00
1931	Oct. 04, 1930	6.80
1932	Jun. 18, 1932	7.70
1947	Jun. 22, 1947	6.70
1948	Jun. 18, 1948	7.15
1949	Jun. 07, 1949	5.82
1950	Jun. 19, 1950	6.00
1951	Jul. 03, 1951	7.44
1952	Jun. 28, 1952	9.29
1953	May 31, 1953	5.75
1954	May 22, 1954	5.57
1955	Aug. 08, 1955	8.02
1956	Jun. 19, 1956	6.12
1957	May 25, 1957	9.05
1958	Jul. 20, 1958	7.71
1959	Jun. 24, 1959	5.47
1960	Jun. 10, 1960	5.35
1961	Jul. 09, 1961	5.50
1962	Jun. 17, 1962	11.46
1963	Jun. 07, 1963	5.83
1964	Jun. 12, 1964	5.61
1965	Jun. 17, 1965	9.30
1966	Jul. 16, 1966	6.02
1967	Jun. 24, 1967	6.86
1968	Jun. 10, 1968	6.24
1969	Jul. 20, 1969	8.19
1970	May 17, 1970	3.98
1971	May 25, 1971	10.57
1972	Jun. 17, 1972	
1973	Sep. 10, 1973	7.31
1974	Mar. 06, 1974	3.50
1975	Jun. 29, 1975	4.27

USGS Gage 06395000 near Edgemont, SD		
Water Year	**Date**	**Gage Height (feet)**
1976	Jun. 18, 1976	5.27
1977	Jul. 10, 1977	5.82
1978	May 20, 1978	13.65
1979	Aug. 11, 1979	5.95
1980	Aug. 17, 1980	4.64
1981	Jul. 15, 1981	5.04
1982	Jun. 03, 1982	6.72
1983	Jul. 19, 1983	5.14
1984	May 3, 1984	4.94
1985	Mar. 19, 1985	3.01
1986	Jun. 11, 1986	6.43
1987	Mar. 08, 1987	6.24
1988	Aug. 06, 1988	2.53
1989	Sep. 22, 1989	5.16
1990	Jul. 23, 1990	4.19
1991	Jun. 02, 1991	9.60
1992	Jul. 29, 1992	2.58
1993	Aug. 20, 1993	7.56
1994	Mar. 03, 1994	6.25
1995	May 10, 1995	5.87
1996	May 29, 1996	5.68
1997	Feb. 19, 1997	4.87
1998	Jun. 19, 1998	5.46
1999	Jun. 13, 1999	7.60
2000	Apr. 20, 2000	5.64
2001	Jun. 07, 2001	4.88
2002	Aug. 31, 2002	3.10
2003	Mar. 19, 2003	5.83
2004	Feb. 25, 2004	3.86
2005	Jun. 13, 2005	6.88
2006	Aug. 07, 2006	5.14
2007	May 7, 2007	5.38
2008	May 25, 2008	9.60
2009	Jul. 03, 2009	5.84
2010	May 22, 2010	6.36
2011	Mar. 15, 2011	8.00
2012	Mar. 13, 2012	3.25
2013	Jul. 09, 2013	5.26
Source: USGS, 2014		

Table 3
Drainage Basin Geomorphology for the Upton Plant Site

Drainage Basin Designation (Subwatersheds)	Drainage Area (mi^2)	Basin Length (mi)	Valley Length (mi)	Channel Length (mi)	Basin Relief (ft)	Valley Relief (ft)	Channel Relief (ft)	Total Stream Length (mi)	Basin Relief Ratio (ft/ft)	Valley Slope (ft/ft)	Channel Slope (ft/ft)	Channel Sinuosity (ft/ft)	Drainage Density (mi/mi^2)
Coyote Creek (total basin to project boundary)	4.48	4.68	4.83	5.12	155	150	150	22.71	0.0063	0.0059	0.0055	1.06	5.07
Entry of Coyote Creek into Permit Boundary	3.34	3.45	3.10	3.43	120	115	115	17.99	0.0066	0.0070	0.0063	1.11	5.39
West of Railroad to Junction 4	1.66	3.43	3.05	3.38	118	113	113	10.95	0.0065	0.0070	0.0063	1.11	6.60
East of Railroad to Junction 4	1.38	3.37	3.49	3.77	155	105	105	4.94	0.0087	0.0057	0.0053	1.08	3.58
CC W Branch 1	0.65	1.53	1.54	1.55	250	100	100	3.98	0.0309	0.0123	0.0122	1.01	6.13
CC W Branch 2	0.54	1.61	1.74	1.76	240	130	130	3.51	0.0282	0.0142	0.0140	1.01	6.50
CC W Branch 3	0.47	1.33	1.33	1.36	215	120	120	3.45	0.0306	0.0171	0.0167	1.02	7.35
CC E Branch 1	0.53	2.64	2.65	2.88	140	95	95	2.88	0.0100	0.0068	0.0062	1.09	5.44
CC E Branch 2	0.64	1.26	0.32	0.35	141	8	8	0.84	0.0212	0.0047	0.0044	1.07	1.32
CC E Branch 3	0.21	1.09	0.84	0.89	20	10	10	1.21	0.0035	0.0023	0.0021	1.07	5.77
CC 1	0.30	1.04	0.97	1.12	190	90	90	2.10	0.0346	0.0175	0.0152	1.15	7.01
CC 2	0.03	0.32	0.16	0.17	15	2	2	0.17	0.0089	0.0023	0.0023	1.01	5.55
CC Sub 1	0.35	0.88	1.05	1.06	150	110	110	1.48	0.0323	0.0198	0.0197	1.01	4.23
CC 3	0.06	0.43	0.46	0.50	22	12	12	0.50	0.0097	0.0049	0.0046	1.08	8.26
CC Sub 2	0.12	0.55	0.53	0.63	12	10	10	0.63	0.0041	0.0035	0.0030	1.18	5.24
CC 4	0.05	0.34	0.27	0.28	7	2	2	0.28	0.0039	0.0014	0.0013	1.05	5.62
CC Sub 3	0.22	0.77	0.89	0.93	185	100	100	0.93	0.0455	0.0213	0.0205	1.04	4.21
CC 5	0.31	0.95	0.55	0.74	145	2	2	0.74	0.0289	0.0007	0.0005	1.35	2.39
UBC Sub 1	0.05	0.47	0.25	0.25	105	40	40	0.25	0.0427	0.0307	0.0306	1.00	4.95
UBC Sub 2	0.15	0.46	0.29	0.29	110	30	30	0.29	0.0449	0.0195	0.0194	1.00	1.95

Table 4
Precipitation Frequency for the Upton Plant Site

Storm Event	Precipitation (in)	Storm Event	Precipitation (in)	Storm Event	Precipitation (in)
2yr-24hr	1.62	2yr-6hr	1.20	2yr-1hr	0.82
5yr-24hr	2.15	5yr-6hr	1.65	5yr-1hr	1.21
10yr-24hr	2.51	10yr-6hr	1.95	10yr-1hr	1.46
25yr-24hr	3.02	25yr-6hr	2.37	25yr-1hr	1.81
50yr-24hr	3.41	50yr-6hr	2.69	50yr-1hr	2.08
100yr-24hr	3.80	100yr-6hr	3.01	100yr-1hr	2.35

Table 5
Curve Numbers at the Upton Plant Site by Drainage Subbasin

Drainage Basin[1]	Area (mi^2)	Weighted Curve Number
CC W Branch 1	0.65	88
CC W Branch 2	0.54	88
CC W Branch 3	0.47	88
CC E Branch 1	0.53	88
CC E Branch 2	0.64	88
CC E Branch 3	0.21	88
CC 1	0.30	88
CC 2	0.03	88
CC Sub 1	0.35	88
CC 3	0.06	88
CC Sub 2	0.12	88
CC 4	0.05	88
CC Sub 3	0.22	88
CC 5	0.31	88
Coyote Creek Subtotal:	**4.48**	
UBC Sub 1	0.05	88
UBC Sub 2	0.15	88
Beaver Creek Subtotal:	**0.20**	

NOTE 1: See Figure 3.5-2 for drainage basin nomenclature.

Table 6
HEC-HMS 24-Hour Peak Flow and Runoff Volumes for the Upton Plant Site

Stream Designation/ Hydrologic Element	Precipitation Distribution	Parameter (Units)	Recurrence Interval (Yr)					
			2	5	10	25	50	100
Coyote Creek at Project Boundary (J9)	SCS Type II, 24-Hr General Storm	Peak (cfs)	568.3	998.8	1318.3	1797.1	2178.3	2568.6
		Vol. (ac-ft)	159.5	259.1	331.3	437.7	521.4	606.4
Entry of Coyote Creek into Project Boundary (J5)	SCS Type II, 24-Hr General Storm	Peak (cfs)	502.5	867.9	1136.6	1530.5	1842.1	2151.8
		Vol. (ac-ft)	119.0	193.3	247.1	326.5	389.0	452.4
Confluence of Tributaries East and West of Railroad (J4)	SCS Type II, 24-Hr General Storm	Peak (cfs)	477.2	819.5	1073.4	1436.9	1731.0	2021.7
		Vol. (ac-ft)	108.3	175.9	224.9	297.1	354.0	411.7

NOTE 1: See Addendum 3.5-A for HEC-HMS input parameters and results.
NOTE 2: See Figure 3.5-2 for HEC-HMS drainage basins.

Table 7
HEC-HMS 6-Hour Peak Flow and Runoff Volumes for the Upton Plant Site

Stream Designation/ Hydrologic Element	Precipitation Distribution	Parameter (Units)	Recurrence Interval (Yr)					
			2	5	10	25	50	100
Coyote Creek at Project Boundary (J9)	SCS Type II, 6-Hr General Storm	Peak (cfs)	278.8	600.3	836.8	1146.7	1383.6	1621.5
		Vol. (ac-ft)	68.1	153.0	216.5	302.6	368.0	435.1
Entry of Coyote Creek into Project Boundary (J5)	SCS Type II, 6-Hr General Storm	Peak (cfs)	241.2	515.9	713.8	971.2	1165.5	1360.7
		Vol. (ac-ft)	50.7	114.1	161.5	225.6	274.4	324.5
Confluence of Tributaries East and West of Railroad (J4)	SCS Type II, 6-Hr General Storm	Peak (cfs)	228.4	487.5	672.5	915.2	1094.1	1277.0
		Vol. (ac-ft)	46.2	103.8	146.9	205.3	249.7	295.3

NOTE 1: See Addendum 3.5-A for HEC-HMS input parameters and results.
NOTE 2: See Figure 3.5-2 for HEC-HMS drainage basins.

Table 8
Surface Water Rights within and 3 Miles Adjacent to the Upton Plant Project Boundary

WR Number	Priority Date	Summary WR Status	Appropriator	Facility Name	Uses	Sec	Qtr-Qtr	Stream Source	Size of Reservoir (AF)	Latitude	Longitude
Township 47 North, Range 65 West											
P1700.0R	01/24/1910		J.H. PERRY	J.H. Perry Reservoir	IRR_SW	01	SENE	West Fork Turner Creek	0	44.0862810	-104.6014530
P9590.0D	01/24/1910		J.H. PERRY	J. H. Perry Ditch	IRR_SW	01	SENE	West Fork Turner Creek	0	44.0865210	-104.6035610
P16477.0D	11/27/1922	Fully Adjudicated	F.L. HUFF	Huff Ditch	IRR_SW; STO	15	NESE	Beaver Creek	0	44.0536300	-104.6412330
CR CR01/007	11/27/1922		F.L. HUFF	Huff Reservoir	IRR_SW; STO	15	NESE	Beaver Creek	224.25	44.0537300	-104.6417500
CR CR02/443	08/30/1940		USDA - NATIONAL FOREST SERVICE	SCS - Beaver Creek Reservoir	STO	04	SWNW	Beaver Creek	69.67	44.0860400	-104.6768500
P20620.0D	02/12/1951	Unadjudicated	JOHN MATERI	Materi No. 1 Pipeline	IRR_SW	05	NENW	Beaver Creek	0	44.0896440	-104.6919050
P500.0S	11/12/1953	Complete	RAYMOND NORRIS	NORRIS NO. 1 STOCK RESERVOIR	STO	07	SESE	Thompson Draw	1.77	44.0638920	-104.7032060
P1216.0S	08/30/1955	Complete	JAMES NORRIS	BOXELDER STOCK RESERVOIR	STO	07	NWNE	Boxelder Draw	1.29	44.0751080	-104.7070330
P1215.0S	08/30/1955	Complete	FRED J & EDITH NORRIS TRUST	SKINNER STOCK RESERVOIR	STO	17	SESW	Skinner Draw	0.34	44.0498140	-104.6920720
P2079.0S	09/11/1957	Complete	RANKIN RANCH, LLC	LONE TREE STOCK RESERVOIR	STO	15	SWSE	East Lone Tree Creek	4.69	44.0503610	-104.6454440
P2637.0S	01/27/1959	Complete	JAMES NORRIS ESTATE	NORRIS STOCK RESERVOIR	STO	08	SWNW	Norris Draw	3.7	44.0718940	-104.6958640
P2646.0S	01/27/1959	Complete	CHARLES RANKIN	STATE STOCK RESERVOIR	STO	16	NWSW	Box Elder Draw	4.8	44.0535030	-104.6766310
P2648.0S	02/02/1959	Complete	CHARLES R. & DEE L. RANKIN	RANKIN PIT STOCK RESERVOIR	STO	09	SWSW	Road Draw	1.11	44.0645640	-104.6760690
P3713.0S	03/31/1961	Complete	CHARLES RANKIN	BEAVER CREEK STOCK RESERVOIR	STO	14	SWSW	Beaver Creek	1.11	44.0518560	-104.6386470
P4114.0S	02/19/1962	Complete	FRED AND EDNA NORRIS	FRED STOCK RESERVOIR	STO	06	SESW	Fred Draw	2.8	44.0793140	-104.7097610
P4113.0S	02/19/1962	Complete	FRED AND EDNA NORRIS	EDITH STOCK RESERVOIR	STO	07	SESW	Lone Tree Creek	13.02	44.0642170	-104.7121250
P4543.0S	05/07/1962	Complete	MATERI BROTHERS	MATERI STOCK RESERVOIR	STO	06	SENW	Materi Draw	1.94	44.0869140	-104.7100220
CR CR04/186	08/08/1962		USDA - NATIONAL FOREST SERVICE	Brown Community #497-4 Stock Reservoir	STO	04	SWSW	Gumbo Draw	1.7	44.0788200	-104.6769000
CR CR03/191	08/08/1962		USDA - NATIONAL FOREST SERVICE	Brown Community #497-3 Stock Reservoir	STO	05	SESW	East Lone Tree Creek	4.7	44.0787800	-104.6919500
CR CR03/192	08/08/1962		USDA - NATIONAL FOREST SERVICE	Brown Community #497-5 Stock Reservoir	STO	08	SENE	East Lone Tree Creek	4.88	44.0715800	-104.6819500
CR CR03/161	08/08/1962		USDA - NATIONAL FOREST SERVICE	Brown Community #497-1 Stock Reservoir	STO	09	SENE	Beaver Creek	3.3	44.0716800	-104.6618600
CR CR03/160	08/08/1962		USDA - NATIONAL FOREST SERVICE	Rankin #388-2 Stock Reservoir	STO	10	SESW	Beaver Creek	0.8	44.0645100	-104.6518100
CR CR03/162	08/08/1962		USDA - NATIONAL FOREST SERVICE	Rankin #388-1 Stock Reservoir	STO	10	NWSW	Beaver Creek	0.8	44.0681000	-104.6568400
CR CR03/189	08/08/1962		USDA - NATIONAL FOREST SERVICE	W. Foltz #497-6 Stock Reservoir	STO	11	SESE	Windy Draw	0.42	44.0646200	-104.6216200
CR CR03/190	03/18/1963		USDA - NATIONAL FOREST SERVICE	Rankin #9-388-3 Stock Reservoir	STO	10	SENE	Rankin Draw	1.35	44.0717600	-104.6417300

WR Number	Priority Date	Summary WR Status	Appropriator	Facility Name	Uses	Sec	Qtr-Qtr	Stream Source	Size of Reservoir (AF)	Latitude	Longitude
P5361.0S	08/26/1963	Complete	DON AND BRUCE GOSE	MCCONNAHEY STOCK RESERVOIR	STO	17	SENE	Box Elder Draw	4.8	44.0577470	-104.6819610
CR CR04/182	09/30/1965		USDA - NATIONAL FOREST SERVICE	Foltz #F.S.9-497-8 Stock Reservoir	STO	11	SENW	Coyote Creek	4.05	44.0717900	-104.6316700
CR CR04/183	03/20/1967		USDA - NATIONAL FOREST SERVICE	Brown #F.S.9-497-9 Stock Reservoir	STO	04	SENE	Puppy Draw	1.05	44.0861300	-104.6617900
CR CR06/300	04/29/1969		USDA - NATIONAL FOREST SERVICE	Martens No. F.S.9-369-4 Stock Reservoir	STO	15	NWNW	Nora Draw	1.01	44.0608800	-104.6568600
CR CR06/301	04/07/1971		USDA - NATIONAL FOREST SERVICE	Brown #F.S. 9-497-11 Stock Reservoir	STO	08	NWSE	Dinky Draw	1.46	44.0679400	-104.6869800
CR CR06/302	05/24/1971	Fully Adjudicated	USDA - NATIONAL FOREST SERVICE	Brown #F.S. 9-497-13 Stock Reservoir	STO	08	NESE	Kahler Draw	0.84	44.0693530	-104.6818750
CR CR09/319	04/26/1973		USDA - NATIONAL FOREST SERVICE	Brown #F.S. 9-497-12 Stock Reservoir	STO	08	NWNW	Ripple Draw	0.97	44.0751400	-104.6969800
CR CC75/038	09/26/1974		USDA - NATIONAL FOREST SERVICE	Coyote Creek Diversion Pipe Arch Canal	FIS; RES	11	NWNW	Coyote Creek	0	44.0753800	-104.6367000
CR CR09/317	09/26/1974		USDA - NATIONAL FOREST SERVICE	Upton Outdoor Lab Site No. 4 Reservoir	FIS	11	NENW	Coyote Creek	111.72	44.0754000	-104.6316700
P8972.0S	11/30/1981	Complete		WILMOT STOCK RESERVOIR	STO	12	SENW	Wilmot Draw	18.5	44.0720610	-104.6103420
CR CR11/279	11/13/1985		TOWN OF UPTON	Upton Wastewater Treatment Reservoir	IND_SW	02	NESE	Iron Creek	61.93	44.0826400	-104.6215900
CR CR11/272	01/14/1986		USDA - NATIONAL FOREST SERVICE	Brown #9-497-14 Stock Reservoir	STO	03	SWSW	Tucker Draw	1.19	44.0789200	-104.6568100
CR CR11/258	01/14/1986		USDI BLM	Brown #9-497-10 Stock Reservoir	STO	05	SWNW	Dipper Draw	1.29	44.0860200	-104.6969400
CR CR11/273	09/03/1986		USDA - NATIONAL FOREST SERVICE	Foltz #9-497-15 Stock Reservoir	STO	14	NWNW	Brooks Draw	2.36	44.0609600	-104.6367000
P10273.0S	08/31/1987	Complete		SITE 64-1 STOCK RESERVOIR	STO	13	SWNE	D64-2 Draw	17.8	44.0579360	-104.6068470
P10274.0S	08/31/1987	Complete		SITE 64-2 STOCK RESERVOIR	STO	13	NESE	D64-6 Draw	4	44.0539250	-104.6014420
P10275.0S	08/31/1987	Complete		SITE 64-3 STOCK RESERVOIR	STO	13	NWNE	D64-1 Draw	7.3	44.0610890	-104.6064920
P10276.0S	08/31/1987	Complete		SITE 64-8 STOCK RESERVOIR	STO	13	NESE	D64-12 Draw	5.9	44.0539250	-104.6014420
P11877.0R	11/13/2001	Unadjudicated		Lake Owyhee Reservoir	STO; WIL; COMBBU	02	SESE	Iron Creek	0		
P11878.0R	11/13/2001	Unadjudicated		Turk Pond Reservoir	STO; WIL; COMBBU	12	NESW	Iron Creek	0	44.0691670	-104.6120280
Township 47 North, Range 66 West											
P5593.0S	05/23/1963	Complete	MATERI BROTHERS	DEAN STOCK RESERVOIR	STO	13	SENW	North Fork Little Soda Creek	3.95	44.0568890	-104.7321310
P6219.0S	07/22/1968	Complete	KEITH E AND DORMIE G MATERI	WAGON #2 STOCK RESERVOIR	STO	02	SWNE	Lone Tree Creek	4.12	44.0858560	-104.7462140
Township 48 North, Range 65 West											
CR CC18/005	01/11/1904		CLARA M. MCKENZIE	Lone Tree Ditch	IRR_SW	32	NENW	Lone Tree Creek	0	44.1042900	-104.6918000
CR CC29/399	09/15/1906		CLARA M. MCKENZIE	Lone Tree Reservoir	IRR_SW	32	NENW	Lone Tree Creek	49	44.1042900	-104.6918000

WR Number	Priority Date	Summary WR Status	Appropriator	Facility Name	Uses	Sec	Qtr-Qtr	Stream Source	Size of Reservoir (AF)	Latitude	Longitude
P1909.0E	03/17/1908	Fully Adjudicated	JOHN C. MINTER	Lone Tree Ditch {Enl. of}	IRR_SW	32	NENW	Lone Tree Creek	0	44.1048780	-104.6906000
CR CC34/120	09/30/1908		THOMAS P. WILSON	Wilson Ditch	IRR_SW	15	NWSE	Dry Draw	0	44.1416500	-104.6458100
CR CC34/121	10/06/1908		THOMAS P. WILSON	Wilson Reservoir	IRR_SW	15	NWSE	Dry Draw	11.5	44.1416500	-104.6458100
P1569.0R	06/25/1909	Unadjudicated	JOHN E. BLAKELY	Brainerd Reservoir	IRR_SW	33	SENE	Coyote Creek	0	44.1010010	-104.6598890
P9159.0D	06/25/1909		JOHN E. BLAKELY	Brainerd Ditch	IRR_SW	33	SENE	Coyote Creek	0	44.1006330	-104.6608430
P9589.0D	01/08/1910		JOHN E. BLAKELY	Brainierd Ditch	IRR_SW	33	SENE	Coyote Creek	0	44.1020490	-104.6605980
P20621.0D	02/12/1951	Unadjudicated	JOHN MATERI	Materi No. 2 Pipeline	IRR_SW	32	SWNE	Beaver Creek	0	44.1006400	-104.6867910
P5806.0R	02/12/1951	Unadjudicated	JOHN MATERI	Materi No. 1 Reservoir	IRR_SW; STO; COMBBU	32	SESW	Beaver Creek	42.88	44.0928290	-104.6895930
P5807.0R	02/12/1951	Unadjudicated	JOHN MATERI	Materi No. 2 Reservoir	IRR_SW; STO; COMBBU	32	SWNE	Beaver Creek	69.25	44.1006400	-104.6867910
P460.0S	10/28/1953	Complete	DONALD AND JUDY BARTELS	COYOTE DRAW STOCK RESERVOIR	STO	33	NENW	Coyote Draw	17.11	44.1045580	-104.6726390
P618.0S	12/21/1953	Complete	DUANE K AND VELVA G ENGEL	HOPPER FLAT STOCK RESERVOIR	STO	25	SENW	Pine Creek	12.14	44.1175250	-104.6129920
P914.0S	09/24/1954	Complete	CHARLES HAGERMAN	PINE RIDGE STOCK RESERVOIR	STO	24	SESW	Pine Creek	4.77	44.1233890	-104.6108190
P2207.0S	01/29/1958	Complete	NORMALEE MATERI	STEVENS STOCK RESERVOIR	STO	29	SWSW	Stevens Creek	0.71	44.1079330	-104.6968080
P6513.0R	06/18/1959	Unadjudicated		Bowl Reservoir	STO	32	NESW	Beaver Creek	65.2	44.0977510	-104.6935120
CR CR03/184	08/08/1962		USDA - NATIONAL FOREST SERVICE	Barton Govt. #166 Stock Reservoir	STO	17	SWSE	Iron Creek	8.5	44.1373700	-104.6864500
P3845.0S	08/08/1962	Complete	USDA - NATIONAL FOREST SERVICE	BARTON GOVT. #166 STOCK RESERVOIR	STO	17	SWSE	Iron Creek	8.5	44.1389170	-104.6851750
CR CR10/028	06/27/1963		BARTONS LAND & LIVESTOCK	Wooley No. 2 Reservoir	STO	29	NWSW	Lone Tree Creek	24.7	44.1115900	-104.6967800
P5112.0S	02/18/1965	Complete	ALBERT NEIMAN	NORTH WEST PASTURE STOCK RESERVOIR	STO	30	NWSE	North West Pasture	0.66	44.1115170	-104.7068940
P5113.0S	02/18/1965	Complete	NORMALEE MATERI	SOUTH WEST PASTURE STOCK RESERVOIR	STO	30	SWSE	Beaver Creek	2.44	44.1070190	-104.7071750
CR CR04/184	03/20/1967		USDA - NATIONAL FOREST SERVICE	Barton #F.S.9-307-2 Stock Reservoir	STO	15	NWNE	Henderson Draw	1.01	44.1489400	-104.6458000
CR CR06/296	02/02/1971		USDA - NATIONAL FOREST SERVICE	Barton #F.S. 9-307-4 Stock Reservoir	STO	14	SENW	Anderson Draw	5.92	44.1455800	-104.6305100
CR CR06/297	09/20/1971		USDA - NATIONAL FOREST SERVICE	Barton #F.S. 9-307-4A Stock Reservoir	STO	14	SENW	Anderson Draw	3.57	44.1455800	-104.6305100
P8009.0S	09/18/1975	Complete	DELMER ELLIS	INDIAN SPRINGS STOCK RESERVOIR	STO	15	SESW	Indian Springs Draw	0.53	44.1377030	-104.6521640
P9608.0S	07/10/1984	Complete		MATERI #9-370-2 STOCK RESERVOIR	STO	31	NESW	Goldfinch Draw	7.98	44.0960000	-104.7110390
CR CR11/271	02/09/1987		USDA - NATIONAL FOREST SERVICE	Barton #9-307-7 Stock Reservoir	STO	20	SWNW	Hyde Draw	4.32	44.1299100	-104.6966500
CR CR11/278	02/09/1987		USDA - NATIONAL FOREST SERVICE	Materi #9-370-5 Stock Reservoir	STO	32	NWNE	Kurt Draw	1.05	44.1043100	-104.6867600

WR Number	Priority Date	Summary WR Status	Appropriator	Facility Name	Uses	Sec	Qtr-Qtr	Stream Source	Size of Reservoir (AF)	Latitude	Longitude
P10263.0S	09/21/1987	Complete		SITE 30-9 STOCK RESERVOIR	STO	24	SWSE	Rug Draw	7.02	44.1232970	-104.6059030
P10299.0S	01/04/1988	Complete		#22-2 STOCK RESERVOIR	STO	16	NESW	Puff Draw	4.3	44.1412390	-104.6711970
P10300.0S	01/04/1988	Complete		#22-3 STOCK RESERVOIR	STO	16	SENW	Dragon Draw (drainage of)	3.2	44.1449080	-104.6711610
P10301.0S	01/04/1988	Complete		#22-7 STOCK RESERVOIR	STO	16	NWSE	Dragon Draw (drainage of)	12.4	44.1413080	-104.6661280
P10302.0S	01/04/1988	Complete		#22-15 STOCK RESERVOIR	STO	16	NESW	Puff Draw	3.7	44.1412390	-104.6711970
P10303.0S	01/04/1988	Complete		#22-24 STOCK RESERVOIR	STO	16	SENW	Spot Draw	3.8	44.1449080	-104.6711610
P10390.0S	05/18/1988	Complete		SR NO. 23-1 STOCK RESERVOIR	STO	11	SESE	Anderson Draw	3.55	44.1545170	-104.6199390
P10425.0S	07/15/1988	Complete		SR NO. 26-6 STOCK RESERVOIR	STO	21	NWNE	D26-3 Draw	2.81	44.1339670	-104.6661970
P10426.0S	07/15/1988	Complete		SR NO 26-1 STOCK RESERVOIR	STO	21	NENW	D-26-1 Draw	3.31	44.1338940	-104.6712720
P10427.0S	07/15/1988	Complete		SR NO. 29-5 STOCK RESERVOIR	STO	21	NWSW	D29-6 Draw	2.9	44.1264720	-104.6757860
CR CR13/165	01/16/1989		BARTONS LAND & LIVESTOCK	SR No. 22-14A Reservoir	REC; STO	09	SWSW	D22-1 Draw	177.12	44.1521900	-104.6761500
CR CR13/166	01/16/1989		BARTONS LAND & LIVESTOCK	SR No. 22-14B Reservoir	REC; STO	09	SESW	D22-1 Draw	33.77	44.1522500	-104.6711000
P11582.0S	04/20/1992	Complete		HUCKINS STOCK RESERVOIR	STO	28	SWNE	Huckins Draw	18.7	44.1159560	-104.6657390
P13140.0S	09/04/1998	Complete	ROBERT GOSE	BOW TIE STOCK RESERVOIR	STO	36	NENE	Gose Draw	9.69	44.1059060	-104.6006580
Township 48 North, Range 66 West											
P2464.0R	02/24/1913		H.P. KINNAMAN	H.P. Kinnaman Reservoir	IRR_SW	23	NWNE	Draw	0	44.1324200	-104.7477590
P11721.0D	02/24/1913		H.P. KINNAMAN	Kinnaman Ditch	IRR_SW	23	NWNE	Draw	0	44.1347790	-104.7451910
P2193.0S	01/20/1958	Complete	VIRGINIA JESPERSON	WOOLEY STOCK RESERVOIR	STO	23	NESE	Needle Creek	2.08	44.1259470	-104.7415500
P2294.0S	05/20/1958	Complete	CHARLES BELTCH	MCCRADY STOCK RESERVOIR	STO	25	SENW	McCrady Draw	3.26	44.1147920	-104.7296560
P3119.0S	03/08/1960	Complete	GENE CRANSTON	CRANSTON STOCK RESERVOIR	STO	35	SENE	East Lone Tree Creek	0.91	44.1005110	-104.7417420
P3811.0S	03/18/1963	Complete	VERNE BARTON	WOOLEY #1 STOCK RESERVOIR	STO	13	SWNW	Muhly Creek	14.2	44.1431640	-104.7358220
CR CR04/335	03/20/1967		USDA - NATIONAL FOREST SERVICE	Mirich #F.S.9-372-2 Stock Reservoir	STO	12	SWSW	Patrick Draw	1.34	44.1514700	-104.7369500
CR CR06/387	02/09/1968		USDA - NATIONAL FOREST SERVICE	Mirich #F.S.9-372-3 Stock Reservoir	STO	13	SENW	Hill Draw	0.66	44.1441800	-104.7319100
CR CR10/114	01/20/1971		BARTONS LAND & LIVESTOCK	Jim Stock Reservoir	STO	25	SWSE	McCrady Draw	1.71	44.1077800	-104.7267700
CR CR10/142	01/20/1971		BARTONS LAND & LIVESTOCK	Upper Muhly Stock Reservoir	STO	24	SENW	Upper Muhly Creek	2.08	44.1296200	-104.7318500
CR CR06/386	02/02/1971		USDA - NATIONAL FOREST SERVICE	Mirich #F.S. 9-372-5 Stock Reservoir	STO	13	NENE	Railroad Draw	3.88	44.1478000	-104.7219100

Source: WYSEO, 2013

Table 9
Surface Water Gaging Stations at the Upton Plant Site

Surface Water Gaging Station	Gage Type	Monitored Feature	Township	Range	Section	Qtr-Qtr	Latitude (°N)	Longitude (°W)
UCC-01	Grab	Coyote Creek	48N	65W	28	SW-SE	44°06' 37.76"	104° 39' 58.56"
UCC-02	Grab	Coyote Creek	48N	65W	28	SW-SE	44° 06' 38.09"	104° 39' 58.07"
UCC-03	Grab	Coyote Creek	48N	65W	33	SE-SE	44° 05' 39.09"	104° 39' 35.15"
USP-01	Grab	USP-01	48N	65W	33	NE-NW	44° 06' 20.34"	104° 40' 24.52"
USP-02	Grab	USP-02	48N	65W	28	SW-SE	44° 06' 35.83"	104° 39' 50.39"
USP-03	Grab	USP-03	48N	65W	28	SE-SE	44° 06' 37.11"	104° 39' 45.39"

Table 10
Upton Plant Site Surface Water Monitoring Results

Site ID		UCC-01			UCC-02			UCC-03			USP-01			USP-02			USP-03		
Parameters	**Units**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**
In Situ Parameters																			
Conductivity	µS/cm	5	651	292 - 1240	1	1210	1210	3	912	708 - 1109	3	1166	4.76 - 1894	3	865	115.1 - 1320	3	978	160.9 - 1833
Flow Velocity	s.u.	2	0.65	0.5 - 0.8	0	NM	NM	2	0.65	0.4 - 0.9	0	NM	NM	0	NM	NM	0	NM	NM
pH	ppm	5	7.3	6.7 - 8.4	2	7.95	7.8 - 8.18	3	6.71	6.48 - 8	3	8.4	8.1 - 8.85	3	8.35	7.9 - 9.9	3	8.37	8.2 - 8.6
Temperature	°C	5	15.6	0 - 32.7	2	8.1	2.8 - 13.3	2	13.7	12.7 - 14.7	3	17.9	11.1 - 22.8	3	20.5	11 - 27.2	3	18.8	9.9 - 24.6
Total Dissolved Solids	mg/L	1	245	245	0	NM	NM	1	462	462	0	NM	NM	0	NM	NM	0	NM	NM
General																			
Alkalinity (Total as CaCO3)	mg/L	7	62	44 - 80	5	58	44 - 87	4	63	37 - 76	5	113	58 - 161	5	254	175 - 346	5	243	163 - 362
Ammonia (Total)	mg/L	7	0.11	<0.05 - 0.36	5	0.18	<0.05 - 0.45	4	0.07	<0.05 - 0.12	5	0.06	<0.05 - 0.12	5	0.23	<0.05 - 0.64	5	0.07	<0.05 - 0.16
Bicarbonate Alkalinity	mg/L	7	75	54 - 98	5	71	53 - 107	4	77	45 - 93	5	131	70 - 190	5	256	146 - 394	5	287	198 - 414
Carbonate Alkalinity	mg/L	7	5	<5	5	5	<5	4	5	<5	5	7	<5 - 15	5	27.6	<5 - 99	5	7.8	<5 - 14
Cyanide (Total)	mg/L	7	0.005	<0.005	5	0.005	<0.005	4	0.005	<0.005	5	0.005	<0.005	5	0.005	<0.005	5	0.005	<0.005
Hardness as CaCO3 (Dissolved)	mg/L	7	110	30 - 210	5	110	30 - 210	4	119	35 - 180	5	856	340 - 2400	5	113	85 - 130	5	71	50 - 90
Laboratory Conductivity	µS/cm	7	662	272 - 1230	5	642	226 - 1210	4	707	202 - 1080	5	2302	1010 - 5590	5	1280	1160 - 1530	5	1319	886 - 1840
Laboratoy pH	s.u.	7	7.33	6.96 - 7.89	5	7.41	7.13 - 7.96	4	7.33	7.17 - 7.91	5	7.69	7.27 - 8.77	5	8.24	7.75 - 9.89	5	8.21	7.94 - 8.5
Nitrate (as N)	mg/L	7	0.79	<0.1 - 3.5	5	0.84	<0.1 - 2.3	4	0.25	<0.1 - 0.7	5	0.1	<0.1	5	0.1	<0.1	5	0.1	<0.1 - 0.1
Nitrate+Nitrite (Dissolved)	mg/L	7	0.83	<0.1 - 3.6	5	0.86	<0.1 - 2.3	4	0.25	<0.1 - 0.7	5	0.1	<0.1	5	0.1	<0.1 - 0.1	5	0.12	<0.1 - 0.2
Nitrite (as N)	mg/L	7	0.1	<0.1 - 0.1	5	0.1	<0.1 - 0.1	4	0.1	<0.1	5	0.1	<0.1	5	0.1	<0.1	5	0.1	<0.1
Oil & Grease	mg/L	7	5.1	<5 - 6	5	5	<5	4	5	<5	5	5	<5	5	5	<5	5	5.2	<5 - 6
Sodium Adsorption Ratio	unitless	7	4.0	3.5 - 5.2	5	4	2.7 - 5.1	4	4	2.1 - 5	5	3.5	1.9 - 5.9	5	10.2	8.6 - 12.7	5	13.4	10.1 - 17
Sulfide (Dissolved)	mg/L	7	0.2	<0.04 - 0.9	5	0.3	0.04 - 1	4	0.3	<0.04 - 0.7	5	0.04	<0.04	5	0.096	0.06 - 0.09	5	0.4	0.1 - 0.8
Total Dissolved Solids	mg/L	7	790	482 - 1250	5	849	462 - 1790	4	840	629 - 1330	5	1962	732 - 5410	5	890	807 - 1110	5	1784	832 - 2850
Total Suspended Solids	mg/L	7	49	<7 - 120	5	169	6 - 470	4	58	19 - 170	5	27	<5 - 96	5	23	7 - 37	5	29	<5 - 62
Organics																			
Coliform (Fecal)	CFU/100mL	7	22	<2 - 100	5	22	<2 - 27	4	11	<2 - <20	5	595	<5 - 2800	5	16	<0 - 33	5	166	<0 - 560
Major Ions																			
Bromide (Dissolved)	mg/L	7	0.1	<0.1	5	0.1	<0.1	4	0.1	<0.1	5	0.1	<0.1	5	0.1	<0.1	5	0.1	<0.1
Calcium (Dissolved)	mg/L	7	26	7 - 49	5	24.6	6 - 46	4	26.5	8 - 39	5	154	62 - 437	5	22.2	14 - 27	5	16	12 - 21
Chloride (Dissolved)	mg/L	7	5.9	3 - 8	5	5.4	4 - 8	4	5.5	4 - 7	5	16.6	4 - 46	5	19.6	18 - 22	5	15.6	8 - 21
Fluoride (Dissolved)	mg/L	7	0.37	0.3 - 0.5	5	0.38	0.3 - 0.5	4	0.4	0.4	5	1.1	0.6 - 2.3	5	0.88	0.8 - 1	5	1.14	0.7 - 1.6
Magnesium (Dissolved)	mg/L	7	11	3 - 21	5	12	3 - 23	4	13	4 - 20	5	116.2	44 - 324	5	13.8	12 - 19	5	7.6	5 - 9
Orthophosphate (Dissolved)	mg/L	7	0.1	<0.1	5	0.1	<0.1	4	0.13	<0.1 - 0.2	5	0.1	<0.1	5	0.18	<0.1 - 0.4	5	0.1	<0.1 - 0.1
Potassium (Dissolved)	mg/L	7	5.4	4 - 8	5	7	5 - 10	4	7	5 - 10	5	15.6	7 - 44	5	8.8	7 - 10	5	8.6	5 - 11
Sodium (Dissolved)	mg/L	7	95	53 - 175	5	92	40 - 170	4	102	29 - 154	5	251	81 - 663	5	245	206 - 321	5	263	181 - 371
Sulfate (Dissolved)	mg/L	7	236	43 - 512	5	235.8	46 - 507	4	266	48 - 448	5	1263	456 - 3700	5	335	294 - 393	5	365	172 - 527
Total Metals																			
Aluminum (Total)	mg/L	7	13.5	1.07 - 41.3	5	33.1	2.08 - 83	4	18.6	1.38 - 61.9	5	1.1	0.08 - 3.78	5	3.5	1.96 - 4.47	5	39.3	15.6 - 72.5
Antimony (Total)	mg/L	7	0.001	<0.001	5	0.001	<0.001	4	0.001	<0.001	5	0.001	<0.001	5	0.001	<0.001	5	0.001	<0.001
Arsenic (Total)	mg/L	7	0.003	<0.001 - 0.008	5	0.007	0.001 - 0.019	4	0.0035	<0.001 - 0.01	5	0.003	0.001 - 0.007	5	0.006	0.004 - 0.008	5	0.009	0.004 - 0.016
Barium (Total)	mg/L	7	0.1	<0.05 - 0.23	5	0.23	<0.05 - 0.53	4	0.13	0.05 - 0.33	5	0.06	<0.05 - 0.08	5	0.06	<0.05 - 0.07	5	0.23	0.1 - 0.43
Beryllium (Total)	mg/L	7	0.001	<0.001 - 0.003	5	0.002	<0.001 - 0.005	4	0.002	<0.001 - 0.003	5	0.001	<0.001	5	0.001	<0.001	5	0.002	<0.001 - 0.004
Boron (Total)	mg/L	7	0.13	<0.1 - 0.2	5	0.14	<0.1 - 0.2	4	0.15	0.1 - 0.2	5	0.52	0.2 - 1.3	5	0.14	0.1 - 0.2	5	0.16	<0.1 - 0.3

Site ID		UCC-01			UCC-02			UCC-03			USP-01			USP-02			USP-03		
Parameters	**Units**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**
Cadmium (Total)	mg/L	7	0.001	<0.001	5	0.001	<0.001	4	0.001	<0.001	5	0.001	<0.001	5	0.001	<0.001	5	0.001	<0.001 - 0.001
Cerium (Total)	mg/L	5	0.03	0.004 - 0.059	3	0.09	0.005 - 0.128	2	0.05	0.013 - 0.077	4	0.002	<0.001 - 0.006	4	0.0055	0.004 - 0.007	4	0.054	0.031 - 0.085
Chromium (Total)	mg/L	7	0.01	0.001 - 0.031	5	0.03	0.002 - 0.082	4	0.02	0.001 - 0.054	5	0.003	<0.001 - 0.008	5	0.0032	0.002 - 0.003	5	0.028	0.012 - 0.057
Cobalt (Total)	mg/L	7	0.003	<0.001 - 0.008	5	0.008	<0.001 - 0.018	4	0.004	<0.001 - 0.012	5	0.002	<0.001 - 0.006	5	0.0016	0.001 - 0.002	5	0.0076	0.003 - 0.016
Copper (Total)	mg/L	7	0.013	<0.005 - 0.032	5	0.03	<0.005 - 0.072	4	0.018	<0.005 - 0.052	5	0.006	<0.005 - 0.008	5	0.0052	<0.005 - 0.006	5	0.032	0.015 - 0.061
Iron (Total)	mg/L	7	7.9	0.79 - 24.4	5	19.7	1.4 - 49.6	4	11.4	0.89 - 36.6	5	1.07	0.17 - 3.34	5	2.206	1.41 - 2.83	5	22.4	8.29 - 41.5
Lanthanum (Total)	mg/L	5	0.015	0.002 - 0.031	3	0.04	0.003 - 0.065	2	0.02	0.006 - 0.038	4	0.002	<0.001 - 0.003	4	0.003	0.002 - 0.004	4	0.028	0.017 - 0.043
Lead (Total)	mg/L	7	0.008	<0.001 - 0.022	5	0.02	0.001 - 0.047	4	0.01	<0.001 - 0.031	5	0.002	<0.001 - 0.004	5	0.0024	0.002 - 0.003	5	0.022	0.008 - 0.041
Lithium (Total)	mg/L	7	0.1	<0.1	5	0.1	<0.1 - 0.1	4	0.1	<0.1	5	0.34	0.1 - 0.9	5	0.26	0.2 - 0.4	5	0.2	0.1 - 0.3
Manganese (Total)	mg/L	7	0.15	0.051 - 0.309	5	0.23	0.026 - 0.596	4	0.15	0.03 - 0.394	5	0.11	0.017 - 0.252	5	0.184	0.058 - 0.481	5	0.36	0.145 - 0.883
Mercury (Total)	mg/L	7	0.0001	<0.0001	5	0.0001	<0.0001	4	0.0001	<0.0001	5	0.0001	<0.0001	5	0.0001	<0.0001	5	0.0001	<0.0001 - 0.0001
Molybdenum (Total)	mg/L	7	0.001	<0.001 - 0.001	5	0.001	<0.001 - 0.002	4	0.002	0.001 - 0.002	5	0.002	<0.001 - 0.004	5	0.0028	0.002 - 0.003	5	0.009	0.004 - 0.013
Nickel (Total)	mg/L	7	0.02	0.009 - 0.04	5	0.039	0.008 - 0.089	4	0.023	0.01 - 0.054	5	0.018	<0.005 - 0.054	5	0.0122	0.01 - 0.014	5	0.048	0.024 - 0.091
Selenium (Total)	mg/L	7	0.001	<0.001 - 0.001	5	0.002	<0.001 - 0.003	4	0.001	<0.001 - 0.002	5	0.002	<0.001 - 0.005	5	0.0012	<0.001 - 0.002	5	0.0024	0.002 - 0.004
Silver (Total)	mg/L	7	0.001	<0.001	5	0.001	<0.001	4	0.001	<0.001	5	0.001	<0.001	5	0.001	<0.001	5	0.001	<0.001
Thallium (Total)	mg/L	7	0.0005	<0.0005	5	0.0006	<0.0005 - 0.0009	4	0.0005	<0.0005 - 0.0006	5	0.0005	<0.0005	5	0.0005	<0.0005	5	0.0005	<0.0005
Thorium (Total)	mg/L	7	0.007	<0.005 - 0.012	5	0.012	<0.005 - 0.023	4	0.008	<0.005 - 0.015	5	0.005	<0.005	5	0.005	<0.005	5	0.0126	<0.005 - 0.022
Uranium (Total)	mg/L	7	0.002	0.0005 - 0.0035	5	0.0029	0.0006 - 0.0071	4	0.0016	0.0008 - 0.0036	5	0.0017	0.0003 - 0.0057	5	0.0038	0.0034 - 0.0042	5	0.0078	0.0047 - 0.0141
Vanadium (Total)	mg/L	7	0.02	<0.01 - 0.05	5	0.044	<0.01 - 0.11	4	0.03	<0.01 - 0.09	5	0.01	<0.01 - 0.01	5	0.01	<0.01	5	0.044	0.02 - 0.08
Zinc (Total)	mg/L	7	0.06	0.012 - 0.156	5	0.139	0.011 - 0.356	4	0.076	0.009 - 0.247	5	0.0086	<0.005 - 0.02	5	0.016	0.012 - 0.024	5	0.142	0.054 - 0.252
Radionuclides																			
Gross Alpha	pCi/L	6	6.9	0.2 - 16.5	5	9.08	-1 - 18.1	4	7.05	-0.6 - 18.4	5	1	-0.6 - 2	4	5.95	4.4 - 6.8	4	26.8	13.8 - 40.8
Gross Alpha MDC	pCi/L	6	2.6	1.7 - 3.8	5	2.72	1.4 - 4.2	4	2.9	1.4 - 4.1	5	7.2	3.7 - 17.1	4	5.1	3.1 - 9.4	4	5.6	3.6 - 7.6
Gross Alpha precision (+/-)	pCi/L	6	1.9	1.4 - 2.6	5	1.98	1.4 - 3.1	4	2.05	1.6 - 2.6	5	4.3	2.3 - 10.2	4	3.4	2.1 - 6	4	4.6	2.9 - 6.5
Gross Beta	pCi/L	6	8.7	6.2 - 12.6	5	13.9	7.3 - 22	4	10.6	7.8 - 15.8	5	12.1	4.8 - 32	4	12.5	9 - 21.2	4	19.5	11.4 - 27.6
Gross Beta MDC	pCi/L	6	3.1	2.7 - 4	5	3.32	2.7 - 3.9	4	3.3	2.9 - 3.5	5	8.94	4.5 - 22.4	4	5.5	3.8 - 6.9	4	5.1	4 - 6.6
Gross Beta precision (+ /-)	pCi/L	6	2.02	1.8 - 2.5	5	2.24	1.9 - 2.8	4	2.15	2 - 2.3	5	5.5	2.9 - 13.9	4	3.5	2.4 - 4.5	4	3.4	2.6 - 4.4
Radium 226	pCi/L	6	0.58	0.06 - 1.6	5	1.08	-0.1 - 2.8	4	0.59	-0.2 - 1.7	5	0.1	-0.03 - 0.22	4	0.22	0.13 - 0.33	4	1.17	0.59 - 2
Radium 226 MDC	pCi/L	6	0.19	0.13 - 0.27	5	0.19	0.16 - 0.23	4	0.19	0.14 - 0.29	5	0.23	0.16 - 0.32	4	0.21	0.16 - 0.31	4	0.22	0.16 - 0.31
Radium 226 precision (+ /-)	pCi/L	6	0.2	0.09 - 0.27	5	0.208	0.09 - 0.35	4	0.16	0.12 - 0.24	5	0.14	0.11 - 0.18	4	0.15	0.13 - 0.21	4	0.26	0.19 - 0.41
Radium 228	pCi/L	6	1.2	0.65 - 1.8	5	1.2	0.03 - 3.2	4	1.3	-0.3 - 3.2	5	0.77	-0.3 - 2.5	4	1.3	-0.3 - 3.2	4	2.33	1.4 - 2.9
Radium 228 MDC	pCi/L	6	1.9	0.74 - 3.5	5	1.7	1.2 - 2.1	4	1.3	0.71 - 1.8	5	1.9	1.3 - 2.6	4	1.8	0.97 - 2.7	4	1.78	1.2 - 2.6
Radium 228 precision (+ /-)	pCi/L	6	1.21	0.47 - 2.1	5	1.08	0.7 - 1.4	4	0.82	0.46 - 1.2	5	1.2	0.76 - 1.7	4	1.1	0.67 - 1.7	4	1.18	0.79 - 1.7
Radon 222	pCi/L	6	-124	-426 - -5	5	-140	-390 - 33.6	4	-108	-383 - -12.1	5	-22.2	-89.9 - 10.4	4	-29.9	-60.6 - 2.2	4	-97.6	-124 - -56.6
Radon 222 MDC	pCi/L	6	192	76 - 342	5	214	82 - 339	4	178	75 - 331	5	116	70.4 - 187	4	104	71.2 - 147	4	104	71.4 - 147
Radon 222 precision (+ /-)	pCi/L	6	112	43.6 - 199	5	125	47.5 - 198	4	104	42.8 - 197	5	67.9	40.7 - 112	4	60.4	40.7 - 87.3	4	59.3	39.9 - 86.5
Strontium 90	pCi/L	6	0.67	-0.8 - 1.5	5	0.66	-0.9 - 1.9	4	0.25	-1.6 - 2	5	1.1	-0.7 - 4.3	4	0.28	-0.7 - 0.8	4	0.58	-1.2 - 2.7
Strontium 90 MDC	pCi/L	6	2.37	1.9 - 2.9	5	3.3	2.2 - 5.2	4	2.5	2.3 - 2.6	5	3.6	2.3 - 6.7	4	3.9	2.3 - 7.1	4	4.4	2.6 - 8.7
Strontium 90 precision (+/-)	pCi/L	6	1.4	1.2 - 1.8	5	2.02	1.4 - 3.1	4	1.48	1.4 - 1.6	5	2.2	1.4 - 4.2	4	2.3	1.3 - 4.2	4	2.6	1.5 - 5.3
Calculated Parameters																			
Anions Sum	meq/L	7	6.4	2.72 - 12.5	5	6	2.22 - 12.6	4	7	1.92 - 11	5	29.1	10.8 - 80.4	5	10.2	15.8	5	12.96	8.97 - 18.3
Cations Sum	meq/L	7	6.5	3.06 - 12	5	6	2.49 - 11.8	4	7	2.09 - 10.5	5	28.5	10.4 - 78.4	5	13.2	16.9	5	13.1	9.03 - 18.2
A/C Balance (%)	%	7	1.11	-2.68 - 5.96	5	2.31	-3.06 - 5.83	4	1.03	-2.23 - 4.25	5	-0.92	-2.55 - 2.05	5	4.06	3.44	5	0.702	-1.66 - 3.29

Site ID		UCC-01			UCC-02			UCC-03			USP-01			USP-02			USP-03		
Parameters	**Units**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**	**Mean**	**Range**
A/C Balance Sigma (%)	%	2	0.45	-0.87 - 1.76	2	0.59	-1.31 - 2.48	2	1.27	0.8 - 1.73	1	1.31	1.31	1	-3.21	-3.21	1	0	0
Calculated TDS	mg/L	1	307	307	1	601	601	0	NM	NM	0	NM	NM	0	NM	NM	0	NM	NM

NOTES:
1. Detection limit values displayed with less than symbol (<)
2. NM - not measured
3. Range statistics calculated using half the detection limit value; arithmetic mean statistics calculated using the detection limit value
4. Lower detected values displayed for maximum range over higher non-detected values when minimum values were detected values.

Table 11
Monitoring Well Network Well Information, Upton Plant Site

Well	Location (WYSP, feet; Easting / Northing) (Bold - surveyed)		TOC Elevation (ft amsl)	Started	Completed	Total Depth (ft bgs)	Total Depth, Elog (ft bgs)	Geophysical Logs	Surface Casing depth ft bgs / ID (in)	Monitor Well Casing Type/ID (in.)	Bottom of Casing (ft bgs)	Screened Interval (ft bgs)	Screen Type/ Slot Size	Sand Pack Interval (ft bgs)	Annulus Seal	Cement Cap depth (ft bgs)	Stickup (ft ags)	Completion Zone	Initial Water Level (ft btoc)	1st Water Sample
UMW-01	1310024.06	788113.75	4272.88	04/16/12	04/21/12	941.00	935	SP, G, C, R, NP	20/10	Steel/4	940.5	892.9 - 932.9	SS - 20	941 - 841	Chips/Plug Gel	20	3.00	Deep - Dakota Aquifer	67.70	4/23/2012
UMW-02	1315237.01	787268.61	4256.02	03/05/12	03/14/12	688.00	687	SP, G, C, R, NP	20/10	Steel/4	654.25	610 - 650	SS - 20	688 - 551	Chips/Plug Gel	25	**	Deep - Dakota Aquifer	Flowing (+8')	3/14/2012
UMW-03	1315193.20	785434.68	4292.02	03/26/12	04/01/12	860.00	859	SP, G, C, R, NP	20/10	Steel/4	850.9	800 - 840	SS - 20	860 - 782.5	Chips/Plug Gel	20	1.90	Deep - Dakota Aquifer	35.00	4/2/2012
UMW-04	1315186.57	787253.45	4255.01	03/15/12	03/17/12	365.00	--	--	20/10	Steel/4	355	345 - 350	SS - 20	365 - 326	Chips/Plug Gel	20	3.25	Deep - Newcastle	340.00	4/25/2012
UMW-05	1309803.11	786319.98	4318	02/07/13	02/26/13	1265.00	1252.8	SP, G, T, R, D, C, CB	20/10	Steel/4	1254.5	1237 - 1227 1252 - 1242	No slots - perforated	None	Cement	20	3.00	Deep - Dakota Aquifer	64.00	2/26/2013
USMW-01	1316036.73	787646.77	4249.07	04/04/12	04/04/12	8.50	--	--	--	PVC Sch. 80/4	8.5	8.5 - 3.5	PVC Slot - 20	8.5 - 2.5	Chips	1	3.00	Shallow - Valley Fill	2.05	5/24/2012
USMW-02	1312098.51	788712.71	4237.29	04/05/12	04/05/12	19.00	--	--	--	PVC Sch. 80/4	19	19 - 9	PVC Slot - 20	19 - 7.5	Chips	1	3.00	Shallow - Valley Fill	13.30	5/24/2012
USMW-03	1309984.31	789623.40	4226.26	04/17/12	04/17/12	17.75	--	--	--	PVC Sch. 80/4	17.75	17.75 - 7.75	PVC Slot - 20	17.75 - 7.6	Chips	1	2.00	Shallow - Valley Fill	Dry	5/24/2012
USMW-04	1310055.77	786296.49	4297.04	05/02/13	05/02/13	8.20	--	--	--	PVC Sch. 80/4	8.2	8.0 - 3.0	PVC Slot - 20	8.2 - 2.5	Chips	1	2.2	Shallow - Weathered Shale	Dry	9/18/2013
USMW-05	1310173	786450	4308	05/02/13	05/02/13	16.75	--	--	--	PVC Sch. 80/4	16.5	16.5 - 6.5	PVC Slot - 20	16.5 - 4.0	Chips	1	2.5	Shallow - Weathered Shale	Dry	9/18/2013

Table 12
In-Situ Field Parameters, Upton Site Groundwater Monitoring

Well	Date Sampled	In-Situ Parameters				
		Conductivity (µS/cm)	Depth to Bottom (ft below MP)	Depth to Water (ft below MP)	pH	Temp. (°C)
UMW-01	4/23/12		940.5	67.7		
UMW-01	9/24/12					
UMW-01	10/10/12	1047	940.5	72.05	9	17.4
UMW-01	3/4/13	996	940.5	70	9.48	16.2
UMW-01	5/2/13					
UMW-01	8/20/13	1040	940.5	78	9.3	17.7
UMW-01	11/11/13	1162	940.5	23.4	9.4	16.7
UMW-01	3/25/14	1206	940.5	72.2	9	15.2
UMW-01	6/30/14	1077	940.5	76.3	9.4	59.8
UMW-01	8/8/14	1040	940.5	73.6	9.3	56.4
UMW-01	12/2/14	972	940.5	92	9.4	59
UMW-02	3/14/12				8.8	12
UMW-02	9/20/12	1108	654.25	0	9	12.9
UMW-02	10/10/12	1102	760	0	9.1	11.2
UMW-02	2/26/13	1108	760		8.98	6.5
UMW-02	5/2/13					
UMW-02	8/14/13	1094	760		9.3	14.1
UMW-02	11/12/13	1141	760		9.4	9.8
UMW-02	3/13/14	1230	760	Flowing	8.3	6.3
UMW-02	6/17/14	1060	760	Flowing	10.6	51.8
UMW-02	8/6/14	1105	760	Flowing	9.1	52.3
UMW-02	12/2/14		760	Below TOC		
UMW-03	4/2/12	1222	850.9	35	7.75	11.2
UMW-03	4/5/12		850.9	48.6		
UMW-03	4/16/12		850.9	43.53		
UMW-03	4/21/12		850.9	43.12		
UMW-03	4/23/12			42.98		
UMW-03	4/25/12			42.83		
UMW-03	9/20/12		850.9	47.98	10	17.9
UMW-03	2/27/13	1571	850.9	53	10.04	16.8
UMW-03	8/19/13	138.9	850.9	53.6	9.9	17.9
UMW-03	11/12/13	1089	850.9	58	9.4	16.4
UMW-03	3/24/14	1174	850.9	58	8.94	14
UMW-03	6/30/14	1110	850.9	58	9.6	57.1
UMW-03	8/8/14	1048	850.9	60	9.4	57.8
UMW-03	12/2/14	1111	850.9	56	9.5	56.2

Well	Date Sampled	In-Situ Parameters				
		Conductivity (µS/cm)	Depth to Bottom (ft below MP)	Depth to Water (ft below MP)	pH	Temp. (°C)
UMW-04	4/25/12		355	340	9.15	13
UMW-04	9/20/12		355	339		
UMW-04	10/10/12		355	342.8		
UMW-04	2/27/13		355	328.9		
UMW-04	8/20/13		355	338		
UMW-04	11/12/13	NR	355	almost dry	NR	NR
UMW-04	3/25/14	NR	355	340	NR	NR
UMW-04	6/30/14		355	dry		
UMW-04	8/8/14		355	dry		
UMW-04	12/2/14		355	dry		
UMW-05	2/26/13	1262	1255	49	8.8	10.2
UMW-05	8/19/13	1177	1255	95	9.3	17.7
UMW-05	11/13/13	1173	1252.8	98.5	9.3	17.6
UMW-05	3/18/14	1206	1252.8	117.4	8.5	15.6
UMW-05	6/30/14	120	1255	101.6	9.2	58.5
UMW-05	8/6/14	1184	1255	126.3	8.9	60.9
UMW-05	12/3/14	1171	1255	103	8.9	62.7
USMW-01	4/16/12		9.4	2.05		
USMW-01	4/21/12		9.4	1.94		
USMW-01	4/25/12			1.09		
USMW-01	5/21/12		10.5	3.1		
USMW-01	8/14/13	7.25	10.2	1.9	7.2	16.5
USMW-01	11/14/13	9.73	8.5	2.35	7.3	8.1
USMW-01	3/13/14	10.4	10.2	2.75	5.5	1
USMW-01	6/27/14	9.95	10.2	1	7.24	52.2
USMW-01	8/8/14	Or	10.2	3.35	7.2	55.7
USMW-01	12/3/14	10.28	10.2	2	7.3	41.5
USMW-02	4/16/12		17.55	13.3		
USMW-02	4/19/12		17.55	13		
USMW-02	4/21/12		17.55	13.88		
USMW-02	4/23/12			12.75		
USMW-02	4/25/12			12.65		
USMW-02	5/21/12		20.3	14.6		
USMW-02	5/24/12			14.5		
USMW-02	2/26/13	1413	20.31	15.84	7.6	12
USMW-02	8/20/13	7.4	19	14.2	7.3	11.3
USMW-02	11/14/13	7.14	19	14.35	7.3	11.3
USMW-02	3/13/14	7.75	19	15.3	4.8	6.1
USMW-02	6/17/14	6.39	19	14.1	7.8	49.5
USMW-02	8/8/14	12.13	19	13.95	7.2	49.3
USMW-02	12/3/14	5.32	19	13.5	6.9	49.1

Well	Date Sampled	In-Situ Parameters				
		Conductivity (µS/cm)	Depth to Bottom (ft below MP)	Depth to Water (ft below MP)	pH	Temp. (°C)
USMW-03	4/18/12		17.1			
USMW-03	4/21/12		17.1			
USMW-03	5/21/12		19.1	16.3		
USMW-03	5/24/12			16.35		
USMW-03	2/26/13		19	14.69	7.2	10.6
USMW-03	8/20/13		20.25	15.7		
USMW-03	9/19/13		20	16.33	7.3	11.9
USMW-03	11/14/13	NR	17.5	14.4	7	11.5
USMW-03	3/13/14	Or	20.25	14.8	5.3	6.6
USMW-03	6/17/14	Or	20.25	14.5	7.1	48.7
USMW-03	8/8/14	Or	20.25	14.1	7	51.3
USMW-03	12/3/14	Or	20.25	14.3	6.9	49
USMW-04	11/13/13	NR	16.75	9.1	7.2	12.1
USMW-04	3/18/14	Or	16.7	10.1	4.4	4.5
USMW-04	5/16/14	Or	16.7	12.9	7	43.5
USMW-04	6/27/14	Or	16.7	12.6	7.1	47.5
USMW-04	8/6/14	Or	16.7	12.3	6.9	48.7
USMW-04	12/3/14	Or	16.7	11.25	7	47.9
USMW-05	11/13/13	NR	8.2	2.15	6.9	8.5
USMW-05	3/18/14	NR	NR	2.85	NR	NR
USMW-05	5/16/14	Or	11.1	2.8	6.8	44.2
USMW-05	6/30/14	Or	11.1	3.6	6.7	56.8
USMW-05	8/6/14	Or	11.1	3.83	6.5	57.7
USMW-05	12/3/14	Or	11.1	3.6	6.8	41

NOTES:
UMW-04 sample on 11/12/13 only 1 L collected before dry.
NR – No reading due to insufficient sample volume
Or – Over Range

Table 13
Water Quality Collection Summary, Upton Site Groundwater Monitoring

Well	Month / Year Sampled																																		
	1Q2012	2Q2012			3Q2012			4Q2012			1Q2013			2Q2013			3Q2013			4Q2013			1Q2014			2Q2014			3Q2014			4Q2014			
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Samples
UMW-01	--	X					X	X					X		X			X			X				X			X		X				X	8
VOC/SVOC															X																				1
UMW-02	X	Dev.					X	X				X			X			X			X				X			X		X				NS	8
VOC/SVOC															X																				1
UMW-03	--	X					X	X				X			X			X			X				X			X		X				X	8
VOC/SVOC															X																				1
UMW-04	--	X					X	NS				X*			X			X*			X*				X*			NS		NS				NS	7
VOC/SVOC																																			0
UMW-05	--	--					--	--				X			X			X			X				X			X		X				X	5
VOC/SVOC																																			0
USMW-01	--		X				NS	NS					X	X				X			X				X			X		X				X	6
VOC/SVOC															X																				1
USMW-02	--		X				NS	NS					X	X				X			X				X			X		X				X	6
VOC/SVOC																																			0
USMW-03	--		X				NS	NS					X		X				X		X				X			X		X				X	6
VOC/SVOC															X																				1
USMW-04	--		--				--	--					--		--				X		X				X		X	X		X				X	3
VOC/SVOC																																			0
USMW-05	--		--				--	--					--		--				X		X				NS		X	X		X				X	2
VOC/SVOC																																			0

NOTES:

X – Indicates sample collected during the month.

VOC/SVOC (Volatile organic compounds/seim-volatile organic compounds) sampling suite.

*UMW-04 samples from 2/13, 8/13, and 11/13 were only analyzed for oil and grease due to insufficient sample volume.

--Well was not yet installed

NS – No sample due to lack of available water for sample.

DEV. – Well development at UMW-02 prohibited sample collection.

Table 14
Upton Site Water Quality Data, Major Ions, Non-Metals, and Data Quality

		Major Ions, Dissolved												Non-Metals									Data Quality		
Well	Date Sampled	Bicarbonate as HCO3	Carbonate as CO3	Chloride	Fluoride	Nitrate (as N)	Nitrate + Nitrite	Nitrite (as N)	Sulphate	Calcium	Magnesium	Potassium	Sodium	Alkalinity (Total as CaCO3)	Conductivity (µS/cm)	Hardness as CaCO3	pH	SAR (unitless)	TDS (mg/L)	Sulphide	Cyanide (Total)	Oil & Grease	Anions Sum (meq/L)	Cations Sum (meq/L)	A/C Balance (%)
UMW-01	4/23/12	201	<5	15	0.7	<0.1	<0.1	<0.1	1160	48	11	4	542	165	2740	160	7.68	18.4	1910	<0.04	<0.005	<5	27.8	27	-1.61
UMW-01	9/24/12	365	23	68	0.5	<0.1	<0.1	<0.1	73	2	<1	1	238	337	994	7	8.76	37.8	571	0.08	<0.005	<5	10.2	10.5	1.55
UMW-01	10/10/12	364	19	67	0.5	<0.1	<0.1	<0.1	116	3	<1	2	248	330	1050	10	8.65	34.4	611	0.07	<0.005	<5	10.9	11	0.33
UMW-01	3/4/13	332	38	68	0.6	<0.1	<0.1	<0.1	120	2	<1	1	245	335	1080	8	9.05	36.8	625	0.11	<0.005	<5	11.1	10.8	-1.36
UMW-01	5/2/13	326	39	68	0.5	<0.1	<0.1	<0.1	78	2	<1	<1	218	332	1020	7	9.1	36.1	598	0.24	<0.005	<5	10.2	9.66	-2.82
UMW-01	8/20/13	332	38	69	0.6	<0.1	<0.1	<0.1	95	2	<1	1	239	335	1060	8	9.13	36.1	598	0.4	<0.005	<5	10.7	10.6	-0.25
UMW-01	11/11/13	320	33	62	0.5	<0.1	<0.1	<0.1	174	4	<1	1	269	317	1210	14	9.11	31.2	698	0.41	<0.005	<5	11.7	12	1.11
UMW-01	3/25/14	342	31	65	0.5	<0.1	<0.1	<0.1	132	5	9	1	306	331	1120	49	9.07	19	649	0.51	<0.005	<5	11.2	14.3	12.1
UMW-01	6/30/14	324	46	67	0.5	<0.1	<0.1	<0.1	118	3	<1	1	244	343	1100	9	8.88	34.8	654	0.64	<0.005	<5	11.3	10.8	-1.96
UMW-01	8/8/14	322	44	67	0.6	<0.1	<0.1	<0.1	70	3	8	1	272	338	1060	42	9.17	18.3	617	0.84	<0.005	<5	10.1	12.7	11.2
UMW-01	12/2/14	356	48	68	0.6	<0.1	<0.1	<0.1	47	2	<1	1	227	372	980	7	9.15	37.1	584	0.81	<0.005	<5	10.4	10	-1.58
	Min	320	19	62	0.5	ND	ND	ND	47	2	<1	<1	218	317	980	7	8.65	18.3	571	0.07	ND	ND	10.1	9.66	--
	Max	365	48	69	0.6	ND	ND	ND	174	5	9	2	306	372	1210	49	9.17	37.8	698	0.84	ND	ND	11.7	14.3	--
	Ave	338	36	67	0.5	ND	ND	ND	102	3	3	1	251	337	1067	16	9.01	32.2	621	0.41	ND	ND	10.8	11.2	--
	St. Dev.	17							37	1			26	14					38						
UMW-02	3/14/12	211	<5	22	0.3	<0.1	<0.1	<0.1	866	55	9	4	453	180	2230	180	8.09	14.8	1530	0.3	<0.005	6	22.3	23.4	2.43
UMW-02	9/20/12	244	10	32	0.3	<0.1	<0.1	<0.1	251	5	<1	1	237	216	1090	16	8.59	26.1	655	<0.04	<0.005	<5	10.5	10.6	0.88
UMW-02	10/10/12	240	13	34	0.3	<0.1	<0.1	<0.1	249	4	<1	1	224	218	1090	13	8.71	26.5	673	0.21	<0.005	<5	10.5	10	-2.3
UMW-02	2/26/13	241	15	33	0.3	<0.1	<0.1	<0.1	245	4	<1	1	232	223	1100	14	8.87	27.3	665	0.33	<0.005	<5	10.5	10.4	-0.51
UMW-02	5/2/13	222	17	34	0.4	<0.1	<0.1	<0.1	254	4	<1	1	220	211	1100	12	8.94	27.6	680	0.24	<0.005	<5	10.5	9.84	-3.14
UMW-02	8/14/13	237	11	34	0.4	<0.1	<0.1	<0.1	265	4	<1	1	221	213	1110	11	8.93	28.8	666	0.24	<0.005	<5	10.8	9.88	-4.3
UMW-02	11/12/13	226	15	32	0.4	<0.1	<0.1	<0.1	252	4	<1	1	233	211	1100	13	8.94	28.6	672	0.25	<0.005	<5	10.4	10.4	0.18
UMW-02	3/13/14	233	11	34	0.4	<0.1	<0.1	<0.1	263	5	1	1	242	210	1100	18	8.79	24.5	686	0.38	<0.005	<5	10.6	10.9	1.36
UMW-02	6/17/14	234	14	34	0.4	<0.1	<0.1	<0.1	280	7	24	2	345	216	1130	120	8.88	14	672	0.22	<0.005	<5	11.1	17.4	21.9
UMW-02	8/6/14	222	16	33	0.4	<0.1	<0.1	<0.1	259	5	2	1	255	209	1110	20	8.93	24.7	685	0.25	<0.005	<5	10.5	11.5	4.65
	Min	222	10	32	0.3	ND	ND	ND	245	4	<1	1	220	209	1090	11	8.59	14	655	<0.04	ND	ND	10.4	9.84	--
	Max	244	17	34	0.4	ND	ND	ND	280	7	24	2	345	223	1130	120	8.94	28.8	686	0.38	ND	ND	11.1	17.4	--
	Ave	233	14	33	0.4	ND	ND	ND	258	5	4	1	245	214	1103	26	8.84	25.3	673	0.25	ND	ND	10.6	11.2	--
	St. Dev.	8							11	1			39	5					10						
UMW-03	4/2/12	408	18	105	0.6	<0.1	<0.1	<0.1	116	2	<1	1	278	364	1220	8	8.41	43.7	735	<0.2	<0.005	6	12.7	12.3	-1.59
UMW-03	9/20/12	217	82	45	0.5	<0.1	<0.1	<0.1	290	3	<1	3	303	315	1370	9	9.6	44	805	<0.04	<0.005	<5	13.6	13.4	-0.64
UMW-03	10/11/12	186	75	43	0.4	<0.1	<0.1	<0.1	310	2	<1	2	297	278	1400	7	9.62	49.6	846	<0.04	<0.005	<5	13.2	13.1	-0.51
UMW-03	2/27/13	179	92	41	0.4	<0.1	<0.1	<0.1	345	2	<1	2	301	299	1500	6	9.78	54.5	886	<0.04	<0.005	<5	14.4	13.3	-3.98
UMW-03	5/7/13	167	98	45	0.4	<0.1	<0.1	<0.1	426	2	<1	3	376	300	1720	5	9.94	69.9	1010	0.05	<0.005	<5	16.1	16.5	1.19
UMW-03	8/19/13	183	77	41	0.4	<0.1	<0.1	<0.1	342	2	<1	2	299	278	1450	6	9.66	53	858	0.11	<0.005	<5	13.9	13.2	-2.58
UMW-03	11/12/13	243	23	36	0.4	<0.1	<0.1	<0.1	227	2	<1	1	238	237	1110	6	9.08	42.4	643	0.15	<0.005	<5	10.5	10.5	-0.07
UMW-03	3/24/14	242	23	34	0.4	<0.1	<0.1	<0.1	237	3	4	1	270	236	1090	22	9.16	24.8	658	0.22	<0.005	<5	10.6	12.2	6.84
UMW-03	6/30/14	215	41	34	0.4	<0.1	<0.1	<0.1	242	2	<1	1	245	244	1090	8	9.01	38	676	0.2	<0.005	<5	10.9	10.8	-0.15
UMW-03	8/8/14	216	30	33	0.4	<0.1	<0.1	<0.1	233	5	2	1	244	227	1110	19	9.13	24.1	677	0.23	<0.005	<5	10.4	11	3.12
UMW-03	12/2/14	197	67	34	0.4	<0.1	<0.1	<0.1	223	3	<1	2	248	272	1120	9	9.63	35.9	681	0.15	<0.005	<5	11.1	11	-0.25
	Min	167	18	33	0.4	ND	ND	ND	116	2	<1	1	238	227	1090	5	8.41	24.1	643	<0.04	ND	<5	10.4	10.5	--
	Max	408	98	105	0.6	ND	ND	ND	426	5	4	3	376	364	1720	22	9.94	69.9	1010	0.23	ND	6	16.1	16.5	--
	Ave	223	57	45	0.4	ND	ND	ND	272	3	1	2	282	277	1289	10	9.37	43.6	770	0.13	ND	5	12.5	12.5	--
	St. Dev.	66							83	0.9			40	41					119						

		Major Ions, Dissolved												Non-Metals									Data Quality		
Well	Date Sampled	Bicarbonate as HCO3	Carbonate as CO3	Chloride	Fluoride	Nitrate (as N)	Nitrate + Nitrite	Nitrite (as N)	Sulphate	Calcium	Magnesium	Potassium	Sodium	Alkalinity (Total as CaCO3)	Conductivity (µS/cm)	Hardness as CaCO3	pH	SAR (unitless)	TDS (mg/L)	Sulphide	Cyanide (Total)	Oil & Grease	Anions Sum (meq/L)	Cations Sum (meq/L)	A/C Balance (%)
UMW-04	4/25/12	77	<5	187	1.5	<0.1	<0.1	<0.1	6020	245	83	14	2470	70	10600	950	8.63	34.7	9180	0.14	<0.005	<5	132	127	-2.08
UMW-04	9/20/12	339	<5	253	2	<0.1	<0.1	<0.1	5130	207	84	12	2290	278	9720	860	7.41	33.9	7330	12	<0.005	<5	120	117	-1.08
UMW-04	2/27/13																					<5			
UMW-04	5/9/13	130	39	465	3.2	<0.1	0.5	0.5	2940	10	3	8	1690	172	7240	35	9.41	124	4650		<0.005	7	78	74.5	-2.31
UMW-04	8/20/13																					6			
UMW-04	3/25/14																					<5			
	Min	77	<5	187	1.5	ND	<0.1	<0.1	2940	10	3	8	1690	70	7240	35	7.41	33.9	4650	0.14	ND	<5	78	74.5	--
	Max	339	39	465	3.2	ND	0.5	0.5	6020	245	84	14	2470	278	10600	950	9.41	124	9180	12	ND	7	132	127	--
	Ave	182	16	302	2.2	ND	0.2	0.2	4697	154	57	11	2150	173	9187	615	8.48	64.2	7053	--	ND	6	110	106	--
	St. Dev.	139							1585	126			408	104					2278						
UMW-05	2/26/13	432	43	131	0.7	<0.1	0.3	0.3	74	9	<1	5	282	425	1290	26	9.06	24.1	759	<0.2	0.189	21	13.8	12.9	-3.38
UMW-05	5/9/13	387	48	133	0.7	<0.1	<0.1	<0.1	25	3	<1	4	283	398	1230	8	9.14	43.9	710	<0.04	0.031	<5	12.3	12.6	1.29
UMW-05	8/19/13	406	43	134	0.6	<0.1	<0.1	<0.1	4	2	<1	2	263	405	1210	5	9.06	51.6	662	<0.04	<0.005	<5	12	11.6	-1.65
UMW-05	11/13/13	406	41	128	0.6	<0.1	<0.1	<0.1	1	2	<1	2	282	401	1180	6	8.99	51	672	<0.04	<0.005	<5	11.7	12.4	3.02
UMW-05	3/18/14	425	34	129	0.6	<0.1	<0.1	<0.1	<1	2	<1	1	271	405	1180	5	8.94	53.9	649	<0.04	<0.005	<5	11.8	11.9	0.65
UMW-05	6/30/14	431	41	131	0.6	<0.1	<0.1	<0.1	<1	2	<1	1	274	422	1170	5	8.83	52.5	677	<0.04	<0.005	<5	12.2	12.1	-0.36
UMW-05	8/6/14	430	30	128	0.7	<0.1	<0.1	<0.1	<1	2	<1	1	282	402	1190	5	8.85	55.6	684	<0.04	<0.005	<5	11.7	12.4	2.97
UMW-05	12/3/14	466	34	127	0.7	<0.1	<0.1	<0.1	<1	2	<1	1	281	439	1170	5	8.85	53.2	689	<0.04	<0.005	<5	12.4	12.4	-0.23
	Min	387	30	127	0.6	ND	<0.1	<0.1	1	2	ND	1	263	398	1170	5	8.83	24.1	649	ND	<0.005	<5	11.7	11.6	--
	Max	466	48	134	0.7	ND	0.3	0.3	74	9	ND	5	283	439	1290	26	9.14	55.6	759	ND	0.189	21	13.8	12.9	--
	Ave	423	39	130	0.7	ND	0.1	0.1	14	3	ND	2	277	412	1203	8	8.97	48.2	688	ND	0.06	9	12.2	12.3	--
	St. Dev.	24							34	2			7	15					34						
USMW-01	5/24/12	812	<5	105	2.6	14.4	14.9	0.5	9650	393	817	10	3270	666	14900	4400	7.8	21.6	14400	<0.04	<0.005	<5	218	229	2.46
USMW-01	3/11/13	1290	<5	104	2.3	0.1	0.3	0.2	9420	420	731	9	3150	1050	14800	4100	7.39	21.5	14400	0.3	<0.005	<5	220	218	-0.42
USMW-01	4/30/13	1280	<5	105	2.4	3.7	3.7	<0.1	8290	405	684	7	2960	1050	13900	3800	7.4	20.8	13400	<0.04	<0.005	<5	197	205	2.06
dup.	4/30/13	1270	<5	105	2.3	3.6	3.6	<0.1	8450	373	705	8	3020	1040	13900	3800	7.4	21.2	13000	<0.04	<0.005	<5	200	208	1.91
USMW-01	8/14/13	421	<5	39	1.3	<0.1	<0.1	<0.1	3410	222	199	6	1360	345	6350	1400	7.2	15.9	5310	<0.04	<0.005	<5	79	86.6	4.57
USMW-01	11/14/13	802	<5	69	1.1	<0.2	<0.2	<0.1	5820	439	434	8	2530	657	9900	2900	7.18	20.5	8800	<0.04	<0.005	<5	136	168	10.3
USMW-01	3/13/14	1040	<5	76	1.3	<0.2	<0.1	<0.1	7020	374	441	7	2370	857	11700	2800	7.3	19.7	11000	0.06	<0.005	<5	165	158	-2.22
USMW-01	6/27/14	1140	<5	79	1.5	0.1	0.2	<0.1	7320	438	503	6	2610	938	11500	3200	7.16	20.2	11200	<0.04	<0.005	<5	173	177	1.06
USMW-01	8/8/14	1110	<5	78	1.5	<0.2	<0.1	<0.1	6990	451	450	6	2440	912	12200	3000	7.1	19.4	11500	<0.04	<0.005	<5	166	166	-0.13
USMW-01	12/3/14	1170	<5	71	1.3	<0.2	0.2	<0.1	6360	424	453	7	2460	959	11000	2900	7.2	19.8	10500	<0.04	<0.005	<5	154	166	3.72
	Min	421	ND	39	1.1	<0.1	<0.1	<0.1	3410	222	199	6	1360	345	6350	1400	7.1	15.9	5310	<0.04	ND	ND	79	86.6	--
	Max	1290	ND	105	2.6	14.4	14.9	0.5	9650	451	817	10	3270	1050	14900	4400	7.8	21.6	14400	0.3	ND	ND	220	229	--
	Ave	1007	ND	81	1.7	2.1	2.2	0.2	7142	396	524	7	2572	826	11806	3167	7.3	19.9	11168	0.1	ND	ND	168	175	--
	St. Dev.	282							1909	70			561	230					2881						
USMW-02	5/24/12	522	<5	48	1.9	<0.1	0.2	0.2	6030	417	340	7	2280	428	10200	2400	7.44	20	9310	<0.04	<0.005	<5	135	148	4.41
USMW-02	3/11/13	612	<5	37	1.4	<0.1	<0.1	<0.1	4880	391	270	6	1780	502	8390	2100	7.38	16.9	7690	<0.04	<0.005	<5	113	119	2.84
USMW-02	4/30/13	378	<5	113	1.7	4.5	4.5	<0.1	7290	384	369	9	2800	310	12300	2500	7.48	24.4	10200	<0.2	<0.005	<5	162	171	2.9
USMW-02	8/20/13	535	<5	37	1.6	0.1	0.1	<0.1	4510	351	198	6	1510	439	7970	1700	7.2	16	7100	<0.04	<0.005	<5	104	99.8	-1.96
USMW-02	11/14/13	556	<5	34	1.2	<0.2	<0.1	<0.1	4430	387	206	5	1500	456	7880	1800	7.27	15.4	6770	<0.04	<0.005	<5	102	102	-0.27
USMW-02	3/13/14	559	<5	33	1.3	<0.1	<0.1	<0.1	4500	345	198	7	1530	458	7740	1700	7.23	16.2	6770	<0.04	<0.005	<5	104	100	-1.83
USMW-02	6/17/14	547	<5	35	0.8	0.9	0.9	<0.1	4300	380	196	5	1440	448	7820	1800	7.21	15	6800	<0.04	<0.005	<5	99.7	97.8	-0.94
USMW-02	8/8/14	498	<5	26	1.3	<0.1	<0.1	<0.1	3860	416	166	4	1210	408	6930	1700	7.15	12.7	6140	<0.04	<0.005	<5	89.2	87.3	-1.1
USMW-02	12/3/14	400	<5	26	0.8	0.2	0.3	<0.1	2990	347	152	7	1140	328	5520	1500	6.85	12.8	4960	<0.04	<0.005	<5	69.5	79.5	6.69
	Min	378	ND	26	0.8	<0.1	<0.1	<0.1	2990	345	152	4	1140	310	5520	1500	6.85	12.7	4960	ND	ND	ND	69.5	79.5	--
	Max	612	ND	113	1.9	4.5	4.5	0.2	7290	417	369	9	2800	502	12300	2500	7.48	24.4	10200	ND	ND	ND	162	171	--
	Ave	512	ND	43	1.3	1.0	1.0	0.1	4754	380	233	6	1688	420	8306	1911	7.25	16.6	7304	ND	ND	ND	109	112	--
	St. Dev.	76							1246	27			534	63					1592						

		Major Ions, Dissolved												Non-Metals									Data Quality		
Well	Date Sampled	Bicarbonate as HCO3	Carbonate as CO3	Chloride	Fluoride	Nitrate (as N)	Nitrate + Nitrite	Nitrite (as N)	Sulphate	Calcium	Magnesium	Potassium	Sodium	Alkalinity (Total as CaCO3)	Conductivity (µS/cm)	Hardness as CaCO3	pH	SAR (unitless)	TDS (mg/L)	Sulphide	Cyanide (Total)	Oil & Grease	Anions Sum (meq/L)	Cations Sum (meq/L)	A/C Balance (%)
USMW-03	5/24/12	355	<5	180	2.1	<1	<0.4	<0.4	51300	469	3450	27	15700	291	51300	15000	7.22	55.2	65500	<0.04	<0.005	<5	1080	992	-4.17
USMW-03	3/11/13	524	<5	214	2.4	<0.1	<0.1	<0.1	53400	490	3820	31	17700	430	53100	17000	7.06	59.2	73300	0.04	<0.005	<5	1130	1110	-0.73
USMW-03	5/3/13	516	<5	186	2	<2	<1	<1	48600	463	3010	31	16500	423	51200	14000	7.19	61.5	68300	<0.04	<0.005	<5	1030	987	-1.9
USMW-03	9/19/13	664	<5	183	4.1	<1	<0.4	<0.4	48600	441	3250	29	15500	544	49600	14000	6.9	56.1	69700	<0.04	<0.005	<5	1030	966	-3.1
USMW-03	11/14/13	533	<5	186	2	<1	<1	<0.4	48000	466	3340	28	16300	437	50500	15000	7.02	57.9	71600	<0.04	<0.005	<5	1010	1010	-0.34
USMW-03	3/13/14	568	<5	201	3.6	<1	<0.4	<0.4	50700	445	3230	31	15200	466	51400	14000	7.13	54.9	69200	<0.04	<0.005	<5	1070	948	-6.14
USMW-03	6/17/14	618	<5	210	2	<0.1	<0.1	<0.1	52100	450	3560	32	16500	507	52700	16000	6.86	57.1	72800	<0.04	<0.005	<5	1100	1030	-3.21
USMW-03	8/8/14	579	<5	190	3.7	<1	<0.4	<0.4	44400	474	3310	29	16700	475	52100	15000	6.84	59.7	73300	<0.04	<0.005	<5	940	1020	4.27
USMW-03	12/3/14	657	<5	191	3	<1	<0.4	<0.4	47600	498	3370	33	16600	539	50000	15000	6.76	58.9	73100	<0.04	<0.005	<5	1010	1030	0.95
	Min	355	ND	180	2	ND	ND	ND	44400	441	3010	27	15200	291	49600	14000	6.76	54.9	65500	<0.4	ND	ND	940	948	--
	Max	664	ND	214	4.1	ND	ND	ND	53400	498	3820	33	17700	544	53100	17000	7.22	61.5	73300	0.04	ND	ND	1130	1110	--
	Ave	557	ND	193	2.8	ND	ND	ND	49411	466	3371	30	16300	457	51322	15000	7	57.8	70756	0.04	ND	ND	1044	1010	--
	St. Dev.	93							2740	19			750	77					2751						
USMW-04	9/18/13	1720	<5	3940	2.4	<1	<0.4	<0.4	34500	519	2100	61	15600	1410	46900	10000	7.11	68	55100	<0.04	<0.005	<5	859	879	1.13
USMW-04	11/13/13	1820	<5	3770	0.5	<1	<0.4	<0.4	32400	492	2060	56	14900	1490	47900	9700	6.98	65.8	55800	<0.04	<0.005	<5	810	842	1.94
USMW-04	3/18/14	1840	<5	3450	1	<1	<0.4	<0.4	31300	452	2000	59	14100	1510	47300	9400	6.94	63.2	53700	<0.2	<0.005	<5	780	800	1.32
USMW-04	5/16/14	1780	<5	3460	1.1	<1	<0.4	<0.4	31700	446	1720	45	13200	1460	47100	8200	6.88	63.6	53300	<0.04	<0.005	<5	787	740	-3.13
USMW-04	6/27/14	1800	<5	3720	<0.1	<0.1	<0.1	<0.1	32900	473	1950	47	14400	1480	44800	9200	6.93	65	54000	<0.04	<0.005	<5	819	810	-0.56
USMW-04	8/6/14	1650	<5	3100	1.4	<1	<1	<0.4	27400	454	1750	44	13500	1350	45900	8300	7.03	64.2	52700	<0.2	<0.005	<5	686	753	4.68
USMW-04	12/3/14	1280	<5	2510	1.3	<1	0.7	0.7	23100	525	1470	46	10600	1050	36100	7400	6.95	53.9	39800	<0.04	<0.005	<5	574	611	3.1
USMW-05	9/18/13	546	<5	205	3.1	<1	<0.4	<0.4	26800	458	3180	47	7400	448	28700	14000	6.4	27	31400	<0.04	<0.005	<5	573	608	2.98
USMW-05	11/13/13	642	<5	207	2.5	<0.5	<0.2	<0.2	23000	432	2870	30	6070	526	28000	13000	6.74	23.2	33200	<0.04	<0.005	<5	496	523	2.65
USMW-05	5/16/14	679	<5	193	2.9	<0.5	<0.2	<0.2	21200	397	2770	24	5870	557	26800	12000	6.47	23	32700	<0.04	<0.005	<5	458	504	4.71
USMW-05	6/30/14	732	<5	191	3.2	<0.5	<0.2	<0.2	22100	392	2560	22	5280	600	26100	12000	6.67	21.4	31300	<0.04	<0.005	<5	477	460	-1.76
USMW-05	8/6/14	772	<5	180	3.3	<0.5	<0.2	<0.2	22200	401	2620	24	5670	633	26600	12000	6.6	22.7	33100	<0.2	<0.005	<5	480	483	0.33
USMW-05	12/3/14	919	<5	204	3.6	<0.5	<0.2	<0.2	21800	443	2690	27	5570	753	26200	12000	6.58	22	33300	<0.04	<0.005	<5	475	487	1.22

NOTES:
All concentrations in units of milligrams per liter (mg/L) unless otherwise noted.
< - Denotes non-detect, followed by detection limit.
Average calculations based on detection limit, if applicable. Min/Max/Averages not calculated for wells with less than 3 samples.
Standard deviation calculated for major constituents bicarbonate, sulphate, calcium, sodium, and for alkalinity and total dissolved solids.
ND - Indicates all constituent results were Non-Detect. SAR - Sodium Adsorption Ration; TDS - Total Dissolved Solids
dup. - Duplicate sample. Only original sample included in max/min/ave/st. dev. Calculations.
Shading indicates non-representative sample possibly contaminanted with drilling fluid

Table 15
Upton Site Water Quality Data, Dissolved Metals

Well	Date Sampled	Dissolved Metals																									
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Cerium	Chromium	Cobalt	Copper	Iron	Lanthanum	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Thallium	Thorium	Uranium	Vanadium	Zinc
UMW-01	4/23/12	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001		<0.001	0.001	<0.005	0.68		<0.001	0.1	1.18	<0.0001	0.003	0.012	0.001	<0.001	<0.0005	<0.005	0.0002	<0.01	<0.005
UMW-01	9/24/12	0.09	<0.001	0.003	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	0.02	0.09	<0.001	0.003	<0.1	0.021	<0.0001	0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	0.0001	<0.01	0.015
UMW-01	10/10/12	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.06	<0.001	<0.001	<0.1	0.034	<0.0001	0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-01	3/4/13	0.16	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.12	<0.001	0.001	<0.1	0.024	<0.0001	0.002	<0.005	0.009	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.012
UMW-01	5/2/13	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.05	<0.001	0.003	<0.1	0.019	<0.0001	0.001	<0.005	0.003	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.014
UMW-01	8/20/13	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.02	<0.0001	0.001	<0.005	0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-01	11/11/13	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.027	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-01	3/25/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	0.009	0.13	<0.001	<0.001	<0.1	0.027	<0.0001	0.001	<0.005	0.004	<0.001	<0.0005	<0.005	0.0019	<0.01	<0.005
UMW-01	6/30/14	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.04	<0.001	<0.001	<0.1	0.018	<0.0001	0.001	<0.005	0.002	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-01	8/8/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.03	<0.001	<0.001	<0.1	0.079	<0.0001	0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	0.0002	<0.01	<0.005
UMW-01	12/2/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.04	<0.001	<0.001	<0.1	0.014	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
	Max	0.16	ND	0.003	ND	ND	0.1	ND	ND	ND	ND	0.02	0.13	ND	0.003	ND	0.079	ND	0.002	ND	0.009	ND	ND	ND	0.0019	ND	0.015
UMW-02	3/14/12	0.19	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001		<0.001	0.002	<0.005	0.07		<0.001	<0.1	0.14	<0.0001	0.003	<0.005	0.001	<0.001	<0.0005	<0.005	0.0004	<0.01	<0.005
UMW-02	9/20/12	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.015	<0.0001	<0.001	<0.005	0.002	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.038
UMW-02	10/10/12	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.017	<0.0001	<0.001	<0.005	0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.052
UMW-02	2/26/13	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.03	<0.001	<0.001	<0.1	0.014	<0.0001	<0.001	<0.005	0.004	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.272
UMW-02	5/2/13	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.017	<0.0001	<0.001	<0.005	0.001	<0.001	<0.0005	<0.005	0.0001	<0.01	0.08
UMW-02	8/14/13	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.013	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.22
UMW-02	11/12/13	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.014	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.087
UMW-02	3/13/14	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.017	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	0.0003	<0.01	0.154
UMW-02	6/17/14	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.164	<0.0001	<0.001	<0.005	0.001	<0.001	<0.0005	<0.005	0.0005	<0.01	0.183
UMW-02	8/6/14	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.014	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	0.0005	<0.01	0.153
	Max	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.03	ND	ND	ND	0.164	ND	ND	ND	0.004	ND	ND	ND	0.0005	ND	0.272
UMW-03	4/2/12	0.16	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.13	<0.001	<0.001	<0.1	0.023	<0.0001	0.001	<0.005	0.002	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-03	9/20/12	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.04	<0.001	<0.001	<0.1	0.006	<0.0001	0.002	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-03	10/11/12	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.011	<0.0001	0.001	<0.005	0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.008
UMW-03	2/27/13	0.1	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.19	<0.001	0.002	<0.1	0.012	<0.0001	<0.001	<0.005	0.006	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.023
UMW-03	5/7/13	0.06	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.04	<0.001	<0.001	<0.1	0.008	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-03	8/19/13	0.23	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.94	<0.001	<0.001	<0.1	0.022	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-03	11/12/13	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.23	<0.001	<0.001	<0.1	0.019	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-03	3/25/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.013	<0.0001	<0.001	<0.005	0.003	<0.001	<0.0005	<0.005	0.0009	<0.01	<0.005
UMW-03	6/30/14	0.07	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.07	<0.001	<0.001	<0.1	0.016	<0.0001	<0.001	<0.005	0.002	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-03	8/8/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.11	<0.001	<0.001	<0.1	0.028	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	0.0004	<0.01	<0.005
UMW-03	12/2/14	<0.05	<0.001	<0.001	<0.05	<0.001	<0.1	<0.001		<0.001	<0.001	<0.005	0.07		<0.001	<0.1	0.007	<0.0001	0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
	Max	0.23	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	0.94	ND	0.002	ND	0.028	ND	0.002	ND	0.006	ND	ND	ND	0.0009	ND	0.023
UMW-04	4/25/12	<0.05	<0.001	0.003	0.2	<0.001	1.5	<0.001	<0.001	0.005	0.001	0.007	0.38	<0.001	<0.001	0.3	0.302	<0.0001	0.018	0.013	0.008	<0.001	<0.0005	0.008	0.0003	<0.01	0.032
UMW-04	9/20/12	<0.05	<0.001	<0.001	<0.05	<0.001	1.2	<0.001	<0.001	<0.001	0.003	<0.005	5.26	<0.001	<0.001	0.3	2.82	<0.0001	0.007	0.017	0.005	<0.001	<0.0005	<0.005	0.0005	<0.01	0.011
UMW-04	5/9/13	0.06	<0.001	0.002	<0.05	<0.001	0.5	<0.001		<0.001	<0.001	<0.005	0.03		<0.001	<0.1	0.01	<0.0001	0.034	0.007	<0.001	<0.001	<0.0005	<0.005	0.0004	<0.01	<0.005
	Max	0.06	ND	0.003	0.2	ND	1.5	ND	ND	0.005	0.003	0.007	5.26	ND	ND	0.3	2.82	ND	0.034	0.017	0.008	ND	ND	0.008	0.0005	ND	0.032
UMW-05	2/26/13	<0.05	<0.001	0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	0.098	0.1	<0.001	<0.001	<0.1	0.03	<0.0001	0.004	<0.005	<0.001	<0.001	<0.0005	<0.005	0.0001	<0.01	<0.005
UMW-05	5/9/13	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	0.01	0.14	<0.001	<0.001	<0.1	0.02	<0.0001	0.002	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	0.007
UMW-05	8/19/13	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	0.002	<0.001	<0.005	0.04	<0.001	<0.001	<0.1	0.009	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-05	11/13/13	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.008	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-05	3/18/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.006	<0.0001	<0.001	<0.005	0.002	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-05	6/30/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.18	<0.001	<0.001	<0.1	0.012	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-05	8/6/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.03	<0.001	<0.001	<0.1	0.009	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
UMW-05	12/3/14	<0.05	<0.001	<0.001	<0.05	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.005	0.11	<0.001	<0.001	<0.1	0.009	<0.0001	<0.001	<0.005	<0.001	<0.001	<0.0005	<0.005	<0.0001	<0.01	<0.005
	Max	ND	ND	0.001	ND	ND	0.1	ND	ND	0.002	ND	0.098	0.18	ND	ND	ND	0.03	ND	0.004	ND	0.002	ND	ND	ND	0.0001	ND	0.007

Well	Date Sampled	Dissolved Metals																									
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Cerium	Chromium	Cobalt	Copper	Iron	Lanthanum	Lead	Lithium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Thallium	Thorium	Uranium	Vanadium	Zinc
USMW-01	5/24/12	0.09	0.001	0.008	0.16	<0.001	1.1	<0.001	0.002	<0.001	0.003	0.061	<0.06	<0.001	<0.001	0.9	0.106	<0.0001	0.027	0.036	0.073	<0.001	<0.0005	<0.005	0.167	<0.01	0.011
USMW-01	3/11/13	0.05	<0.001	<0.001	<0.05	<0.001	1.5	<0.001	0.003	<0.001	0.008	0.067	0.07	<0.001	<0.001	0.9	1.52	<0.0001	0.021	0.047	0.005	<0.001	<0.0005	0.009	0.178	<0.01	0.047
USMW-01	4/30/13	0.3	<0.001	0.003	0.08	<0.001	1.3	<0.001	0.003	<0.001	0.004	0.089	0.15	<0.001	<0.001	0.9	0.583	<0.0001	0.02	0.043	0.005	<0.001	<0.0005	<0.005	0.195	<0.01	0.027
dup.	4/30/13	0.33	<0.001	0.004	0.05	<0.001	1.1	<0.001	0.001	<0.001	0.003	0.089	0.21	<0.001	<0.001	0.8	0.588	<0.0001	0.022	0.043	0.007	<0.001	<0.0005	<0.005	0.2	<0.01	0.029
USMW-01	8/14/13	<0.05	<0.001	0.001	<0.05	<0.001	0.7	<0.001	0.002	0.003	0.011	<0.005	0.62	<0.001	<0.001	0.4	1.6	<0.0001	0.01	0.013	<0.002	<0.001	<0.0005	<0.005	0.0652	<0.01	0.015
USMW-01	11/14/13	<0.05	<0.001	0.003	<0.05	<0.001	1.2	<0.001	0.001	<0.001	0.019	<0.005	2.38	<0.001	<0.001	0.7	2.66	<0.0001	0.014	0.028	0.001	<0.001	<0.0005	0.008	0.136	<0.01	0.009
USMW-01	3/13/14	<0.05	<0.001	0.001	<0.05	<0.001	1.1	<0.001	0.001	0.001	0.005	0.014	0.07	<0.001	<0.001	0.6	1.18	<0.0001	0.009	0.028	0.003	<0.001	<0.0005	<0.005	0.139	<0.01	0.018
USMW-01	6/27/14	<0.05	<0.001	0.002	<0.05	<0.001	1.2	<0.001		<0.001	0.006	0.01	<0.08		<0.001	0.7	2.72	<0.0001	0.011	0.035	0.007	<0.001	<0.0005	<0.005	0.132	<0.01	0.048
USMW-01	8/8/14	<0.05	<0.001	0.002	<0.05	<0.001	1.3	<0.001	0.002	<0.001	0.015	0.006	0.62	<0.001	<0.001	0.9	3.83	<0.0001	0.012	0.033	0.004	<0.001	<0.0005	<0.005	0.135	<0.01	0.018
USMW-01	12/3/14	0.05	<0.001	0.002	<0.05	<0.001	1.1	<0.001	<0.001	<0.001	0.009	0.006	0.08	<0.001	<0.001	0.9	2.81	<0.0001	0.01	0.03	0.002	<0.001	<0.0005	<0.005	0.116	<0.01	<0.005
	Max	0.3	0.001	0.008	0.16	ND	1.5	ND	0.003	0.003	0.019	0.089	2.38	ND	ND	0.9	3.83	ND	0.027	0.047	0.073	ND	ND	0.009	0.195	ND	0.048
USMW-02	5/24/12	<0.05	<0.001	0.004	<0.05	<0.001	1.1	<0.001	0.001	<0.001	0.005	0.018	<0.06	<0.001	<0.001	0.5	0.486	<0.0001	0.024	0.022	0.03	<0.001	<0.0005	<0.005	0.0986	<0.01	<0.005
USMW-02	3/11/13	<0.05	<0.001	0.003	<0.05	<0.001	1.2	<0.001	0.004	<0.001	0.004	0.04	0.62	0.001	<0.001	0.6	1.05	<0.0001	0.008	0.014	0.001	<0.001	0.0006	<0.005	0.072	<0.01	0.057
USMW-02	4/30/13	3.11	<0.001	0.002	0.05	<0.001	0.7	<0.001	<0.001	0.005	0.003	0.071	1.04	<0.001	0.001	0.7	0.143	<0.0001	0.011	0.018	0.025	<0.001	<0.0005	<0.005	0.0801	<0.01	0.047
USMW-02	8/20/13	<0.05	<0.001	<0.001	<0.05	<0.001	1.2	<0.001	<0.001	<0.001	0.002	0.021	0.28	<0.001	<0.001	0.5	0.393	<0.0001	0.003	0.013	0.001	<0.001	<0.0005	<0.005	0.0444	<0.01	0.015
USMW-02	11/14/13	<0.05	<0.001	0.001	<0.05	<0.001	1.2	<0.001	<0.001	<0.001	0.003	<0.005	0.03	<0.001	<0.001	0.5	0.728	<0.0001	0.005	0.012	<0.001	<0.001	<0.0005	<0.005	0.052	<0.01	0.008
USMW-02	3/13/14	<0.05	<0.001	0.001	<0.05	<0.001	1.2	<0.001	<0.001	<0.001	0.005	0.024	0.05	<0.001	<0.001	0.5	1.25	<0.0001	0.003	0.013	0.015	<0.001	<0.0005	<0.005	0.0468	<0.01	0.023
USMW-02	6/17/14	<0.05	<0.001	<0.001	<0.05	<0.001	1	<0.001	<0.001	<0.001	<0.001	0.013	<0.03	<0.001	<0.001	0.5	0.53	<0.0001	0.005	0.012	0.002	<0.001	<0.0005	<0.005	0.0471	<0.01	<0.005
USMW-02	8/8/14	<0.05	<0.001	<0.001	<0.05	<0.001	1.1	<0.001	0.01	<0.001	<0.001	<0.005	<0.03	0.004	<0.001	0.5	0.839	<0.0001	0.004	0.012	<0.001	<0.001	<0.0005	<0.005	0.0358	<0.01	0.007
USMW-02	12/3/14	5.33	<0.001	0.002	0.07	<0.001	1	<0.001		0.006	0.004	0.006	2.48		0.001	0.5	1.48	<0.0001	0.003	0.017	0.002	<0.001	<0.0005	<0.005	0.0234	0.01	0.014
	Max	5.33	ND	0.004	0.07	ND	1.2	ND	0.01	0.006	0.005	0.071	2.48	0.004	0.001	0.7	1.48	ND	0.024	0.022	0.03	ND	0.0006	ND	0.0986	0.01	0.057
USMW-03	5/24/12	0.09	<0.001	0.012	0.05	<0.001	2.4	<0.001	0.01	0.008	0.005	0.047	<0.3	0.002	0.001	4.6	1.3	<0.0001	0.043	0.061	0.19	<0.001	0.0006	<0.005	0.0609	0.02	0.346
USMW-03	3/11/13	0.16	<0.002	<0.006	<0.05	0.001	3.5	0.002	0.007	0.011	0.025	0.119	0.8	0.001	0.003	5.8	15.1	<0.0001	0.013	0.133	0.009	<0.001	<0.0005	0.016	0.0665	<0.01	0.09
USMW-03	5/3/13	0.28	0.001	<0.005	<0.05	<0.001	3.2	0.002	0.008	0.03	0.016	0.024	0.57	0.002	<0.001	5.7	12.2	<0.0001	0.024	0.111	<0.02	<0.002	<0.0005	0.044	0.0679	<0.01	<0.006
USMW-03	9/19/13	0.09	0.001	0.003	<0.05	<0.001	3.4	0.002	0.005	<0.001	0.048	0.038	8.1	0.002	<0.001	4.9	21.8	<0.0001	0.006	0.185	0.012	<0.001	<0.0005	0.009	0.0732	<0.01	0.055
USMW-03	11/14/13	0.08	<0.001	0.006	<0.05	<0.001	3.3	0.002	0.004	<0.009	0.012	0.029	0.09	0.002	0.002	5.4	10.5	<0.0001	0.009	0.114	<0.008	<0.001	<0.0005	0.008	0.0593	<0.01	0.05
USMW-03	3/13/14	0.16	<0.002	<0.003	<0.05	<0.001	4.2	<0.001	0.005	<0.001	0.018	0.011	1.2	<0.003	<0.001	4.6	17.6	<0.0001	0.012	0.134	0.01	<0.001	<0.0007	0.028	0.0664	<0.01	0.05
USMW-03	6/17/14	0.08	<0.002	<0.005	<0.05	<0.001	3.5	<0.007	0.005	<0.001	0.026	0.006	1.7	<0.003	<0.001	5.5	22.1	<0.0001	0.005	0.156	<0.02	<0.002	<0.0005	0.011	0.0597	<0.01	0.043
USMW-03	8/8/14	<0.05	<0.001	<0.005	<0.05	<0.001	3.8	<0.001	0.005	<0.001	0.029	0.015	1.02	0.002	<0.001	6.1	24.6	<0.0001	0.003	0.154	<0.02	<0.001	<0.0005	<0.005	0.0583	<0.01	0.076
USMW-03	12/3/14	0.06	0.001	<0.003	<0.05	<0.001	4.1	0.003		<0.007	0.042	<0.005	5.46		0.001	5.9	33.8	<0.0001	0.006	0.199	<0.003	<0.001	0.0013	<0.005	0.0627	<0.01	0.03
	Max	0.28	0.001	0.012	0.05	0.001	4.2	0.003	0.01	0.03	0.048	0.119	8.1	0.002	0.003	6.1	33.8	ND	0.043	0.199	0.19	ND	0.0013	0.044	0.0732	0.02	0.346
USMW-04	9/18/13	0.06	0.001	0.002	<0.05	<0.001	2	<0.001	0.014	0.016	0.019	0.056	0.9	0.002	0.003	3.2	1.7	<0.0001	0.005	0.177	0.008	<0.001	0.0009	0.011	0.456	<0.01	0.044
USMW-04	11/13/13	0.07	0.001	0.007	<0.05	<0.001	1.8	<0.001	0.024	0.002	0.03	0.022	2.43	0.003	0.002	3	2.69	<0.0001	0.006	0.173	0.004	<0.001	0.0009	0.02	0.446	<0.01	0.029
USMW-04	3/18/14	0.08	<0.001	0.007	<0.05	<0.001	1.6	<0.001	0.016	0.002	0.032	0.053	2.6	0.002	0.001	2.7	2.67	<0.0001	0.006	0.177	0.016	<0.001	<0.0006	0.016	0.406	0.01	0.08
USMW-04	5/16/14	0.09	<0.001	0.007	<0.05	<0.001	1.5	<0.001	0.008	<0.001	0.02	0.024	3.1	<0.002	0.001	2.6	2.01	<0.0001	0.002	0.147	<0.007	<0.001	<0.0005	<0.005	0.349	<0.01	0.082
USMW-04	6/27/14	<0.05	0.9	0.008	<0.05	<0.001	1.7	<0.001	0.009	0.006	0.026	0.034	5	<0.002	0.003	2.7	2.73	<0.0001	0.003	0.144	0.007	<0.001	<0.0005	<0.005	0.416	<0.01	0.023
USMW-04	8/6/14	<0.3	<0.001	<0.002	0.05	<0.001	1.7	<0.001	0.004	0.006	0.028	0.037	0.4	<0.002	0.001	2.7	2.22	<0.0001	0.002	0.146	<0.009	<0.001	<0.0005	<0.005	0.432	0.04	0.13
USMW-04	12/3/14	0.08	<0.001	0.004	<0.05	<0.001	1.9	<0.001	0.006	0.001	0.021	0.019	1.56	0.001	<0.001	2.3	2.02	<0.0001	0.003	0.144	0.003	<0.001	<0.0005	<0.005	0.314	<0.01	0.013
	Max	0.09	0.9	0.008	0.05	ND	2	ND	0.024	0.016	0.032	0.056	5	0.003	0.003	3.2	2.73	ND	0.006	0.177	0.016	ND	0.0009	0.02	0.456	0.04	0.13
USMW-05	9/18/13	0.22	0.001	0.001	<0.05	<0.001	12	0.001	0.038	0.002	0.09	0.033	1.4	0.006	0.004	4	4.87	<0.0001	<0.001	0.33	0.004	0.001	0.0011	0.025	0.0256	<0.01	0.256
USMW-05	11/13/13	0.17	0.003	0.003	<0.05	<0.001	7.7	<0.001	0.016	<0.001	0.063	0.023	<0.03	0.003	<0.001	2.6	3.04	<0.0001	<0.001	0.208	<0.004	<0.001	0.0007	0.006	0.0379	<0.01	0.161
USMW-05	5/16/14	0.1	<0.001	<0.002	<0.05	<0.001	6.1	<0.001	0.012	0.001	0.041	0.078	2.2	<0.002	<0.001	2.6	3.36	<0.0001	0.002	0.17	<0.009	<0.001	<0.0005	<0.005	0.0282	<0.01	0.121
USMW-05	6/30/14	0.08	<0.001	<0.002	<0.05	<0.001	6.8	<0.001	0.011	<0.001	0.057	0.006	0.9	0.002	<0.001	2.4	3.17	<0.0001	0.003	0.174	<0.007	<0.001	<0.0005	0.04	0.0328	<0.01	0.153
USMW-05	8/6/14	0.07	<0.001	0.005	0.06	<0.001	6.7	<0.001	0.008	0.006	0.056	0.049	1.1	0.002	0.002	2.5	3.63	<0.0001	0.003	0.158	<0.009	<0.001	0.0017	<0.005	0.0403	0.03	0.113
USMW-05	12/3/14	0.08	0.001	0.002	<0.05	<0.001	8	<0.001	0.01	<0.001	0.058	<0.005	2.45	0.002	<0.001	2.6	3.98	<0.0001	0.004	0.161	<0.001	<0.001	0.0011	0.008	0.0476	<0.01	0.072
	Max	0.22	0.003	0.005	0.06	ND	12	0.001	0.038	0.006	0.09	0.078	2.45	0.006	0.004	4	4.87	ND	0.004	0.33	0.004	0.001	0.0017	0.04	0.0476	0.03	0.256

NOTES:
< - Denotes non-detect, followed by detection limit.
dup. - Duplicate sample
Shading indicates non-representative sample possibly contaminated with drilling fluid

Table 16
Upton Site Water Quality Data, Radionuclides

Well	Date Sampled	Radionuclides																	
		Gross Alpha (pCi/L)	Gross Alpha MDC (pCi/L)	Gross Alpha precision (+/-) (pCi/L)	Gross Beta (pCi/L)	Gross Beta MDC (pCi/L)	Gross Beta precision (+/-) (pCi/L)	Radium 226 (pCi/L)	Radium 226 MDC (pCi/L)	Radium 226 precision (+/-) (pCi/L)	Radium 228 (pCi/L)	Radium 228 MDC (pCi/L)	Radium 228 precision (+/-) (pCi/L)	Radon 222 (pCi/L)	Radon 222 MDC (pCi/L)	Radon 222 precision (+/-) (pCi/L)	Strontium 90 (pCi/L)	Strontium 90 MDC (pCi/L)	Strontium 90 precision (+/-) (pCi/L)
UMW-01	4/23/12	21.6	7.8	6.4	-2	12.4	7.4	0.98	0.18	0.23	1.8	1.4	0.89	311	158	98.2	-0.4	2.4	1.4
UMW-01	9/24/12	-2	2.4	1.3	0.6	3.4	2	0.16	0.19	0.13	0.36	1.8	1.1	450	167	106	4.5	6	3.8
UMW-01	10/10/12	-1	3.1	1.8	-0.5	3.5	2.1	0.26	0.18	0.15	-0.4	2.1	1.2	424	392	239	1.4	2.6	1.6
UMW-01	3/4/13	9.5	2.8	2.2	-2	3.9	2.3	0.16	0.15	0.11	0.46	1.3	0.78	439	229	142	0.5	2.9	1.8
UMW-01	5/2/13	-0.009	2.7	1.6	-3	3.4	1.9	0.03	0.16	0.09	-1	2.1	1.2	464	336	207	-0.6	2.5	1.4
UWM-01	8/20/13	-2	5.2	3	-4	8.3	4.9	0.15	0.19	0.14	-0.3	1.5	0.86	96.1	87	51.6	0.5	2.9	1.7
UMW-01	11/11/13	-0.3	2.5	1.5	-0.8	3.7	2.2	0.14	0.17	0.12	0.07	1.3	0.79	123	85	50.6	1.3	2.2	1.4
UMW-01	3/25/14	-1	4.1	2.4	1.5	3.8	2.3	0.42	0.19	0.17	0.08	1.3	0.75	123	71	42.9	1.2	1.7	1.1
UMW-01	6/30/14	-0.7	2.4	1.4	0.3	2.9	1.7	0.13	0.14	0.1	-0.6	1.3	0.76	16.8	222	128	1.1	3.2	1.9
UMW-01	8/8/14	-0.07	2.4	1.4	-0.002	3.5	2.1	0.14	0.1	0.07	0.59	1.3	0.82	184	104	62.4	-0.7	11.4	6.8
UMW-01	12/2/14	4.6	3.2	2.1	0.8	3.5	2.1	0.07	0.18	0.11	1.9	1	0.7	139	76	46	1.6	6.7	4
	Min	-2			-4			0.03			-1			16.8			-0.7		
	Max	9.5			1.5			0.42			1.9			464			4.5		
	Ave	0.7			-0.7			0.2			0.1			246			1.1		
UMW-02	3/14/12	79.2	14.5	11.8	68.8	17.3	11.6	0.97	0.18	0.23	2.9	1.4	0.96	33.1	100	59.7	-0.2	2.9	1.7
UMW-02	9/20/12	-0.9	2.3	1.3	-2	3.6	2.1	0.06	0.17	0.11	-0.2	1.9	1.1	393	354	216	1.1	1.7	1
UMW-02	10/10/12	-2	2.7	1.5	-1	3.4	2	0.38	0.17	0.16	0.66	1.9	1.2	45.6	399	238	0.1	1.6	1
UMW-02	2/26/13	2.1	2.8	1.8	-0.4	3.2	1.9	0.1	0.23	0.15	1.9	1.7	1.1	185	222	135	0.9	2.4	1.5
UMW-02	5/2/13	-1	2.6	1.5	-1	3.3	2	-0.01	0.11	0.06	-0.3	2.2	1.3	254	332	202	-0.3	2.3	1.4
UMW-02	8/14/13	-2	3	1.7	0.06	3.5	2.1	0.04	0.18	0.11	0.18	1.3	0.75	84.2	60	36	-0.6	3.2	1.8
UMW-02	11/12/13	-0.4	2.1	1.2	-3	3.6	2.1	0.15	0.17	0.12	1.2	1.4	0.88	57.1	73	42.8	0.7	2.2	1.3
UMW-02	3/13/14	0.5	3.8	2.3	2.5	3.8	2.3	0.13	0.12	0.09	-0.03	1.1	0.64	55.8	131	76.3	0.6	2.3	1.4
UMW-02	6/17/14	-0.2	3.5	2.1	-0.002	3.9	2.3	0.02	0.18	0.11	0.95	1.1	0.72	74.2	84	49.3	-0.2	2.4	1.4
UMW-02	8/6/14	-0.5	3.5	2	0.7	3.8	2.3	0.12	0.1	0.07	1.2	1.3	0.86	127	154	90.8	0.8	7.8	4.7
	Min	-2			-3			-0.01			-0.3			45.6			-0.6		
	Max	2.1			2.5			0.38			1.9			393			1.1		
	Ave	-0.5			-0.5			0.1			0.6			142			0.3		
UMW-03	4/2/12	4.6	4.9	3.1	5.7	5.8	3.6	0.51	0.17	0.18	1.6	1.3	0.84	220	148	90.9	0.1	2.1	1.3
UMW-03	9/20/12	-4	3.7	2	0.2	4.1	2.5	0.23	0.11	0.1	-0.2	1.3	0.74	518	351	216	0.8	1.8	1.1
UMW-03	10/11/12	-0.7	3.3	1.9	-1	4.1	2.4	0.36	0.16	0.15	0.4	1.9	1.1	419	393	240	0	1.6	1
UMW-03	2/27/13	-3	3.9	2.2	-0.4	4.7	2.8	0.15	0.19	0.13	-0.05	1.6	0.95	509	228	143	1	2.4	1.5
UMW-03	5/7/13	-2	3.7	2.1	-0.2	4.5	2.6	0.2	0.29	0.2	0.1	2	1.2	383	185	115	1	2.6	1.6
UMW-03	8/19/13	-3	3.9	2.2	0.5	4.2	2.5	0.2	0.32	0.22	1.2	2.5	1.5	132	74	44.5	-0.8	2.9	1.7
UMW-03	11/12/13	-0.03	2.4	1.4	-0.05	3.3	2	0.47	0.17	0.17	0.94	1.3	0.85	150	71	43.2	0.9	2.1	1.3
UMW-03	3/24/14	2.5	3.7	2.3	1	3.6	2.2	0.37	0.2	0.17	0.46	1.3	0.8	118	87	51.6	0.4	0.7	0.4
UMW-03	6/30/14	-0.4	2.1	1.2	-2	3.9	2.3	0.22	0.14	0.11	1.3	1.3	0.87	106	214	125	1.1	3.3	2
UMW-03	8/8/14	1.1	2.9	1.8	-0.7	3.8	2.3	0.11	0.09	0.07	0.85	1.3	0.8	152	106	63	0	2.6	1.5
UMW-03	12/2/14	0.6	2.6	1.6	2.4	3.7	2.2	-0.1	0.2	0.09	-0.3	1.4	0.8	-28.9	74	42.3	0.8	5.5	3.3
	Min	-4			-2			-0.1			-0.3			-28.9			-0.8		
	Max	4.6			5.7			0.51			1.6			518			1.1		
	Ave	-0.4			0.5			0.2			0.6			243			0.5		
UMW-04	4/25/12	62.6	57.2	36.8	46.7	72.3	44.1	0.65	0.36	0.31	1	2.6	1.6	250	358	217	0.9	2.4	1.5
UMW-04	9/20/12	34.2	48.2	30.3	34.2	51.1	31.1	1.4	0.21	0.28	1.4	1.2	0.77	13.9	363	216	2.9	6.2	3.8

Well	Date Sampled	Radionuclides																	
		Gross Alpha (pCi/L)	Gross Alpha MDC (pCi/L)	Gross Alpha precision (+/-) (pCi/L)	Gross Beta (pCi/L)	Gross Beta MDC (pCi/L)	Gross Beta precision (+/-) (pCi/L)	Radium 226 (pCi/L)	Radium 226 MDC (pCi/L)	Radium 226 precision (+/-) (pCi/L)	Radium 228 (pCi/L)	Radium 228 MDC (pCi/L)	Radium 228 precision (+/-) (pCi/L)	Radon 222 (pCi/L)	Radon 222 MDC (pCi/L)	Radon 222 precision (+/-) (pCi/L)	Strontium 90 (pCi/L)	Strontium 90 MDC (pCi/L)	Strontium 90 precision (+/-) (pCi/L)
UMW-05	2/26/13	7.6	5.5	3.6	5.4	7	4.3	1.1	0.17	0.23	1.2	1.5	0.93	262	219	134	0.8	2.8	1.7
UMW-05	5/9/13	3.7	4.4	2.8	1.5	4.2	2.5	0.09	0.15	0.1	-0.1	1.6	0.92	193	332	200	-0.9	2.8	1.6
UMW-05	8/19/13	-2	3.3	1.8	1.2	4.3	2.6	0.16	0.17	0.13	0.58	1.3	0.83	106	87	51.8	-0.9	2.6	1.5
UMW-05	11/13/13	0.4	2.6	1.5	0.4	3.8	2.3	0.24	0.15	0.12	1.5	1.6	1	155	150	89	-0.8	2.7	1.6
UMW-05	3/18/14	7.6	2.2	1.9	-2	3.9	2.3	0.13	0.16	0.11	0.35	1.4	0.87	162	85	51.5	1.6	1.9	1.2
UMW-05	6/30/14	-4	3.8	2.1	-1	4.1	2.4	0.21	0.15	0.12	0.17	1.5	0.88	80.9	207	121	3.4	3.7	2.3
UMW-05	8/6/14	-0.4	3	1.8	0.8	4.2	2.5	0.12	0.12	0.08	1.4	1.6	1	129	154	90.6	-1.8	7.2	4.2
UMW-05	12/3/14	-0.1	3	1.7	1.6	4.2	2.6	0.03	0.18	0.11	0.53	1.2	0.74	84.9	63	37.7	0.8	2.1	1.3
	Min	-4			-2			0.03			-0.1			80.9			-1.8		
	Max	7.6			5.4			1.1			1.5			262			3.4		
	Ave	1.6			1.0			0.3			0.7			147			0.3		
USMW-01	5/24/12	131	51	36.7	25.8	64.5	39.1	0.1	0.31	0.2	1.6	2.6	1.6	69.5	142	85.7	-0.9	8.7	5.1
USMW-01	3/11/13	175	49.7	37.5	30.6	66.2	40.3	0.9	0.45	0.38	2	1.9	1.2	274	181	112	-1.2	2	1.1
USMW-01	4/30/13	177	42.1	33.8	-3	67.6	40.6	0.64	0.31	0.27	-0.9	3	1.8	347	195	121	0.3	2.6	1.6
dup.	4/30/13	161	44.2	34.1	17.2	64.8	39.2	0.78	0.31	0.29	-0.1	3.1	1.8	5140	195	174	1.3	2.5	1.5
USMW-01	8/14/13	84.2	31.5	22.6	-9	36.7	21.8	0.32	0.2	0.16	1.1	1.4	0.89	183	61	37.7	0	2.5	1.5
USMW-01	11/14/13	95.8	31.2	22.7	25	40.1	24.5	0.44	0.21	0.18	3.4	2.2	1.5	13.3	129	74.7	-0.6	3.2	1.9
USMW-01	3/13/14	162	47.2	35.2	39	49.1	30.3	0.83	0.22	0.21	1.2	1.9	1.2	152	131	78	1	1.9	1.2
USMW-01	6/27/14	226	51.5	40.5	2.2	48.9	29.5	0.17	0.3	0.2	-0.5	2.4	1.4	-11.9	107	61.5	0.5	6.6	4
USMW-01	8/8/14	132	37.2	29.2	8	54.3	32.7	0.59	0.3	0.24	4.9	4.1	2.7	7.9	107	61.7	-1.7	4	2.3
USMW-01	12/3/14	94.8	43.8	30	13.5	40.7	24.7	0.33	0.23	0.18	1.4	1.5	0.98	6.2	62	35.6	1.6	9.5	5.8
	Min	84.2			-9			0.1			-0.9			-11.9			-1.7		
	Max	226			39			0.9			4.9			347			1.6		
	Ave	142			14.7			0.5			1.6			116			-0.1		
USMW-02	5/24/12	106	39.2	28.3	22.2	53.2	32.3	0.4	0.29	0.22	7.6	2.3	1.8	1190	141	99.5	-0.3	9.6	5.7
USMW-02	3/11/13	62.6	29.2	20.2	-7	34.5	20.5	0.61	0.17	0.17	2.4	1.6	1.1	581	183	117	-1.8	2	1.1
USMW-02	4/30/13	95.1	50.2	33.5	30.6	54.1	32.9	1.2	0.2	0.26	1.3	2	1.3	1480	193	135	1.3	2.5	1.5
USMW-02	8/20/13	62.1	23.2	16.9	-20	29.9	17.5	0.16	0.15	0.11	1.1	1.2	0.76	199	72	44.1	0	2	1.2
USMW-02	11/14/13	56.2	31.1	20.6	-10	32.6	19.4	0.3	0.13	0.12	3.7	1.6	1.2	82.8	128	74.9	-0.6	3.2	1.9
USMW-02	3/13/14	91.5	28.2	21.1	27.1	33	20.3	0.64	0.11	0.12	1.5	1	0.65	79	128	74.9	2.5	3.8	2.4
USMW-02	6/17/14	46.8	23.5	16.6	15.9	37	22.5	0.17	0.16	0.12	0.41	1.2	0.72	200	85	51.5	-0.2	1.2	0.7
USMW-02	8/8/14	48.7	21.2	15.1	8.2	29.2	17.6	0.29	0.09	0.08	2	1.2	0.83	253	106	64.8	0	1.7	1
USMW-02	12/3/14	33.1	24.9	16.5	18.2	38.3	23.3	0.76	0.17	0.2	0.93	1.1	0.72	212	62	38.7	4.6	7.8	4.9
	Min	33.1			-20			0.16			0.41			79			-1.8		
	Max	106			30.6			1.2			7.6			1480			4.6		
	Ave	67			9.5			0.5			2.3			475			0.6		
USMW-03	5/24/12	-200	242	131	-100	241	142	0.78	0.18	0.2	1.4	1.5	0.97	282	141	87.8	-0.7	7.6	4.5
USMW-03	3/11/13	-30	295	174	-100	267	157	1.9	0.21	0.31	4.6	2	1.4	344	184	114	-3.5	4.3	2.4
USMW-03	5/3/13	-100	252	145	-100	265	155	0.85	0.13	0.17	0.48	1.1	0.66	309	282	172	0.9	5	3
USMW-03	9/19/13	-30	179	105	-100	261	153	1.1	0.15	0.22	1.4	1.6	1	76	129	75.6	0.7	2.7	1.6
USMW-03	11/14/13	96	242	148	-60	257	153	0.59	0.18	0.18	1.7	1.9	1.2	24.1	127	73.5	-0.7	3.4	2
USMW-03	3/13/14	-40	261	152	162	316	191	1.3	0.23	0.25	2.6	2	1.3	65.1	129	75.6	1.1	2.2	1.4
USMW-03	6/17/14	339	199	138	-5	271	162	0.17	0.23	0.16	5.2	1.7	1.3	59.4	84	49.3	-0.2	4.8	2.8
USMW-03	8/8/14	-50	205	118	48.6	273	164	0.96	0.34	0.3	-0.6	5.6	3.3	-4.5	104	60.1	0.3	17	10.1
USMW-03	12/3/14	45.8	146	89.1	-50	265	157	1	0.18	0.23	0.66	1.2	0.77	50.3	62	36.7	0.5	5.6	3.3
	Min	-200			-100			0.17			-0.6			-4.5			-3.5		
	Max	339			162			1.9			5.2			344			1.1		
	Ave	3			-34			1.0			1.9			134			-0.2		

Well	Date Sampled	Radionuclides																	
		Gross Alpha (pCi/L)	Gross Alpha MDC (pCi/L)	Gross Alpha precision (+/-) (pCi/L)	Gross Beta (pCi/L)	Gross Beta MDC (pCi/L)	Gross Beta precision (+/-) (pCi/L)	Radium 226 (pCi/L)	Radium 226 MDC (pCi/L)	Radium 226 precision (+/-) (pCi/L)	Radium 228 (pCi/L)	Radium 228 MDC (pCi/L)	Radium 228 precision (+/-) (pCi/L)	Radon 222 (pCi/L)	Radon 222 MDC (pCi/L)	Radon 222 precision (+/-) (pCi/L)	Strontium 90 (pCi/L)	Strontium 90 MDC (pCi/L)	Strontium 90 precision (+/-) (pCi/L)
USMW-04	9/18/13	262	195	129	66.3	256	154	1.2	0.16	0.23	1.7	1.5	0.96	-50.4	153	87.7	1.3	2.4	1.5
USMW-04	11/13/13	302	167	115	197	238	146	0.95	0.21	0.24	4.8	2.2	1.6	-130	153	86.4	-0.9	2.7	1.6
USMW-04	3/18/14	745	181	153	17.8	254	152	0.55	0.74	0.5	-2	8.8	5.1	-1.9	85	49	4.7	9.9	6.1
USMW-04	5/16/14	226	196	128	-20	267	159	1.5	0.29	0.34	2.7	1.9	1.2	-65.7	104	59	1.7	12.3	7.4
USMW-04	6/27/14	240	263	168	-200	283	166	0.64	0.29	0.26	1.8	2.3	1.5	-105	106	59.5	0.7	5.8	3.5
USMW-04	8/6/14	435	351	226	10.6	295	176	1.4	0.39	0.37	6.2	5.3	3.5	-172	151	84.6	0.2	4.7	2.8
USMW-04	12/3/14	303	188	123	161	151	93.3	0.46	0.18	0.17	1.2	1.2	0.79	-83.8	63	35.1	1.3	7.6	4.6
	Min	226			-200			0.46			-2			-172			-0.9		
	Max	745			197			1.5			6.2			-1.9			4.7		
	Ave	359			33			1.0			2.3			-87			1.3		
USMW-05	9/18/13	120	105	68.7	23.6	150	90.3	0.65	0.17	0.19	2	1.5	1	-77.7	153	87	1.1	2	1.2
USMW-05	11/13/13	48.4	85.8	53.7	-40	138	81.7	0.56	0.2	0.19	2.6	2.1	1.4	-35.3	154	88.5	0	2.3	1.4
USMW-05	5/16/14	7.9	128	76.2	-60	141	82.9	0.39	0.21	0.17	2.2	1.3	0.91	14.6	104	60.5	-3.5	11.7	6.8
USMW-05	6/30/14	-40	131	76	-50	147	86.5	0.18	0.21	0.15	0.16	2	1.2	-28.4	212	122	2.9	5.7	3.5
USMW-05	8/6/14	38.4	127	77	64.5	148	89.4	0.73	0.4	0.31	8.8	5.5	3.7	-55.2	153	87.7	3.6	4.8	3
USMW-05	12/3/14	-40	131	75.6	32	143	85.6	0.2	0.17	0.13	1.1	1.2	0.76	-7.9	64	36.7	1.8	5.4	3.3
	Min	-40			-60			0.18			0.16			-77.7			-3.5		
	Max	120			64.5			0.73			8.8			14.6			3.6		
	Ave	22			-5			0.5			2.8			-32			1.0		

NOTES:
MDC - Minimum detectable concentration
Min/Max/Averages not calculated for wells with less than 3 samples. Min/Max/Average calculations not evaluated for MDC and precision values.
Shading indicates non-representative sample possibly contaminated with drilling fluid

Table 17
Upton Site Water Quality Data, Volatile Organic Compounds

	Monitor Well and Date Sampled				
	UMW-01	UMW-02	UMW-03	USMW-01	USMW-03
Analyte	5/3/2013	5/7/2013	5/7/2013	5/9/2013	5/3/2013
1,1,1,2-Tetrachloroethane	<1	<1	<1	<1	<1
1,1,1-Trichloroethane	<1	<1	<1	<1	<1
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	<1
1,1,2-Trichloroethane	<1	<1	<1	<1	<1
1,1-Dichloroethane	<1	<1	<1	<1	<1
1,1-Dichloroethane	<1	<1	<1	<1	<1
1,1-Dichloroethene	<1	<1	<1	<1	<1
1,1-Dichloropropene	<1	<1	<1	<1	<1
1,2,3-Trichlorobenzene	<1	<1	<1	<1	<1
1,2,3-Trichloropropane	<1	<1	<1	<1	<1
1,2,4-Trichlorobenzene	<1	<1	<1	<1	<1
1,2,4-Trimethylbenzene	0.32	<1	0.38	<1	<1
1,2-Dibromo-3-chloropropane	<1	<1	<1	<1	<1
1,2-Dichlorobenzene	<1	<1	<1	<1	<1
1,2-Dichloroethane	<1	<1	<1	<1	<1
1,2-Dichloropropane	<1	<1	<1	<1	<1
1,3,5-Trimethylbenzene	<1	<1	0.14	<1	<1
1,3-Dichlorobenzene	<1	<1	<1	<1	<1
1,3-Dichloropropane	<1	<1	<1	<1	<1
1,4-Dichlorobenzene	<1	<1	<1	<1	<1
2,2-Dichloropropane	<1	<1	<1	<1	<1
2-Chloroethyl vinyl ether	<1	<1	<1	<1	<1
2-Chlorotoluene	<1	<1	<1	<1	<1
2-Hexanone	<20	<20	<20	<20	<20
4-Chlorotoluene	<1	<1	<1	<1	<1
Acetone	<20	<20	<20	<20	<20
Acetonitrile	<20	<20	<20	<20	<20
Acrolein	<20		<20	<20	<20
Acrylonitrile	<20		<20	<20	<20
Benzene	<1	<1	0.18	<1	<1
Bromobenzene	<1	<1	<1	<1	<1
Bromochloromethane	<1	<1	<1	<1	<1
Bromodichloromethane	<1	<1	<1	<1	<1
Bromoform	<1	<1	<1	<1	<1
Bromomethane	<1	<1	<1	<1	<1
Carbon disulfide	<1	<1	0.18	<1	<1
Carbon Tetrachloride	<1	<1	<1	<1	<1
Chlorobenzene	<1	<1	<1	<1	<1
Chlorodibromomethane	<1	<1	<1	<1	<1
Chloroethane	<1	<1	<1	<1	<1
Chloroform	<1	<1	<1	<1	<1
Chloromethane	<1	<1	<1	<1	<1
cis-1,2-Dichloroethene	<1	<1	<1	<1	<1
cis-1,3-Dichloropropene	<1	<1	<1	<1	<1
Dibromoethane	<1	<1	<1	<1	<1
Dichlorodifluoromethane	<1	<1	<1	<1	<1
Ethylbenzene	<1	<1	0.096	<1	<1
Hexachlorobutadiene	<1	<1	<1	<1	<1
Iodomethane	<1	<1	<1	<1	<1
Isopropylbenzene	<1	<1	<1	<1	<1
M/P-Xylene	<1	<1	0.26	<1	<1
Methyl ethyl ketone	<20	<20	<20	<20	<20
Methyl isobutyl ketone	<20	<20	<20	<20	<20
Methylene chloride	0.12	<1	<1	<1	<1
Methyl-tertiary-butyl ether	<1	<1	<1	<1	<1
Naphthalene	<1	<1	<1	<1	<1

Analyte	Monitor Well and Date Sampled				
	UMW-01	UMW-02	UMW-03	USMW-01	USMW-03
	5/3/2013	5/7/2013	5/7/2013	5/9/2013	5/3/2013
n-Butylbenzene	<1	<1	<1	<1	<1
n-Propylbenzene	<1	<1	<1	<1	<1
O-Xylene	0.13	<1	0.17	<1	<1
p-Isopropyltoluene	<1	<1	<1	<1	<1
sec-Butylbenzene	<1	<1	<1	<1	<1
Styrene	<1	<1	<1	<1	<1
tert-Butylbenzene	<1	<1	<1	<1	<1
Tetrachloroethene	<1	<1	<1	<1	<1
Toluene	15	<1	46	<1	<1
trans-1,2-Dichloroethene	<1	<1	<1	<1	<1
trans-1,3-Dichloropropene	<1	<1	<1	<1	<1
Trichloroethene	<1	<1	<1	<1	<1
Trichlorofuoromethane	<1	<1	<1	<1	<1
Vinyl acetate	<1	<1	<1	<1	<1
Vinyl Chloride	<1	<1	<1	<1	<1
Xylene	0.13	<1	0.42	<1	<1

NOTES:
All units in micrograms per liter (µg/L)

Table 18
Upton Site Water Quality Data, Semi-Volatile Organic Compounds

Analyte	Monitor Well and Date Sampled				
	UMW-01	UMW-02	UMW-03	USMW-01	USMW-03
	5/3/2013	5/7/2013	5/7/2013	5/9/2013	5/3/2013
1,2,4-Trichlorobenzene	<10	<10	<10	<10	<10
1,2-Dichlorobenzene	<10	<10	<10	<10	<10
1,3-Dichlorobenzene	<10	<10	<10	<10	<10
1,4-Dichlorobenzene	<10	<10	<10	<10	<10
1-Methylnaphthalene	<10	<10	<10	<10	<10
2,4,5-Trichlorophenol	<10	<10	<10	<10	<10
2,4,6-Trichlorophenol	<10	<10	<10	<10	<10
2,4-Dichlorophenol	<10	<10	<10	<10	<10
2,4-Dimethylphenol	<10	<10	<10	<10	<10
2,4-Dinitrophenol	<50	<50	<50	<50	<50
2,4-Dinitrotoluene	<10	<10	<10	<10	<10
2,6-Dinitrotoluene	<10	<10	<10	<10	<10
2-Chloronaphthalene	<10	<10	<10	<10	<10
2-Chlorophenol	<10	<10	<10	<10	<10
2-Methylnaphthalene	<10	<10	<10	<10	<10
2-Nitrophenol	<10	<10	<10	<10	<10
3,3'-Dichlorobenzidine	<10	<10	<10	<10	<10
4,6-Dinitro-2-methylphenol	<50	<50	<50	<50	<50
4-Bromophenyl phenyl ether	<10	<10	<10	<10	<10
4-Chloro-3-methylphenol	<10	<10	<10	<10	<10
4-Chlorophenol	<10	<10	<10	<10	<10
4-Chlorophenyl phenyl ether	<10	<10	<10	<10	<10
4-Nitrophenol	<50	<50	<50	<50	<50
Acenaphthene	<10	<10	<10	<10	<10
Acenaphthylene	<10	<10	<10	<10	<10
Anthracene	<10	<10	<10	<10	<10
Azobenzene	<10	<10	<10	<10	<10
Benzidine	<10	<10	<10	<10	<10
Benzo(a)anthracene	<10	<10	<10	<10	<10
Benzo(a)pyrene	<10	<10	<10	<10	<10
Benzo(b)fluoranthene	<10	<10	<10	<10	<10
Benzo(g,h,i)perylene	<10	<10	<10	<10	<10
Benzo(k)fluoranthene	<10	<10	<10	<10	<10
bis(-2-chloroethoxy)Methane	<10	<10	<10	<10	<10
bis(-2-chloroethyl)Ether	<10	<10	<10	<10	<10
bis(2-chloroisopropyl)Ether	<10	<10	<10	<10	<10
bis(2-ethylhexyl)Phthalate	<10	<10	<10	<10	<10
Butylbenzylphthalate	<10	<10	<10	<10	<10
Chrysene	<10	<10	<10	<10	<10
Dibenzo(a,h)anthracene	<10	<10	<10	<10	<10
Diethyl phthalate	<10	<10	<10	<10	7.8
Dimethyl phthalate	<10	<10	<10	<10	<10
Di-n-butyl phthalate	<10	<10	<10	<10	<10
Di-n-octyl phthalate	<10	<10	<10	<10	<10
Fluoranthene	<10	<10	<10	<10	<10
Fluorene	<10	<10	<10	<10	<10
Hexachlorobenzene	<10	<10	<10	<10	<10
Hexachlorobutadiene	<10	<10	<10	<10	<10
Hexachlorocyclopentadiene	<10	<10	<10	<10	<10
Hexachloroethane	<10	<10	<10	<10	<10
Indeno(1,2,3-cd)pyrene	<10	<10	<10	<10	<10
Isophorone	<10	<10	<10	<10	<10
m+p-Cresols	<10	<10	<10	<10	<10
Naphthalene	<10	<10	<10	<10	<10
Nitrobenzene	<10	<10	<10	<10	<10
n-Nitrosodimethylamine	<10	<10	<10	<10	<10
n-Nitroso-di-n-propylamine	<10	<10	<10	<10	<10
n-Nitrosodiphenylamine	<10	<10	<10	<10	<10

Analyte	Monitor Well and Date Sampled				
	UMW-01	UMW-02	UMW-03	USMW-01	USMW-03
	5/3/2013	5/7/2013	5/7/2013	5/9/2013	5/3/2013
o-Cresol	<10	<10	<10	<10	<10
Pentachlorophenol	<50	<50	<50	<50	<50
Phenanthrene	<10	<10	<10	<10	<10
Phenol	<10	<10	<10	<10	<10
Pyrene	<10	<10	<10	<10	<10
Pyridine	<10	<10	<10	<10	<10

NOTES:
All units in micrograms per liter (µg/L)

Table 19
Groundwater Rights within and 3 Miles Adjacent to the Upton Plant Project Boundary

WR Number	Priority Date	Summary WR Status	Appropriator	Facility Name	Uses	Sec	Qtr-Qtr	Well Log (Y/N)	Total Flow (CFS)/ Appropriation (GPM)	Total Depth (ft)	Static Water Level (Ft)	Latitude	Longitude
Township 47 North, Range 65 West													
P18227.0P	07/22/1942	Complete		RAY NORRIS #1	DOM_GW	18	NWNW	Unknown	20	110.00	70	44.0605800	-104.7170900
P12699.0P	03/02/1944	Complete		MARTENS #IK 17	STK	14	NESW	Unknown	4	1700.00	-6	44.0537800	-104.6316800
P5537.0P	07/31/1954	Complete	MARY ANN SHANNON	SHANNON #6	STK	18	SWSE	Unknown	5	160.00	-1	44.0497500	-104.7071700
P12698.0P	12/31/1959	Complete		FOLTZ #IK 26	STK	13	SESE	Unknown	4	638.00	-6	44.0503300	-104.6014400
CR UW05/101	02/13/1974		TOWN OF UPTON	TOWN OF UPTON WELL NO. 5	MUN_GW	01	NENW	Unknown	35			44.0896330	-104.6116830
CR UW16/135	02/13/1974		TOWN OF UPTON	TOWN OF UPTON WELL NO. 5	MUN_GW	01	NENW	Unknown				44.0896330	-104.6116830
P36695.0W	03/21/1977	Complete	FRANK A. & JENNY L. WATSON	WATSON #1	DOM_GW	01	NESE	Unknown	4	610.00	150	44.0826900	-104.6014500
P42867.0W	04/17/1978	Complete	WILLIAM P. GARDNER JR.	PINE HOLE	DOM_GW; STK	01	NESE	Unknown	15	85.00	18	44.0826900	-104.6014500
P44733.0W	08/11/1978	Complete	R. DON & JUDITH A. WARKENTIN	PINEY #1	DOM_GW	12	NWNE	Unknown	5	80.00	35	44.0754800	-104.6064900
P47576.0W	04/23/1979	Complete	DERK J. OR BETTY A. BRADFORD	BRADFORD #1	DOM_GW	12	NENE	Unknown	8	100.00	10	44.0755000	-104.6014500
P55924.0W	03/10/1981	Complete	DALE E. BOE	BOE #1	DOM_GW	01	NESW	Unknown	4	480.00	460	44.0826600	-104.6115200
CR UW07/040	09/09/1982	Fully Adjudicated	TOWN OF UPTON	UPTON WELL #6	MUN_GW	01	NENW	Unknown	200	3310.00	61.6	44.0898500	-104.6115100
P150030.0W	03/25/2003	Complete		NOLD # 2	DOM_GW	01	NWSE	Unknown	5	817.00	10	44.0826800	-104.6064900
P196069.0W	06/29/2011	Complete	RAYMOND NORRIS REVOCABLE TRUST, RAYMOND NORRIS	R NORRIS #1	DOM_GW; STK	18	NWNE	N	5	118.00	92	44.0604170	-104.7070330
P199618.0W	01/25/2013	Incomplete	MARK AND LISA GRIFFITH	GRIFFITH #1	DOM_GW	17	NESE	Unknown	20			44.0530170	-104.6821140
Township 47 North, Range 66 West													
P5535.0P	11/25/1966	Complete	MARY ANN SHANNON	SHANNON #4	DOM_GW	13	SWSE	Unknown	10	100.00		44.0496500	-104.7271500
P5668.0W	05/29/1970	Complete	MARY ANN SHANNON	SHANNON #7	DOM_GW; STK	13	SWSE	Unknown	5	180.00	40	44.0496500	-104.7271500
P31075.0W	09/18/1975	Complete		M. NORRIS #1	DOM_GW	13	NENE	Unknown	7	372.00	120	44.0605600	-104.7220400
P56135.0W	03/25/1981	Complete	FRED NORRIS	NORRIS #6	STK	12	SWNE	Unknown	3	300.00	160	44.0714200	-104.7269800
P93631.0W	12/13/1993	Complete	FLYING J RANCH	MCKENZIE 1A	STK	01	NWNE	Unknown	5	125.00	35	44.0895500	-104.7268000
Township 48 North, Range 65 West													
P18705.0P	04/22/1969	Complete	LEONARD N. HANSON	LEONARD HANSON #1	DOM_GW; STK	35	SESW	Unknown	15	36.50	14	44.0934600	-104.6315700
P28338.0W	02/13/1974	Fully Adjudicated		TOWN OF UPTON WELL #5	MUN_GW	35	SWSW	Unknown	35	545.00	120	44.0934500	-104.6365900
CR UW05/098	02/13/1974	Fully Adjudicated	TOWN OF UPTON	TOWN OF UPTON WELL #2	MUN_GW	25	NWSW	Unknown	205	3162.00	-1	44.1121600	-104.6160900
CR UW05/099	02/13/1974	Fully Adjudicated	TOWN OF UPTON	TOWN OF UPTON WELL #3	MUN_GW	25	NESW	Unknown	35	804.00	200	44.1121300	-104.6111100
CR UW05/100	02/13/1974	Fully Adjudicated	TOWN OF UPTON	TOWN OF UPTON WELL #4	MUN_GW	35	SWSW	Unknown	205	-1.00	-1	44.0934500	-104.6365900
P26846.0W	05/31/1974	Complete	LEONARD N. HANSON	HANSON WELL #2	DOM_GW	35	SWSW	Unknown	5	21.00	4	44.0934500	-104.6365900
P26847.0W	05/31/1974	Complete	LEONARD N. HANSON	HANSON WELL #3	DOM_GW	35	SWSW	Unknown	6	30.00	6	44.0934500	-104.6365900
P43774.0W	06/16/1978	Complete	ALVIN HUCKINS	HUCKINS #1	DOM_GW; STK	21	NWNW	Unknown	15	720.00	150	44.1338200	-104.6763500
P49344.0W	08/07/1979	Complete	JOHN W. & CAROLE L. HOLMES	HOLMES #1	DOM_GW	25	NWSW	Unknown	10	50.00	14	44.1121600	-104.6160900
P50697.0W	11/16/1979	Complete	SAMUEL AND OR JOYCE A. HAPTONSTALL	HAP #1	STK	25	NWNW	Unknown	10	40.00	1.5	44.1196700	-104.6158800
P56239.0W	07/09/1980	Complete	LEONARD N. HANSON	HANSON #4	DOM_GW;	35	SESW	Unknown	9	50.00	38	44.0934600	-104.6315700

WR Number	Priority Date	Summary WR Status	Appropriator	Facility Name	Uses	Sec	Qtr-Qtr	Well Log (Y/N)	Total Flow (CFS)/ Appropriation (GPM)	Total Depth (ft)	Static Water Level (Ft)	Latitude	Longitude
					STK								
P55797.0W	02/20/1981		ROBERT P. VAN LOAN	R & R #1	MIS	26	SENE	Unknown	11	683.00	94	44.1159200	-104.6209800
P55909.0W	03/09/1981	Complete	JAMES C. OR HARRIETT E. NORRIS	NORRIS #1	DOM_GW; STK	23	SESW	Unknown	2	640.00	200	44.1233600	-104.6308600
P61798.0W	08/19/1982	Complete	JOHN W. & CAROLE L. HOLMES	HOLMES #2	DOM_GW	25	NWSW	Unknown	5	590.00	80	44.1121600	-104.6160900
CR UW05/103	01/28/1983	Fully Adjudicated	TOWN OF UPTON	ENL TOWN OF UPTON WELL #2	MUN_GW	25	NWSW	Unknown	120	3162.00	385.9	44.1121600	-104.6160900
CR UW05/104	01/28/1983	Fully Adjudicated	TOWN OF UPTON	ENL TOWN OF UPTON WELL #4	MUN_GW	35	SWSW	Unknown	170	3193.00	151.86	44.0934500	-104.6365900
P77358.0W	06/24/1988	Complete	HENRY L. MARTENS	RALSTON #1	STK	28	NESW	Unknown	6.5	810.00	90	44.1117700	-104.6715500
P96809.0W	08/19/1994	Complete	CAROLYN HOLSO	HOLSO #1	DOM_GW	26	NENW	Unknown	10	664.00	147	44.1195900	-104.6309800
P97549.0W	10/17/1994	Complete		HS MW-1	MON	35	SWSE	Unknown	0	14.00	6	44.0934700	-104.6265400
P97550.0W	10/17/1994	Complete		HS MW-2	MON	35	SWSE	Unknown	0	11.00	5	44.0934700	-104.6265400
P97551.0W	10/17/1994	Complete		HS MW-3	MON	35	SWSE	Unknown	0	14.00	6	44.0934700	-104.6265400
P97552.0W	10/17/1994	Complete		HS MW-4	MON	35	SWSE	Unknown	0	14.00	6	44.0934700	-104.6265400
P97553.0W	10/17/1994	Complete		AG MW-1	MON	35	SWSE	Unknown	0	14.00	7	44.0934700	-104.6265400
P97554.0W	10/17/1994	Complete		AG MW-2	MON	35	SWSE	Unknown	0	14.00	8	44.0934700	-104.6265400
P97555.0W	10/17/1994	Complete		AG MW-3	MON	35	SWSE	Unknown	0	14.00	6	44.0934700	-104.6265400
P97556.0W	10/17/1994	Complete		AG MW-4	MON	35	SWSE	Unknown	0	14.00	5	44.0934700	-104.6265400
P97557.0W	10/17/1994	Complete		CS MW-1	MON	35	SWSE	Unknown	0	14.00	6	44.0934700	-104.6265400
P97559.0W	10/17/1994	Complete		BAB MW-1	MON	35	NESW	Unknown	0	12.00	6	44.0971800	-104.6314900
P97560.0W	10/17/1994	Complete		BAB MW-2	MON	35	NESW	Unknown	0	14.00	5	44.0971800	-104.6314900
P97561.0W	10/17/1994	Complete		BAB MW-3	MON	35	NESW	Unknown	0	14.00	6	44.0971800	-104.6314900
P97562.0W	10/17/1994	Complete		JSV MW-1	MON	35	NESW	Unknown	0	14.00	3	44.0971800	-104.6314900
P97563.0W	10/17/1994	Complete		JSV MW-2	MON	35	NESW	Unknown	0	14.00	3	44.0971800	-104.6314900
P98208.0W	01/09/1995	Fully Adjudicated		UPTON WELL #7	MUN_GW	25	NWSW	Unknown	200	3466.00	199.61	44.1121600	-104.6160900
CR UW12/037	01/09/1995	Fully Adjudicated	TOWN OF UPTON	UPTON WELL NO. 7	MUN_GW	25	NWSW	Unknown	375			44.1115390	-104.6173810
P104313.0W	10/21/1996	Complete	JOSEPH E/DENISE R LORENZ	LORENZ 01	DOM_GW	23	NWSE	Unknown	10	683.00	110	44.1272500	-104.6256100
P108946.0W	02/18/1998	Complete		ENL LORENZ 01	DOM_GW	23	NWSE	Unknown	5	683.00	110	44.1272500	-104.6256100
P130058.0W	10/17/2000	Complete	AMERICAN COLLOID COMPANY	FOCI #1	DOM_GW; STK	21	SWSW	Unknown	25	800.00	150	44.1227800	-104.6764700
P134275.0W	04/02/2001	Fully Adjudicated		UPTON ACC #2	MIS	27	SWSW	Unknown	0	834.00	13.5	44.1082100	-104.6564800
CR UW11/156	04/12/2001		AMERICAN COLLOID COMPANY		MIS	27	SWSW	Unknown	50			44.1082100	-104.6564800
P145598.0W	07/01/2002	Complete		MW2334	MON	35	SWNE	Unknown	0	20.00	15	44.1009200	-104.6263900
P151382.0W	05/09/2003	Complete	HAROLD R. CUMMINGS	CUMMINGS #1	DOM_GW	23	NWSE	Unknown	12	864.00	125	44.1272500	-104.6256100
P151917.0W	06/10/2003	Complete	ANDY KELLER	ANDY KELLER # 1	DOM_GW; STK	26	NENW	Unknown	12	666.00	300	44.1195900	-104.6309800
P157956.0W	04/20/2004	Complete	LES R & HEATHER BUTTS	BUTTS #1	DOM_GW	26	NWNE	Unknown	12	825.00	7.88	44.1196300	-104.6259300
P163277.0W	10/14/2004	Complete	SAM AND MICHELE SANCHEZ	SANCHEZ 1	DOM_GW	23	NWNE	Unknown	10	640.00	90	44.1349000	-104.6252500
P163461.0W	10/29/2004		PAUL & DANIELLE KLINE	KLINE #1	DOM_GW	23	NESW	Unknown	15			44.1271500	-104.6307200
P167388.0W	04/28/2005	Complete	ROBERT FINN	HOOT #1	DOM_GW	25	SWNW	N	12	700.00	70	44.1155000	-104.6163330
P175186.0W	08/12/2005	Incomplete		UPTON NO. 8 WELL	MUN_GW	25	NWSW	N	265	3350.00	133.61	44.1120000	-104.6156670
CR UW18/034	08/12/2005	Fully Adjudicated	TOWN OF UPTON	UPTON NO. 8 WELL	MUN_GW	25	NWSW	Unknown	400			44.1122810	-104.6161080
P169555.0W	08/18/2005	Complete	MARK R. & CINDY D. DUCA	R & R 1	DOM_GW	26	SWSE	Unknown	11	683.00	94	44.1083900	-104.6262300
P175070.0W	05/18/2006	Complete	GARY D. AND ROBERTA PAUL	HOBO #1	DOM_GW; STK	25	SESW	N	25	480.00	85	44.1087330	-104.6128000

WR Number	Priority Date	Summary WR Status	Appropriator	Facility Name	Uses	Sec	Qtr-Qtr	Well Log (Y/N)	Total Flow (CFS)/ Appropriation (GPM)	Total Depth (ft)	Static Water Level (Ft)	Latitude	Longitude
P179841.0W	02/28/2007	Complete	E. ROBERT AND LAVADA J. DAHLKE	RENA NO. 1	DOM_GW	23	SWNW	N	4.2	690.00	350	44.1304000	-104.6352000
P180996.0W	04/11/2007	Complete	GINGER JESPERSON	GINGER JESPERSON #1	STK	18	SENW	N	25	1125.00	278	44.1451000	-104.7121000
P183066.0W	08/21/2007	Complete	WES AND SARAH RHODEN	SARAH 1	DOM_GW; STK	14	SESE	N	10	540.00	310	T48N, R65W, Sec 14, SE1/4 - SE1/4	Move to SESE
P185992.0W	03/13/2008	Complete	JOHN EDWARDS	J&B WELL	DOM_GW	23	SWSE	N	12	595.00	280	44.1229670	-104.6259830
P187846.0W	08/11/2008	Complete	DOYLE BAYER	WELL, ONE	DOM_GW	14	NWSW	N	10	660.00	125	44.1413940	-104.6330560
P188054.0W	08/12/2008	Incomplete	SHAWN AND KRISTIE AYLESWORTH	AYLESWORTH #1	DOM_GW; STK	11	SESW	Unknown	8			44.1532000	-104.6306470
P194002.0W	07/22/2010	Incomplete	DAVID AND SANDRA UPTON	DTU #1	STK	26	SWSE	Unknown	10			44.1089220	-104.6277780
P198689.0W	08/24/2012	Incomplete	RALPH SHUCK	SHUCK #1	DOM_GW; MIS; STK	24	SENW	Unknown	25			44.1305470	-104.6105140
Township 48 North, Range 66 West													
P21110.0P	12/31/1915	Complete	GENE CRANSTON	LOWELL #2	STK	26	NWSE	Unknown	25	20.00	15	44.1115000	-104.7466800
P21109.0P	12/31/1918	Complete	GENE CRANSTON	LOWELL #1	STK	26	NWSE	Unknown	3	18.00	10	44.1115000	-104.7466800
P177299.0W	09/20/2006	Complete	DOUG MATERI	MATERI S.S. #1	STK	36	SESW	N	5	225.00	102	44.0943670	-104.7296170
P198924.0W	08/02/2012	Incomplete	USDA-NATIONAL FOREST SERVICE	ENL. OF MATERI S.S. #1	MIS	36	SESW	Unknown	10			44.0926500	-104.7317470

Source: WYSEO, 2013

Table 20. Upton Plant Site Surface Water Flow Summary

Stream Gage	Period	Number of Samples	Average Velocity (fps)	Channel Width (ft)	Channel Depth (ft)	Channel Area (ft^2)	Flow Rate (cfs)	Flow Rate (gpm)
CCI	2012-2014	2	0.5-0.8	5.7-7.0	1.5-1.7	9.4-10.5	5.3-7.5	2379-3366
	2018	2	0.1-3.0	0.2-1.0	0.05-0.6	0.01-0.6	0.001-1.8	0.4-808
CCO	2012-2014	2	0.4-0.9	2.0-3.0	0.3-0.7	0.6-2.1	0.5-0.8	224-359
	2018	1	0.6	2.4	0.40	1.0	0.6	259

Note: Average velocities, channel widths and flow depths were obtained from field notes.

Table 21. Upton Plant Site 2018 Surface Water Monitoring Results

Parameter	Units	CCI			CCO		
		N	Average	Range	N	Average	Range
General							
Alkalinity (as CaCO3)	mg/l	3	151	86-227	2	123	88-157
Bromide	mg/l	3	*	<0.1	2	*	<0.1
Fluoride	mg/l	3	0.50	0.1-0.7	2	0.40	0.2-0.6
Hardness (as CaCO3)	mg/l	3	163	59-270	2	150	110-190
Laboratory conductivity	umhos/cm	3	741	526-992	2	554	384-724
Nitrate	mg/l	3	*	<0.1-0.1	2	*	<0.1
Nitrate/Nitrite	mg/l	3	*	<0.1-0.1	2	*	<0.1
Nitrite	mg/l	3	*	<0.1	2	*	<0.1
Oil and grease	mg/l	3	*	<5	2	*	<5
pH	s.u.	3	7.65	7.28-8.3	2	7.87	7.56-8.18
Phosphorus, Dissolved Orthophosphate as P	mg/l	3	*	<0.1	2	*	<0.1
Sodium Adsorption Ratio (SAR)	unitless	3	4.17	0-7.1	2	2.35	0-4.7
Sulfide	mg/l	3	*	<0.04-1.2	2	*	<0.04-1
Temperature	Deg C	3	20.0	18-21	2	19.5	18-21
Total Dissolved Solids	mg/l	3	2037	332-3810	2	769	238-1300
Total Suspended Solids	mg/l	3	*	<1-50	2	150	4-296
Major Ions							
Bicarbonate	mg/l	3	183	104-277	2	150	108-192
Carbonate	mg/l	3	*	<5	2	*	<5
Calcium	mg/l	3	47.0	23-82	2	40.0	26-54
Chloride	mg/l	3	*	<1-17	2	*	<1-5
Magnesium	mg/l	3	14.7	10-17	2	13.0	12-14
Potassium	mg/l	3	7.0	3-11	2	5.0	3-7
Sodium	mg/l	3	95.0	3-157	2	59.0	2-116
Sulfate	mg/l	3	210	60-389	2	149	43-255
Organics							
Bacteria, Fecal Coliform	mpn/100 ml	3	494	54.6-1300	2	*	<1-3.1
Radiologic							
Gross Alpha	pCi/l	3	12.3	0.6-24.1	2	4.00	0.4-7.6
Gross Alpha MDC	pCi/l	3	2.70	2.3-3.2	2	2.35	2-2.7
Gross Alpha precision (±)	pCi/l	3	3.67	1.4-5.7	2	2.00	1.2-2.8
Gross Beta	pCi/l	3	14.4	4.1-27.3	2	6.85	3.8-9.9
Gross Beta MDC	pCi/l	3	3.57	3-4.7	2	2.90	2.9-2.9
Gross Beta precision (±)	pCi/l	3	2.73	1.9-4.1	2	1.95	1.8-2.1
Ra-226 - Total	pCi/l	3	1.50	0.2-2.8	2	0.57	0.03-1.1
Radium 226 MDC	pCi/l	3	0.13	0.1-0.2	2	0.20	0.2-0.2
Radium 226 precision (±)	pCi/l	3	0.37	0.1-0.6	2	0.20	0.1-0.3
Ra-228 - Total	pCi/l	3	4.63	2.2-9.4	2	2.90	1.7-4.1
Radium 228 MDC	pCi/l	3	1.53	1.5-1.6	2	1.50	1.4-1.6
Radium 228 precision (±)	pCi/l	3	1.30	0.8-2.2	2	0.95	0.8-1.1
Radon 222	pCi/l	3	-99.1	-236-53.7	2	-18.6	-62.6-25.5
Radon 222 MDC	pCi/l	3	94.9	75-119	2	83.3	75.2-91.4
Radon 222 precision (±)	pCi/l	3	53.2	41.5-65.1	2	47.8	42.5-53.1
Strontium 90	pCi/l	3	2.33	0.4-4.6	2	0.45	-1-1.9
Strontium 90 MDC	pCi/l	3	1.70	0.9-2.9	2	2.25	1.1-3.4
Strontium 90 precision (±)	pCi/l	3	1.33	0.8-1.7	2	1.45	0.9-2

Table 21. Upton Plant Site 2018 Surface Water Monitoring Results (cont.)

Parameter	Units	CCI			CCO		
		N	Average	Range	N	Average	Range
Metals							
Aluminum, Dissolved	mg/l	3	*	<0.03-32.8	2	*	<0.03-1.87
Aluminum, Total Recoverable	mg/l	3	*	<0.03-71	2	10.7	0.05-21.4
Antimony, Dissolved	mg/l	3	*	<0.001	2	*	<0.001
Antimony, Total Recoverable	mg/l	3	*	<0.001	2	*	<0.001
Arsenic, Dissolved	mg/l	3	0.005	0.001-0.011	2	0.003	0.002-0.003
Arsenic, Total Recoverable	mg/l	3	0.011	0.002-0.024	2	0.005	0.003-0.007
Barium, Dissolved	mg/l	3	0.17	0.1-0.26	2	0.14	0.13-0.14
Barium, Total Recoverable	mg/l	3	0.30	0.14-0.57	2	0.16	0.13-0.18
Beryllium, Dissolved	mg/l	3	*	<0.001-0.003	2	*	<0.001
Beryllium, Total Recoverable	mg/l	3	*	<0.001-0.006	2	*	<0.001-0.001
Boron, Dissolved	mg/l	3	*	<0.05-0.17	2	*	<0.05-0.17
Boron, Total Recoverable	mg/l	3	*	<0.05-0.26	2	*	<0.05-0.16
Cadmium, Dissolved	mg/l	3	*	<0.001	2	*	<0.001
Cadmium, Total Recoverable	mg/l	3	*	<0.001-0.001	2	*	<0.001
Cerium, Dissolved	mg/l	3	*	<0.001-0.063	2	*	<0.001-0.007
Cerium, Total Recoverable	mg/l	3	*	<0.001-0.146	2	*	<0.001-0.035
Chromium, Dissolved	mg/l	3	*	<0.001-0.026	2	*	<0.001
Chromium, Total Recoverable	mg/l	3	*	<0.001-0.05	2	*	<0.001-0.016
Cobalt, Dissolved	mg/l	3	*	<0.001-0.011	2	*	<0.001-0.002
Cobalt, Total Recoverable	mg/l	3	*	<0.001-0.023	2	*	<0.001-0.006
Copper, Dissolved	mg/l	3	*	<0.005-0.041	2	*	<0.005-0.01
Copper, Total Recoverable	mg/l	3	*	<0.005-0.085	2	*	<0.005-0.026
Cyanide, Total	mg/l	3	*	<0.005	2	*	<0.005
Iron, Dissolved	mg/l	3	8.97	0.02-25	2	0.89	0.03-1.75
Iron, Total Recoverable	mg/l	3	25.7	0.14-57.3	2	7.8	0.22-15.4
Lanthanum, Dissolved	mg/l	3	*	<0.001-0.031	2	*	<0.001-0.003
Lanthanum, Total Recoverable	mg/l	3	*	<0.001-0.072	2	*	<0.001-0.018
Lead, Dissolved	mg/l	3	*	<0.001-0.028	2	*	<0.001-0.004
Lead, Total Recoverable	mg/l	3	*	<0.001-0.062	2	*	<0.001-0.018
Lithium, Dissolved	mg/l	3	*	<0.1	2	*	<0.1
Lithium, Total Recoverable	mg/l	3	*	<0.1-0.1	2	*	<0.1
Manganese, Dissolved	mg/l	3	0.242	0.012-0.514	2	0.078	0.023-0.133
Manganese, Total Recoverable	mg/l	3	0.460	0.012-1.04	2	0.139	0.037-0.24
Mercury, Dissolved	mg/l	3	*	<0.0001	2	*	<0.0001-0.0002
Mercury, Total Recoverable	mg/l	3	*	<0.0001	2	*	<0.0001
Molybdenum, Dissolved	mg/l	3	*	<0.001-0.002	2	*	<0.001
Molybdenum, Total Recoverable	mg/l	3	*	<0.001-0.002	2	0.002	0.001-0.002
Nickel, Dissolved	mg/l	3	*	<0.005-0.052	2	*	<0.005-0.017
Nickel, Total Recoverable	mg/l	3	*	<0.005-0.104	2	*	<0.005-0.036
Selenium, Dissolved	mg/l	3	*	<0.001-0.002	2	*	<0.001
Selenium, Total Recoverable	mg/l	3	*	<0.001-0.003	2	*	<0.001-0.002
Silver, Dissolved	mg/l	3	*	<0.001	2	*	<0.001
Silver, Total Recoverable	mg/l	3	*	<0.001	2	*	<0.001
Thallium, Dissolved	mg/l	3	*	<0.0005-0.0007	2	*	<0.0005
Thallium, Total Recoverable	mg/l	3	*	<0.0005-0.0009	2	*	<0.0005
Thorium, Dissolved	mg/l	3	*	<0.005-0.016	2	*	<0.005
Thorium, Total Recoverable	mg/l	3	*	<0.005-0.029	2	*	<0.005-0.008
Uranium, Dissolved	mg/l	3	0.0028	0.0015-0.0047	2	0.0013	0.0011-0.0014
Uranium, Total Recoverable	mg/l	3	0.0052	0.0016-0.0095	2	0.0020	0.0016-0.0024
Vanadium, Dissolved	mg/l	3	*	<0.01-0.04	2	*	<0.01
Vanadium, Total Recoverable	mg/l	3	*	<0.01-0.06	2	*	<0.01-0.02
Zinc, Dissolved	mg/l	3	*	<0.005-0.211	2	*	<0.005-0.035
Zinc, Total Recoverable	mg/l	3	*	<0.005-0.45	2	*	<0.005-0.131

Table 21. Upton Plant Site 2018 Surface Water Monitoring Results (cont.)

Parameter	Units	CCI			CCO		
		N	Average	Range	N	Average	Range
QA/QC							
A/C Balance	%	3	1.86	-1.31-5.96	2	0.56	-0.62-1.73
Anions	meq/l	3	7.66	5.84-10.1	2	5.66	4.07-7.25
Cations	meq/l	3	7.97	5.68-10.3	2	5.77	4.02-7.51

* Indicates that average was not calculated since one or more values are less than the detection limit.

< Less than, where the value following the "<" is the detection limit.

Table 22. Upton Plant Site Groundwater Monitoring

Well	Date Sampled	Conductivity (µS/cm)	Depth to Bottom (ft below MP)	Depth to Water (ft below MP)	pH	Temp (°F)
UMW-01	7/10/2018	1.17	940.5	51.3	9.79	54.1
UMW-02	7/3/2018	0.98	760	Flowing	10.2	65
UMW-03	7/10/2018	1.04	850.9	71.2	9.8	54.6
UMW-04			Not Sampled - Dry			
UMW-05	7/9/2018	1.29	1255	111.6	9.69	53.5
USMW-01	7/3/2018	9.47	10.2	1.5	7.2	54.2
USMW-02	7/2/2018	2.36	19	11.7	7.65	51.4
USMW-03	7/2/2018	Out of Range	20.25	13.6	7.13	50.9
USMW-04	7/9/2018	12.26	16.7	11.2	7.8	55.7
USMW-05	7/9/2018	19.14	N/A	2.6	6.8	60.9

Table 23. Valley Fill and Weathered Shale Monitor Wells 2018 Water Quality Data for the Upton Plant Site

Station Name	Units	USMW-01	USMW-02	USMW-03	USMW-04	USMW-05
Sample Date		**7/3/2018**	**8/31/2018**	**7/2/2018**	**7/9/2018**	**7/9/2018**
General						
Alkalinity (as CaCO3)	mg/l	892	221	461	358	602
Fluoride	mg/l	1	0.6	2.9	0.7	3
Hardness (as CaCO3)	mg/l	2400	340	14000	2000	9700
Laboratory conductivity	umhos/cm	10100	3720	50800	13300	22600
Nitrate	mg/l	<0.2	<0.1	<1	11	<0.5
Nitrate/Nitrite	mg/l	<0.1	<0.1	<0.4	11	<0.2
Nitrite	mg/l	<0.1	<0.1	<0.4	<0.1	<0.2
Oil and grease	mg/l	<5	<5	<5	<5	<5
pH	s.u.	7.07	6.98	6.84	7.37	6.54
Sodium Adsorption Ratio (SAR)	unitless	18.4	11.2	61.8	29.7	20.3
Sulfide	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04
Temperature	Deg C	15	21	14	20	20
Total Dissolved Solids	mg/l	9230	2930	72200	12200	28900
Major Ions						
Bicarbonate	mg/l	1090	269	562	436	734
Carbonate	mg/l	<5	<5	<5	<5	<5
Calcium	mg/l	358	78	407	380	382
Chloride	mg/l	59	20	175	526	178
Magnesium	mg/l	375	35	3060	261	2120
Potassium	mg/l	6	4	32	16	20
Sodium	mg/l	2080	476	16600	3070	4580
Sulfate	mg/l	5650	1930	46200	7660	18300
Radiologic						
Gross Alpha	pCi/l	66.8	6.4	10.6	37.1	36.3
Gross Alpha MDC	pCi/l	33.8	9	222	26.4	42.6
Gross Alpha precision (±)	pCi/l	32.7	7.5	158	19.2	25.5
Gross Beta	pCi/l	29.9	16.6	116	42.6	57
Gross Beta MDC	pCi/l	48.8	14.3	286	41.9	75.1
Gross Beta precision (±)	pCi/l	24	8.6	172	26.7	48.2
Ra-226 - Total	pCi/l	0.2	0.3	0.6	0.3	0.4
Radium 226 MDC	pCi/l	0.1	0.1	0.2	0.1	0.1
Radium 226 precision (±)	pCi/l	0.1	0.1	0.2	0.1	0.1
Ra-228 - Total	pCi/l	1.8	1.9	0.6	1.3	2.6
Radium 228 MDC	pCi/l	1.7	1.4	1.9	1.7	1.7
Radium 228 precision (±)	pCi/l	0.9	0.9	1.2	1	1.1
Radon 222	pCi/l	-5.4	-4.5	60.9	62.3	1.3
Radon 222 MDC	pCi/l	73.4	120	85.1	79.8	80.4
Radon 222 precision (±)	pCi/l	42.2	69.2	49.9	46.9	46.4
Strontium 90	pCi/l	1.1	3.7	0.5	1.5	0.8
Strontium 90 MDC	pCi/l	1.9	1.3	2.5	2.1	2.1
Strontium 90 precision (±)	pCi/l	1.9	1.3	1.5	1.7	1.3

Table 23. Valley Fill and Weathered Shale Monitor Wells 2018 Water Quality Data for the Upton Plant Site (cont.)

Station Name	Units	USMW-01	USMW-02	USMW-03	USMW-04	USMW-05
Sample Date		**7/3/2018**	**8/31/2018**	**7/2/2018**	**7/9/2018**	**7/9/2018**
Metals						
Aluminum, Dissolved	mg/l	0.03	0.07	<0.03	0.1	0.07
Antimony, Dissolved	mg/l	<0.001	<0.001	<0.004	<0.004	<0.009
Arsenic, Dissolved	mg/l	0.001	0.003	0.005	<0.002	<0.002
Barium, Dissolved	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Beryllium, Dissolved	mg/l	<0.001	<0.001	<0.006	<0.001	<0.001
Boron, Dissolved	mg/l	0.69	0.29	4.0	1.2	7.1
Cadmium, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cerium, Dissolved	mg/l	<0.001	<0.001	0.005	<0.001	0.005
Chromium, Dissolved	mg/l	<0.001	<0.001	0.015	<0.002	<0.002
Cobalt, Dissolved	mg/l	0.004	0.006	0.043	0.001	0.062
Copper, Dissolved	mg/l	<0.005	<0.005	0.02	0.008	0.023
Cyanide, Total	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005
Iron, Dissolved	mg/l	0.14	2.44	4	0.07	4
Lanthanum, Dissolved	mg/l	<0.001	<0.001	0.001	<0.001	<0.001
Lead, Dissolved	mg/l	<0.001	<0.001	<0.003	<0.001	<0.001
Lithium, Dissolved	mg/l	0.9	0.1	7	0.8	1.9
Manganese, Dissolved	mg/l	2.52	1.46	33.9	0.065	4.85
Mercury, Dissolved	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum, Dissolved	mg/l	0.006	0.005	0.005	0.002	0.003
Nickel, Dissolved	mg/l	0.026	0.014	0.233	0.031	0.16
Selenium, Dissolved	mg/l	0.001	<0.001	0.016	<0.003	<0.003
Silver, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium, Dissolved	mg/l	<0.0005	<0.0005	<0.0007	<0.0007	0.0011
Thorium, Dissolved	mg/l	<0.005	<0.005	<0.01	<0.01	<0.01
Uranium, Dissolved	mg/l	0.0911	0.0043	0.047	0.0678	0.025
Vanadium, Dissolved	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc, Dissolved	mg/l	0.028	<0.005	0.1	0.03	0.17
QA/QC						
A/C Balance	%	0.86	-23.9	0.8	-2.25	-0.69
Anions	meq/l	137	45.2	977	182	398
Cations	meq/l	140	27.8	993	174	393

< Less than, where the value following the "<" is the detection limit.

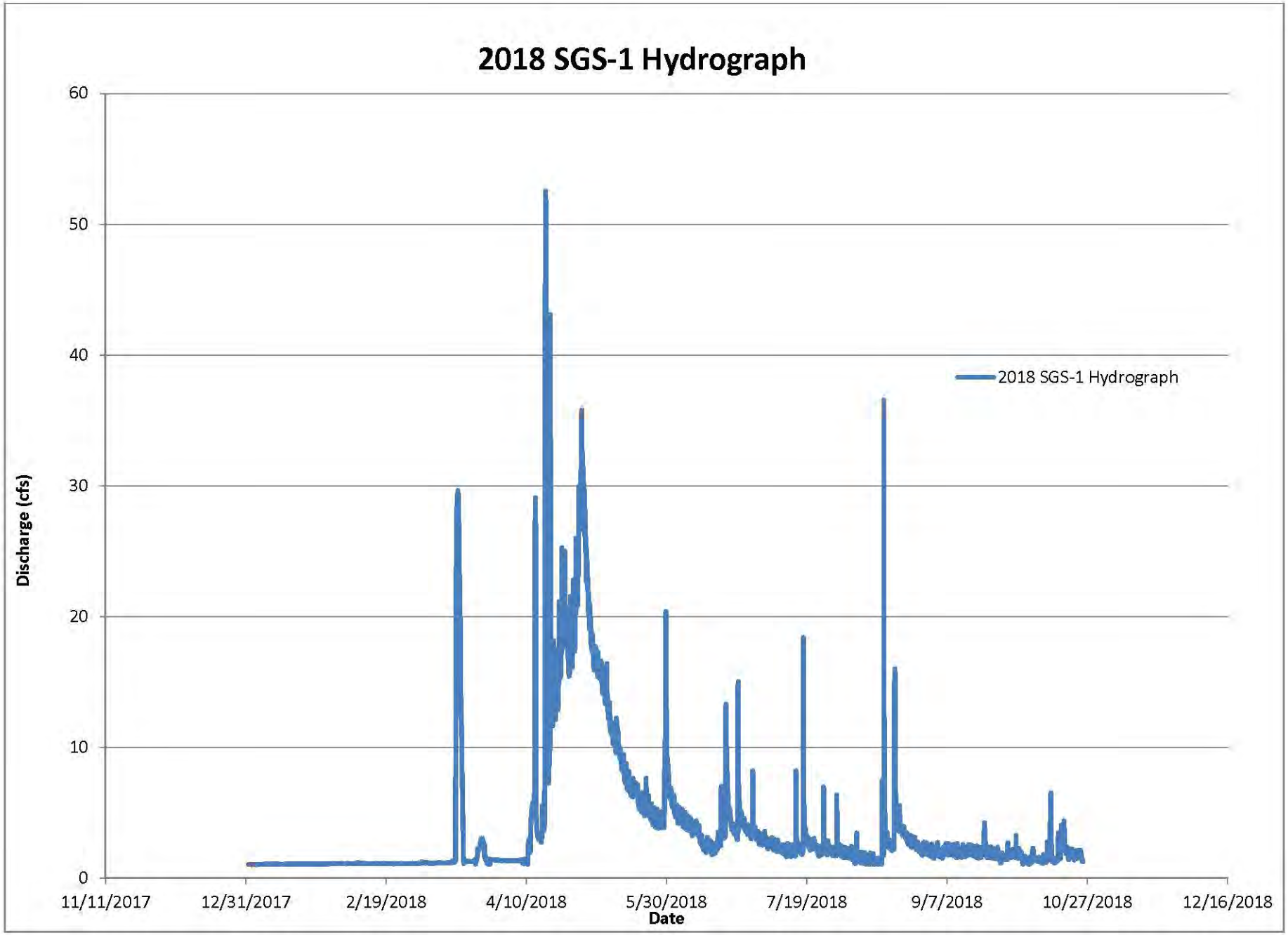
Table 24. Newcastle and Dakota Monitor Wells 2018 Water Quality Data for the Upton Plant Site

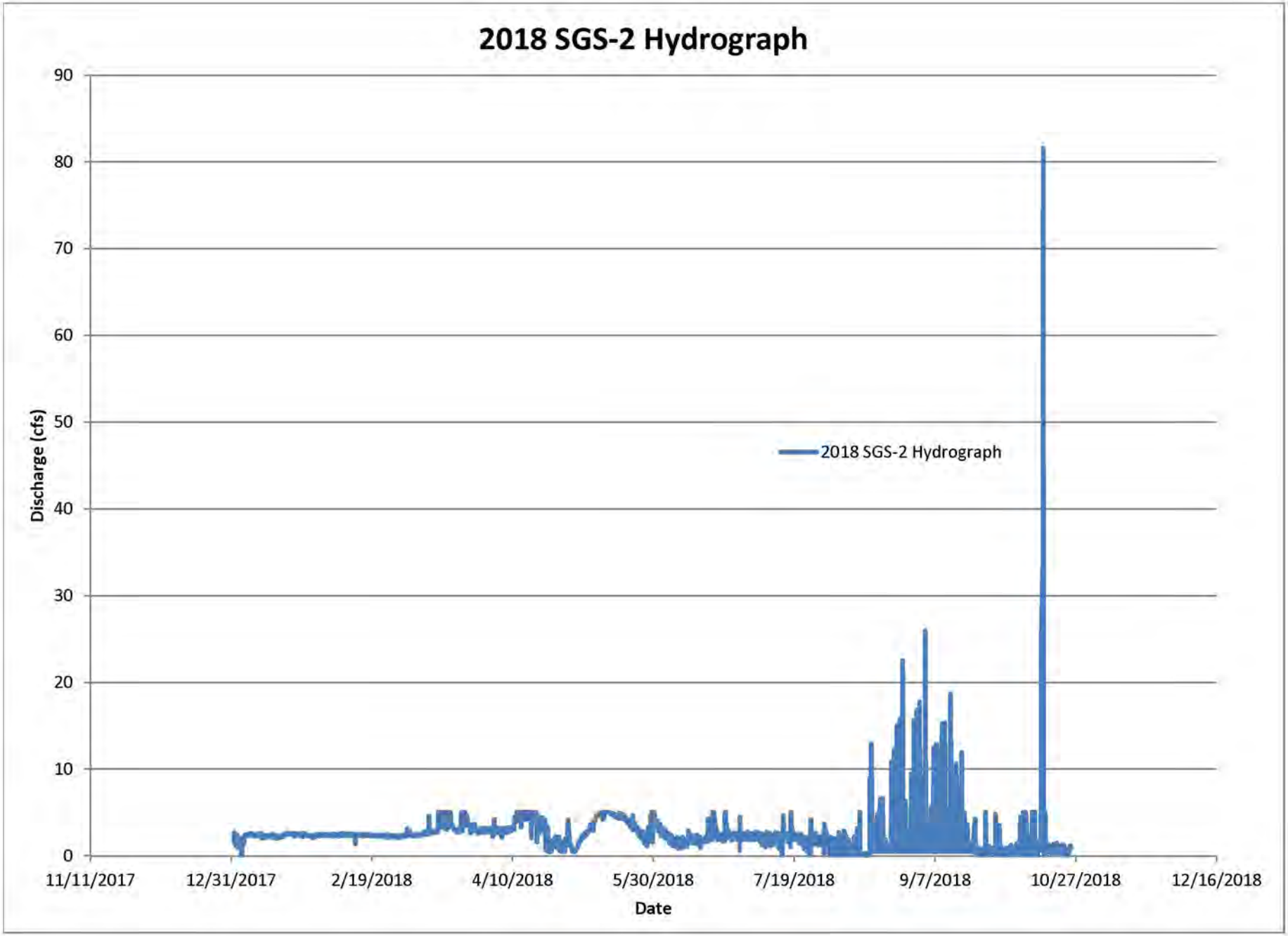
Station Name	Units	UMW-01	UMW-02	UMW-03	UMW-05
Sample Date		7/10/2018	7/3/2018	7/10/2018	7/9/2018
General					
Alkalinity (as CaCO3)	mg/l	260	240	362	423
Fluoride	mg/l	0.3	0.3	0.5	0.6
Hardness (as CaCO3)	mg/l	17	14	8	64
Laboratory conductivity	umhos/cm	1080	1080	958	1180
Nitrate	mg/l	<0.1	<0.1	<0.1	<0.1
Nitrate/Nitrite	mg/l	<0.1	<0.1	<0.1	<0.1
Nitrite	mg/l	<0.1	<0.1	<0.1	<0.1
Oil and grease	mg/l	<5	<5	<5	<5
pH	s.u.	9.43	9.16	9.13	9.04
Sodium Adsorption Ratio (SAR)	unitless	26.7	29	35.4	16.3
Sulfide	mg/l	13	0.4	13	<0.04
Temperature	Deg C	20	14	21	20
Total Dissolved Solids	mg/l	680	670	581	689
Major Ions					
Bicarbonate	mg/l	215	236	351	423
Carbonate	mg/l	51	28	44	46
Calcium	mg/l	4	4	2	4
Chloride	mg/l	32	32	69	129
Magnesium	mg/l	2	<1	<1	13
Potassium	mg/l	1	2	<1	1
Sodium	mg/l	256	252	228	300
Sulfate	mg/l	216	234	35	7
Radiologic					
Gross Alpha	pCi/l	2.7	-0.7	3	4.4
Gross Alpha MDC	pCi/l	2.2	2.4	2.9	2
Gross Alpha precision (±)	pCi/l	1.6	1.4	2.5	1.9
Gross Beta	pCi/l	3.4	4.3	0.2	0.7
Gross Beta MDC	pCi/l	4.7	4.6	2.9	3.5
Gross Beta precision (±)	pCi/l	2.9	2.6	1.8	2.1
Ra-226 - Total	pCi/l	0.3	0.3	0.2	0.3
Radium 226 MDC	pCi/l	0.2	0.2	0.2	0.1
Radium 226 precision (±)	pCi/l	0.1	0.2	0.1	0.1
Ra-228 - Total	pCi/l	0.4	0.4	-0.6	-0.1
Radium 228 MDC	pCi/l	2.4	1.7	2.4	1.8
Radium 228 precision (±)	pCi/l	1.5	1.1	1.4	1.1
Radon 222	pCi/l	6.3	49.6	-18.9	0.5
Radon 222 MDC	pCi/l	68.7	73.9	67.9	78.2
Radon 222 precision (±)	pCi/l	39.7	43.3	38.9	45.1
Strontium 90	pCi/l	1.3	0.07	1.5	1
Strontium 90 MDC	pCi/l	3.2	2.3	3.7	4.2
Strontium 90 precision (±)	pCi/l	10.6	1.4	7.6	2.6

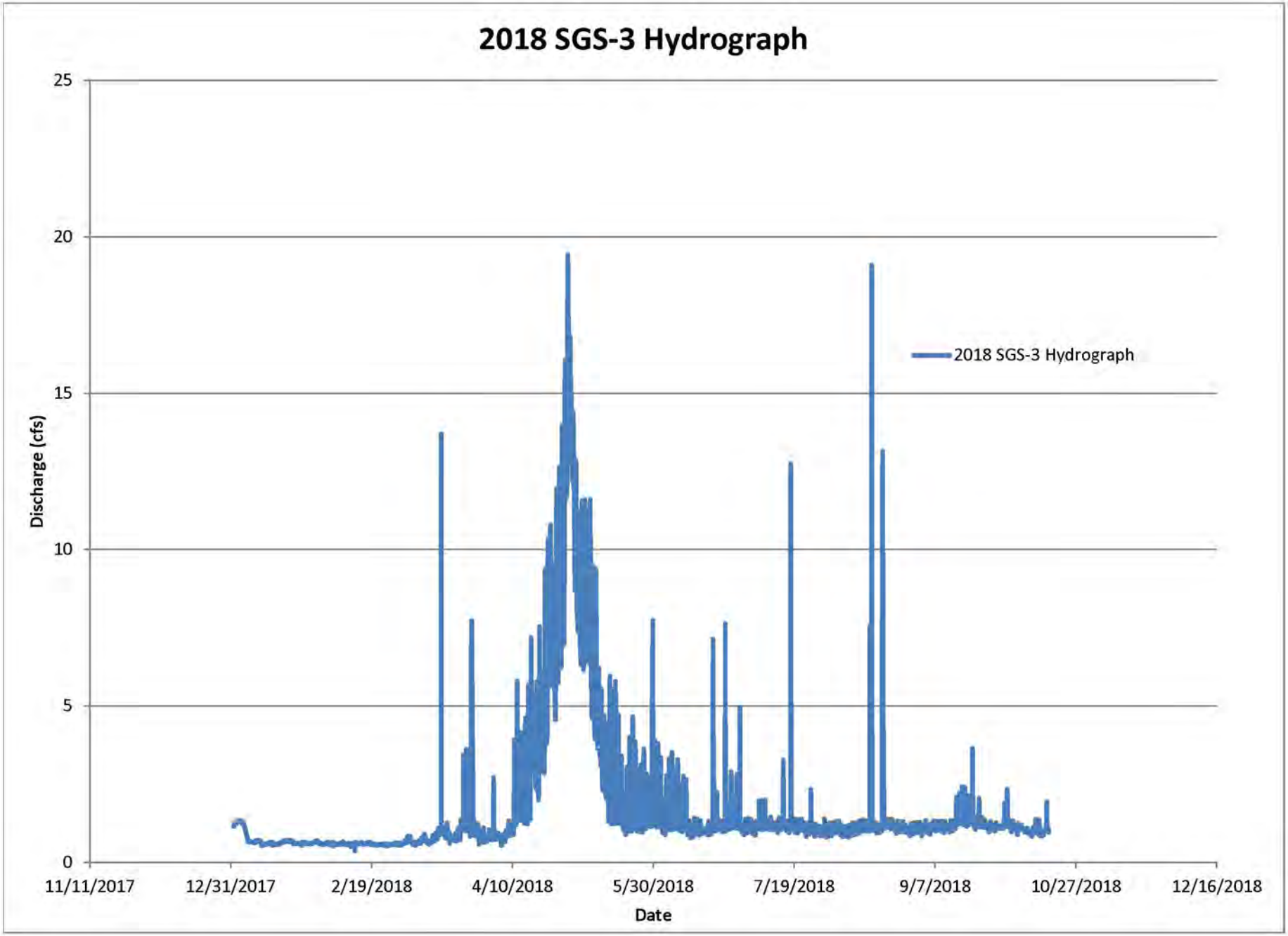
Table 24. Newcastle and Dakota Monitor Wells 2018 Water Quality Data for the Upton Plant Site (cont.)

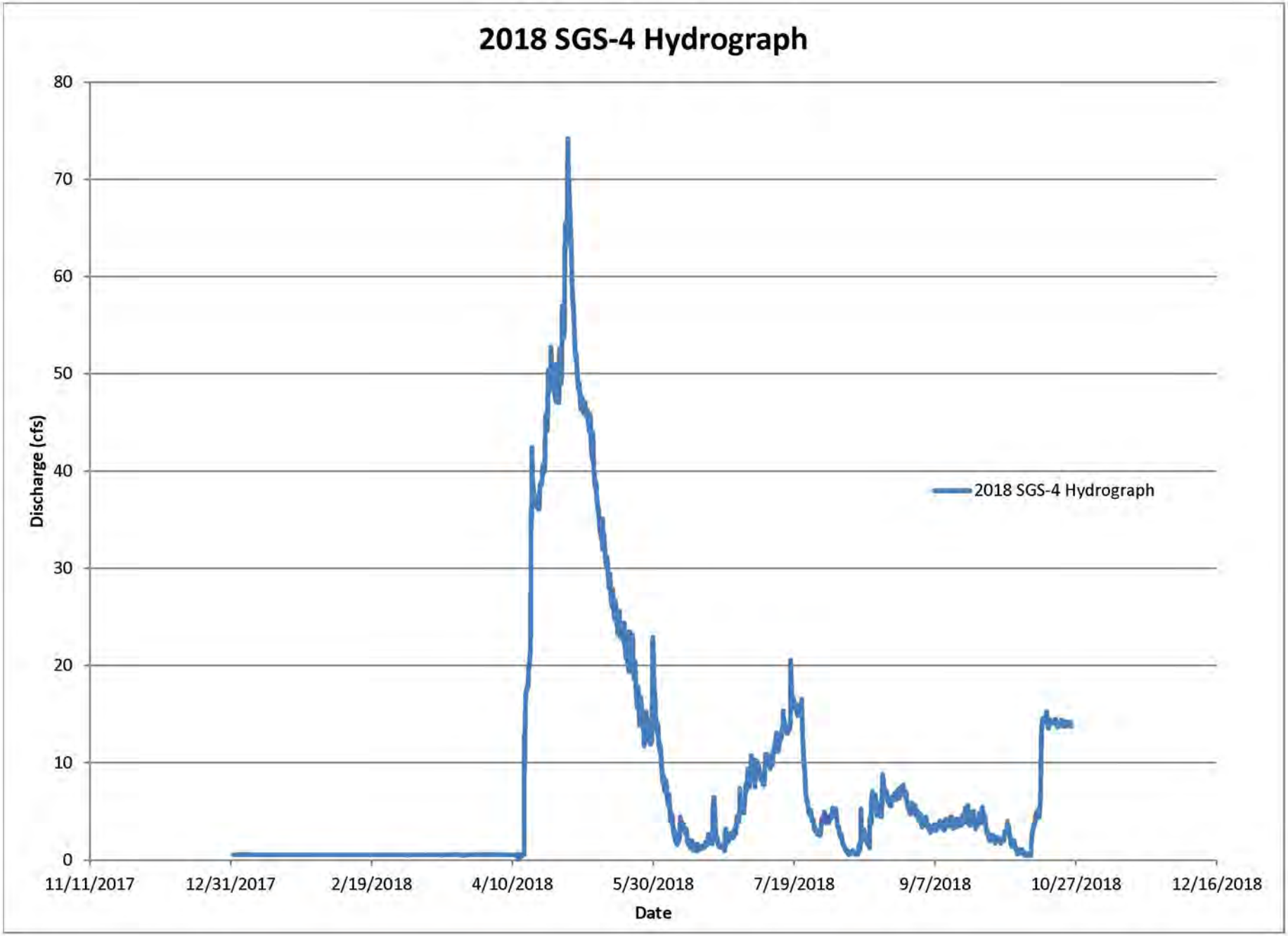
Station Name	Units	UMW-01	UMW-02	UMW-03	UMW-05
Sample Date		7/10/2018	7/3/2018	7/10/2018	7/9/2018
Metals					
Aluminum, Dissolved	mg/l	<0.03	0.11	0.03	<0.03
Antimony, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Arsenic, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Barium, Dissolved	mg/l	<0.05	<0.05	<0.05	<0.05
Beryllium, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Boron, Dissolved	mg/l	0.13	0.08	0.18	0.24
Cadmium, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Cerium, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Chromium, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Cobalt, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Copper, Dissolved	mg/l	<0.005	<0.005	<0.005	<0.005
Cyanide, Total	mg/l	<0.005	<0.005	<0.005	<0.005
Iron, Dissolved	mg/l	0.04	0.1	0.07	0.04
Lanthanum, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Lead, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Lithium, Dissolved	mg/l	<0.1	<0.1	<0.1	<0.1
Manganese, Dissolved	mg/l	0.007	0.021	0.008	0.038
Mercury, Dissolved	mg/l	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Nickel, Dissolved	mg/l	<0.005	<0.005	<0.005	<0.005
Selenium, Dissolved	mg/l	0.068	0.002	0.062	<0.001
Silver, Dissolved	mg/l	<0.001	<0.001	<0.001	<0.001
Thallium, Dissolved	mg/l	<0.0005	<0.0005	<0.0005	<0.0005
Thorium, Dissolved	mg/l	<0.005	<0.005	<0.005	<0.005
Uranium, Dissolved	mg/l	0.0003	0.0002	<0.0001	0.0002
Vanadium, Dissolved	mg/l	<0.01	<0.01	<0.01	<0.01
Zinc, Dissolved	mg/l	<0.005	0.15	<0.005	0.007
QA/QC					
A/C Balance	%	3.94	3.3	0.83	7.84
Anions	meq/l	10.6	10.6	9.94	12.3
Cations	meq/l	11.5	11.3	10.1	14.4

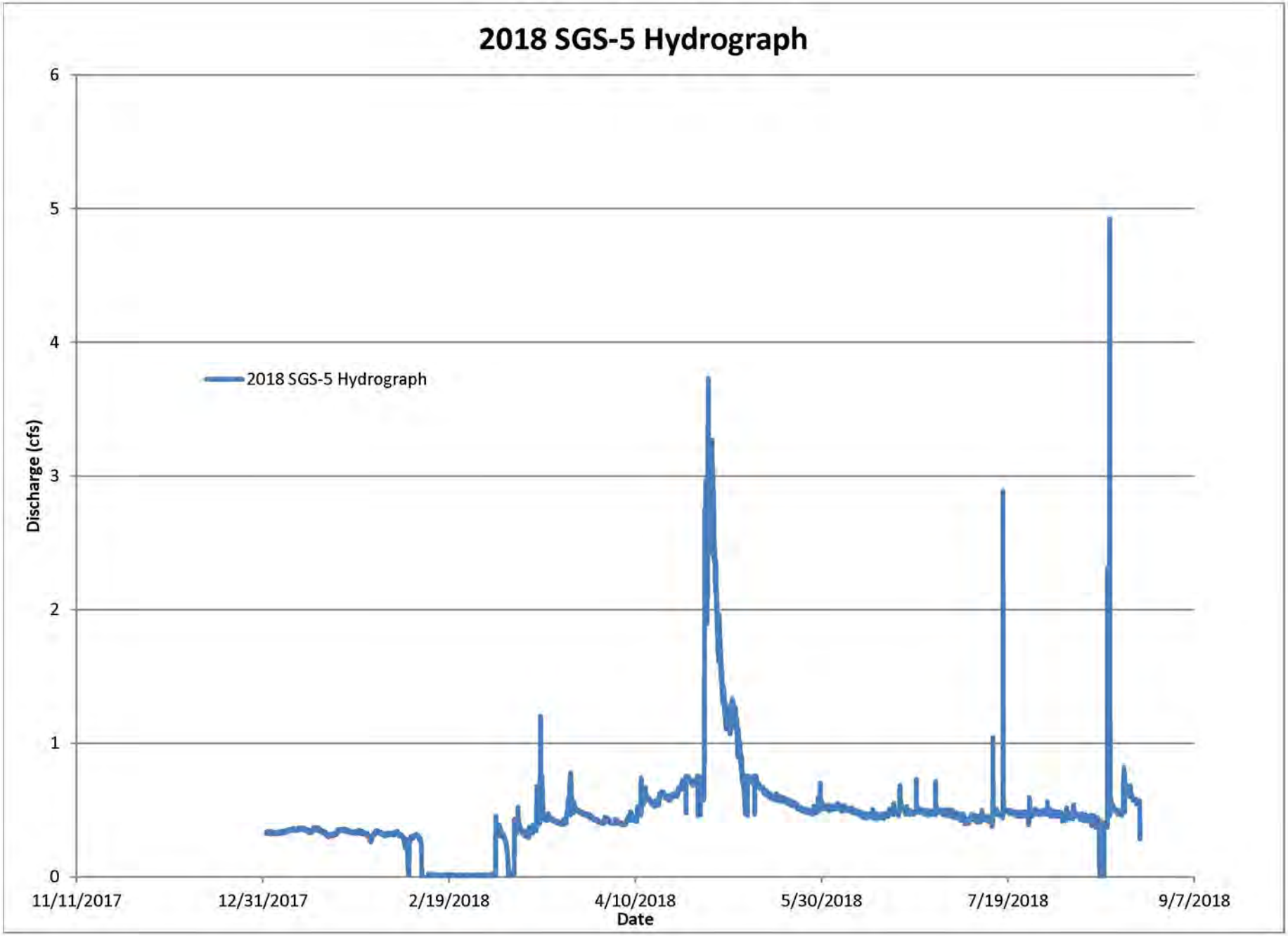
< Less than, where the value following the "<" is the detection limit.

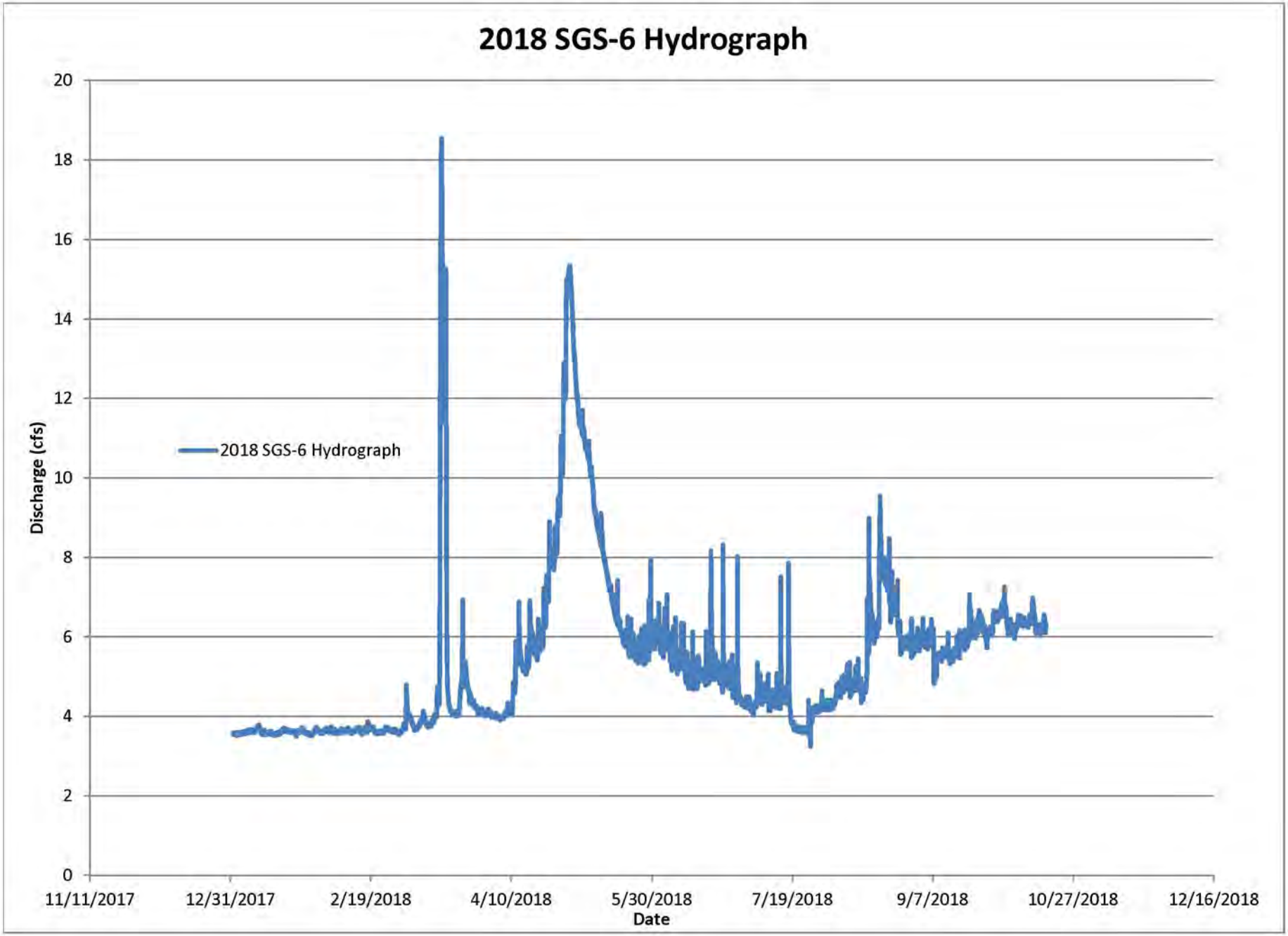

2018 SGS-1 Hydrograph
Discharge (cfs)
60
50
40
30
20
10
0
11/11/2017
12/31/2017
2/19/2018
4/10/2018
5/30/2018
7/19/2018
9/7/2018
10/27/2018
12/16/2018
Date
2018 SGS-1 Hydrograph


2018 SGS-2 Hydrograph
Discharge (cfs)
90
80
70
60
50
40
30
20
10
0
2018 SGS-2 Hydrograph
11/11/2017
12/31/2017
2/19/2018
4/10/2018
5/30/2018
7/19/2018
9/7/2018
10/27/2018
12/16/2018
Date


2018 SGS-3 Hydrograph
25
20
15
10
5
0
Discharge (cfs)
2018 SGS-3 Hydrograph
11/11/2017
12/31/2017
2/19/2018
4/10/2018
5/30/2018
7/19/2018
9/7/2018
10/27/2018
12/16/2018
Date


2018 SGS-4 Hydrograph
Discharge (cfs)
80
70
60
50
40
30
20
10
0
11/11/2017
12/31/2017
2/19/2018
4/10/2018
5/30/2018
7/19/2018
9/7/2018
10/27/2018
12/16/2018
Date
2018 SGS-4 Hydrograph


2018 SGS-5 Hydrograph
2018 SGS-5 Hydrograph
Discharge (cfs)
0
1
2
3
4
5
6
11/11/2017
12/31/2017
2/19/2018
4/10/2018
5/30/2018
7/19/2018
9/7/2018
Date


2018 SGS-6 Hydrograph
Discharge (cfs)
20
18
16
14
12
10
8
6
4
2
0
2018 SGS-6 Hydrograph
11/11/2017
12/31/2017
2/19/2018
4/10/2018
5/30/2018
7/19/2018
9/7/2018
10/27/2018
12/16/2018
Date

Appendix D: Surface Runoff Estimates

Inputs

Basin: Coyote Creek
    Description: RER Plant
    Last Modified Date: 30 April 2014
    Last Modified Time: 17:12:41
    Version: 3.5
    Filepath Separator: \
    Unit System: English
    Missing Flow To Zero: No
    Enable Flow Ratio: No
    Allow Blending: No
    Compute Local Flow At Junctions: No

    Enable Sediment Routing: No

    Enable Quality Routing: No
End:

Subbasin: CC WBranch 1
    Description: Upstream of RER Plant Boundary
    Canvas X: -6258.660508083141
    Canvas Y: 4699.769053117783
    Area: 0.65
    Downstream: Junction-1

    Canopy: None

    Surface: None

    LossRate: SCS
    Percent Impervious Area: 0.0
    Curve Number: 88

    Transform: SCS
    Lag: 38
    Unitgraph Type: STANDARD

    Baseflow: None
End:

Junction: Junction-1
    Description: Upstream of RER Plant Boundary
    Canvas X: -5889.145496535797
    Canvas Y: 4191.685912240185

Downstream: Reach-1
End:

Reach: Reach-1
Description: Upstream of RER Plant Boundary
Canvas X: -5404.157043879908
Canvas Y: 3337.1824480369514
From Canvas X: -5889.145496535797
From Canvas Y: 4191.685912240185
Downstream: Junction-2

Route: Muskingum Cunge
Channel: Trapezoid
Length: 6812
Energy Slope: 0.0051
Width: 6
Side Slope: 3
Mannings n: 0.05
Use Variable Time Step: No
Channel Loss: None
End:

Subbasin: CC WBranch 2
Description: Upstream of RER Plant Boundary
Canvas X: -6966.224366706876
Canvas Y: 3624.8492159227985
Area: 0.54
Downstream: Junction-2

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 44
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Junction-2
    Description: Upstream of RER Plant Boundary
    Canvas X: -5404.157043879908
    Canvas Y: 3337.1824480369514
    Downstream: Reach-2
End:

Reach: Reach-2
    Description: Junction 2 to Junction 4
    Canvas X: -4157.043879907622
    Canvas Y: 2124.7113163972285
    From Canvas X: -5404.157043879908
    From Canvas Y: 3337.1824480369514
    Label X: 82.0
    Label Y: -41.0
    Downstream: Junction-4

    Route: Muskingum Cunge
    Channel: Trapezoid
    Length: 3378
    Energy Slope: 0.0021
    Width: 6
    Side Slope: 3
    Mannings n: 0.05
    Use Variable Time Step: No
    Channel Loss: None
End:

Subbasin: CC EBranch 2
    Description: Upstream of RER Plant Boundary
    Canvas X: -2240.1847575057736
    Canvas Y: 4064.6651270207853
    Area: 0.64
    Downstream: Junction-3

    Canopy: None

    Surface: None

    LossRate: SCS
    Percent Impervious Area: 0.0
    Curve Number: 88

Transform: SCS
Lag: 38
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: CC EBranch 1
Description: Upstream of RER Plant Boundary
Canvas X: -3854.0410132689985
Canvas Y: 4143.546441495778
Area: 0.53
Downstream: Junction-3

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 62
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Junction-3
Description: Upstream of RER Plant Boundary
Canvas X: -3256.35103926097
Canvas Y: 3533.487297921478
Downstream: Reach-3
End:

Reach: Reach-3
Description: Junction 3 to Junction 4
Canvas X: -4157.043879907622
Canvas Y: 2124.7113163972285
From Canvas X: -3256.35103926097
From Canvas Y: 3533.487297921478

Downstream: Junction-4

Route: Muskingum Cunge
Channel: Trapezoid
Length: 4719
Energy Slope: 0.0021
Width: 6
Side Slope: 3
Mannings n: 0.05
Use Variable Time Step: No
Channel Loss: None
End:

Subbasin: CC WBranch 3
Description: Upstream of RER Plant Boundary
Canvas X: -6194.209891435465
Canvas Y: 2430.6393244873343
Area: 0.47
Downstream: Junction-4

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 32
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: CC EBranch 3
Description: Upstream of RER Plant Boundary
Canvas X: -3033.775633293125
Canvas Y: 2454.764776839566
Area: 0.21
Downstream: Junction-4

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 51
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Junction-4
Description: Upstream of RER Plant Boundary
Canvas X: -4157.043879907622
Canvas Y: 2124.7113163972285
Downstream: Reach-4
End:

Reach: Reach-4
Description: Junction 4 to Junction 5
Canvas X: -3764.4341801385685
Canvas Y: 1062.355658198614
From Canvas X: -4157.043879907622
From Canvas Y: 2124.7113163972285
Label X: -1.0
Label Y: 0.0
Downstream: Junction-5

Route: Muskingum Cunge
Channel: Trapezoid
Length: 260
Energy Slope: 0.0038
Width: 6
Side Slope: 3
Mannings n: 0.05
Use Variable Time Step: No
Channel Loss: None
End:

Subbasin: CC 1

Description: Upstream of RER Plant Boundary
Canvas X: -4792.147806004619
Canvas Y: 1374.1339491916856
Area: 0.30
Downstream: Junction-5

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 29
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Junction-5
Description: Coyote Creek Enters the Permit Boundary
Canvas X: -3764.4341801385685
Canvas Y: 1062.355658198614
Downstream: Reach-5
End:

Reach: Reach-5
Description: Junction 5 to Junction 6
Canvas X: -3071.5935334872984
Canvas Y: -34.64203233256376
From Canvas X: -3764.4341801385685
From Canvas Y: 1062.355658198614
Downstream: Junction-6

Route: Muskingum Cunge
Channel: Trapezoid
Length: 880
Energy Slope: 0.0034
Width: 12
Side Slope: 3
Mannings n: 0.05

Use Variable Time Step: No
Channel Loss: None
End:

Subbasin: CC Sub 1
Description: Within RER Plant Boundary
Canvas X: -4553.6791314837155
Canvas Y: 319.66224366706865
Area: 0.35
Downstream: Junction-6

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 26
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: CC 2
Description: Within RER Plant Boundary
Canvas X: -2201.447527141134
Canvas Y: 331.7249698431842
Label X: 0.0
Label Y: 2.0
Area: 0.03
Downstream: Junction-6

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 16
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Junction-6
Description: Within RER Plant Boundary
Canvas X: -3071.5935334872984
Canvas Y: -34.64203233256376
Downstream: Reach-6
End:

Reach: Reach-6
Description: Junction 6 to Junction 7
Canvas X: -2193.9953810623556
Canvas Y: -1085.4503464203235
From Canvas X: -3071.5935334872984
From Canvas Y: -34.64203233256376
Label X: -3.0
Label Y: 0.0
Downstream: Junction-7

Route: Muskingum Cunge
Channel: Trapezoid
Length: 2618
Energy Slope: 0.0038
Width: 12
Side Slope: 3
Mannings n: 0.05
Use Variable Time Step: No
Channel Loss: None
End:

Subbasin: CC Sub 2
Description: Within RER Permit Boundary
Canvas X: -1344.9939686369125
Canvas Y: -597.1049457177323
Area: 0.12
Downstream: Junction-7

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 34
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: CC 3
Description: Within RER Permit Boundary
Canvas X: -3311.2183353437877
Canvas Y: -657.4185765983111
Area: 0.06
Downstream: Junction-7

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 31
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Junction-7
Description: Within RER Permit Boundary
Canvas X: -2193.9953810623556
Canvas Y: -1085.4503464203235
Downstream: Reach-7
End:

Reach: Reach-7
    Description: Junction 7 to Junction 8
    Canvas X: -1824.4803695150122
    Canvas Y: -2159.3533487297927
    From Canvas X: -2193.9953810623556
    From Canvas Y: -1085.4503464203235
    Label X: -1.0
    Label Y: 0.0
    Downstream: Junction-8

    Route: Muskingum Cunge
    Channel: Trapezoid
    Length: 1484
    Energy Slope: 0.0034
    Width: 12
    Side Slope: 3
    Mannings n: 0.05
    Use Variable Time Step: No
    Channel Loss: None
End:

Subbasin: CC Sub 3
    Description: Within RER Permit Boundary
    Canvas X: -2997.5874547647772
    Canvas Y: -1731.0012062726173
    Area: 0.22
    Downstream: Junction-8

    Canopy: None

    Surface: None

    LossRate: SCS
    Percent Impervious Area: 0.0
    Curve Number: 88

    Transform: SCS
    Lag: 26
    Unitgraph Type: STANDARD

    Baseflow: None
End:

Subbasin: CC 4
    Description: Within RER Permit Boundary
    Canvas X: -874.5476477683951
    Canvas Y: -1718.9384800965017
    Label X: 0.0
    Label Y: 3.0
    Area: 0.05
    Downstream: Junction-8

    Canopy: None

    Surface: None

    LossRate: SCS
    Percent Impervious Area: 0.0
    Curve Number: 88

    Transform: SCS
    Lag: 24
    Unitgraph Type: STANDARD

    Baseflow: None
End:

Junction: Junction-8
    Description: Within RER Permit Boundary
    Canvas X: -1824.4803695150122
    Canvas Y: -2159.3533487297927
    Downstream: Reach-8
End:

Reach: Reach-8
    Description: Junction 8 to Junction 9
    Canvas X: -854.5034642032333
    Canvas Y: -3348.7297921478057
    From Canvas X: -1824.4803695150122
    From Canvas Y: -2159.3533487297927
    Downstream: Junction-9

    Route: Muskingum Cunge
    Channel: Trapezoid
    Length: 3905
    Energy Slope: 0.0038

Width: 12
Side Slope: 3
Mannings n: 0.05
Use Variable Time Step: No
Channel Loss: None
End:

Subbasin: CC 5
Description: Within RER Permit Boundary
Canvas X: -2515.078407720145
Canvas Y: -2840.772014475271
Area: 0.31
Downstream: Junction-9

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 37
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: Junction-9
Description: Outfall of Coyote Creek from RER Permit Boundary
Canvas X: -854.5034642032333
Canvas Y: -3348.7297921478057
End:

Subbasin: UBC Sub 1
Description: Subbasin 1 to Beaver Creek at Upton Plant
Canvas X: -5868.516284680338
Canvas Y: -2285.8866103739447
Area: 0.05
Downstream: UBC Sub 1 Outfall

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 14
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: UBC Sub 1 Outfall
Description: UBC Sub 1 Outfall
Canvas X: -5759.951749095296
Canvas Y: -3480.0965018094084
End:

Subbasin: UBC Sub 2
Description: Subbasin 2 to Beaver Creek at Upton Plant
Canvas X: -4034.981905910736
Canvas Y: -2310.012062726176
Area: 0.15
Downstream: UBC Sub 2 Outfall

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 0.0
Curve Number: 88

Transform: SCS
Lag: 20
Unitgraph Type: STANDARD

Baseflow: None
End:

Junction: UBC Sub 2 Outfall

Description: UBC Sub 2 Outfall
Canvas X: -3781.664656212304
Canvas Y: -3492.159227985525
End:

Basin Schematic Properties:
Last View N: 4568.548387096775
Last View S: 3441.532258064516
Last View W: -3606.8548387096776
Last View E: -3274.1935483870966
Maximum View N: 5000.0
Maximum View S: -5000.0
Maximum View W: -5000.0
Maximum View E: 5000.0
Extent Method: Elements
Buffer: 0
Draw Icons: Yes
Draw Icon Labels: Yes
Draw Map Objects: No
Draw Gridlines: No
Draw Flow Direction: No
Fix Element Locations: No
Fix Hydrologic Order: No
End:

Results

Demonstration Plant Site: 2-Year, 24-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	142.0	02May2014, 12:35	23.2
Junction-1	0.65	142.0	02May2014, 12:35	23.2
Reach-1	0.65	138.7	02May2014, 13:00	23.2
CC WBranch 2	0.54	106.7	02May2014, 12:40	19.3
Junction-2	1.19	228.8	02May2014, 12:55	42.5
Reach-2	1.19	213.5	02May2014, 13:15	42.4
CC EBranch 2	0.64	139.9	02May2014, 12:35	22.9
CC EBranch 1	0.53	81.7	02May2014, 13:00	18.9
Junction-3	1.17	205.6	02May2014, 12:40	41.8
Reach-3	1.17	192.5	02May2014, 13:05	41.6
CC WBranch 3	0.47	115.6	02May2014, 12:25	16.8
CC EBranch 3	0.21	37.2	02May2014, 12:50	7.5
Junction-4	3.04	477.2	02May2014, 13:10	108.3
Reach-4	3.04	476.8	02May2014, 13:10	108.3
CC 1	0.30	78.6	02May2014, 12:25	10.7
Junction-5	3.34	502.5	02May2014, 13:10	119.0
Reach-5	3.34	500.4	02May2014, 13:10	119.0
CC Sub 1	0.35	98.9	02May2014, 12:20	12.5
CC 2	0.03	11.4	02May2014, 12:10	1.1
Junction-6	3.72	528.7	02May2014, 13:10	132.6
Reach-6	3.72	523.0	02May2014, 13:20	132.5
CC Sub 2	0.12	28.3	02May2014, 12:30	4.3
CC 3	0.06	15.1	02May2014, 12:25	2.1
Junction-7	3.90	538.5	02May2014, 13:15	138.9
Reach-7	3.90	535.5	02May2014, 13:20	138.9
CC Sub 3	0.22	62.2	02May2014, 12:20	7.9
CC 4	0.05	14.7	02May2014, 12:20	1.8
Junction-8	4.17	552.1	02May2014, 13:20	148.5
Reach-8	4.17	546.5	02May2014, 13:35	148.5
CC 5	0.31	69.0	02May2014, 12:30	11.1
Junction-9	4.48	568.3	02May2014, 13:30	159.5
UBC Sub 1	0.05	19.8	02May2014, 12:05	1.8
UBC Sub 1 Outfall	0.05	19.8	02May2014, 12:05	1.8
UBC Sub 2	0.15	49.8	02May2014, 12:15	5.4
UBC Sub 2 Outfall	0.15	49.8	02May2014, 12:15	5.4

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 2-Year, 6-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	68.6	02May2014, 05:00	9.9
Junction-1	0.65	68.6	02May2014, 05:00	9.9
Reach-1	0.65	66.7	02May2014, 05:35	9.9
CC WBranch 2	0.54	51.7	02May2014, 05:05	8.2
Junction-2	1.19	107.1	02May2014, 05:30	18.1
Reach-2	1.19	101.0	02May2014, 05:50	18.1
CC EBranch 2	0.64	67.5	02May2014, 05:00	9.7
CC EBranch 1	0.53	40.7	02May2014, 05:30	8.1
Junction-3	1.17	100.8	02May2014, 05:05	17.8
Reach-3	1.17	94.9	02May2014, 05:40	17.7
CC WBranch 3	0.47	55.2	02May2014, 04:55	7.2
CC EBranch 3	0.21	18.3	02May2014, 05:15	3.2
Junction-4	3.04	228.4	02May2014, 05:45	46.2
Reach-4	3.04	228.0	02May2014, 05:45	46.2
CC 1	0.30	37.4	02May2014, 04:50	4.6
Junction-5	3.34	241.2	02May2014, 05:45	50.7
Reach-5	3.34	239.8	02May2014, 05:45	50.7
CC Sub 1	0.35	46.5	02May2014, 04:50	5.3
CC 2	0.03	5.2	02May2014, 04:40	0.5
Junction-6	3.72	255.2	02May2014, 05:45	56.5
Reach-6	3.72	253.4	02May2014, 05:55	56.5
CC Sub 2	0.12	13.6	02May2014, 04:55	1.8
CC 3	0.06	7.2	02May2014, 04:55	0.9
Junction-7	3.90	261.1	02May2014, 05:55	59.3
Reach-7	3.90	259.6	02May2014, 06:00	59.2
CC Sub 3	0.22	29.2	02May2014, 04:50	3.4
CC 4	0.05	7.0	02May2014, 04:45	0.8
Junction-8	4.17	269.3	02May2014, 06:00	63.4
Reach-8	4.17	267.4	02May2014, 06:15	63.3
CC 5	0.31	33.3	02May2014, 05:00	4.7
Junction-9	4.48	278.8	02May2014, 06:15	68.1
UBC Sub 1	0.05	9	02May2014, 04:40	0.8
UBC Sub 1 Outfall	0.05	9	02May2014, 04:40	0.8
UBC Sub 2	0.15	23	02May2014, 04:45	2.3
UBC Sub 2 Outfall	0.15	23	02May2014, 04:45	2.3

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 5-Year, 24-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	236.9	02May2014, 12:30	37.7
Junction-1	0.65	236.9	02May2014, 12:30	37.7
Reach-1	0.65	230.9	02May2014, 12:55	37.7
CC WBranch 2	0.54	177.9	02May2014, 12:40	31.3
Junction-2	1.19	387.9	02May2014, 12:50	69.0
Reach-2	1.19	363.4	02May2014, 13:10	68.8
CC EBranch 2	0.64	233.3	02May2014, 12:30	37.1
CC EBranch 1	0.53	136.4	02May2014, 13:00	30.7
Junction-3	1.17	343.5	02May2014, 12:40	67.9
Reach-3	1.17	323.0	02May2014, 13:00	67.6
CC WBranch 3	0.47	193.0	02May2014, 12:25	27.3
CC EBranch 3	0.21	62.3	02May2014, 12:45	12.2
Junction-4	3.04	819.5	02May2014, 13:00	175.9
Reach-4	3.04	817.6	02May2014, 13:05	175.9
CC 1	0.30	130.8	02May2014, 12:20	17.4
Junction-5	3.34	867.9	02May2014, 13:00	193.3
Reach-5	3.34	864.0	02May2014, 13:05	193.3
CC Sub 1	0.35	164.5	02May2014, 12:20	20.3
CC 2	0.03	18.8	02May2014, 12:10	1.7
Junction-6	3.72	913.9	02May2014, 13:00	215.3
Reach-6	3.72	908.1	02May2014, 13:10	215.2
CC Sub 2	0.12	47.1	02May2014, 12:30	7.0
CC 3	0.06	25.2	02May2014, 12:25	3.5
Junction-7	3.90	936.0	02May2014, 13:10	225.7
Reach-7	3.90	931.8	02May2014, 13:10	225.6
CC Sub 3	0.22	103.4	02May2014, 12:20	12.8
CC 4	0.05	24.6	02May2014, 12:15	2.9
Junction-8	4.17	963.4	02May2014, 13:10	241.3
Reach-8	4.17	955.0	02May2014, 13:20	241.1
CC 5	0.31	115.4	02May2014, 12:30	18.0
Junction-9	4.48	998.8	02May2014, 13:20	259.1
UBC Sub 1	0.05	33.0	02May2014, 12:05	2.9
UBC Sub 1 Outfall	0.05	33.0	02May2014, 12:05	2.9
UBC Sub 2	0.15	82.3	02May2014, 12:15	8.7
UBC Sub 2 Outfall	0.15	82.3	02May2014, 12:15	8.7

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 5-Year, 6-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	140.6	02May2014, 05:00	22.3
Junction-1	0.65	140.6	02May2014, 05:00	22.3
Reach-1	0.65	136.4	02May2014, 05:30	22.2
CC WBranch 2	0.54	106.3	02May2014, 05:05	18.5
Junction-2	1.19	226.3	02May2014, 05:25	40.7
Reach-2	1.19	213.9	02May2014, 05:40	40.6
CC EBranch 2	0.64	138.5	02May2014, 05:00	21.9
CC EBranch 1	0.53	83.9	02May2014, 05:25	18.2
Junction-3	1.17	208.0	02May2014, 05:05	40.1
Reach-3	1.17	195.9	02May2014, 05:30	39.9
CC WBranch 3	0.47	113.0	02May2014, 04:55	16.1
CC EBranch 3	0.21	37.6	02May2014, 05:15	7.2
Junction-4	3.04	487.5	02May2014, 05:35	103.8
Reach-4	3.04	486.5	02May2014, 05:35	103.8
CC 1	0.30	76.7	02May2014, 04:50	10.3
Junction-5	3.34	515.9	02May2014, 05:35	114.1
Reach-5	3.34	512.4	02May2014, 05:35	114.1
CC Sub 1	0.35	94.8	02May2014, 04:50	12.0
CC 2	0.03	10.6	02May2014, 04:40	1.0
Junction-6	3.72	546.0	02May2014, 05:35	127.1
Reach-6	3.72	542.6	02May2014, 05:45	127.0
CC Sub 2	0.12	27.8	02May2014, 04:55	4.1
CC 3	0.06	14.7	02May2014, 04:55	2.1
Junction-7	3.90	559.4	02May2014, 05:45	133.2
Reach-7	3.90	556.6	02May2014, 05:50	133.2
CC Sub 3	0.22	59.6	02May2014, 04:50	7.5
CC 4	0.05	14.3	02May2014, 04:45	1.7
Junction-8	4.17	577.2	02May2014, 05:45	142.4
Reach-8	4.17	573.7	02May2014, 06:00	142.4
CC 5	0.31	68.2	02May2014, 05:00	10.6
Junction-9	4.48	600.3	02May2014, 05:55	153.0
UBC Sub 1	0.05	18.3	02May2014, 04:35	1.7
UBC Sub 1 Outfall	0.05	18.3	02May2014, 04:35	1.7
UBC Sub 2	0.15	46.7	02May2014, 04:40	5.1
UBC Sub 2 Outfall	0.15	46.7	02May2014, 04:40	5.1

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 10-Year, 24-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	305.4	02May2014, 12:30	48.2
Junction-1	0.65	305.4	02May2014, 12:30	48.2
Reach-1	0.65	297.9	02May2014, 12:55	48.1
CC WBranch 2	0.54	228.9	02May2014, 12:40	40.0
Junction-2	1.19	504.8	02May2014, 12:50	88.2
Reach-2	1.19	476.9	02May2014, 13:05	88.0
CC EBranch 2	0.64	300.7	02May2014, 12:30	47.4
CC EBranch 1	0.53	175.6	02May2014, 13:00	39.3
Junction-3	1.17	442.4	02May2014, 12:40	86.7
Reach-3	1.17	416.8	02May2014, 13:00	86.5
CC WBranch 3	0.47	248.5	02May2014, 12:25	34.8
CC EBranch 3	0.21	80.3	02May2014, 12:45	15.6
Junction-4	3.04	1073.4	02May2014, 13:00	224.9
Reach-4	3.04	1070.9	02May2014, 13:00	224.9
CC 1	0.30	168.6	02May2014, 12:20	22.2
Junction-5	3.34	1136.6	02May2014, 13:00	247.1
Reach-5	3.34	1130.4	02May2014, 13:00	247.1
CC Sub 1	0.35	211.4	02May2014, 12:20	25.9
CC 2	0.03	24.1	02May2014, 12:10	2.2
Junction-6	3.72	1201.6	02May2014, 13:00	275.3
Reach-6	3.72	1192.2	02May2014, 13:05	275.2
CC Sub 2	0.12	60.6	02May2014, 12:25	8.9
CC 3	0.06	32.4	02May2014, 12:25	4.4
Junction-7	3.90	1232.0	02May2014, 13:05	288.5
Reach-7	3.90	1225.9	02May2014, 13:10	288.5
CC Sub 3	0.22	132.9	02May2014, 12:20	16.3
CC 4	0.05	31.7	02May2014, 12:15	3.7
Junction-8	4.17	1267.0	02May2014, 13:05	308.5
Reach-8	4.17	1256.9	02May2014, 13:15	308.3
CC 5	0.31	148.6	02May2014, 12:30	23.0
Junction-9	4.48	1318.3	02May2014, 13:15	331.3
UBC Sub 1	0.05	42.5	02May2014, 12:05	3.7
UBC Sub 1 Outfall	0.05	42.5	02May2014, 12:05	3.7
UBC Sub 2	0.15	105.5	02May2014, 12:15	11.1
UBC Sub 2 Outfall	0.15	105.5	02May2014, 12:15	11.1

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 10-Year, 6-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	190.9	02May2014, 05:00	31.5
Junction-1	0.65	190.9	02May2014, 05:00	31.5
Reach-1	0.65	185.9	02May2014, 05:25	31.5
CC WBranch 2	0.54	144.4	02May2014, 05:05	26.2
Junction-2	1.19	311.8	02May2014, 05:20	57.6
Reach-2	1.19	294.3	02May2014, 05:35	57.5
CC EBranch 2	0.64	187.9	02May2014, 05:00	31.0
CC EBranch 1	0.53	114.1	02May2014, 05:25	25.7
Junction-3	1.17	282.9	02May2014, 05:05	56.7
Reach-3	1.17	267.2	02May2014, 05:30	56.4
CC WBranch 3	0.47	153.3	02May2014, 04:55	22.8
CC EBranch 3	0.21	51.1	02May2014, 05:15	10.2
Junction-4	3.04	672.5	02May2014, 05:30	146.9
Reach-4	3.04	670.6	02May2014, 05:30	146.9
CC 1	0.30	104.1	02May2014, 04:50	14.5
Junction-5	3.34	713.8	02May2014, 05:30	161.5
Reach-5	3.34	710.0	02May2014, 05:35	161.4
CC Sub 1	0.35	128.4	02May2014, 04:50	17.0
CC 2	0.03	14.3	02May2014, 04:40	1.5
Junction-6	3.72	755.7	02May2014, 05:30	179.8
Reach-6	3.72	751.6	02May2014, 05:40	179.8
CC Sub 2	0.12	37.8	02May2014, 04:55	5.8
CC 3	0.06	19.9	02May2014, 04:55	2.9
Junction-7	3.90	775.7	02May2014, 05:40	188.5
Reach-7	3.90	773.1	02May2014, 05:45	188.5
CC Sub 3	0.22	80.7	02May2014, 04:50	10.7
CC 4	0.05	19.3	02May2014, 04:45	2.4
Junction-8	4.17	802.5	02May2014, 05:40	201.6
Reach-8	4.17	797.5	02May2014, 05:50	201.5
CC 5	0.31	92.5	02May2014, 05:00	15.0
Junction-9	4.48	836.8	02May2014, 05:50	216.5
UBC Sub 1	0.05	24.8	02May2014, 04:35	2.4
UBC Sub 1 Outfall	0.05	24.8	02May2014, 04:35	2.4
UBC Sub 2	0.15	63.3	02May2014, 04:40	7.3
UBC Sub 2 Outfall	0.15	63.3	02May2014, 04:40	7.3

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 25-Year, 24-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	405.4	02May2014, 12:30	63.6
Junction-1	0.65	405.4	02May2014, 12:30	63.6
Reach-1	0.65	393.4	02May2014, 12:55	63.6
CC WBranch 2	0.54	303.2	02May2014, 12:40	52.9
Junction-2	1.19	672.1	02May2014, 12:50	116.5
Reach-2	1.19	632.0	02May2014, 13:00	116.2
CC EBranch 2	0.64	399.1	02May2014, 12:30	62.7
CC EBranch 1	0.53	233.3	02May2014, 12:55	51.9
Junction-3	1.17	588.0	02May2014, 12:35	114.6
Reach-3	1.17	555.2	02May2014, 12:55	114.3
CC WBranch 3	0.47	329.3	02May2014, 12:25	46.0
CC EBranch 3	0.21	106.6	02May2014, 12:45	20.6
Junction-4	3.04	1436.9	02May2014, 12:55	297.1
Reach-4	3.04	1432.4	02May2014, 12:55	297.1
CC 1	0.30	223.8	02May2014, 12:20	29.4
Junction-5	3.34	1530.5	02May2014, 12:55	326.5
Reach-5	3.34	1519.0	02May2014, 13:00	326.4
CC Sub 1	0.35	279.6	02May2014, 12:20	34.3
CC 2	0.03	31.8	02May2014, 12:10	2.9
Junction-6	3.72	1622.9	02May2014, 12:55	363.6
Reach-6	3.72	1609.0	02May2014, 13:00	363.5
CC Sub 2	0.12	80.5	02May2014, 12:25	11.8
CC 3	0.06	42.9	02May2014, 12:25	5.9
Junction-7	3.90	1667.8	02May2014, 13:00	381.1
Reach-7	3.90	1660.0	02May2014, 13:05	381.1
CC Sub 3	0.22	175.8	02May2014, 12:20	21.5
CC 4	0.05	42.0	02May2014, 12:15	4.9
Junction-8	4.17	1718.3	02May2014, 13:00	407.5
Reach-8	4.17	1707.8	02May2014, 13:10	407.3
CC 5	0.31	197.1	02May2014, 12:30	30.4
Junction-9	4.48	1797.1	02May2014, 13:10	437.7
UBC Sub 1	0.05	56.3	02May2014, 12:05	4.9
UBC Sub 1 Outfall	0.05	56.3	02May2014, 12:05	4.9
UBC Sub 2	0.15	139.2	02May2014, 12:15	14.7
UBC Sub 2 Outfall	0.15	139.2	02May2014, 12:15	14.7

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 25-Year, 6-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	256.0	02May2014, 05:00	44.0
Junction-1	0.65	256.0	02May2014, 05:00	44.0
Reach-1	0.65	249.1	02May2014, 05:25	44.0
CC WBranch 2	0.54	193.8	02May2014, 05:05	36.6
Junction-2	1.19	421.9	02May2014, 05:20	80.5
Reach-2	1.19	401.6	02May2014, 05:35	80.3
CC EBranch 2	0.64	252.0	02May2014, 05:00	43.4
CC EBranch 1	0.53	153.3	02May2014, 05:25	35.9
Junction-3	1.17	380.2	02May2014, 05:05	79.3
Reach-3	1.17	358.3	02May2014, 05:30	78.9
CC WBranch 3	0.47	205.4	02May2014, 04:55	31.8
CC EBranch 3	0.21	68.5	02May2014, 05:15	14.2
Junction-4	3.04	915.2	02May2014, 05:30	205.3
Reach-4	3.04	914.1	02May2014, 05:30	205.3
CC 1	0.30	139.6	02May2014, 04:50	20.3
Junction-5	3.34	971.2	02May2014, 05:30	225.6
Reach-5	3.34	968.6	02May2014, 05:30	225.6
CC Sub 1	0.35	171.9	02May2014, 04:50	23.7
CC 2	0.03	19.1	02May2014, 04:40	2.0
Junction-6	3.72	1032.8	02May2014, 05:30	251.3
Reach-6	3.72	1026.6	02May2014, 05:35	251.3
CC Sub 2	0.12	50.6	02May2014, 04:55	8.1
CC 3	0.06	26.6	02May2014, 04:55	4.1
Junction-7	3.90	1061.5	02May2014, 05:35	263.5
Reach-7	3.90	1055.4	02May2014, 05:40	263.5
CC Sub 3	0.22	108.1	02May2014, 04:50	14.9
CC 4	0.05	25.9	02May2014, 04:45	3.4
Junction-8	4.17	1096.8	02May2014, 05:35	281.7
Reach-8	4.17	1090.8	02May2014, 05:45	281.6
CC 5	0.31	124.0	02May2014, 05:00	21.0
Junction-9	4.48	1146.7	02May2014, 05:45	302.6
UBC Sub 1	0.05	33.2	02May2014, 04:35	3.4
UBC Sub 1 Outfall	0.05	33.2	02May2014, 04:35	3.4
UBC Sub 2	0.15	84.9	02May2014, 04:40	10.2
UBC Sub 2 Outfall	0.15	84.9	02May2014, 04:40	10.2

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 50-Year, 24-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	483.2	02May2014, 12:30	75.8
Junction-1	0.65	483.2	02May2014, 12:30	75.8
Reach-1	0.65	470.8	02May2014, 12:50	75.7
CC WBranch 2	0.54	361.5	02May2014, 12:35	63.0
Junction-2	1.19	803.3	02May2014, 12:45	138.7
Reach-2	1.19	762.7	02May2014, 13:00	138.5
CC EBranch 2	0.64	475.7	02May2014, 12:30	74.6
CC EBranch 1	0.53	278.3	02May2014, 12:55	61.8
Junction-3	1.17	701.7	02May2014, 12:35	136.5
Reach-3	1.17	664.2	02May2014, 12:55	136.1
CC WBranch 3	0.47	392.2	02May2014, 12:25	54.8
CC EBranch 3	0.21	127.0	02May2014, 12:45	24.5
Junction-4	3.04	1731.0	02May2014, 12:55	354.0
Reach-4	3.04	1726.5	02May2014, 12:55	354.0
CC 1	0.30	266.7	02May2014, 12:20	35.0
Junction-5	3.34	1842.1	02May2014, 12:55	389.0
Reach-5	3.34	1831.5	02May2014, 12:55	388.9
CC Sub 1	0.35	332.7	02May2014, 12:20	40.8
CC 2	0.03	37.8	02May2014, 12:10	3.5
Junction-6	3.72	1956.9	02May2014, 12:55	433.2
Reach-6	3.72	1943.2	02May2014, 13:00	433.1
CC Sub 2	0.12	96.0	02May2014, 12:25	14.0
CC 3	0.06	51.0	02May2014, 12:25	7.0
Junction-7	3.90	2012.5	02May2014, 13:00	454.0
Reach-7	3.90	2000.8	02May2014, 13:00	454.0
CC Sub 3	0.22	209.1	02May2014, 12:20	25.7
CC 4	0.05	50.1	02May2014, 12:15	5.8
Junction-8	4.17	2078.6	02May2014, 13:00	485.5
Reach-8	4.17	2062.9	02May2014, 13:10	485.2
CC 5	0.31	234.8	02May2014, 12:30	36.2
Junction-9	4.48	2178.3	02May2014, 13:05	521.4
UBC Sub 1	0.05	67.0	02May2014, 12:05	5.8
UBC Sub 1 Outfall	0.05	67.0	02May2014, 12:05	5.8
UBC Sub 2	0.15	165.8	02May2014, 12:10	17.5
UBC Sub 2 Outfall	0.15	165.8	02May2014, 12:10	17.5

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 50-Year, 6-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	303.8	02May2014, 05:00	53.5
Junction-1	0.65	303.8	02May2014, 05:00	53.5
Reach-1	0.65	294.8	02May2014, 05:25	53.5
CC WBranch 2	0.54	230.1	02May2014, 05:05	44.5
Junction-2	1.19	502.0	02May2014, 05:20	97.9
Reach-2	1.19	478.0	02May2014, 05:35	97.7
CC EBranch 2	0.64	299.1	02May2014, 05:00	52.7
CC EBranch 1	0.53	182.2	02May2014, 05:25	43.7
Junction-3	1.17	451.8	02May2014, 05:05	96.4
Reach-3	1.17	426.3	02May2014, 05:25	96.0
CC WBranch 3	0.47	243.6	02May2014, 04:55	38.7
CC EBranch 3	0.21	81.4	02May2014, 05:15	17.3
Junction-4	3.04	1094.1	02May2014, 05:25	249.7
Reach-4	3.04	1091.4	02May2014, 05:30	249.7
CC 1	0.30	165.7	02May2014, 04:50	24.7
Junction-5	3.34	1165.5	02May2014, 05:25	274.4
Reach-5	3.34	1159.8	02May2014, 05:30	274.4
CC Sub 1	0.35	203.9	02May2014, 04:50	28.8
CC 2	0.03	22.6	02May2014, 04:40	2.5
Junction-6	3.72	1241.0	02May2014, 05:25	305.7
Reach-6	3.72	1231.2	02May2014, 05:35	305.6
CC Sub 2	0.12	60.1	02May2014, 04:55	9.9
CC 3	0.06	31.6	02May2014, 04:50	4.9
Junction-7	3.90	1276.4	02May2014, 05:30	320.4
Reach-7	3.90	1271.8	02May2014, 05:35	320.3
CC Sub 3	0.22	128.2	02May2014, 04:50	18.1
CC 4	0.05	30.8	02May2014, 04:45	4.1
Junction-8	4.17	1321.4	02May2014, 05:35	342.6
Reach-8	4.17	1313.5	02May2014, 05:45	342.4
CC 5	0.31	147.1	02May2014, 05:00	25.5
Junction-9	4.48	1383.6	02May2014, 05:40	368.0
UBC Sub 1	0.05	39.4	02May2014, 04:35	4.1
UBC Sub 1 Outfall	0.05	39.4	02May2014, 04:35	4.1
UBC Sub 2	0.15	100.7	02May2014, 04:40	12.4
UBC Sub 2 Outfall	0.15	100.7	02May2014, 04:40	12.4

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 100-Year, 24-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	561.7	02May2014, 12:30	88.2
Junction-1	0.65	561.7	02May2014, 12:30	88.2
Reach-1	0.65	548.3	02May2014, 12:50	88.1
CC WBranch 2	0.54	420.4	02May2014, 12:35	73.3
Junction-2	1.19	938.6	02May2014, 12:45	161.4
Reach-2	1.19	887.8	02May2014, 13:00	161.1
CC EBranch 2	0.64	553.1	02May2014, 12:30	86.8
CC EBranch 1	0.53	323.8	02May2014, 12:55	71.9
Junction-3	1.17	816.6	02May2014, 12:35	158.7
Reach-3	1.17	772.7	02May2014, 12:55	158.4
CC WBranch 3	0.47	455.7	02May2014, 12:25	63.8
CC EBranch 3	0.21	147.7	02May2014, 12:45	28.5
Junction-4	3.04	2021.7	02May2014, 12:55	411.7
Reach-4	3.04	2018.6	02May2014, 12:55	411.7
CC 1	0.30	310.0	02May2014, 12:20	40.7
Junction-5	3.34	2151.8	02May2014, 12:50	452.4
Reach-5	3.34	2146.5	02May2014, 12:55	452.3
CC Sub 1	0.35	386.1	02May2014, 12:20	47.5
CC 2	0.03	43.8	02May2014, 12:10	4.1
Junction-6	3.72	2295.2	02May2014, 12:50	503.9
Reach-6	3.72	2277.5	02May2014, 13:00	503.7
CC Sub 2	0.12	111.6	02May2014, 12:25	16.3
CC 3	0.06	59.2	02May2014, 12:25	8.1
Junction-7	3.90	2367.0	02May2014, 12:55	528.1
Reach-7	3.90	2355.1	02May2014, 13:00	528.0
CC Sub 3	0.22	242.7	02May2014, 12:20	29.8
CC 4	0.05	58.2	02May2014, 12:15	6.8
Junction-8	4.17	2447.6	02May2014, 12:55	564.6
Reach-8	4.17	2431.8	02May2014, 13:05	564.3
CC 5	0.31	272.8	02May2014, 12:30	42.1
Junction-9	4.48	2568.6	02May2014, 13:05	606.4
UBC Sub 1	0.05	77.9	02May2014, 12:05	6.8
UBC Sub 1 Outfall	0.05	77.9	02May2014, 12:05	6.8
UBC Sub 2	0.15	192.7	02May2014, 12:10	20.4
UBC Sub 2 Outfall	0.15	192.7	02May2014, 12:10	20.4

***Event Start Time: 02May2014, 00:00

Demonstration Plant Site: 100-Year, 6-Hour Event

Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak	Volume (acre-ft)
CC WBranch 1	0.65	351.8	02May2014, 05:00	63.3
Junction-1	0.65	351.8	02May2014, 05:00	63.3
Reach-1	0.65	342.5	02May2014, 05:20	63.2
CC WBranch 2	0.54	266.5	02May2014, 05:05	52.6
Junction-2	1.19	583.6	02May2014, 05:15	115.8
Reach-2	1.19	557.5	02May2014, 05:30	115.5
CC EBranch 2	0.64	346.4	02May2014, 05:00	62.3
CC EBranch 1	0.53	211.2	02May2014, 05:25	51.6
Junction-3	1.17	523.7	02May2014, 05:05	113.9
Reach-3	1.17	495.5	02May2014, 05:25	113.5
CC WBranch 3	0.47	282.0	02May2014, 04:55	45.8
CC EBranch 3	0.21	94.3	02May2014, 05:15	20.5
Junction-4	3.04	1277.0	02May2014, 05:25	295.3
Reach-4	3.04	1274.4	02May2014, 05:25	295.3
CC 1	0.30	191.8	02May2014, 04:50	29.2
Junction-5	3.34	1360.7	02May2014, 05:25	324.5
Reach-5	3.34	1353.0	02May2014, 05:25	324.4
CC Sub 1	0.35	236.0	02May2014, 04:45	34.1
CC 2	0.03	26.1	02May2014, 04:40	2.9
Junction-6	3.72	1449.5	02May2014, 05:25	361.4
Reach-6	3.72	1440.3	02May2014, 05:30	361.3
CC Sub 2	0.12	69.6	02May2014, 04:55	11.7
CC 3	0.06	36.6	02May2014, 04:50	5.8
Junction-7	3.90	1492.6	02May2014, 05:30	378.9
Reach-7	3.90	1484.4	02May2014, 05:35	378.8
CC Sub 3	0.22	148.4	02May2014, 04:45	21.4
CC 4	0.05	35.6	02May2014, 04:45	4.9
Junction-8	4.17	1545.6	02May2014, 05:30	405.1
Reach-8	4.17	1538.6	02May2014, 05:40	404.9
CC 5	0.31	170.3	02May2014, 05:00	30.2
Junction-9	4.48	1621.5	02May2014, 05:35	435.1
UBC Sub 1	0.05	45.6	02May2014, 04:35	4.9
UBC Sub 1 Outfall	0.05	45.6	02May2014, 04:35	4.9
UBC Sub 2	0.15	116.6	02May2014, 04:40	14.6
UBC Sub 2 Outfall	0.15	116.6	02May2014, 04:40	14.6

***Event Start Time: 02May2014, 00:00

Appendix E: US Fish and Wildlife Service Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
5353 Yellowstone Road, Suite 308A
Cheyenne, WY 82009

OCT 31 2012

In Reply Refer To:
06E13000/WY13CPA0009

William Vetter, Senior Manager/Wildlife Biologist
ICF International
405 West Boxelder Road, Suite A-5
Gillette, Wyoming 82718

Dear Mr. Vetter:

Thank you for your email of October 3, 2012, regarding the study plan for proposed wildlife baseline surveys at the Rare Element Resources Bull Hill Mine and Upton Plant project sites (Project). The Bull Hill Mine will be located in all or portions of Sections 5, 7-10, 15-18, 20, and 21, T52N, R63W in Crook County, Wyoming. The Upton Plant will be located in all or portions of Sections 20, 28, 29, 32, and 33, T48N, R65W in Weston County, Wyoming.

Your letter provided sufficient information for the U.S. Fish and Wildlife Service (Service) to evaluate the effects of this project to federally listed species. Based on the information provided, it is unlikely that the proposed work will adversely affect any threatened or endangered species. You may consider this project, as proposed, to be in compliance with the Endangered Species Act of 1973, as amended (Act), 16 U.S.C. 1531 *et seq*.

Your proposed wildlife baseline studies plan methodology is in accordance with standard biological practices and takes into account the particular species of concern and threatened and endangered species likely to occur within or near the Project area. The Service would appreciate a copy of your Project-specific wildlife baseline report once it becomes available. Additionally, we would appreciate being notified when additional plans are considered for this Project and other similar projects.

This Project should be re-analyzed if new information reveals effects of the action that may affect listed species or designated or proposed critical habitat in a manner or to an extent not considered in this letter; if the action is subsequently modified in a manner that causes an effect to a listed or proposed species or designated or proposed critical habitat that was not considered in this letter; and/or if a new species is listed or critical habitat is designated that may be affected by this project.

We appreciate your efforts to ensure the conservation of endangered, threatened, and candidate species and migratory birds. If you have questions regarding this letter or your responsibilities under the Act and/or other authorities or resources described above, please contact Genevieve Skora of my office at the letterhead address or phone (307) 772-2374, extension 225.

Sincerely,

For R. Mark Sattelberg
Field Supervisor
Wyoming Field Office

cc: USFS, District Ranger, Sundance, WY (S. Kozel)
WDEQ-LQD, District 3 Supervisor, Sheridan, WY (M. Rogaczewski)
WGFD, Non-game Coordinator, Lander, WY (B. Oakleaf)
WGFD, Statewide Habitat Protection Coordinator, Cheyenne, WY (M. Flanderka)

Appendix F: Radiological Dose Evaluation

MEMORANDUM

MEMO

To:	Jaye Pickarts, RER
From:	Jess Joyce
Cc:	Mike Schierman
Date:	9 September 2022
Total	Radiological dose evaluation supporting the license application for the Rare Earth Element Separation and Processing Demonstration Project

1 Introduction

Rare Element Resources, Inc. (RER) is proposing to conduct a Rare Earth Element (REE) Separation and Processing Demonstration Project (Demonstration Project) in northeastern Wyoming in collaboration with General Atomics (GA), GA's European affiliate Umwelt-und Ingenieurtechnik GmbH Dresden (UIT) and engineering and construction subcontractor LNV, an Ardurra Group, Inc. company (LNV). RER, GA, UIT, and LNV are collectively referred to in this document as the Team.

The Demonstration Project is being developed as a 50% commercial / 50% government-funded cooperative agreement between the Team and the US Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy under DOE's Critical Materials Funding Opportunity Announcement (FOA) with a total project budget of $43.8 million. The Demonstration Project includes the engineering, construction, and operation of a REE separation and processing Demonstration Plant.

The Demonstration Project proposes to demonstrate the domestic production of neodymium-praseodymium and other rare earth oxides (REOs). Approximately 1,000 tons of exploration sample removed previously from the Bear Lodge project in Wyoming are available for processing. The Team plans to design, construct, and operate a demonstration-scale hydrometallurgical, separation, and refining plant at a processing rate of up to 3 tons of feed material per day as a research and development scale-up. The Demonstration Plant is planned to operate for approximately one year.

RER will possess source material[1] incident to the recovery of REEs and will be required to obtain a radioactive material license. This memorandum, which evaluates the potential for radiological dose to workers and members of the public from the proposed Demonstration Project, has been prepared as a supplement to RER's license application (RER 2022a) and is attached as an appendix to RER's *Environmental Report* (RER 2022b).

[1] Defined in 10 CFR 40.4 as "(1) Uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight one-twentieth of one percent (0.05%) or more of: (i) Uranium, (ii) thorium or (iii) any combination thereof. Source material does not include special nuclear material."

1.1 Purpose and Scope

Many ores processed for their mineral content, including REE, contain naturally occurring radioactive material such as potassium-40 and the thorium decay series (Figure 1) and uranium decay series (Figure 2) radionuclides (UNSCEAR 2000). The minerals used for commercial sources of REE, including monazite and bastnasite ores, contain elevated concentrations of radionuclides in the thorium decay series and, to a lesser degree, the uranium decay series (IAEA 2007). Radionuclides can mobilize during processing and migrate to dust, scales, and other process residues, therefore potentially leading to higher concentrations of radionuclides than the feedstock. This potential increase in the concentrations of radionuclides can change the magnitude of radiological hazards.

Source material in sample and process residues poses potential hazards to workers and members of the public because it emits and/or contains ionizing radiation. The purpose of this report is to identify potential human exposure pathways to source material associated with the Demonstration Project and to provide a conservative estimate of the magnitude of expected radiation doses to workers and members of the public. This memorandum is intended as a prospective dose evaluation ***only***, as identified in NUREG-1748 *Environmental Review Guidance for Licensing Actions Associated with NMSS Programs* (NRC 2003, Section 6.4.12.2), and is not intended to identify specific components of the radiation protection program.

This memo is organized as follows:

Section 1 provides introductory information, regulatory context, and information inputs to the dose assessment
Section 2 provides an occupational (worker) dose evaluation
Section 3 provides a public dose evaluation
Section 4 provides references.

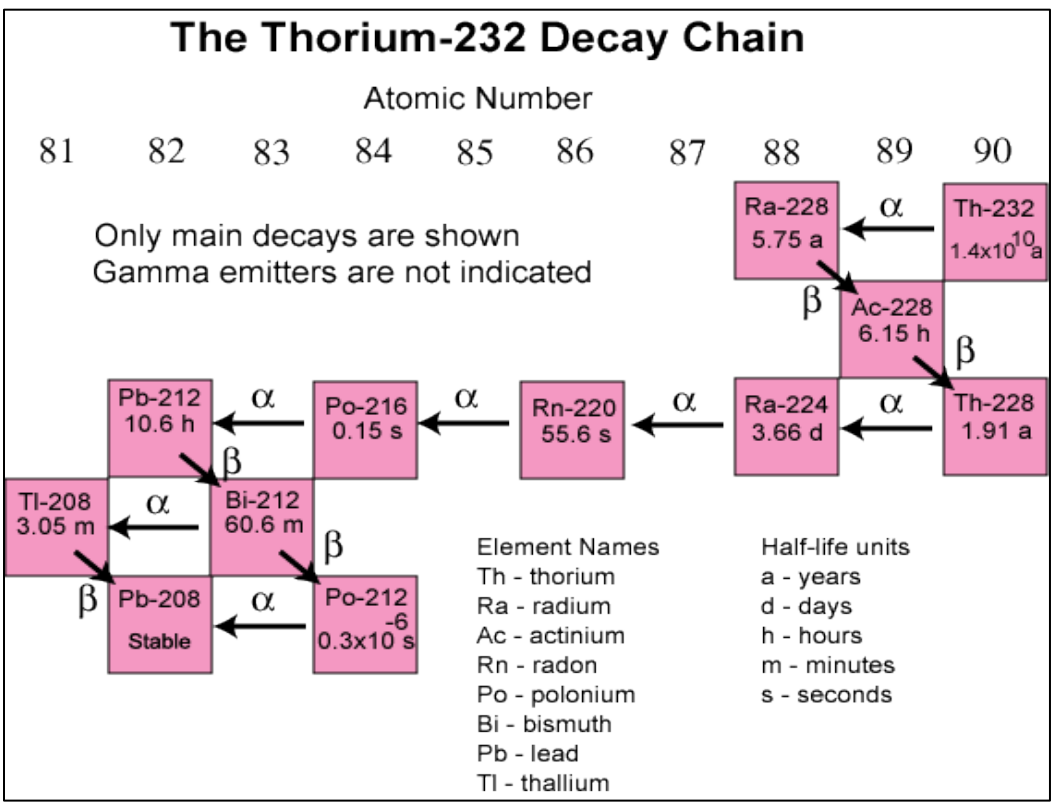


Figure 1. Thorium-232 decay series (https://www.epa.gov/radiation/radioactive-decay)

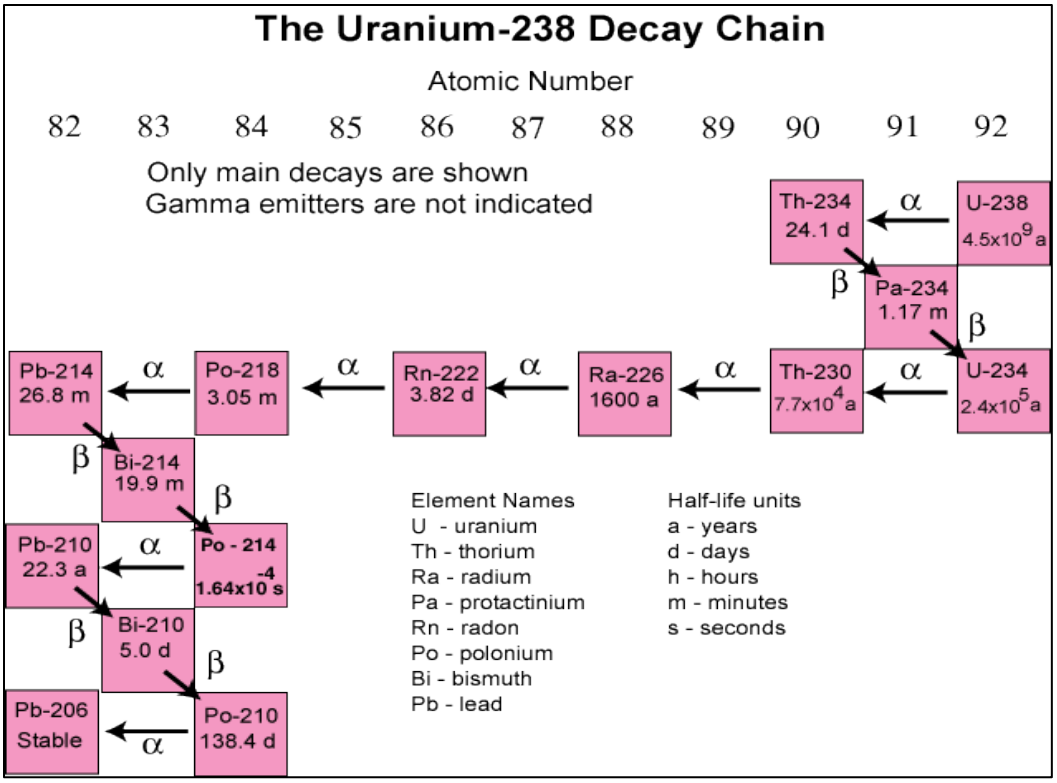


Figure 2. Uranium-238 decay series (https://www.epa.gov/radiation/radioactive-decay)

1.2 Regulatory Context

The US Nuclear Regulatory Commission (NRC) regulates radioactive materials subject to the Atomic Energy Act, as amended. This includes source, byproduct, and special nuclear material. The Demonstration Project meets the requirements for domestic licensing of source material in 10 CFR 40 and operations will be subject to the radiation protection requirements of 10 CFR 20 and individual dose reporting requirements of 10 CFR 19. Transportation requirements from 10 CFR 71 and 49 CFR 173 will also apply.

The NRC excludes from regulation source material in “unrefined or unprocessed ore” (10 CFR 40.13 (b)). Based on this definition and exclusion, the Bull Hill Mine sample is not subject to NRC regulation until processing begins.

The occupational and public radiation dose limits are specified in 10 CFR 20. NRC also requires, to the extent practical, implementation of procedures and engineering controls based on sound radiation protection principles to achieve doses that are as low as is reasonably achievable (ALARA). ALARA is the optimization component of radiation protection.

Table 1 identifies key limiting parameters for the radionuclides of interest.

Table 2 lists the activity concentration and total activity below which materials would be excluded from regulation under 49 CFR 173 Subpart I for transportation of natural uranium and thorium.

Table 1. Summary of limiting parameters for radionuclides of interest

Radionuclide		Inhalation DAC [a] (μCi mL^{-1})		Inhalation ALI [a] (μCi)		Air Effluent Concentration Limit [b] (μCi mL^{-1})	
Natural thorium [c]		8.90E-13		1.80E-03		7.10E-15	
Natural uranium [d]		2.00E-11	Class Y	5.00E-02	Class Y	9.00E-14	Class Y
Key thorium-232 series radionuclides	Th-232	5.00E-13	Class W	1.00E-03	Class W bone surface	4.00E-15	Class W
	Ra-228	5.00E-10	Class W	1.00E+00	Class W	2.00E-12	Class W
	Ac-228	4.00E-09	Class D	9.00E+00	Class D bone surface	2.00E-11	Class D
	Th-228	4.00E-12	Class W	1.00E-02	Class W bone surface	3.00E-14	Class W
	Ra-224	7.00E-10	Class W	2.00E+00	Class W	2.00E-12	Class W
	Rn-220 [e]	9.00E-09 1 WL	with decay products present	2.00E+01 12 WLM	with decay products present	3.00E-11	with decay products present
	Pb-212	1.00E-08	Class D	3.00E+01	Class D bone surface	5.00E-11	Class D
Key urainum-238 series radionuclides	U-238	2.00E-11	Class Y	4.00E-02	Class Y	6.00E-14	Class Y
	Th-234	8.00E-08	Class W	2.00E+02	Class W	2.00E-10	Class Y
	U-234	2.00E-11	Class Y	4.00E-02	Class Y	5.00E-14	Class Y
	Th-230	3.00E-12	Class W	6.00E-03	Class W bone surface	2.00E-14	Class W
	Ra-226	3.00E-10	Class W	6.00E-01	Class W	9.00E-13	Class W
	Rn-222 [e]	3.00E-08 0.33 WL	with decay products present	1.00E+02 4 WLM	with decay products present	1.00E-10	with decay products present
	Pb-214	3.00E-07	Class D	8.00E+02	Class D	1.00E-09	Class D
	Bi-214	3.00E-07	Class D	8.00E+02	Class D	1.00E-09	Class D

[a] 10 CFR 20 Appendix B Table 1 – inhalation DAC for most limiting solubility class
[b] 10 CFR 20 Appendix B Table 2
[c] Values for natural thorium were calculated from the limits for thorium-228 and thorium-232 based on equal activity contributions from these two isotopes as 1/(0.5/Th-232 + 0.5/Th-228) as indicated in footnote 4 to 10 CFR 20 Appendix B.
[d] Natural uranium values are provided in 10 CFR 20 Appendix B
[e] Building and restricted area boundary radon will be measured with the ability to distinguish contributions from Rn-222 and Rn-220.

ALI – annual limit on intake
DAC – derived air concentration
μCi – microcuries
μCi mL^{-1} – microcuries per milliliter (10^9 picocuries per liter)
Ra – radium
Rn - radon
Th – thorium
U – uranium
WL – working level
WLM – working level month

Table 2. Activity concentrations and activity limits excluded from transportation requirements in 49 CFR 173 Subpart I

Parameter	Activity concentration for excluded material	Activity limit for excluded consignment	Mass concentration for excluded material	Mass limit for excluded consignment
Natural thorium	≤ 270 pCi g^{-1}	≤ 0.27 μCi	1200 mg kg^{-1}	1200 mg
Natural uranium	≤ 270 pCi g^{-1}	≤ 0.27 μCi	400 mg kg^{-1}	400 mg

Note: Activity concentrations and activities less than 10 times the exempt material activity concentration values specified in 49 CFR 173.436 are out of scope of 49 CFR 173 Subpart I pursuant to 49 CFR 173.401(b).

mg - milligrams
mg kg^{-1} - milligrams per kilogram
μCi - microcuries
pCi g^{-1} – picocuries per gram

1.3 Information Inputs

This section presents baseline conditions, a process description, source term information, and dose coefficients used to perform the dose assessment.

1.3.1 Baseline Conditions

A baseline radiological investigation conducted in 2015 included a gamma survey, random soil sampling, exposure rate monitoring, radon flux measurements, radon measurements in air, and airborne particulate measurements (ERG 2015). The spatial scope of the baseline investigations focused on the proposed site of the commercial-scale Bear Lodge Project (RER 2015a, 2015b), which would have been located to the northwest (1.4 miles via road, 0.8 miles directly) of the Demonstration Project site.

Additional soil sampling was conducted in 2022 to supplement the previously reported values. This study composited samples for each of six boreholes across three sample depths, 0-18 inches, 18-30 inches, and 30-60 inches. A site visit in November 2021 also included scoping gamma count rate measurements with a 2-inch by 2-inch thallium-doped sodium iodide detector and a scoping walkover scan of the Demonstration Plant site; no areas of noticeably elevated gamma count rates were recorded.

The results of the baseline investigations are summarized in Table 3.

Table 3. Summary of baseline radiological investigations

Parameter	Unit	Study	Min	Mean	Max	SD
External exposure rate	μR hr^{-1}	(ERG 2015)	10.1	13.8	19.3	--
External dose rate	mrem y^{-1}	(ERG 2015)	96	103	118	--
Soil concentrations						
Natural thorium	pCi g^{-1}	2022	3.6	4.5	5.7	0.4
Natural uranium [a]	pCi g^{-1}	2022	1.7	1.8	2.0	0.1
Radium-228	pCi g^{-1}	2022	0.3	0.9	1.7	0.4
Radium-226	pCi g^{-1}	2022	0.6	1.0	1.4	0.2
Particulate air concentrations						
Natural thorium	μCi mL^{-1}	(ERG 2015)	ND	4.1E-17	2.4E-16	--
Natural uranium	μCi mL^{-1}	(ERG 2015)	ND	3.6E-17	1.2E-16	--
Thorium-230	μCi mL^{-1}	(ERG 2015)	ND	2.6E-17	1.7E-16	--
Radium-226	μCi mL^{-1}	(ERG 2015)	ND	1.0E-16	3.5E-15	--
Radon [b]						
Radon air concentration	μCi mL^{-1}	(ERG 2015)	7E-10	--	1.6E-9	--
Radon flux	pCi m^{-2} s^{-1}	(ERG 2015)	0.2	0.69	1.22	--

[a] The distribution of natural uranium concentrations measured in soil was non-normal, with a median value of 1.4 pCi g^{-1}.
[b] All measured radon was assumed to be radon-222.
μCi mL^{-1} – microcuries per milliliter
μR hr^{-1} – microRoentgen per hour
mrem y^{-1} – millirem per year
ND – not detected
pCi g^{-1} – picocuries per gram
pCi m^{-2} s^{-1} – picocuries per square meter per second
SD – standard deviation

1.3.2 Process Description and Sources

The REE separation and refining process is described in section 9 and Appendix C of the license application (RER 2022a) and section 2.1.2 of the *Environmental Report* (RER 2022b). Potential sources of worker and public exposure to source material are identified in Table 7. Relevant details to this dose assessment include:

- Physical upgrading (PUG) of the exploration sample (sample) feedstock results in a comminuted and screened sample with well-characterized uranium and thorium concentrations (see Table 8). The PUG process is a potentially dust-generating, dry process. After comminution, the sample will be stored in super

sacks in the PUG/Sample Storage Facility, carried with a forklift to the Main Process Facility, and loaded into a hopper for primary processing (PP).

- PP is an acid leach process which generates a solid washed leach residue, solids from acid recycling, and wastewater from acid recycling – these residues are recombined and referred to as PP tailings (see Table 8). Radium is retained in the leach residue by coprecipitation with barium. Uranium, after being mobilized into the wastewater, is recombined with the leach residue and referred to as PP tailings. Thorium is precipitated from the leach solution with the total rare earth oxide (TREO), generating the material referred to as TREO(Th), and is carried through to the thorium-cerium separation (TCS) stage.
- The TCS stage results in a small volume of solid radioactive waste containing high concentrations of thorium and wastewater. These residues are combined and referred to as TCS tailings (see Table 8)
- PP tailings and TCS tailings are combined as total tailings in a process which involves no interim storage. Total tailings are placed in waste containers outside of the main process facility prior to shipment for disposal.
- Only trace or undetectable radioactive material is anticipated in stages beyond the TCS.

An evaluation of chemical compounds of uranium for relevant stages of the process is provided in Table 4. Dissolved uranium species in the pregnant leach solution and barren solution left after oxalate precipitation of TREO(Th) are assumed to be inhalation class D uranium compounds, although these solutions will be in closed process containers with emissions controls. The requirement to limit soluble uranium intake to 10 milligrams per week for chemical toxicity in 10 CFR 20.1201(e) is applicable in the primary processing and waste stages within the Main Process Facility.

Table 4. Uranium compounds in relevant processing streams

Pregnant leach solution (PLS):	All U species dissolved, UO_2Cl^+ (dominant), UO_2^{2+} and UO_2Cl_2 (minor)
Barren solution left after oxalate precipitation of REE (Th):	All U species dissolved, UO_2Cl^+ (dominant), UO_2^{2+} and UO_2Cl_2 (minor), solubility of uranyl oxalate $UO_2C_2O_4(H_2O)_3$ in the order of g/L (i.e., this solid is not evident in this specific case)

Evaluations of chemical compounds of thorium and actinium for relevant stages of the process are provided in Table 5 (thorium) and Table 6 (actinium). Dissolved species of thorium are inhalation class W (all compounds except oxides and hydroxides). Dissolved species of actinium are inhalation class W (chlorides) or D (all compounds except halides, nitrates, oxides, and hydroxides). These solutions will be in closed process containers with emissions controls.

Table 5. Thorium compounds in relevant processing streams

Pregnant leach solution (PLS):	All Th species dissolved, Th^{4+}, $ThCl^{3+}$, $ThCl_2^{2+}$, $ThCl_3^{3+}$ (dominant) , $ThCl_4$ and others minor species, no solid phases at relevant Th concentration
Oxalate precipitate:	$Th(C_2O_4)_2(H_2O)_4$ (solid)
Calcined oxalate:	ThO_2 (solid in TREYO)
Th in nitric acid:	Th^{4+} (dissolved)
Th in the precipitate of Ce-Th (oxalate):	$Th(C_2O_4)_2(H_2O)_4$, solid

Table 6. Actinium compounds in relevant processing streams

Pregnant leach solution (PLS):	All Ac species dissolved, $AcCl_3$ (known compound), possibly $AcCl_2^+$, $AcCl^{2+}$, Ac^{3+} as well
Barren solution left after oxalate precipitation of REE (Th):	All Ac species dissolved, $AcCl_3$ (known compound), possibly $AcCl_2^+$, $AcCl^{2+}$, Ac^{3+} as well
Comment:	If any Ac should be precipitated as oxalate, then this Ac would decay at a half life of 6.15 d, i.e., it disappears after a few days effectively.

Table 7. Potential sources of exposure to source material

Area	Activity[1]	Potential exposure scenario	Potential exposure route	Dose estimated	Justification
PUG/Sample Storage Facility	Unloading exploration sample into PUG building	Workers	Inhalation	Not Estimated	Shorter duration than PUG building air estimate below
	Emissions from any open system into the building air	Workers	Inhalation / Ingestion	See section 2.3	Conservative use of airborne dust concentration for dose estimate over processing duration. Also compared to 10 CFR 20 Appendix B derived air concentration.
	Standing or working near stored sample	Workers	External	See section 2.3	Conservative estimate assuming infinite plane "wall" source and 25% occupancy
	Airborne emissions from the PUG/Sample Storage Facility	Public	Inhalation	See section 3.3	Conservative estimate of released inventory
Main Process Facility	Loading the hopper into the PP stage	Workers	Inhalation	Not estimated	Continuous process with no buildup time–material transferred to roll-off bins in waste storage area
	PP tailings mixing (real time or batched)	Workers	External	Not estimated	Continuous process with no buildup time–material transferred to roll-off bins in waste storage area
	PP to TCS stage transfer lines (contain TREO(Th))	Workers	External	Not estimated	Emissions controlled through closed process with local ventilation control; high building ventilation rate
	TCS tailings mixing (real time or batched)	Workers	External	Not estimated	Continuous process with no buildup time–material transferred to roll-off bins in waste storage area
	Total tailings mixing (real time or batched)	Workers	External	Not estimated	Continuous process with no buildup time–material transferred to roll-off bins in waste storage area
	Emissions from any open system into building air	Workers	Inhalation	Not estimated	Emissions controlled through closed process with local ventilation control; high building ventilation rate
	Airborne emissions from the Main Process Facility	Public	Inhalation	Not estimated	Dose potential is expected to be lower than PUG emissions above
Waste Storage Area	Reconfiguring waste	Workers	Inhalation	Not estimated	Wet process; short exposure duration
	Standing or working near stored waste	Workers	External	Not estimated	Lower concentrations, lower volumes, and more shielding compared to standing or working near stored sample in PUG building above

Area	Activity[1]	Potential exposure scenario	Potential exposure route	Dose estimated	Justification
Other	Transport of exploration sample between buildings	Workers	Inhalation	Not estimated	Transfer of supersack using forklift to emission-controlled bag breaker – no emissions during normal operations

[1]All activities listed were considered as potential sources of exposure to source material. However, most activities were evaluated qualitatively, and a dose estimate was not performed. This table provides clarification of the scope of each evaluation for activities potentially causing worker exposure.

PP – primary processing
PUG – physical upgrade
TCS – thorium cerium separation
TREO(Th) – total rare earth oxide concentrate with thorium

1.3.3 Source Terms

1.3.3.1 Radioactive Material Concentrations

Within the Bull Hill Mine sample, measured thorium and uranium concentrations have a reliably linear correlation to TREO concentration, which is reported as grade [in weight percent, parts per million (ppm), or milligrams TREO per kilogram sample (mg kg^{-1})]. This relationship is presented on Figure 3 (UIT 2022). The exploration sample which will be used for the Demonstration Project contains a high TREO grade, averaging 2,911 ppm thorium and 111 ppm uranium.

The Demonstration Project total inventory source term is identified in section 5 of the license application (RER 2022a). System modeling was used to estimate concentrations in process materials and residues (UIT 2022; Maerten 2022). Key source term parameters are summarized in Table 8.

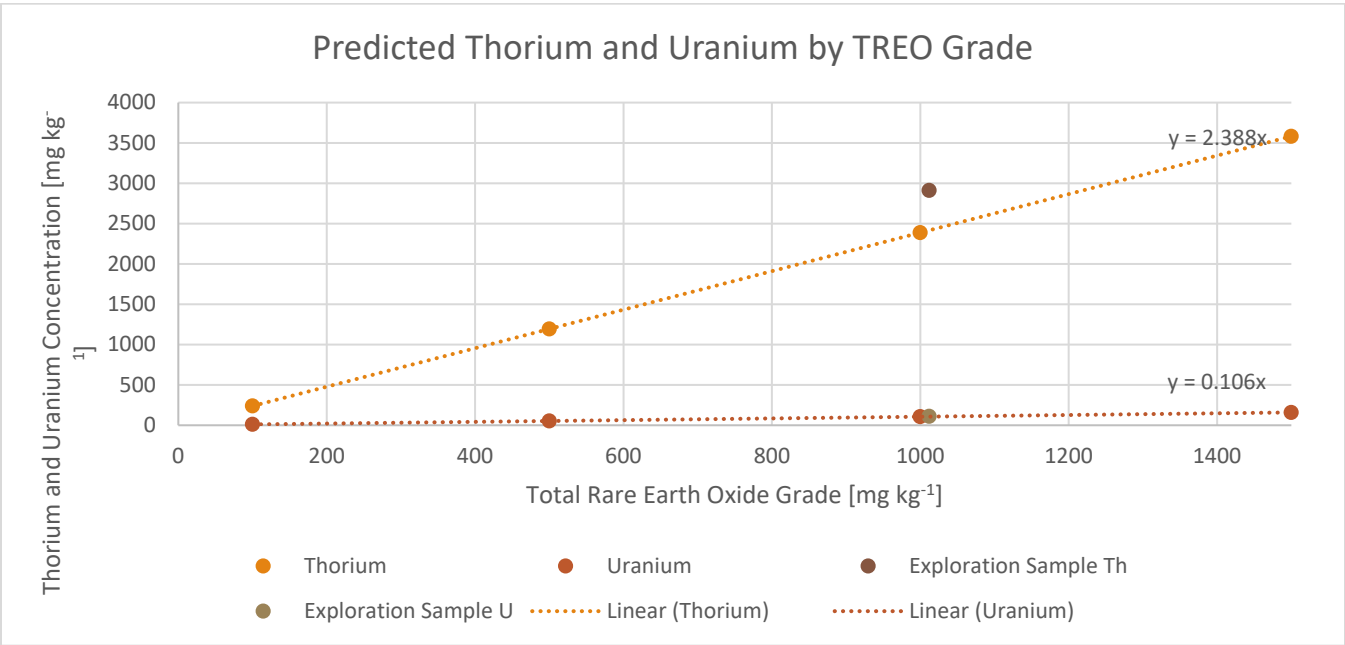


Figure 3. Predicted thorium and uranium content of sample based on linear correlation to TREO grade. Note any thorium, uranium, or combination exceeding 0.05% (500 mg kg^{-1}) would require a source material license.

Table 8. Source term inputs

Material	Total mass [a] [metric ton]	Mass per day [b] [metric ton]	Thorium-natural [d]						Th-232 or Th-228 [c,d]					Uranium-natural [d]						U-238 [d]				
			Mass concentration [ppm]	Activity concentration [pCi g^{-1}]	Total mass [kg]	Total activity [Ci]	Daily mass [kg]	Daily activity [µCi]	Activity concentration [pCi g^{-1}]	Total mass [kg]	Total activity [Ci]	Daily mass [kg]	Daily activity [µCi]	Mass concentration [ppm]	Activity concentration [pCi g^{-1}]	Total mass [kg]	Total activity [Ci]	Daily mass [kg]	Daily activity [µCi]	Activity concentration [pCi g^{-1}]	Total mass [kg]	Total activity [Ci]	Daily mass [kg]	Daily activity [µCi]
Exploration sample	907	2.79	2911	646	2641	0.586	8.1	1803	320	2640	0.29	8.12	893	111	75	101	0.068	0.31	210	38	100	0.034	0.31	105
PP leach residue	946	2.91	590	131	558	0.124	1.7	381	65	558	0.06	1.72	189	2	1	2	0.001	0.01	4	1	1.9	0.001	0.01	2
PP wastewater (acid recycle)	767	2.36	0	0	0	0	0	0	0	0	0	0	0	87	59	67	0.045	0.21	139	30	66	0.023	0.20	69
PP tailings	1925	5.92	188	42	362	0.080	1.1	247	21	362	0.04	1.11	122	50	34	96	0.065	0.30	200	17	96	0.032	0.29	100
TCS feed material [c] [TREO(Th)]	98	0.3	11523	2558	1124	0.250	3.5	767	1267	1124	0.12	3.46	380	0	0	0	0	0	0	0	0	0	0	0
TCS radioactive waste [c] (thorium oxalate)	75	0.23	51652	11467	3863	0.858	11.9	2637	5682	3862	0.42	11.88	1307	0	0	0	0	0	0	0	0	0	0	0
TCS wastewater (acidic bleed streams)	205	0.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCS tailings [c]	293	0.9	8563	1901	2506	0.556	7.7	1711	942	2505	0.28	7.71	848	0	0	0	0	0	0	0	0	0	0	0
Total tailings [e]	2221	6.83	1293	287	2872	0.586	8.8	1961	142	2871	0.29	8.83	971	44	30	98	0.066	0.30	203	15	97	0.033	0.30	101

[a] Total inventory of exploration sample is 1,000 short tons (907 metric tons). Other mass inputs are from mass balance [Appendix C of license application, (RER 2022a)].
[b] Daily operating capacity is approximately 3 short tons (2.79 metric tons). Other mass inputs are from mass balance and design team (Maerten 2022).
[c] TCS residues are assumed to contain equal activity concentrations of thorium-232 and thorium-228 because the sample is in secular equilibrium and the chemical properties of these isotopes should be identical.
[d] Specific activities included 2.22E-07 Ci g^{-1} natural thorium, 1.1E-07 Ci g^{-1} Th-232, 3.4E-07 Ci g^{-1} U-238 (Johnson and Birky 2012, Table 8.4.1) and 6.77 E-07 Ci g^{-1} natural uranium (footnote 3 to 10 CFR 20 Appendix B).
[e] Assumes 100% of radioactive material goes to total tailings and tailings are uniformly mixed (Maerten 2022).

Ci – Curies
Conc. - concentration
kg – kilograms
MBq – Megabequerels
µCi – microcuries
pCi g^{-1} – picocuries per gram
ppm – parts per million
Th-232 – thorium-232
U-238 – uranium-238

1.3.3.2 Airborne Particulates and Radon

Dust containing source material has the potential for delivering an internal radiation dose to workers and the public, predominantly by way of inhalation. Table 9 summarizes the airborne particulate emission estimates and other parameters for selected sources in Table 7, which include indoor air and airborne emissions from the PUG/Sample Storage Facility and Main Process Facility.

1.3.3.2.1 PUG/Sample Storage Facility

The airborne particulate dose assessment approach for the PUG process was to assume air concentrations will be limited to the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL)[2] of 5 mg m^{-3} for respirable dust. This is a conservative value compared to an anticipated level of 1 mg m^{-3}, which is a reasonable estimate of typical dust levels at processing facilities.

Airborne emissions from the PUG/Sample Storage Facility were modeled for the public dose estimate (section 3.2) consistent with conservative predictions in the air quality permit application (TetraTech 2022), provided as *Environmental Report* Appendix I. The air quality permit application predicted particulate matter emissions from processing 1,000 tons of exploration sample at the PUG/Sample Storage Facility as follows:

- 0.009 tons from potential stationary source emissions during primary and secondary crushing (9E-6 of the total inventory) (TetraTech 2022, Table 5)
- 0.38 tons from potential fugitive particulate emissions during exploration sample truck loadout, pre-crushing storage, pre-crushing mixing, transfer, post-crushing mixing, and bulk bag-filling (3.8E-4 of the total inventory) (TetraTech 2022, Appendix A)

Therefore, a conservative estimated release of 1.1E-4 Ci of each of the thorium series radionuclides and 2.6E-5 of each of the uranium series radionuclides was modeled, see section 3.2.5. Uranium-235 series radionuclides were neglected due to their low abundance.

In general, the ambient diffusion of radon (either radon-222 or radon-220) from the open side of the PUG/Sample Storage Facility is expected to control radon and its decay products to acceptable levels. During PUG processing, the radon concentration is conservatively estimated to be 1.7E-9 µCi mL^{-1} for radon-220 and 1.1E-8 µCi mL^{-1} for radon-222, calculated using the approach described below:

- PUG/Sample Storage Facility volume is 120*25*55ft = 165,000 ft^3 or 4670 m^3
- Assume 10% release of radon gas during crushing and grinding (NRC 1987b, Section 2.2)
- Activity release rate $\dot{A}\ \left(\frac{\text{pCi}}{\text{hr}}\right)$ is calculated using the initial concentration and anticipated processing rate:

$$\dot{A}_{Rn-220} = 320\ \frac{\text{pCi}}{\text{g}} \times 11.3\frac{\text{tons}}{\text{hour}} \times 1\text{E}6\frac{\text{g}}{\text{ton}} \times 10\% = 3.62\text{E}8\frac{\text{pCi}}{\text{hr}}$$

$$\dot{A}_{Rn-222} = 38\ \frac{\text{pCi}}{\text{g}} \times 11.3\frac{\text{tons}}{\text{hour}} \times 1\text{E}6\frac{\text{g}}{\text{ton}} \times 10\% = 4.29\text{E}7\frac{\text{pCi}}{\text{hr}}$$

- Decay constant $\lambda_{effective}$ is the sum of the radioactive decay constants for radon-220 (45 hr^{-1}) or radon-222 (0.0076 hr^{-1}) and the open building's air exchange rate (conservatively estimated to be 0.8 hr^{-1}) (EPA 2018, Table 19-30). The actual air exchange rate for the open PUG/Sample Storage facility is unknown but is expected to be greater than 0.8 hr^{-1}.

$$\lambda_{effective,Rn-220} = 45.8\ \text{hr}^{-1}$$

[2] The OSHA PEL is a limit on the time weighted average over an eight-hour work shift, the provided value of 5 mg m^{-3} is for respirable dust (<4 µm). The American Conference of Governmental Industrial Hygienists provides a recommended threshold limit value of 10 mg m^{-3} for inhalable dust (<100 µm), however the PEL will be used as a value that more appropriately reflects the dose-delivering particle size.

$$\lambda_{effective,Rn-222} = 0.8076\ \mathrm{hr}^{-1}$$

- Equilibrium air concentration is estimated as follows:

$$C = \frac{\dot{A}}{\lambda_{effective} V}$$

$$C_{Rn-220} = \frac{3.62\mathrm{E}8\,\frac{\mathrm{pCi}}{\mathrm{hr}}}{\frac{45.8}{\mathrm{hr}} \times\ 4670\ \mathrm{m}^3} \times \frac{\mu\mathrm{Ci}}{10^6\mathrm{pCi}} \times \frac{\mathrm{m}^3}{10^6\mathrm{mL}} = 1.7 \times 10^{-9}\ \frac{\mu\mathrm{Ci}}{\mathrm{mL}}$$

$$C_{Rn-222} = \frac{4.29\mathrm{E}7\,\frac{\mathrm{pCi}}{\mathrm{hr}}}{\frac{0.8076}{\mathrm{hr}}\ \times\ 4670\mathrm{m}^3} \times \frac{\mu\mathrm{Ci}}{10^6\mathrm{pCi}} \times \frac{\mathrm{m}^3}{10^6\mathrm{mL}} = 1.1 \times 10^{-8}\ \frac{\mu\mathrm{Ci}}{\mathrm{mL}}$$

These estimated air concentrations represent 9% of the DAC for radon-220 and 19% of the DAC for radon-222 (assuming NRC's recommended indoor equilibrium fraction of 50% equilibrium).

During sample storage following crushing, negligible radon will be released from stored sample due to reduction in radon flux due to storage of the sample in impermeable super sacks with a 6-mil polyethylene liner (EPA 1994).

Because the PUG/Sample Storage Facility will be partially open to the outside, for the public dose estimate, 100% of the radon gas in the exploration sample was modeled as being released during processing (0.29 Ci of radon-220 and 0.034 Ci of radon-222). The conservative assumption is that all accumulated radon in ore is released during the processing of that ore.

1.3.3.2.2 Main Process Facility

All process steps, after loading the hopper into the PP stage, were assumed to be non-dust generating, so no particulate estimates were calculated for the Main Process Facility. Facility processes and emission controls planned for the Main Process Facility "include cyclones and dust collectors to minimize dust generation from material handling systems, and wet scrubbers to eliminate vapor emissions from the chemical storage tanks, calciner, and leaching and precipitation circuits. Additionally, the Main Process Facility is fully enclosed and the heating, ventilation, air conditioning (HVAC) system will be equipped with a high-efficiency particulate air filtration (HEPA) system" (TetraTech 2022).The ambient diffusion of radon (either radon-222 or radon-220) from open areas and active ventilation of enclosed processes are expected to control radon and its decay products to near-ambient levels. Because the Main Process Facility will be extensively ventilated[3], radon from this facility was not considered further in the dose evaluation.

Table 9. Airborne particulates and radon by source

Demonstration Project Area	Activities	Airborne Particulate Source	Radon Source	Effective Release Height	Dust estimate
PUG/Sample Storage Facility	Emissions from any open system into the building air	Yes	Yes	1 m	5 mg m^{-3}
	Airborne emissions from the PUG/Sample Storage Facility	Yes	Yes	1 m	Modeled 3.8E-4 of inventory
Main Process Facility	Emissions from any open system into building air	No	No	--	None
	Emissions from the Main Process Facility stack(s)	No	No	10 m	None

[3] Preliminary design review estimates for Main Process Facility systems indicate an air turnover rate in the building of 6 air exchanges per hour.

Demonstration Project Area	Activities	Airborne Particulate Source	Radon Source	Effective Release Height	Dust estimate

m – meters
PP – primary processing
PUG – physical upgrade
TCS – thorium cerium separation

1.3.3.3 Thorium Concentrates

The process design does not include any accumulation of TREO(Th), TCS radioactive waste, or TCS tailings, which are the three process residues with the highest predicted thorium concentrations. However, due to the relatively short half-life of thorium-228, ingrowth of gamma-emitting decay products could occur rapidly after isolation of this element, reaching a maximum at approximately 28 days post-separation (Figure 4, Figure 5).

In previous dose assessments for the Bear Lodge Project, external dose from thorium concentrates was a key consideration in facility design and administrative controls of the radiation protection program (ERG 2014). Because of the small scale and short duration of the Demonstration Project and design controls that will limit accumulation and storage of thorium concentrates, the external dose potential from TREO(Th), TCS radioactive waste, and TCS tailings was not evaluated further in this dose assessment. Routine exposure rate checks of equipment and areas contacting these process residues should be sufficient to detect any unexpected buildup of gamma-emitting radioactive material.

(yrs)	Th-228	Ra-224	Rn-220	Po-216	Pb-212	Bi-212	Po-212	Tl-208
0.077	9.72E-01	9.73E-01	9.73E-01	9.73E-01	9.73E-01	9.73E-01	6.23E-01	3.50E-01

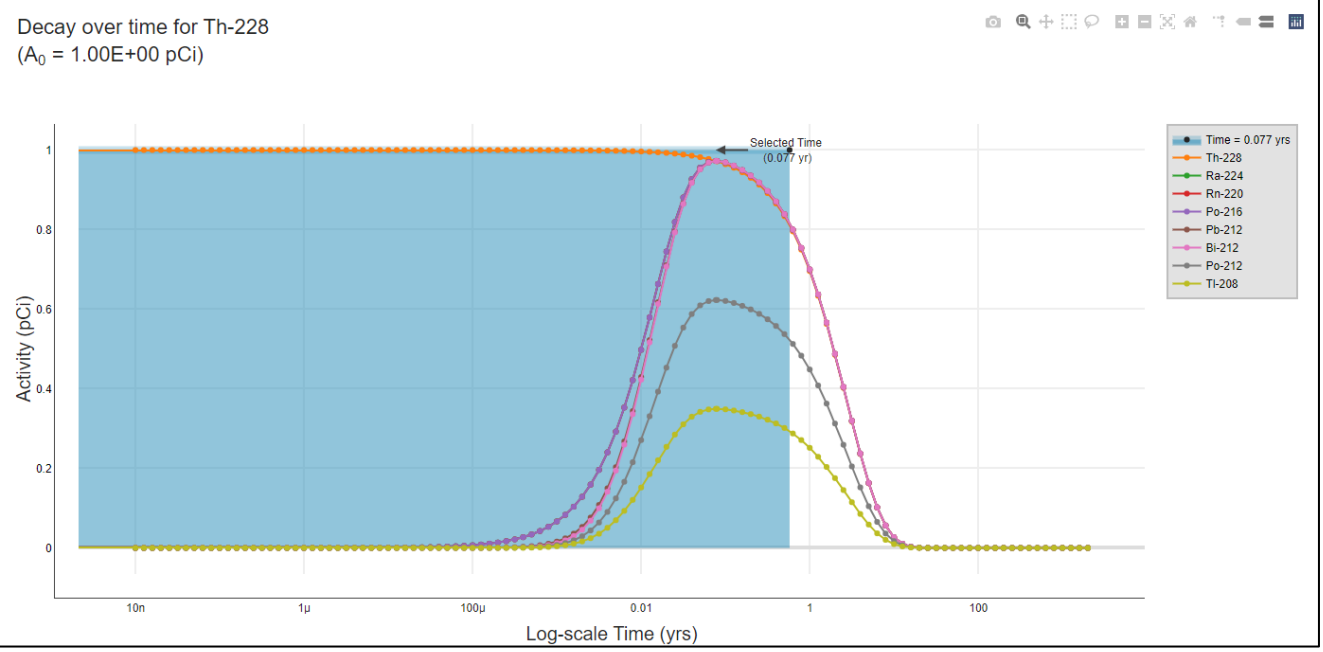


Figure 4. Ingrowth of thorium-228 decay products (displayed relative to thorium-228 at 28 days) calculated by Oak Ridge National Laboratory decay chain calculator[4]

[4] https://rais.ornl.gov/cgi-bin/chain/chain.pl

Activities for Th-232 and daughters at T = 0.077 yrs where initial activity = 1 pCi

Time of Interest (yrs)	Th-232	Ra-228	Ac-228	Th-228	Ra-224	Rn-220	Po-216	Pb-212	Bi-212	Po-212	Tl-208
0.077	1.00E+00	9.24E-03	9.12E-03	1.25E-04	8.63E-05	8.63E-05	8.63E-05	8.18E-05	8.13E-05	5.21E-05	2.92E-05

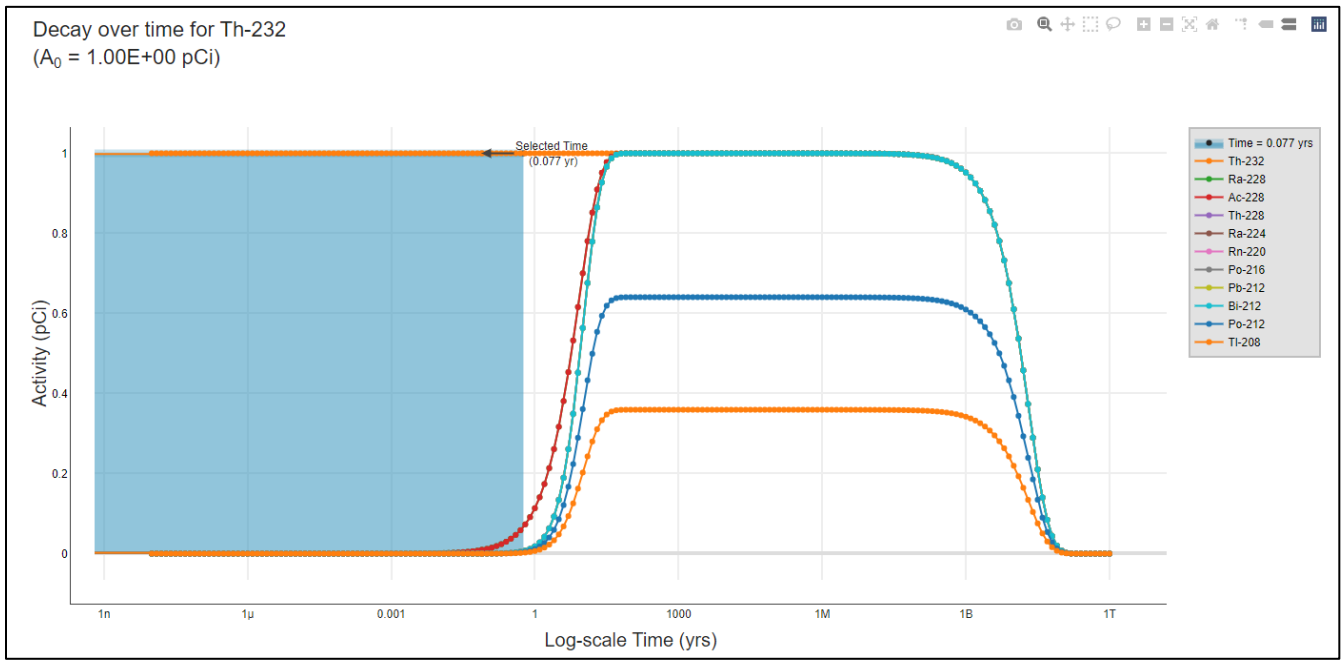


Figure 5. Ingrowth of thorium-232 decay products (displayed relative to thorium-232 at 28 days) calculated by Oak Ridge National Laboratory decay chain calculator[5]

1.3.4 Dose Conversion Factors

Table 10 lists potentially applicable dose conversion factors (DCFs) for radionuclides of interest.

Internationally accepted internal DCFs (ICRP 1994, 1996, 2012; EPA 2019) were used to estimate doses from inhalation and ingestion of source material in dust. These DCFs are used for prospective dose evaluation only and will not be used for operational compliance, which will rely on DCFs based on earlier ICRP publications (ICRP 1977, 1978; EPA 1988)[6]. This evaluation omits the small contributions to dose from the uranium-235 decay series. The DCFs for each radionuclide in the thorium and uranium decay series (other than radon) were summed to generate thorium and uranium decay series DCFs. As in the external dose estimate, radionuclides in each decay series were assumed to be in equilibrium in the exploration sample.

[5] https://rais.ornl.gov/cgi-bin/chain/chain.pl

[6] A comparison of DCFs based on ICRP publications 26 and 30 (EPA 1988) with the DCFs provided in Table 7 indicates that the older DCFs are generally higher, with combined inhalation DCFs for thorium and uranium being 7.0 and 3.2 times higher, respectively, ingestion DCFs for thorium and uranium being 1.3 and 1.7 times higher, respectively. Combined external DCFs in FGR 15 (EPA 2019) for these radionuclides are within 10% of those in FGR 12 (EPA 1993). Therefore, any protections implemented using the older values will be protective.

Table 10. Dose conversion factors for radionuclides of interest

Radionuclide		Inhalation DCF [a]		Ingestion DCF [a] (mrem pCi^{-1})	External DCF [b] (mrem hr^{-1} pCi g^{-1})
Natural thorium		1.80E-01	mrem pCi^{-1}	3.82E-03	1.67E-03
Natural uranium		1.71E-01	mrem pCi^{-1}	5.58E-03	1.29E-03
Radon [c]	Rn-220	5.56E+02	mrem y^{-1} per pCi L^{-1}	N/A	N/A
	Rn-222	1.67E+02	mrem y^{-1} per pCi L^{-1}	N/A	N/A
Thorium-232 series radionuclides	Th-232	1.07E-01	mrem pCi^{-1}	8.14E-04	5.84E-08
	Ra-228	6.29E-03	mrem pCi^{-1}	2.48E-03	1.57E-08
	Ac-228	1.07E-04	mrem pCi^{-1}	1.59E-06	5.88E-04
	Th-228	9.25E-02	mrem pCi^{-1}	2.66E-04	8.48E-07
	Ra-224	8.88E-03	mrem pCi^{-1}	2.41E-04	5.61E-06
	Po-216	Included in parent		Included in parent	1.01E-08
	Pb-212	1.22E-04	mrem pCi^{-1}	2.18E-05	7.42E-05
	Bi-212	1.44E-04	mrem pCi^{-1}	9.62E-07	9.31E-05
	Po-212 (64%)	Included in parent		Included in parent	0.00E+00
	Tl-208 (36%)	Included in parent		Included in parent	2.51E-03
Urainum-238 series radionuclides	U-238	2.11E-02	mrem pCi^{-1}	1.63E-04	1.96E-08
	Pa-234m	Included in parent		Included in parent	5.09E-05
	Th-234	2.15E-05	mrem pCi^{-1}	1.26E-05	3.41E-06
	U-234	2.52E-02	mrem pCi^{-1}	1.81E-04	4.01E-08
	Th-230	1.04E-01	mrem pCi^{-1}	7.77E-04	1.32E-07
	Ra-226	8.14E-03	mrem pCi^{-1}	1.04E-03	3.67E-06
	Po-218	Included in parent		Included in parent	2.58E-10
	Pb-214	1.78E-05	mrem pCi^{-1}	5.18E-07	1.49E-04
	Bi-214	7.77E-05	mrem pCi^{-1}	4.07E-07	1.07E-03
	Po-214	Included in parent		Included in parent	5.46E-08
	Pb-210	4.07E-03	mrem pCi^{-1}	2.52E-03	2.69E-07
	Bi-210	2.22E-04	mrem pCi^{-1}	4.81E-06	1.47E-05
	Po-210	8.14E-03	mrem pCi^{-1}	8.88E-04	6.39E-09

[a] Radiation DCFs from ICRP 68 (ICRP 1994; Johnson and Birky 2012, Tables 13.29 and 13.30) except for revised radium-226 inhalation coefficients from ICRP 119 (ICRP 2012). All DCFs are for the most limiting solubility class. Inhalation dose coefficients are for 5-micron particle size.
[b] External DCFs from FGR 15 (EPA 2019) Table 4-5 adult reference person effective dose rate coefficients for soil layer (infinite plane source) of infinite thickness, intended to represent a worker standing 1 meter away from shelved, stored super sacks containing the comminuted exploration sample, without taking credit for any dose reduction provided by space between the super sacks, shelving, or shielding. This table assumes a soil density of 1600 kilograms per cubic meter.
[c] Radon DCFs are based on conversion of the 10 CFR 20 Appendix B derived air concentration values and assume a 2000-hour exposure to radon with all decay products at 100% equilibrium.

Ac – actinium
Bi – bismuth
DCF – dose conversion factor
mrem – millirem
Pb – lead
pCi - picocurie
Po - polonium
Ra – radium
Rn - radon
Th – thorium
U – uranium
WL – working level
WLM – working level month

2 Occupational Dose Evaluation

This section presents a summary of the estimates for Demonstration Project workers updating an occupational dose assessment prepared for the commercial facility (ERG 2014). Table 11 summarizes the estimated doses.

Because there is potential for workers (including declared pregnant workers), to receive a radiation dose more than 100 mrem y^{-1}, RER will develop and implement a radiation protection program to control worker exposure to ionizing radiation to levels that are below regulatory limits and ALARA (see section 1.2).

2.1 Exposure Pathways

This section is intended to provide an overview of the kinds and magnitudes of potential radiological exposure associated with the Demonstration Project. At this stage of project development, specific estimates of worker exposures to radiation and radioactivity based on measured values are not available. Based on data in Table 8, the concentrations of source material in the exploration sample and total tailings are low, however the TCS feed material and tailings contain high levels of thorium.

Occupational radiation exposure (resulting in radiation dose) can occur from being exposed to gamma radiation from sources outside of the body and through radiation that is taken into the body through inhalation or ingestion. The following general comments apply with respect to possible pathways of exposure at the Demonstration Project:

- **Internal doses from particulate inhalation:** Processes at the Demonstration Project have the potential to create dust containing radionuclides in the thorium and uranium decay series. Scrubbers and bag houses will be used to control emissions from PUG processes, and active ventilation of process buildings will occur.
- **Internal doses from radon inhalation** (both radon-222 and radon-220 and their short-lived decay products): Active ventilation of process buildings is expected to control workplace radon and radon decay products to near-ambient levels.
- **Ingestion:** Unintended ingestion of dust containing thorium and uranium and their decay products is a minor potential pathway for internal doses. This pathway is typically controlled administratively by using workplace rules and best practices such as prohibiting smoking in the workplace and providing a clean lunch and break area. Contamination in the process areas will be controlled via good housekeeping practices which minimize the migration of source material from the plant to clean areas such as lunch/break rooms.
- **External doses:** Gamma emitting radionuclides are present in both the uranium and thorium decay series. The magnitude of the external dose is directly related to the amounts of uranium and/or thorium in the material being processed and inversely related to the distance from the material or source. If external gamma levels are unacceptably elevated, external doses can be reduced using administrative controls (e.g., increasing distance from source and/or reducing time near source) or engineering controls such as shielding. The primary external dose concern at the Demonstration Plant is exposure to the stored exploration sample.

2.2 Input Parameters

The nominal average uranium and thorium concentrations in the exploration sample (Table 8) were used to estimate prospective worker doses. The thorium and uranium series decay products were also assumed to be in radioactive equilibrium in the exploration sample. This is a reasonable assumption for the sample and pre-concentrate, but not necessarily for materials that have undergone chemical processing (e.g., the PP and TCS tailings and raffinates).

Equation 1 was used to estimate internal doses from inhalation, Equation 2 was used to estimate internal doses from ingestion, and Equation 3 was used to estimate external doses from source material.

$$D_{inh} = [(U \times DCU_{inh}) + (Th \times DCT_{inh})]C_d \times W_{inh} \times t \qquad \text{Equation 1}$$

$$D_{ing} = \left[\left(U \times DCU_{ing}\right) + (Th \times DCT_{ing})\right]W_{ing} \times t \qquad \text{Equation 2}$$

$$D_{ext} = [(U \times DCU_{ext}) + (Th \times DCT_{ext})]t \qquad \text{Equation 3}$$

Where:

D_{inh} inhalation dose (mrem y^{-1})

D_{ing}	ingestion dose (mrem y^{-1})
D_{ext}	external dose (mrem y^{-1})
U	concentration of uranium in exploration sample
Th	concentration of thorium in exploration sample
DCU_{inh}	inhalation dose conversion factor for uranium (Table 10)
DCT_{inh}	inhalation dose conversion factor for thorium (Table 10)
DCU_{ing}	ingestion dose conversion factor for uranium (Table 10)
DCT_{ing}	ingestion dose conversion factor for thorium (Table 10)
DCU_{ext}	external dose conversion factor for uranium (Table 10)
DCT_{ext}	external dose conversion factor for thorium (Table 10)
W_{inh}	worker inhalation rate, 1.2 m^3 h^{-1} (ICRP 1994)
W_{ing}	worker ingestion rate, 0.05 g d^{-1} (EPA 2011)
t	worker exposure duration per year (2000 h y^{-1} or 250 d y^{-1}) adjusted by occupancy factor if needed
C_d	mass-based dust concentration g m^{-3} (see section 1.3.3.2)

2.3 Worker Dose Estimates

It has been shown that external and internal doses at REE processing facilities are typically similar, with annual doses ranging from 300 to 900 mrem y^{-1} (IAEA 2007). Use of engineering controls will reduce airborne concentrations of radionuclides in the workplace. The Demonstration Plant Main Process Facility is designed to control particulate and gaseous emission in the work area via system ventilation and scrubbers.

Given the level of source material in the exploration sample and waste products, and assuming effective implementation of the radiation protection program, occupational doses from Demonstration Project activities will be well below regulatory limits and can be optimized using ALARA principles.

2.3.1 Airborne Particulate Inhalation and Ingestion

Within the PUG/Sample Storage Facility, inhalation of thorium and uranium bearing dust is possible from sample handling and crushing. A conservative dose estimate using the OSHA permissible exposure limit for respirable dust is below the regulatory limit for occupational radiation doses and national and international guidance for radiation dose limits for workers of 5000 mrem y^{-1}. With indoor air dust levels at the OSHA permissible exposure limit, the radionuclide concentration would be 3.6 times the derived air concentration (DAC, Table 1) for natural thorium and 0.02 times the DAC for natural uranium. However, the expected duration of PUG processing is short, expected to occur over 2 weeks.

The dose estimates in Table 11 assumed a 2-week exposure to a worker during PUG processing and were calculated using Equation 1 and Equation 2.

2.3.2 Radon Inhalation

Based on the conservatively predicted radon concentrations during PUG processing in section 1.3.3.2, estimated doses would be:

Radon-220: $\frac{5000\ \mathrm{mrem}}{2000\ \mathrm{h} \times 9 \frac{\mathrm{pCi}}{\mathrm{L}}} \times 1.7 \frac{\mathrm{pCi}}{\mathrm{L}} \times 50\%\ \mathrm{equilibrium} \times 80\ \mathrm{h} = 19\ \mathrm{mrem}$ using 9% of the DAC conversion (see Table 10)

Radon-222: $\frac{5000\ \text{mrem}}{2000\ \text{h} \times 30 \frac{\text{pCi}}{\text{L}}} \times 11 \frac{\text{pCi}}{\text{L}} \times 50\%\ \text{equilibrium} \times 80\ \text{h} = 38\ \text{mrem}$ using 19% of the DAC conversion (see Table 10)

Due to extensive ventilation of the Main Process Facility and process-specific emission controls, near-ambient levels of radon are expected in working areas, and a dose was not estimated for occupational exposure in this facility.

2.3.3 External

The source material content of the exploration sample contributes a significant external dose rate to an individual standing or working near the stored sample. External doses to workers in the PUG/Sample Storage Facility were estimated using Equation 3 and assuming a "wall" source, approximated as an isotropic, infinite plane. This "wall" source is intended to represent a worker standing 1 meter away from shelved, stored super sacks containing the comminuted exploration sample, without taking credit for any dose reduction provided by space between the super sacks, shelving, or shielding. A 25% occupancy assumption has been used. Assuming the exploration sample density is 1,600 kg m^{-3}, the conservatively estimated dose rate is 0.58 mrem hr^{-1} for this worker, or 290 mrem y^{-1} (Table 11). A review of the assumptions in FGR 15, Table 4-5 (EPA 2019), as well as a comparison to the DCFs in FGR 12, Table III.7 (EPA 1993), concluded that these DCFs are appropriate for the purpose of this conservative estimate.

The external dose rate in the vicinity of the stored exploration sample is expected to be higher than the rate near the waste mixing equipment and roll-off bins for the following reasons:

- The anticipated activity concentration of Th-232 series radionuclides is 142 pCi g^{-1} in total tailings compared to 320 pCi g^{-1} in the exploration sample, and for U-238 series radionuclides is 15 pCi g^{-1} in total tailings compared to 38 pCi g^{-1} in the exploration sample (see Table 8). A conservative reduction of the calculated dose rate using FGR 15 values with the same assumptions described above reduces the potential dose rate from 0.58 mrem hr^{-1} to 0.26 mrem hr^{-1}.
- Waste containers and process components will be smaller than an infinite plane source,
- Waste containers and process components will provide additional shielding (approximately 3 millimeters of steel)
- Stored waste will be located outdoors in a lower occupancy area, and
- Routine waste shipments will limit accumulation of tailings to approximately 1 roll-off bin per week.

Table 11. Radiation dose estimates for hypothetical maximally exposed workers

Demonstration Project Area	Activities	External	Inhalation	Ingestion	Total
PUG/Sample Storage Facility	Particulate emissions from any open system into the building air	Not evaluated	62 mrem	1 mrem	63 mrem
	Radon emissions to building air during PUG processing	Not evaluated	57 mrem	Not evaluated	57 mrem
	Standing or working near stored sample	290 mrem	Not evaluated	Not evaluated	290 mrem

PUG – physical upgrade
mrem - millirem

3 Public Dose Evaluation

This section is intended to provide an overview of the kinds and magnitudes of potential public doses associated with the proposed Demonstration Project. At this stage of project development, specific estimates of public doses from radiation and radioactivity based on measured values are not available and must be estimated using

conservative estimates of source terms coupled with computer modeling. The selection of the most appropriate model is based on likely exposure pathways (Table 7).

3.1 Exposure Pathways

The predominant pathway by which the public can receive doses from the ionizing radiation is inhalation of source material in dust released from the PUG process. Doses from gamma radiation from sources external to the body, such as deposited dust particles, and ingestion of deposited radionuclides are also potential pathways. Access controls such as fencing and visitor escorts will limit any direct public exposure to licensed material, and there are no other discharges anticipated from the Demonstration Project.

For this public dose evaluation, the inhalation of particulates emitted from the PUG/Sample Storage Facility is considered the most important pathway leading to potential public doses (Table 12). However, emissions of Rn-220 and Rn-222 were also modeled.

3.2 Atmospheric Dispersion Model

There are many atmospheric dispersion models that could be used to estimate off-site impacts from radon and particulate emissions from the Demonstration Project, including MILDOS-AREA, CAP-88, AERMOD, CALPUF, and RESRAD-OFFSITE. For this evaluation, CAP-88 was chosen because of its simplicity in providing a conservative dose estimate to selected receptors using a steady-state Gaussian plume model.

Input parameters are summarized in the following subsections. Attachment 1 provides summary output from the CAP-88 models.

3.2.1 Population

A series of midpoints was entered based on CAP-88 default population distances, which included between 100 and 70,000 meters (0.06 – 43 miles) from the facility (Figure 6). Notably, the nearest potential resident is located approximately 1,000 meters to the East Southeast of the facility. The 100-meter distance is unrealistically close for a full-time resident; however, this distance was modeled to be inclusive of potential public receptors in unrestricted areas within the site boundary fence. Potential onsite receptors could include visitors and delivery persons, whose occupancy would be a small fraction of the nearest resident.

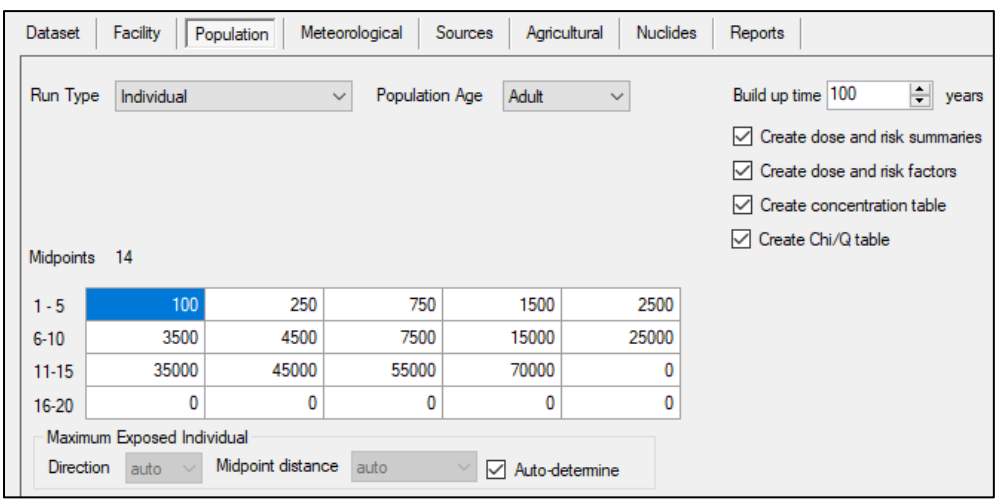


Figure 6. CAP-88 population distance inputs

3.2.2 Meteorological

The metrological inputs for precipitation, temperature, and humidity were from the Upton site meteorological station installed by RER and reported in the Rare Element Resources Upton Meteorological Monitoring Network Annual Report June 2020-June 2021 (IML 2021). The CAP-88 meteorological basis "wind" file was adapted using site-specific meteorological data from the Upton monitoring station identified in Map 5 of the *Environmental Report* (RER 2022b) for 2017-2021, see Attachment 1.

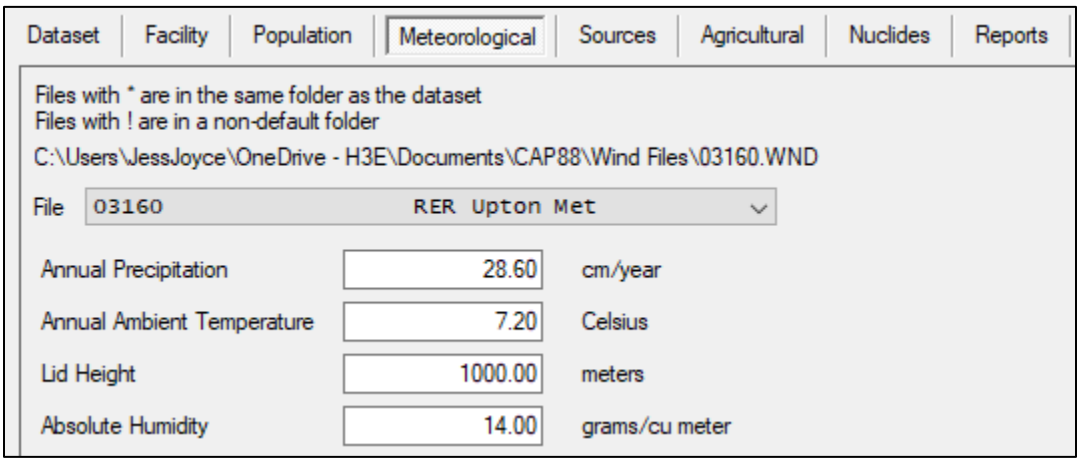


Figure 7. CAP-88 meteorological inputs

3.2.3 Sources

Stacks from the PUG building and Demonstration Plant building were modeled separately using conservative assumptions for stack diameter and release rate (Figure 8).

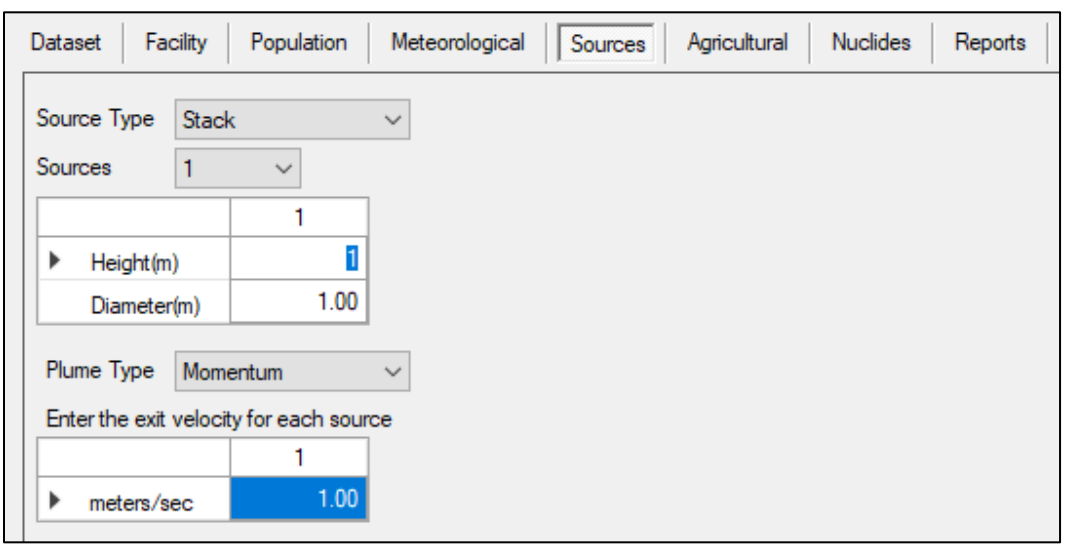


Figure 8. CAP-88 source data (single plume)

3.2.4 Agricultural

A rural agricultural scenario was used, and agricultural data were the CAP-88 defaults for Wyoming (Figure 9).

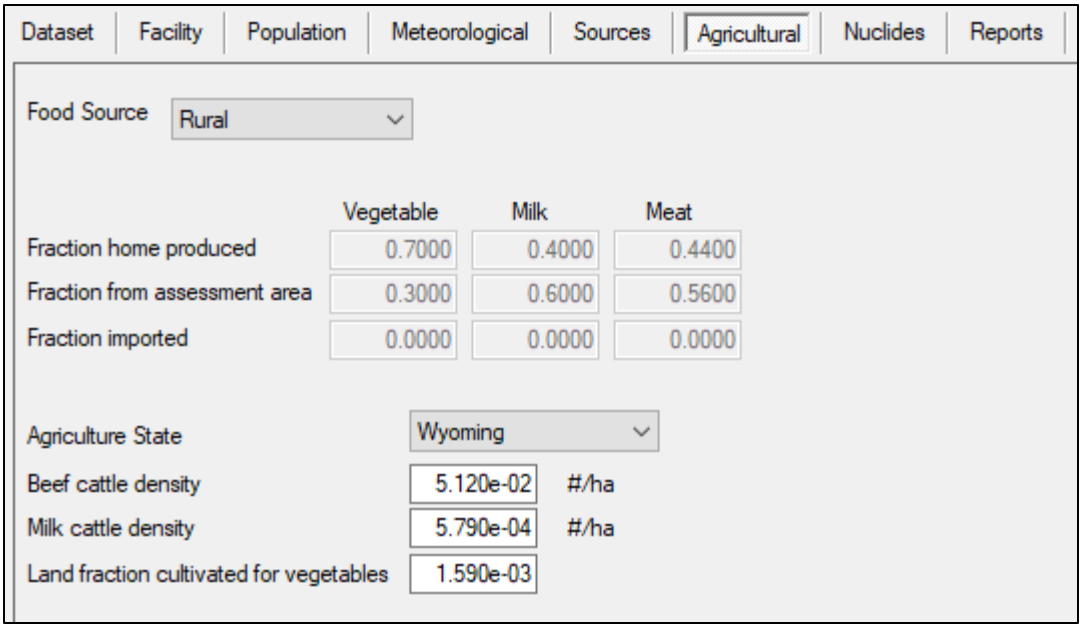


Figure 9. CAP-88 agricultural data

3.2.5 Nuclides

Based on the assumption in section 1.3.3.2 that a total of 3.8E-4 of the total inventory is emitted over the PUG process, the modeled radionuclide inputs in Figure 10 were used. The full decay series was included, however only particulates were run in the particulate model, assuming a size of 1 µm. A separate model was run for radon-220 and radon-222 assuming a release of 100% of "fresh" radon gas (radon-220 and radon-222 with no decay products initially present) during PUG processing (Figure 11).

Dataset | Facility | Population | Meteorological | Sources | Agricultural | Nuclides | Reports

Chain Length max | Radon Only | Ac-223 | Add

Released Nuclide Count 18 Total Nuclide Count 179 | Delete rows w/all 0 RR | Remove selected row | Remove

Adjust nuclide parameters, and enter release rates (ci/year) for each source

Note: Nuclides with no chemical form have no internal dose coefficient.

Chn	Nuclide	Chem Form	Type	Size	RR1
1	Th-232	Particulate	S	1.00...	1.100e-04
1	Ra-228	Particulate	M	1.00...	1.100e-04
1	Ac-228	Particulate	M	1.00...	1.100e-04
1	Th-228	Particulate	S	1.00...	1.100e-04
1	Ra-224	Particulate	M	1.00...	1.100e-04
1	Pb-212	Particulate	M	1.00...	1.100e-04
1	Bi-212	Particulate	M	1.00...	1.100e-04
2	U-238	Particulate	M	1.00...	2.600e-05
2	Th-234	Particulate	S	1.00...	2.600e-05
2	Pa-234	Particulate	M	1.00...	2.600e-05
2	U-234	Particulate	M	1.00...	2.600e-05
2	Th-230	Particulate	S	1.00...	2.600e-05
2	Ra-226	Particulate	M	1.00...	2.600e-05
2	Pb-214	Particulate	M	1.00...	2.600e-05
2	Bi-214	Particulate	M	1.00...	2.600e-05
2	Pb-210	Particulate	M	1.00...	2.600e-05
2	Bi-210	Particulate	M	1.00...	2.600e-05
2	Po-210	Inorganic	M	1.00...	2.600e-05

Figure 10. CAP-88 modeled airborne particulate radionuclides

Dataset | Facility | Population | Meteorological | Sources | Agricultural | Nuclides | Reports

Chain Length max | Radon Only | Ac-223 | Add

Released Nuclide Count 2 Total Nuclide Count 19 | Delete rows w/all 0 RR | Remove selected row | Remove

Adjust nuclide parameters, and enter release rates (ci/year) for each source

Note: Nuclides with no chemical form have no internal dose coefficient.

Chn	Nuclide	Chem Form	Type	Size	RR1
2	Rn-220			0.00...	2.900e-01
3	Rn-222			0.00...	3.400e-02

Figure 11. CAP-88 modeled radon

3.3 Public Dose Estimates

The dose estimated using CAP-88 (Table 12) for the hypothetical maximally exposed member of the public based on the inputs above was 0.87 mrem at the location 100 meters north northwest of the PUG/Sample Storage Facility. This assessment demonstrates that using conservative dose estimate methods, no publicly accessible locations had a dose greater than 100 mrem y^{-1}, the NRC public dose standard. If corrected for the location of the nearest actual receptor and reduced occupancy, the estimated dose would be even lower. Similarly, potential onsite receptors could include visitors and delivery persons, whose occupancy would be a small fraction of the nearest resident.

Given the level of source material in the exploration sample and waste products, and assuming effective implementation of the radiation protection program, public doses from Demonstration Project activities will be well below regulatory limits and can be optimized using ALARA principles.

Table 12. Radiation dose estimate for hypothetical maximally exposed member of the public

Demonstration Project Area	Activities	External (mrem)	Inhalation (mrem)	Ingestion (mrem)	Total (mrem)
PUG/Sample Storage Facility	Airborne emissions from the PUG/Sample Storage Facility (particulates)	0.178	0.624	0.062	0.865
PUG/Sample Storage Facility	Airborne emissions from the PUG/Sample Storage Facility (radon)[a]	0	0.002	0	0.002
Main Process Facility	Airborne emissions from the Main Process Facility	Not estimated	Not estimated	Not estimated	Not estimated

[a] CAP-88 calculates decay product concentration using radioactive ingrowth at each dose point; the equilibrium fraction is not considered and working levels are not reported. Air concentrations of all decay products at the maximum modeled dose location (100 m north northwest of the facility) are included in Attachment 1.
PUG – physical upgrade

4 References

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Attachment 1: CAP-88 Model Outputs

C A P 8 8 - P C

Version 4.1

Clean Air Act Assessment Package - 1988

S Y N O P S I S R E P O R T

Non-Radon Individual Assessment
Mon Aug 29 12:08:37 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:
DOSE Age Group: Adult

Comments: CAP-88 PC 4.1 run for Demonstration Project April
PUG particulate emissions

Effective Dose Equivalent (mrem)
8.65E-01

At This Location: 100 Meters North Northwest

Dataset Name: PUGparticulate08
Dataset Date: Aug 29, 2022 12:07 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 100 Meters North Northwest
Lifetime Fatal Cancer Risk: 6.01E-07

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Dose Equivalent (mrem)
Adrenals	1.70E-01
UB_Wall	1.88E-01
Bone_Sur	6.50E+00
Brain	1.79E-01
Breasts	1.95E-01
St_Wall	1.81E-01
SI_Wall	1.80E-01
ULI_Wall	1.86E-01
LLI_Wall	2.02E-01
Kidneys	3.45E-01
Liver	3.51E-01
Muscle	2.01E-01
Ovaries	2.08E-01
Pancreas	1.72E-01
R_Marrow	5.62E-01
Skin	1.31E+00
Spleen	2.35E-01
Testes	2.34E-01
Thymus	1.80E-01
Thyroid	1.86E-01
GB_Wall	1.72E-01
Ht_Wall	1.79E-01
Uterus	1.78E-01
ET_Reg	1.42E+00
Lung	4.68E+00
Effectiv	8.65E-01

RADIONUCLIDE EMISSIONS DURING THE YEAR

Nuclide	Type	Size	Source #1 Ci/y	TOTAL Ci/y
Th-232	S	1.000	1.1E-04	1.1E-04
Ra-228	M	1.000	1.1E-04	1.1E-04
Ac-228	M	1.000	1.1E-04	1.1E-04
Th-228	S	1.000	1.1E-04	1.1E-04
Ra-224	M	1.000	1.1E-04	1.1E-04
Pb-212	M	1.000	1.1E-04	1.1E-04
Bi-212	M	1.000	1.1E-04	1.1E-04
U-238	M	1.000	2.6E-05	2.6E-05
Th-234	S	1.000	2.6E-05	2.6E-05
Pa-234	M	1.000	2.6E-05	2.6E-05
U-234	M	1.000	2.6E-05	2.6E-05
Th-230	S	1.000	2.6E-05	2.6E-05
Ra-226	M	1.000	2.6E-05	2.6E-05
Pb-214	M	1.000	2.6E-05	2.6E-05
Bi-214	M	1.000	2.6E-05	2.6E-05
Pb-210	M	1.000	2.6E-05	2.6E-05
Bi-210	M	1.000	2.6E-05	2.6E-05
Po-210	M	1.000	2.6E-05	2.6E-05

SITE INFORMATION

Temperature:	7.200	degrees C
Precipitation:	28.600	cm/y
Humidity:	14.000	g/cu m
Mixing Height:	1000.0	m

SOURCE INFORMATION

Source Number: 1

Stack Height (m): 1.00
Diameter (m): 1.00

Plume Rise
Momentum (m/s): 1.00
(Exit Velocity)

ADJUSTED AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	0.7000	0.4000	0.4400
Fraction From Assessment Area:	0.3000	0.6000	0.5600
Fraction Imported:	0.0000	0.0000	0.0000

Food Arrays were not generated for this run.
Default Values used.

DISTANCES (M) USED FOR MAXIMUM INDIVIDUAL ASSESSMENT

100	250	750	1500	2500	3500	4500
7500	15000	25000	35000	45000	55000	70000

C A P 8 8 - P C

Version 4.1

Clean Air Act Assessment Package - 1988

W E A T H E R D A T A

Non-Radon Individual Assessment
Mon Aug 29 12:08:37 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:

Comments: CAP-88 PC 4.1 run for Demonstration Project April
PUG particulate emissions

Dataset Name: PUGparticulate08
Dataset Date: Aug 29, 2022 12:07 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind Files\03160.WND

HARMONIC AVERAGE WIND SPEEDS (WIND TOWARDS)

	Pasquill Stability Class							
Dir	A	B	C	D	E	F	G	Wind Freq
N	1.750	2.370	3.330	3.070	2.530	0.820	0.000	0.085
NNW	1.490	2.190	3.250	3.530	2.350	0.860	0.000	0.274
NW	1.440	1.880	2.190	3.160	1.700	0.700	0.000	0.077
WNW	1.230	1.430	1.780	2.970	1.310	0.550	0.000	0.015
W	1.190	1.340	2.110	2.740	1.660	0.460	0.000	0.009
WSW	1.320	1.800	2.650	3.680	2.150	0.630	0.000	0.011
SW	1.440	2.540	3.820	4.280	2.410	0.590	0.000	0.017
SSW	1.420	2.540	3.680	4.340	2.030	0.510	0.000	0.025
S	1.560	2.420	3.020	4.350	1.600	0.540	0.000	0.048
SSE	1.700	2.550	3.640	5.010	2.300	0.640	0.000	0.184
SE	1.770	2.770	3.770	5.090	3.050	0.990	0.000	0.138
ESE	1.880	2.600	3.260	4.500	2.940	0.880	0.000	0.046
E	1.430	2.610	3.430	4.150	2.870	0.760	0.000	0.021
ENE	1.670	2.630	3.560	4.480	2.130	0.980	0.000	0.014
NE	1.660	2.580	2.820	4.040	2.430	0.730	0.000	0.015
NNE	1.540	2.850	3.650	3.830	2.230	0.540	0.000	0.021

ARITHMETIC AVERAGE WIND SPEEDS (WIND TOWARDS)

	Pasquill Stability Class						
Dir	A	B	C	D	E	F	G
N	2.010	2.830	4.090	4.110	3.130	1.260	0.000
NNW	1.810	2.770	4.000	5.190	2.890	1.310	0.000
NW	1.740	2.500	2.980	4.450	2.510	1.040	0.000
WNW	1.480	1.750	2.620	3.820	1.870	0.960	0.000
W	1.460	1.820	3.300	3.780	2.140	0.900	0.000
WSW	1.550	2.570	3.680	4.510	2.620	1.060	0.000
SW	1.720	3.060	4.420	5.160	3.100	1.070	0.000
SSW	1.800	3.000	4.200	5.360	2.550	0.910	0.000
S	1.860	2.900	3.900	5.620	2.050	0.970	0.000
SSE	2.010	3.010	4.340	6.740	3.000	1.170	0.000
SE	2.080	3.070	4.310	6.420	3.540	1.480	0.000
ESE	2.070	3.110	3.990	5.320	3.570	1.390	0.000
E	1.620	3.030	3.910	5.080	3.440	1.370	0.000
ENE	1.840	3.010	4.280	5.900	2.630	1.400	0.000
NE	1.890	2.980	3.810	5.370	2.850	1.430	0.000
NNE	1.910	3.150	4.210	4.630	2.750	1.310	0.000

FREQUENCIES OF STABILITY CLASSES (WIND TOWARDS)

	Pasquill Stability Class						
Dir	A	B	C	D	E	F	G
N	0.0037	0.0029	0.0054	0.0371	0.0226	0.0128	0.0000
NNW	0.0064	0.0054	0.0161	0.1528	0.0657	0.0280	0.0000
NW	0.0052	0.0050	0.0093	0.0381	0.0061	0.0135	0.0000
WNW	0.0040	0.0017	0.0017	0.0022	0.0010	0.0043	0.0000
W	0.0030	0.0005	0.0006	0.0017	0.0008	0.0021	0.0000
WSW	0.0022	0.0007	0.0010	0.0044	0.0007	0.0021	0.0000
SW	0.0025	0.0008	0.0019	0.0093	0.0008	0.0019	0.0000
SSW	0.0031	0.0015	0.0030	0.0121	0.0018	0.0032	0.0000
S	0.0046	0.0035	0.0056	0.0257	0.0025	0.0059	0.0000
SSE	0.0053	0.0053	0.0138	0.1205	0.0257	0.0136	0.0000
SE	0.0043	0.0034	0.0059	0.0844	0.0303	0.0093	0.0000
ESE	0.0028	0.0016	0.0018	0.0252	0.0092	0.0053	0.0000
E	0.0015	0.0011	0.0012	0.0102	0.0042	0.0031	0.0000
ENE	0.0015	0.0008	0.0014	0.0060	0.0016	0.0029	0.0000
NE	0.0021	0.0008	0.0012	0.0062	0.0013	0.0034	0.0000
NNE	0.0026	0.0012	0.0017	0.0075	0.0024	0.0055	0.0000
TOTAL	0.0048	0.0040	0.0095	0.0853	0.0301	0.0146	0.0000

ADDITIONAL WEATHER INFORMATION

Average Air Temperature: 7.2 degrees C
280.36 K
Precipitation: 28.6 cm/y
Humidity: 14.0 g/cu m
Lid Height: 1000.0 meters
Surface Roughness Length: 0.010 meters
Height Of Wind Measurements: 10.0 meters
Average Wind Speed: 4.274 m/s

Vertical Temperature Gradients:
STABILITY E 0.073 k/m
STABILITY F 0.109 k/m
STABILITY G 0.146 k/m

D O S E A N D R I S K S U M M A R I E S

Non-Radon Individual Assessment
Mon Aug 29 12:08:37 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:
DOSE Age Group: Adult

Comments: CAP-88 PC 4.1 run for Demonstration Project April PUG particulate emissions

Dataset Name: PUGparticulate08
Dataset Date: Aug 29, 2022 12:07 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind Files\03160.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem)
Adrenals	1.70E-01
UB_Wall	1.88E-01
Bone_Sur	6.50E+00
Brain	1.79E-01
Breasts	1.95E-01
St_Wall	1.81E-01
SI_Wall	1.80E-01
ULI_Wall	1.86E-01
LLI_Wall	2.02E-01
Kidneys	3.45E-01
Liver	3.51E-01
Muscle	2.01E-01
Ovaries	2.08E-01
Pancreas	1.72E-01
R_Marrow	5.62E-01
Skin	1.31E+00
Spleen	2.35E-01
Testes	2.34E-01
Thymus	1.80E-01
Thyroid	1.86E-01
GB_Wall	1.72E-01
Ht_Wall	1.79E-01
Uterus	1.78E-01
ET_Reg	1.42E+00
Lung	4.68E+00
Effectiv	8.65E-01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem)
INGESTION	6.24E-02
INHALATION	6.24E-01
AIR IMMERSION	5.44E-06
GROUND SURFACE	1.78E-01
INTERNAL	6.87E-01
EXTERNAL	1.78E-01
TOTAL	8.65E-01

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem)
Th-232	2.31E-01
Ra-228	5.79E-02
Ac-228	5.67E-02
Th-228	3.07E-01
Ra-224	2.02E-02
Rn-220	4.06E-05
Po-216	9.79E-07
Pb-212	1.00E-02
Bi-212	1.06E-02
Po-212	0.00E+00
Tl-208	7.18E-02
U-238	5.24E-03
Th-234	1.58E-04
Pa-234m	1.79E-03
Pa-234	3.72E-05
U-234	6.30E-03
Th-230	3.02E-02
Ra-226	1.21E-02
Rn-222	5.93E-06
Po-218	1.06E-10
Pb-214	3.89E-03
At-218	3.99E-10
Bi-214	2.27E-02
Rn-218	2.31E-12
Po-214	1.25E-06
Tl-210	8.84E-06
Pb-210	8.46E-03
Bi-210	7.12E-04
Hg-206	4.52E-11
Po-210	7.67E-03
Tl-206	1.31E-09
TOTAL	8.65E-01

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Clean Air Act Assessment Package - 1988

C O N C E N T R A T I O N T A B L E S

Non-Radon Individual Assessment
Mon Aug 29 12:08:37 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:

Comments: CAP-88 PC 4.1 run for Demonstration Project April
PUG particulate emissions

Dataset Name: PUGparticulate08
Dataset Date: Aug 29, 2022 12:07 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind Files\03160.WND

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2-s)	Wet Depo Rate (pCi/cm2-s)	Ground Depo Rate (pCi/cm2-s)
NNW	100	Th-232	4.68E-04	8.42E-11	7.83E-13	8.50E-11
NNW	100	Ra-228	4.68E-04	8.42E-11	7.83E-13	8.50E-11
NNW	100	Ac-228	4.68E-04	8.42E-11	7.83E-13	8.50E-11
NNW	100	Th-228	4.68E-04	8.42E-11	7.83E-13	8.50E-11
NNW	100	Ra-224	4.68E-04	8.42E-11	7.83E-13	8.50E-11
NNW	100	Rn-220	2.36E-04	0.00E+00	0.00E+00	0.00E+00
NNW	100	Po-216	2.32E-04	4.18E-11	3.67E-13	4.21E-11
NNW	100	Pb-212	4.67E-04	8.41E-11	7.83E-13	8.49E-11
NNW	100	Bi-212	4.68E-04	8.42E-11	7.83E-13	8.50E-11
NNW	100	Po-212	3.00E-04	5.39E-11	5.02E-13	5.44E-11
NNW	100	Tl-208	3.45E-05	6.21E-12	5.36E-14	6.27E-12
NNW	100	U-238	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Th-234	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Pa-234m	4.74E-05	8.53E-12	7.47E-14	8.61E-12
NNW	100	Pa-234	1.10E-04	1.99E-11	1.85E-13	2.00E-11
NNW	100	U-234	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Th-230	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Ra-226	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Rn-222	1.50E-08	0.00E+00	0.00E+00	0.00E+00
NNW	100	Po-218	2.10E-09	3.78E-16	3.05E-18	3.81E-16
NNW	100	Pb-214	1.08E-04	1.94E-11	1.81E-13	1.95E-11
NNW	100	At-218	4.01E-13	7.22E-20	5.81E-22	7.28E-20
NNW	100	Bi-214	1.10E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Rn-218	4.08E-16	0.00E+00	0.00E+00	0.00E+00
NNW	100	Po-214	1.10E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Tl-210	9.27E-09	1.67E-15	1.46E-17	1.68E-15
NNW	100	Pb-210	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Bi-210	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Hg-206	1.78E-13	3.21E-20	2.76E-22	3.24E-20
NNW	100	Po-210	1.11E-04	1.99E-11	1.85E-13	2.01E-11
NNW	100	Tl-206	2.28E-11	4.11E-18	3.54E-20	4.14E-18

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Clean Air Act Assessment Package - 1988

S Y N O P S I S R E P O R T

Non-Radon Individual Assessment
Tue Aug 23 13:44:56 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:
DOSE Age Group: Adult

Comments: CAP-88 PC 4.1 run for Demonstration Project 2022
PUG radon emissions (radon gas only)

Effective Dose Equivalent
(mrem)

2.22E-03

At This Location: 100 Meters North Northwest

Dataset Name: PUGradon0823noDP
Dataset Date: Aug 23, 2022 01:44 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 100 Meters North Northwest
Lifetime Fatal Cancer Risk: 2.67E-09

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Dose Equivalent (mrem)
Adrenals	1.86E-05
UB_Wall	2.02E-05
Bone_Sur	2.11E-04
Brain	1.97E-05
Breasts	2.10E-05
St_Wall	2.46E-05
SI_Wall	3.08E-05
ULI_Wall	6.36E-05
LLI_Wall	7.05E-05
Kidneys	1.80E-04
Liver	6.20E-05
Muscle	2.06E-05
Ovaries	1.92E-05
Pancreas	1.86E-05
R_Marrow	3.67E-05
Skin	7.45E-05
Spleen	1.95E-05
Testes	2.06E-05
Thymus	1.97E-05
Thyroid	1.99E-05
GB_Wall	1.88E-05
Ht_Wall	1.94E-05
Uterus	1.88E-05
ET_Reg	8.33E-03
Lung	1.80E-02
Effectiv	2.22E-03

RADIONUCLIDE EMISSIONS DURING THE YEAR

Nuclide	Type	Size	Source #1 Ci/y	TOTAL Ci/y
Rn-220	B	0.000	2.9E-01	2.9E-01
Rn-222	B	0.000	3.4E-02	3.4E-02

SITE INFORMATION

Temperature:	7.200	degrees C
Precipitation:	28.600	cm/y
Humidity:	14.000	g/cu m
Mixing Height:	1000.0	m

SOURCE INFORMATION

Source Number: 1

Stack Height (m): 1.00
Diameter (m): 1.00

Plume Rise
Momentum (m/s): 1.00
(Exit Velocity)

ADJUSTED AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	0.7000	0.4000	0.4400
Fraction From Assessment Area:	0.3000	0.6000	0.5600
Fraction Imported:	0.0000	0.0000	0.0000

Food Arrays were not generated for this run.
Default Values used.

DISTANCES (M) USED FOR MAXIMUM INDIVIDUAL ASSESSMENT

100	250	750	1500	2500	3500	4500
7500	15000	25000	35000	45000	55000	70000

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Version 4.1

Clean Air Act Assessment Package - 1988

W E A T H E R D A T A

Non-Radon Individual Assessment
Tue Aug 23 13:44:56 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:

Comments: CAP-88 PC 4.1 run for Demonstration Project 2022
PUG radon emissions (radon gas only)

Dataset Name: PUGradon0823noDP
Dataset Date: Aug 23, 2022 01:44 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind Files\03160.WND

HARMONIC AVERAGE WIND SPEEDS (WIND TOWARDS)

	Pasquill Stability Class							
Dir	A	B	C	D	E	F	G	Wind Freq
N	1.750	2.370	3.330	3.070	2.530	0.820	0.000	0.085
NNW	1.490	2.190	3.250	3.530	2.350	0.860	0.000	0.274
NW	1.440	1.880	2.190	3.160	1.700	0.700	0.000	0.077
WNW	1.230	1.430	1.780	2.970	1.310	0.550	0.000	0.015
W	1.190	1.340	2.110	2.740	1.660	0.460	0.000	0.009
WSW	1.320	1.800	2.650	3.680	2.150	0.630	0.000	0.011
SW	1.440	2.540	3.820	4.280	2.410	0.590	0.000	0.017
SSW	1.420	2.540	3.680	4.340	2.030	0.510	0.000	0.025
S	1.560	2.420	3.020	4.350	1.600	0.540	0.000	0.048
SSE	1.700	2.550	3.640	5.010	2.300	0.640	0.000	0.184
SE	1.770	2.770	3.770	5.090	3.050	0.990	0.000	0.138
ESE	1.880	2.600	3.260	4.500	2.940	0.880	0.000	0.046
E	1.430	2.610	3.430	4.150	2.870	0.760	0.000	0.021
ENE	1.670	2.630	3.560	4.480	2.130	0.980	0.000	0.014
NE	1.660	2.580	2.820	4.040	2.430	0.730	0.000	0.015
NNE	1.540	2.850	3.650	3.830	2.230	0.540	0.000	0.021

ARITHMETIC AVERAGE WIND SPEEDS (WIND TOWARDS)

	Pasquill Stability Class						
Dir	A	B	C	D	E	F	G
N	2.010	2.830	4.090	4.110	3.130	1.260	0.000
NNW	1.810	2.770	4.000	5.190	2.890	1.310	0.000
NW	1.740	2.500	2.980	4.450	2.510	1.040	0.000
WNW	1.480	1.750	2.620	3.820	1.870	0.960	0.000
W	1.460	1.820	3.300	3.780	2.140	0.900	0.000
WSW	1.550	2.570	3.680	4.510	2.620	1.060	0.000
SW	1.720	3.060	4.420	5.160	3.100	1.070	0.000
SSW	1.800	3.000	4.200	5.360	2.550	0.910	0.000
S	1.860	2.900	3.900	5.620	2.050	0.970	0.000
SSE	2.010	3.010	4.340	6.740	3.000	1.170	0.000
SE	2.080	3.070	4.310	6.420	3.540	1.480	0.000
ESE	2.070	3.110	3.990	5.320	3.570	1.390	0.000
E	1.620	3.030	3.910	5.080	3.440	1.370	0.000
ENE	1.840	3.010	4.280	5.900	2.630	1.400	0.000
NE	1.890	2.980	3.810	5.370	2.850	1.430	0.000
NNE	1.910	3.150	4.210	4.630	2.750	1.310	0.000

FREQUENCIES OF STABILITY CLASSES (WIND TOWARDS)

	Pasquill Stability Class						
Dir	A	B	C	D	E	F	G
N	0.0037	0.0029	0.0054	0.0371	0.0226	0.0128	0.0000
NNW	0.0064	0.0054	0.0161	0.1528	0.0657	0.0280	0.0000
NW	0.0052	0.0050	0.0093	0.0381	0.0061	0.0135	0.0000
WNW	0.0040	0.0017	0.0017	0.0022	0.0010	0.0043	0.0000
W	0.0030	0.0005	0.0006	0.0017	0.0008	0.0021	0.0000
WSW	0.0022	0.0007	0.0010	0.0044	0.0007	0.0021	0.0000
SW	0.0025	0.0008	0.0019	0.0093	0.0008	0.0019	0.0000
SSW	0.0031	0.0015	0.0030	0.0121	0.0018	0.0032	0.0000
S	0.0046	0.0035	0.0056	0.0257	0.0025	0.0059	0.0000
SSE	0.0053	0.0053	0.0138	0.1205	0.0257	0.0136	0.0000
SE	0.0043	0.0034	0.0059	0.0844	0.0303	0.0093	0.0000
ESE	0.0028	0.0016	0.0018	0.0252	0.0092	0.0053	0.0000
E	0.0015	0.0011	0.0012	0.0102	0.0042	0.0031	0.0000
ENE	0.0015	0.0008	0.0014	0.0060	0.0016	0.0029	0.0000
NE	0.0021	0.0008	0.0012	0.0062	0.0013	0.0034	0.0000
NNE	0.0026	0.0012	0.0017	0.0075	0.0024	0.0055	0.0000
TOTAL	0.0048	0.0040	0.0095	0.0853	0.0301	0.0146	0.0000

ADDITIONAL WEATHER INFORMATION

Average Air Temperature: 7.2 degrees C
280.36 K
Precipitation: 28.6 cm/y
Humidity: 14.0 g/cu m
Lid Height: 1000.0 meters
Surface Roughness Length: 0.010 meters
Height Of Wind Measurements: 10.0 meters
Average Wind Speed: 4.274 m/s

Vertical Temperature Gradients:
STABILITY E 0.073 k/m
STABILITY F 0.109 k/m
STABILITY G 0.146 k/m

D O S E A N D R I S K S U M M A R I E S

Non-Radon Individual Assessment
Tue Aug 23 13:44:56 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:
DOSE Age Group: Adult

Comments: CAP-88 PC 4.1 run for Demonstration Project 2022
PUG radon emissions (radon gas only)

Dataset Name: PUGradon0823noDP
Dataset Date: Aug 23, 2022 01:44 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind Files\03160.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem)
Adrenals	1.86E-05
UB_Wall	2.02E-05
Bone_Sur	2.11E-04
Brain	1.97E-05
Breasts	2.10E-05
St_Wall	2.46E-05
SI_Wall	3.08E-05
ULI_Wall	6.36E-05
LLI_Wall	7.05E-05
Kidneys	1.80E-04
Liver	6.20E-05
Muscle	2.06E-05
Ovaries	1.92E-05
Pancreas	1.86E-05
R_Marrow	3.67E-05
Skin	7.45E-05
Spleen	1.95E-05
Testes	2.06E-05
Thymus	1.97E-05
Thyroid	1.99E-05
GB_Wall	1.88E-05
Ht_Wall	1.94E-05
Uterus	1.88E-05
ET_Reg	8.33E-03
Lung	1.80E-02
Effectiv	2.22E-03

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem)
INGESTION	3.44E-09
INHALATION	2.21E-03
AIR IMMERSION	3.87E-06
GROUND SURFACE	8.66E-06
INTERNAL	2.21E-03
EXTERNAL	1.25E-05
TOTAL	2.22E-03

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem)
Rn-220	2.06E-06
Po-216	5.07E-08
Pb-212	2.10E-03
Bi-212	4.21E-06
Po-212	0.00E+00
Tl-208	5.54E-06
Rn-222	2.96E-07
Po-218	8.95E-12
Pb-214	1.05E-04
At-218	6.69E-13
Bi-214	3.85E-06
Rn-218	2.30E-14
Po-214	8.15E-11
Tl-210	5.46E-10
Pb-210	1.79E-09
Bi-210	2.06E-08
Hg-206	1.67E-15
Po-210	5.36E-12
Tl-206	4.82E-14
TOTAL	2.22E-03

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Version 4.1

Clean Air Act Assessment Package - 1988

C O N C E N T R A T I O N T A B L E S

Non-Radon Individual Assessment
Tue Aug 23 13:44:56 2022

Facility: Demonstration Project
Address:
City:
State: WY Zip:

Source Category:
Source Type: Stack
Emission Year:

Comments: CAP-88 PC 4.1 run for Demonstration Project 2022
PUG radon emissions (radon gas only)

Dataset Name: PUGradon0823noDP
Dataset Date: Aug 23, 2022 01:44 PM
Wind File: C:\Users\JessJoyce\OneDrive - H3E\Documents\CAP88\Wind Files\03160.WND

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2-s)	Wet Depo Rate (pCi/cm2-s)	Ground Depo Rate (pCi/cm2-s)
NNW	100	Rn-220	6.29E-01	0.00E+00	0.00E+00	0.00E+00
NNW	100	Po-216	6.21E-01	1.12E-07	1.10E-09	1.13E-07
NNW	100	Pb-212	8.87E-04	1.60E-10	1.40E-12	1.61E-10
NNW	100	Bi-212	7.97E-06	1.43E-12	1.17E-14	1.45E-12
NNW	100	Po-212	5.11E-06	9.19E-13	7.48E-15	9.26E-13
NNW	100	Tl-208	3.62E-07	6.51E-14	5.10E-16	6.56E-14
NNW	100	Rn-222	1.47E-01	0.00E+00	0.00E+00	0.00E+00
NNW	100	Po-218	2.93E-02	5.27E-09	4.55E-11	5.32E-09
NNW	100	Pb-214	5.60E-04	1.01E-10	8.14E-13	1.02E-10
NNW	100	At-218	5.67E-06	1.02E-12	8.79E-15	1.03E-12
NNW	100	Bi-214	1.15E-05	2.08E-12	1.62E-14	2.09E-12
NNW	100	Rn-218	5.76E-09	0.00E+00	0.00E+00	0.00E+00
NNW	100	Po-214	1.15E-05	2.08E-12	1.62E-14	2.09E-12
NNW	100	Tl-210	5.08E-10	9.15E-17	7.05E-19	9.22E-17
NNW	100	Pb-210	3.28E-13	5.90E-20	4.53E-22	5.94E-20
NNW	100	Bi-210	1.23E-17	2.21E-24	1.69E-26	2.23E-24
NNW	100	Hg-206	2.01E-22	3.62E-29	0.00E+00	3.65E-29
NNW	100	Po-210	1.40E-23	2.51E-30	0.00E+00	2.53E-30
NNW	100	Tl-206	1.12E-23	2.02E-30	0.00E+00	2.04E-30

Appendix G: USDA Forest Service Non-Federal Commercial Road Use Permit

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

NON-FEDERAL COMMERCIAL ROAD USE PERMIT

AUTHORITY:

Section 4 and Section 6 of the National Forest Roads and Trails Act
16 U.S.C. 535 and 537

Rare Element Resources, LTD is hereby granted use and maintenance of the following roads or road segments and related transportation facilities NFSR 838, NFSR 851 and NFSR 879.1 on the Bearlodge Hills Ranger Districts, Black Hills National Forest, for access to private property with construction equipment and haul trucks and reconstruction of NFSR 879.1 per the plans and drawings Rare Element Resources, LTD submitted.

TERMS AND CONDITIONS

I. GENERAL TERMS

A. AUTHORITY. This permit is issued pursuant to the National Forest Roads and Trails Act, 16 U.S.C. 535 and 537, and 36 CFR Part 212, Subpart A, as amended, and is subject to their provisions.

B. RESPONSIBLE OFFICIAL. The responsible official is the district ranger or a subordinate officer with delegated authority.

C. TERM. This permit shall expire at midnight on 12/31/23 from the date of issuance. Expiration of this permit shall not require notice, a decision document, or any environmental analysis or other documentation.

D. RENEWAL. This permit is not renewable. Prior to expiration of this permit, the holder may apply for a new permit that would renew the use authorized by this permit. Renewal of the use shall be at the sole discretion of the responsible official.

E. AMENDMENT. This permit may be amended in whole or in part by the Forest Service when, at the discretion of the responsible official, this action is deemed necessary or desirable to incorporate new terms that may be required by law, regulation, directive, the applicable land management plan, or projects and activities implementing a land management plan pursuant to 36 CFR part 215.

F. COMPLIANCE WITH LAWS, REGULATIONS, AND OTHER LEGAL REQUIREMENTS. In exercising the rights and privileges granted by this permit, the holder shall comply with all present and future federal laws and regulations and all present and future state, county, and municipal laws, regulations, and other legal requirements, including state traffic laws, that apply to the permit area, to the extent they do not conflict with federal law, regulation, or policy The Forest Service assumes no responsibility for enforcing laws, regulations, and other legal requirements that fall under the jurisdiction of other governmental entities.

G. NON-EXCLUSIVE USE. The use authorized by this permit is not exclusive. The Forest Service reserves the right to use the roads authorized by this permit and to allow others to use them at any time. The holder shall use the roads authorized by this permit in a manner that will not unreasonably or unnecessarily interfere with their use by others, including the Forest Service. Except for any restrictions that the holder and the Forest Service agree are necessary to protect public safety and road investments, the roads authorized by this permit shall remain open to the public for all lawful purposes.

H. ASSIGNABILITY. This permit is not assignable or transferable.

II. OPERATIONS

A. ANNUAL OPERATING PLAN. The holder shall prepare and annually revise by January 1 an operating plan. The annual operating plan shall be prepared in consultation with the responsible official or the responsible official's designated representative and shall cover all operations authorized by this permit. At a minimum, the annual operating plan shall specify the date the use authorized by this permit will commence, the duration and extent of the use, the products that will be hauled, a traffic control plan per clause II.C, the names of the holder's employees, contractors, and subcontractors who will use the roads authorized by this permit on behalf of the holder, and any other information regarding the authorized use deemed necessary by the responsible official. The annual operating plan shall be submitted by the holder and approved by the responsible official or the responsible official's designated representative prior to commencement of commercial hauling under this permit and shall be attached to this permit as Appendix A. If there is any material change in the information contained in the annual operating plan, the holder shall notify the responsible official promptly in writing of the change.

B. HOLDER'S REPRESENTATIVE. The holder shall designate a representative for purposes of administration of this permit and shall notify the responsible official in writing who the holder's representative will be.

C. USE RECORDS. Every [N/A] during periods the holder is conducting commercial hauling on the roads covered by this permit, the holder shall provide scale or other records acceptable to the responsible official that document the quantity hauled, calculated in the unit of measure (e.g., thousands of board feet, tons, cubic yards, or vehicle units) used to determine payments in lieu of performance under clause III.E or the holder's investment share under section V.

D. PUBLIC SAFETY. When the holder is engaged in commercial hauling adjacent to or on National Forest System roads or National Forest System trails open to public travel, the holder shall provide users with adequate warning of hazardous conditions associated with the holder's operations. A traffic control plan for each commercial hauling project shall be approved by the responsible official in writing before commercial hauling commences. Warning devices shall be appropriate for current conditions and shall be covered or removed when not needed. Flags and other warning devices shall comply with the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) and any specifications attached to this permit.

E. TRAFFIC RULES AND USE RESTRICTIONS

1. The holder and its agents, employees, and contractors shall comply with all traffic rules and use restrictions imposed by the Forest Service, including:

a. Road closures or use restrictions prompted by weather conditions, a fire hazard, or road construction or maintenance.

b. Traffic rules for safe and effective use of roads.

c. Regulation of the number of vehicles using a road to prevent traffic congestion.

2. Unless specified in this permit or approved in writing by the responsible official, use of motor vehicles by the holder or its agents, employees, or contractors must be in accordance with the applicable motor vehicle use map (36 CFR 261.13).

3. Temporary traffic control signs, flagging, and warning devices for road construction, operation, or maintenance conducted under this permit shall comply with Part 6 of the MUTCD.

4. The holder shall not load logs on trucks parked on a road, except to recover lost logs.

5. The holder shall not operate vehicles or equipment with cleats or other tracks that will injure the road surface.

6. The holder shall not operate logging trucks more than _____ feet wide, more than _____ feet long, or with a gross weight and load of more than_____ tons.

F. REQUIREMENT TO CARRY A COPY OF THE PERMIT. Drivers of all vehicles operating under this permit shall have a copy of the first sheet of this permit in their vehicle. The copy will be presented, on request, to any Forest Service officer.

G. LOAD MARKING. Unless otherwise approved in writing by the responsible official, when hauling wood products under authority of this permit, a 6" minimum size red letter "P" shall be painted on three or more ends of logs visible from the front and on three or more ends of logs visible from the back of the load.

III. PERFORMANCE AND COST RECOVERY

A. RECONSTRUCTION REQUIRED TO ACCOMMODATE USE. The holder shall perform any road reconstruction required to accommodate the holder's use under this permit, or deposit funds sufficient to cover the cost of the reconstruction, before the holder's use commences.

B. RECONSTRUCTION SCHEDULE, PLANS, AND SPECIFICATIONS. To accommodate the authorized use, the holder shall perform the road reconstruction described in the attached schedule (Appendix B), in accordance with that schedule and the attached plans and specifications (Appendix C).

C. COMMENSURATE SHARE

1. The holder shall perform maintenance, or deposit funds sufficient to cover the cost of maintenance, commensurate with the holder's use of the roads authorized by this permit (the holder's commensurate share), measured, e.g., in thousand board feet, cubic yards, or vehicle units. The holder shall be entirely responsible for maintenance that is necessitated by the holder's use, i.e., maintenance which would not be necessary if the holder's use did not occur. The holder shall be proportionately responsible with other users of the roads authorized by this permit for maintenance not necessitated by traffic, i.e., maintenance that is necessary due to natural causes such as rain, wind, rock fall, and growth of brush. Maintenance that could be required or for which payment could be required by this clause includes, at a minimum, work addressed in section IV of this permit.

2. The initial calculation of the holder's commensurate share, including the maintenance made necessary by the authorized use and the cost of the maintenance, is shown in Appendix A. The value of the holder's commensurate share for the use authorized by this permit is $ (See Appendix A), provided that the rate shall be revised upward or downward on the anniversary date of this permit, based on estimated costs and anticipated use of the roads authorized under this permit. If the value of the holder's commensurate share exceeds the cost of maintenance that is performed on the roads authorized by this permit, the difference between the value of the holder's commensurate share and the cost of the maintenance performed shall be deposited in cash, as provided in clause III.E.

D. PERFORMANCE BOND FOR ROAD MAINTENANCE. As a further guarantee of the holder's commensurate share obligation, the responsible official may require the holder to furnish a surety bond or other security.

1. As a further guarantee of compliance with the holder's commensurate share obligation, the holder shall deliver and maintain a surety bond or other acceptable security, such as cash deposited and maintained in a federal depository or negotiable securities of the United States, in the amount of $_____. The responsible official may periodically evaluate the adequacy of the bond or other security and increase or decrease the amount as appropriate. If the bond or other security becomes unsatisfactory to the responsible official, the holder shall within 30 days of demand furnish a new bond or other security issued by a surety that is solvent and satisfactory to the responsible official. If the holder fails to meet any of the requirements secured under this clause, money deposited pursuant to this clause shall be retained by the United States to the extent

necessary to satisfy the obligations secured under this clause, without prejudice to any other rights and remedies of the United States.

2. The bond shall be released or other security returned 30 days after (a) the responsible official certifies that the obligations covered by the bond or other security are met and (b) the holder establishes to the satisfaction of the responsible official that all claims for labor and material for the secured obligations have been paid or released.

E. PAYMENT IN LIEU OF PERFORMANCE. An initial payment in lieu of performance of maintenance in the amount of $_____ shall be made before use commences under this permit. Thereafter, payments in lieu of performance shall be made [weekly/monthly] in the amount of $_____, calculated using the rate of payment for the holder's commensurate share in clause III.C. Payments shall be based on monthly use records submitted per clause II.C. Payments shall be sent to [address]. In lieu of an advance payment, the holder may deliver and maintain a surety bond or other acceptable security, such as cash deposited and maintained in a federal depository or negotiable securities of the United States, in the amount of $_____. If the holder fails to meet the payment obligation secured under this clause, money deposited pursuant to this clause shall be retained by the United States to the extent necessary to satisfy the obligation, without prejudice to any other rights and remedies of the United States. The surety bond shall be released or other security returned 30 days after the responsible official certifies that the obligation covered by the bond or other security is met.

IV. REQUIREMENTS FOR CONDUCTING MAINTENANCE

A. IN GENERAL. When maintenance is performed, it shall be conducted in accordance with the following requirements and the requirements in Appendix E:

1. The holder shall perform maintenance on the roads authorized by this permit that is necessary to protect and repair the roadbed, road surface, and associated transportation facilities.

2. The holder shall resurface the roads authorized by this permit to the extent loss of surfacing is caused by the use authorized by this permit.

3. If other commercial haulers are operating on the roads authorized by this permit, the holder and those commercial haulers shall enter into an agreement for performance of maintenance on these roads. If conflicts arise regarding responsibility for the maintenance, commercial hauling on these roads shall cease until the conflicts are resolved.

B. SNOW REMOVAL. Snow removal shall be conducted in a manner that protects roads, ensures safe and efficient transportation of materials, and prevents erosion damage to roads, streams, and adjacent lands. The holder shall:

1. Remove snow from the entire width of the road surface, including turnouts.

2. Remove snow slides, earth slides, fallen timber, and boulders that obstruct the road surface.

3. Remove snow, ice, and debris from ditches and culverts so that the drainage system will function efficiently at all times.

4. Deposit all debris, except snow and ice, removed from the road surface and ditches at locations approved by the responsible official and away from stream channels.

5. Leave at least 2 inches of snow to protect the road.

6. Restore any damage resulting from snow removal in a timely manner.

7. Ensure that snow plowing is conducted in accordance with the traffic control plan required under clause II.C.

The holder shall not:

8. Undercut constructed slopes or remove gravel or other surfacing material from the road surface.

9. Leave snow berms on the road surface. Berms on the shoulder of the road shall be removed or drainage holes shall be opened and maintained. Drainage holes shall be spaced as necessary to obtain satisfactory surface drainage without discharge on erodible fills.

10. Use equipment with cleats or other tracks to plow snow without prior written approval of the responsible official.

C. ROAD USE TICKET. N/A

V. INVESTMENT SHARING. The holder is hauling non-federal forest products from land tributary to roads authorized under this permit, and is therefore subject to investment sharing under 16 U.S.C. 535. The holder and the responsible official have entered into a cooperative agreement for the agency to recoup the holder's share of the construction costs for roads authorized under this permit that have been borne by the agency (the holder's investment share). The holder may contribute funds or may perform maintenance or reconstruction required to accommodate the holder's use to satisfy the holder's investment sharing obligation. The cooperative agreement shall include the holder's investment share calculation and shall be attached to this permit.

V. INVESTMENT SHARING

1. The holder is hauling non-federal forest products from land tributary to roads authorized under this permit, and is therefore subject to investment sharing under 16 U.S.C. 535. The holder shall reimburse the Forest Service or, in lieu of reimbursement, perform maintenance or reconstruction required to accommodate the holder's use, for the holder's share of the construction costs for roads authorized under this permit that have been borne by the Forest Service (the holder's investment share). If reconstruction to accommodate the holder's use is required, it shall be completed before the holder's use commences.

2. The holder's investment share shall be based on the percentage of total non-federal forest products on lands tributary to the roads authorized by this permit that the holder will be hauling. The value of the holder's investment share is $_____, calculated using the rate of payment for the holder's commensurate share in clause III.C. Payments shall be based on monthly use records submitted per clause II.C. Payments shall be sent to [address]. The holder's investment share shall be paid off at a rate of the total construction costs for roads authorized under this permit divided by the total volume of non-federal forest products (e.g., measured in thousand board feet, tons, cubic yards, or vehicle units) that will be hauled from lands tributary to the roads authorized by this permit over [specify period, typically 20 years]. The calculation of the holder's investment share and the rate of payment are shown in Appendix F.

VI. RIGHTS AND LIABILITIES

A. LEGAL EFFECT OF THE PERMIT. This permit, which is revocable and terminable, is a federal license. This permit does not constitute a contract or lease for purposes of the Contract Disputes Act, 41 U.S.C. 601. This

permit is not real property, does not convey any interest in real property, and may not be used as collateral for a loan.

B. VALID OUTSTANDING RIGHTS. This permit is subject to all valid outstanding rights.

C. ABSENCE OF THIRD-PARTY BENEFICIARY RIGHTS. The parties to this permit do not intend to confer any rights on any third party as a beneficiary under this permit.

D. RISK OF LOSS. The holder assumes all risk of loss associated with use of the roads authorized by this permit, including but not limited to theft, vandalism, fire and any fire-fighting activities (including prescribed burns), avalanches, rising waters, winds, falling limbs or trees, and acts of God.

E. DAMAGE TO UNITED STATES PROPERTY. The holder has an affirmative duty to protect from damage the land, property, and other interests of the United States. Damage includes but is not limited to fire suppression costs, damage to government improvements covered by this permit, and all costs and damages associated with or resulting from the release or threatened release of a hazardous material occurring during or as a result of activities of the holder or the holder's heirs, assigns, agents, employees, contractors, or lessees on, or related to, the lands, property, and other interests covered by this permit. For purposes of this clause, "hazardous material" shall mean any hazardous substance, pollutant, contaminant, hazardous waste, oil, and/or petroleum product, as those terms are defined under any federal, state, or local law or regulation.

1. The holder shall avoid damaging or contaminating the environment, including but not limited to the soil, vegetation (such as trees, shrubs, and grass), surface water, and groundwater, while conducting commercial hauling under this permit. If the environment or any government property covered by this permit becomes damaged during the holder's use under this permit, the holder shall immediately repair the damage or replace the damaged items to the satisfaction of the responsible official and at no expense to the United States.

2. The holder shall be liable for all injury, loss, or damage, including fire suppression, or other costs in connection with rehabilitation or restoration of natural resources associated with the use authorized by this permit. Compensation shall include but not be limited to the value of resources damaged or destroyed, the costs of restoration, cleanup, or other mitigation, fire suppression or other types of abatement costs, and all administrative, legal (including attorney's fees), and other costs. Such costs may be deducted from a performance bond required under clause IV.D.

3. The holder shall be liable for damage caused by use of the holder or the holder's heirs, assigns, agents, employees, contractors, or lessees to all roads and trails of the United States to the same extent as provided under clause VI.E.1.

F. HEALTH, SAFETY, AND ENVIRONMENTAL PROTECTION. The holder shall promptly abate as completely as possible and in compliance with all applicable laws and regulations any activity or condition arising out of or relating to use of the roads authorized by this permit that causes or threatens to cause a hazard to public health or the safety of the holder's employees or agents or harm to the environment (including areas of vegetation or timber, fish or other wildlife populations, their habitats, or any other natural resources). The holder shall immediately notify the responsible official of all traffic accidents and any other serious accidents that occur in connection with the authorized use. The responsibility to protect the health and safety of all persons affected by use of the roads authorized by this permit is solely that of the holder. The Forest Service has no duty under the terms of this permit to inspect the roads authorized by this permit or authorized activities of the holder for hazardous conditions or compliance with health and safety standards.

G. COMPLIANCE WITH ENVIRONMENTAL LAWS. The holder shall in connection with use of the roads authorized by this permit comply with all applicable federal, state, and local environmental laws and regulations, including but not limited to those established pursuant to the Resource Conservation and Recovery Act, as amended, 42 U.S.C. 6901 *et seq.*, the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 *et seq.*, the Oil Pollution Act, as amended, 33 U.S.C. 2701 *et seq.*, the Clean Air Act, as amended, 42 U.S.C. 7401 *et seq.*, the Comprehensive Environmental Response,

Compensation, and Liability Act (CERCLA), as amended, 42 U.S.C. 9601 *et seq.*, the Toxic Substances Control Act, as amended, 15 U.S.C. 2601 *et seq.*, the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, 7 U.S.C. 136 *et seq.*, and the Safe Drinking Water Act, as amended, 42 U.S.C. 300f *et seq.*

H. INDEMNIFICATION OF THE UNITED STATES. The holder shall indemnify, defend, and hold harmless the United States for any costs, damages, claims, liabilities, and judgments arising from past, present, and future acts or omissions of the holder or the holder's employees, contractors, or subcontractors in connection with use of the roads authorized by this permit. This indemnification provision includes but is not limited to acts and omissions of the holder or the holder's heirs, assigns, agents, employees, or contractors in connection with use of the roads authorized by this permit which result in (1) violations of any laws and regulations which are now or which may in the future become applicable, and including but not limited to those environmental laws listed in clause V.G of this permit; (2) judgments, claims, demands, penalties, or fees assessed against the United States; (3) costs, expenses, and damages incurred by the United States; or (4) the release or threatened release of any solid waste, hazardous waste, hazardous substance, pollutant, contaminant, oil in any form, or petroleum product into the environment. The responsible official may prescribe terms that allow the holder to replace, repair, restore, or otherwise undertake necessary curative actions to mitigate damages in addition to or as an alternative to monetary indemnification.

I. INSURANCE

1. The holder or the holder's employees, contractors, or subcontractors shall have in force automobile insurance covering losses associated with the use authorized by this permit in at least the amount of $ 100,000 for injury or death to one person, $ 300,000 for injury or death to two or more persons, and $ 100,000 for property damage. Minimum amounts of coverage and other insurance requirements are subject to change at the sole discretion of the responsible official on the anniversary date of this permit.

2. Any insurance policies obtained by the holder pursuant to this clause shall name the United States as an additional insured, and the additional insured provision shall provide for insurance coverage for the United States as required under clause VI.I. The policies also shall specify that the insurance company shall give 30 days prior written notice to the responsible official of cancellation of or any modification to the policies.

3. The holder shall furnish proof of insurance, such as a certificate of insurance, to the responsible official prior to issuance of this permit and each year thereafter that this permit is in effect. The Forest Service reserves the right to review and approve the insurance policy prior to issuance. The holder shall send an authenticated copy of any insurance policy obtained pursuant to clause VI.I to the responsible official immediately upon issuance of the policy. The certificate of insurance, the authenticated copy of the insurance policy, and written notice of cancellation or modification of insurance should be sent to [address of responsible official].

VII. REVOCATION, SUSPENSION, AND TERMINATION

A. REVOCATION AND SUSPENSION. The responsible official may revoke or suspend this permit in whole or in part for:

1. Noncompliance with federal, state, or local law.

2. Noncompliance with the terms of this permit.

3. Abandonment or other failure of the holder to exercise the privileges granted.

Prior to revocation or suspension, other than immediate suspension under clause VII.B, the responsible official shall give the holder written notice of the grounds for revocation or suspension and a reasonable

time, typically not to exceed 90 days, to cure any noncompliance. Revocation or suspension of this permit shall not give rise to any claim for damages by the holder against the Forest Service.

B. IMMEDIATE SUSPENSION. The responsible official may immediately suspend this permit in whole or in part when necessary to protect public health or safety or the environment. The suspension decision shall be in writing.

C. TERMINATION. This permit shall terminate when by its terms a fixed or agreed upon condition, event, or time occurs without any action by the responsible official, such as expiration of the permit by its terms on a specified date or with the consent of the holder. Termination of this permit shall not give rise to any claim for damages by the holder against the Forest Service.

VIII. MISCELLANEOUS PROVISIONS

A. MEMBERS OF CONGRESS. No member of or delegate to Congress or Resident Commissioner shall benefit from this permit either directly or indirectly, except to the extent the authorized use provides a general benefit to a corporation.

B. CURRENT ADDRESSES. The holder and the responsible official shall keep each other informed of current mailing addresses, including those necessary for payment of the holder's commensurate or investment share.

C. SUPERIOR CLAUSES. If there is a conflict between any of the preceding printed clauses and any of the following clauses, the preceding printed clauses shall control.

THIS PERMIT IS ACCEPTED SUBJECT TO ALL ITS TERMS AND CONDITIONS.

BEFORE ANY PERMIT IS ISSUED TO AN ENTITY, DOCUMENTATION MUST BE PROVIDED TO THE RESPONSIBLE OFFICIAL OF THE AUTHORITY OF THE SIGNATORY FOR THE ENTITY TO BIND IT TO THE TERMS AND CONDITIONS OF THE PERMIT.

ACCEPTED:

President & CEO
Randall J. Scott — Randall J. Scott — 2/16/22

HOLDER NAME, PRECEDED BY NAME AND TITLE OF PERSON SIGNING ON BEHALF OF HOLDER, IF HOLDER IS AN ENTITY — SIGNATURE — DATE

APPROVED:

Michael Gosse — Michael Gosse — 2/16/2022

NAME AND TITLE OF RESPONSIBLE OFFICIAL — SIGNATURE — DATE

According to the Paperwork Reduction Act of 1995, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 0596-0016. The time required to complete this information collection is estimated to have no associated burden per response, including the time for

reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

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The Privacy Act of 1974 (5 U.S.C. 552a) and the Freedom of Information Act (5 U.S.C. 552) govern the confidentiality to be provided for information received by the Forest Service.

Appendix H: Radiological Baseline Data

Baseline Radiological Investigation 2015 (ML15134A348)

BASELINE RADIOLOGICAL INVESTIGATION REPORT

BEAR LODGE PROJECT UPTON PLANT
Weston County, Wyoming

April 2015

Submitted to and Prepared for:

Rare Element Resources, Inc.
225 Union Blvd, Suite 250
Lakewood, CO 80228

Prepared by:

Environmental Restoration Group, Inc.
8809 Washington Street NE
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TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 DESCRIPTION OF THE PROJECT 2
1.2 PURPOSE AND SCOPE 2
1.3 ORGANIZATION AND CONTENTS 2

2.0 BASELINE FIELD INVESTIGATION SUMMARY AND SCOPE 4

2.1 OVERALL SCOPE OF PROJECT 4
2.2 DEVIATIONS FROM THE SAP 5
2.3 FUTURE WORK 6

3.0 GPS-BASED GAMMA (DIRECT RADIATION) SURVEY 7

3.1 GPS SURVEY METHODS 7
3.2 RESULTS OF GPS-BASED GAMMA SURVEY 7
3.3 DERIVATION OF EXPOSURE RATES BASED ON HPIC CORRELATION 12

4.0 BASELINE RADIOLOGICAL INVESTIGATION SOIL SAMPLING 17

4.1 SAMPLING STRATEGY AND APPROACH 17
4.2 RADIONUCLIDE CONCENTRATIONS IN SURFACE SOILS 19
4.3 SUMMARY OF RADIUM-226 RESULTS 20
4.4 OTHER RADIONUCLIDES 21
4.5 SURFACE SOIL RADIUM-226 AND NATURAL THORIUM ESTIMATES BASED ON GAMMA-SOIL RADIUM CORRELATION 22

5.0 DATA QUALITY ASSESSMENT 26

6.0 RADON FLUX MEASUREMENTS 28

7.0 AMBIENT RADON MEASUREMENTS 29

7.1 MEASUREMENT LOCATIONS 29
7.2 MEASUREMENT RESULTS 29

8.0 ENVIRONMENTAL DOSIMETER MEASUREMENTS 34

8.1 MEASUREMENT LOCATIONS 34
8.2 MEASUREMENT RESULTS 34

9.0 AIRBORNE PARTICULATES 36

9.1 TOTAL PARTICULATES 36
9.1.1 Radioactive Particulates *37*
9.1.2 Lanthanide Particulates *43*
9.2 PARTICULATE MATTER FRACTIONS 47

10.0 SUMMARY AND CONCLUSIONS 58

11.0 REFERENCES 60

TABLE OF CONTENTS (CONTINUED)

List of Illustrations

Illustration 3.1	Histogram of Gamma Count Rates
Illustration 3.2	Normal Probability Plot of Gamma Count Rates
Illustration 3.3	Lognormal Probability Plot of Gamma Count Rates

List of Tables

Table 2.1	Summary of Radiological Investigation Scope
Table 3.1	Statistical Summary of Gamma Count Rates
Table 3.2	Integrated Gamma Count Rates and High Pressure Ion Chamber Measurements
Table 3.3	Statistical Summary of Predicted Exposure Rates
Table 4.1	Sample Location Coordinates
Table 4.2	Laboratory Analytical Results for Soil Samples
Table 4.3	Summary Statistics for Radium-226 Concentrations in Soil Samples
Table 4.4	Summary Statistics for Other Radionuclide Concentrations in Soil Samples
Table 4.5	Radium-226 Concentrations and Integrated Gamma Count Rates
Table 4.6	Statistical Summary of Radium-226 and Natural Thorium Concentrations Predicted from Gamma Count Rates
Table 5.1	QA-QC Comparison Results
Table 5.2	QA-QC Comparisons: RPD and RER Summary
Table 6.1	Radon Flux Results
Table 7.1	Ambient Radon Track Etch Detector Locations
Table 7.2	Ambient Radon Track Etch Detector Results
Table 8.1	Environmental Dosimeter Results
Table 9.1	Radionuclide Concentrations in Air
Table 9.2	Summary Statistics for Radionuclide Concentrations in Air

TABLE OF CONTENTS (CONCLUDED)

Table 9.3	Lanthanide Concentrations in Air
Table 9.4	Summary Statistics for Lanthanide Concentrations in Air
Table 9.5	PM_{10} Concentrations Measured at Upton Air Monitoring Stations
Table 9.6	$PM_{2.5}$ Concentrations Measured at Upton Air Monitoring Stations

List of Figures

Figure 1.1	Upton Site Layout and Geographic Setting
Figure 3.1	High Pressure Ion Chamber and Gamma Count Rate Measurement Locations
Figure 3.2	High Pressure Ion Chamber and Gamma Count Rate Measurement Linear Regression Model
Figure 3.3	Exposure Rates Predicted from Gamma Count Rates
Figure 4.1	Soil Sample and Radon Flux Locations
Figure 7.1	Ambient Radon Track Etch Detector and Air Monitoring Station Locations

List of Appendices

Appendix A	Instrument Calibration and Function Check Forms
Appendix B	Laboratory Analytical Data: Soils
Appendix C	Radon Flux Measurement Documentation
Appendix D	Laboratory Analytical Data: Ambient Radon Concentrations
Appendix E	Laboratory Analytical Data: Environmental Dosimeters
Appendix F	Laboratory Analytical Data: Particulates

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
cm	centimeters
cpm	counts per minute
EPA	U.S. Environmental Protection Agency
ERG	Environmental Restoration Group, Inc.
GPS	Global Positioning System
HPIC	High Pressure Ion Chamber
in.	inch
IQR	interquartile range
km	kilometer
LLD	lower limit of detection
$\mu R\ hr^{-1}$	microRoentgens per hour
m, $m\ s^{-1}$	meter, meters per second
MDL	method detection limit
$mg\ kg^{-1}$	milligrams per kilogram
n	number of observations
$pCi\ g^{-1}$	picocuries per gram
$pCi\ m^{-2}\ s^{-1}$	picocuries per meter squared per second
QA/QC	Quality Assurance/Quality Control
Ra-226	radium-226
Ra-228	radium-228
RER	Rare Element Resources, Inc.
RER	replicate error ratio
RL	reporting limit
Rn-222	radon-222, or radon
RPD	relative percent difference
SAP	Sampling and Analysis and Quality Assurance Plans (Draft)

ACRONYMS AND ABBREVIATIONS (CONCLUDED)

Acronym	Definition
TSF	tailings storage facility
Th-nat	natural thorium
UAMS	Upton air monitoring station
$\mu Ci\ f^{-1}$	microcuries per filter
$\mu Ci\ ml^{-1}$	microcuries per milliliter
$\mu g\ f^{-1}$	micrograms per filter
$\mu g\ m^{-3}$	micrograms per cubic meter
U-nat	natural uranium

1.0 INTRODUCTION

Rare Element Resources, Inc. (RER) is proposing the construction of a rare earth element (REE) mine and hydrometallurgical (hydromet) processing plant, as part of its Bear Lodge Project. The mine will be located in Crook County, Wyoming, approximately 12 miles north of Sundance, Wyoming. Mine ore will be physically upgraded into a pre-concentrate and shipped to the Upton Plant that includes the hydromet facility and tailings storage facility (TSF) near Upton in Weston County, Wyoming. The hydromet will process the pre-concentrate through leaching, neutralization and precipitation to a final REE product. Tailings generated from the hydromet will be placed in the TSF.

Environmental Restoration Group, Inc. (ERG) conducted a baseline radiological investigation of the Upton Plant site in support of this proposed development, as requested by RER. The work described in this report was performed in accordance with applicable requirements in *Bear Lodge Project Upton Plant/TSF Environmental Sampling and Analysis and Quality Assurance Plans (Draft)* (SAP [RER, 2011]).

The objective of the radiological investigation —and monitoring program by extension— is to establish the baseline condition of the Upton Plant including 1) concentrations of radionuclides and lanthanides (cerium and lanthanum) in airborne particulates and gases (i.e. radon-222[radon]), surface soil, surface water, and groundwater, 2) gamma exposure rates, and 3) radon flux from soil surface to assess future potential impacts to human health and the environment during project construction, operation, and closure. Radiological impacts incurred during the development and operation of the Upton Plant, if any, will be evaluated in part by comparing the data sets of the baseline and operational monitoring. The monitoring of particulate matter (particles with diameters less than 10 (PM_{10}) and ($PM_{2.5}$) 2.5 microns —unrelated to radiological monitoring but relevant to pre-operational site conditions— is addressed in this investigation.

It is anticipated that radon, natural uranium and thorium, radium-226, and radium-228 will be the primary radionuclides of potential concern in assessments of exposure pathways.

Phase 1 of the work, conducted in June 2012 with continued air monitoring, addressed radon concentrations in air and baseline radionuclide concentrations in soils; and associated radon flux and gamma exposure rates. This report contains the results of baseline measurements of 1) radioactive and lanthanide (cerium and lanthanum) particulates and 2) PM_{10} and $PM_{2.5}$ concentrations in air, all obtained from June 2012 to September 2014. Baseline radionuclide concentrations in groundwater and surface water are addressed and reported separately in the environmental report of RER's license application to the U.S. Nuclear Regulatory Commission (RER, 2015).

1.1 Description of the Project

The Project is located in Weston County, Wyoming; specifically Township 48 North, Range 65 West including all of Section 33 and parts of Sections 28, 29, and 32. Surface ownership within the Project is comprised of 850 acres of private land. Figure 1.1 shows the location of the Upton Plant.

1.2 Purpose and Scope

The objective of the investigation was to establish baseline concentrations of radon and radioactive, lanthanide, PM_{10} and $PM_{2.5}$ particulates in air; and radionuclides in surface soil (0-15 centimeters [cm]) and related radon flux and exposure rates at the Upton Plant. This information will be used in part to assess future potential impacts to human health and the environment, if any, during construction, operation, and closure phases. The results from monitoring of radionuclides in groundwater and surface water have been investigated and are reported separately in the Environmental Report (ER) submitted to NRC as part of the license application (RER, 2015).

The collection of soil samples and other quality-affecting work performed in June 2012 were conducted in accordance with

- the requirements of Section 2.3 of the SAP;
- applicable ERG Standard Operating Procedures; and
- RER's Health and Safety Program and the *Bear Lodge Project Health and Safety Plan, Draft* (Knight Piésold, 2011).

1.3 Organization and Contents

Following this introduction, Section 2 summarizes the scope of the investigation and identifies any deviations from the SAP. Section 3 documents the results of the gamma survey and associated predictions of exposure rates. Section 4 documents the analytical results for soil samples and predictions of radium-226 and natural thorium concentrations in surface soil samples from gamma survey results. Section 5 discusses associated data quality issues. Section 6 presents the results of radon flux measurements. Section 7 presents a description of and the locations of passive radon track etch detectors. Section 8 presents the particulate concentrations (long-lived radionuclides, stable rare earth elements, and PM_{10} and $PM_{2.5}$ fractions of particulate matter) in air. Section 9 presents the summary and conclusions, followed by references in Section 10.

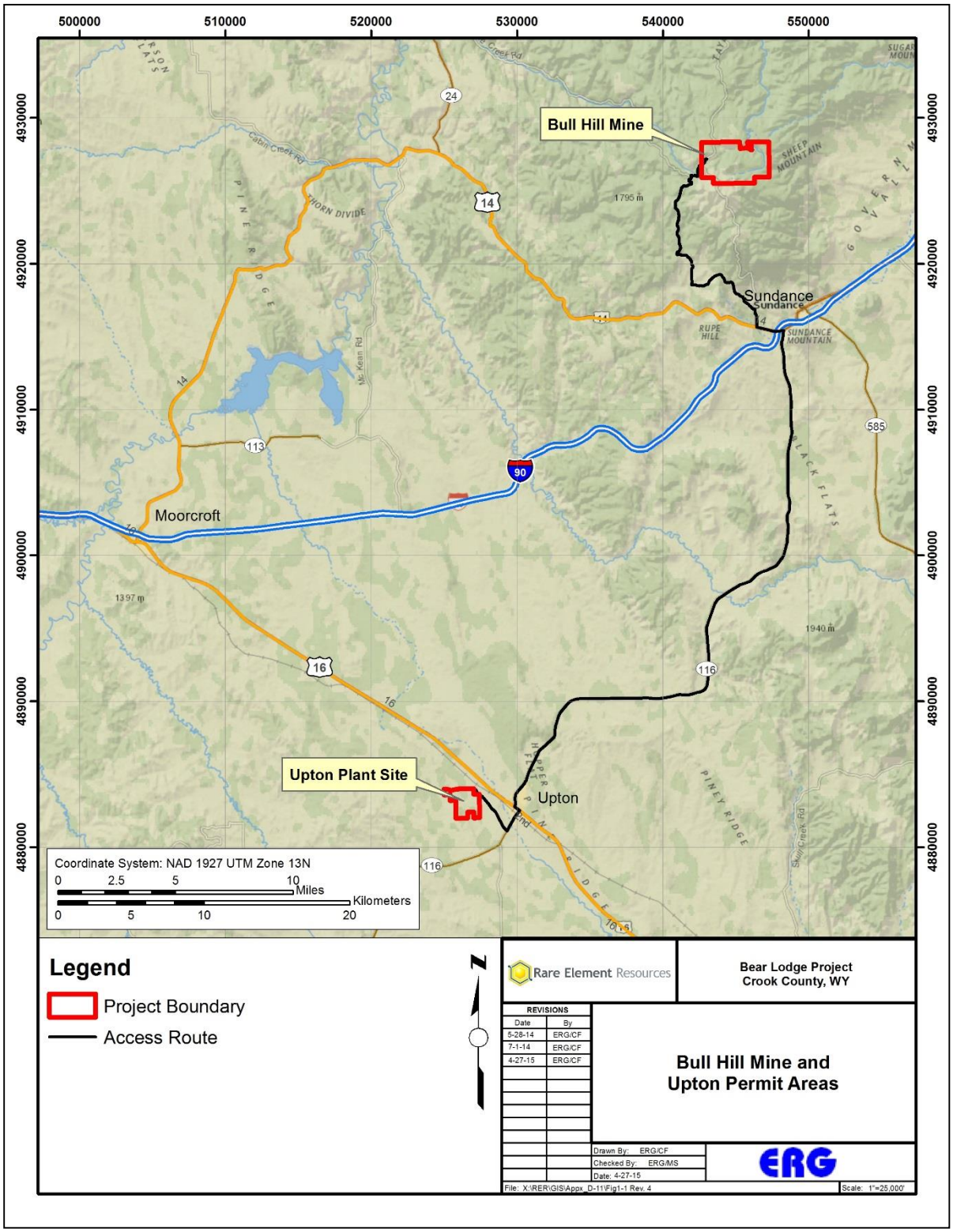

Figure 1.1. Upton Plant Site Layout and Geographic Setting

2.0 BASELINE FIELD INVESTIGATION SUMMARY AND SCOPE

2.1 Overall Scope of Project

The baseline radiological field investigation consisted of:

- a Global Positioning System (GPS)-based gamma survey conducted along transects, spaced at 100 meters (m), spanning the Upton Plant;
- co-located exposure and integrated gamma count rate measurements;
- deployment of passive radon track etch detectors at nine biased locations;
- collection of surface soil samples at 16 randomly selected locations;
- radon flux measurements at five of the soil sample locations; and
- collection of particulate concentrations (long-lived radionuclides, stable rare earth elements, and PM_{10} and $PM_{2.5}$ fractions of particulate matter) in air at five Upton air monitoring stations (UAMS).

Table 2.1 summarizes the scope of the field program and the following section identifies deviations from the SAP.

To assist the reader, it is important to note the following issues that are relevant to the scope of work:

> ***Differences in scanning and integrated gamma-ray measurements.*** *Scanning measurements are those recorded during the walking survey, with the ratemeter/scaler in ratemeter mode. Count rate measurements are recorded every second in this method and stored individually, each with its own geoposition. Integrated measurements, on the other hand, are recorded, in the case of this investigation, at one location for one minute, with the ratemeter/scaler in scaler (integrating) mode. In this mode, the detector integrates the number of interactions (counts) within the one minute counting period. Both types of measurements are reported as counts per minute (cpm).*
>
> ***Presentation of the scanning data.*** *Project-wide exposure rates and radium-226 concentrations were predicted from linear correlations between integrated gamma count rates and co-located exposure rate measurements and soil samples, respectively. Because the predicted values are multiplicative and additive factors of gamma count rates, figures depicting Upton Plant-wide scanning gamma count rates; and predicted exposure rates and/or radium-226 concentrations will appear similar. Of these, we have chosen to display only the predicted exposure rates, because they are the most directly meaningful to worker and public safety.*

Table 2.1. Summary of Radiological Investigation Scope

Survey Method/Endpoint	Baseline Investigation Scope	Parameters Evaluated
Gamma Survey	Scanning measurements of gamma count rates, tagged with x- and y- geopositions, taken every second at approximately 0.5 m. above ground surface along 100 m transects at less than 1.5 m s^{-1}.	Used to estimate exposure rates, surface soil radium-226 and natural thorium concentrations, and to identify anomalies and/or areas for biased sampling.
Random Soil Sampling	Random samples collected at 16 locations. All random samples were surface (0-15 cm) samples. Four duplicate samples were collected.	Th-nat and U-nat (ICP-MS); Ra-226 and Ra-228 (Gamma Spectroscopy)
Exposure Rate Monitoring	External dose rates were assessed by way of correlating exposure rate and co-located, integrated gamma count rate measurements. Given the strong linear correlation between the exposure rate and associated gamma survey measurements, ERG considers the interpolated exposure rates documented herein to be reliable estimates.	Exposure Rates
Radon Flux Measurements	Radon flux measurements at five locations (coinciding with random soil samples). Two duplicate measurements were made.	Rn-222 flux from soil
Radon Measurements in Air	Radon track etch measurements at nine locations.	Rn-222 in air
Airborne Particulate Measurements	Air sampling (total, stable rare earth elements, $PM_{2.5}$, and PM_{10}) at four locations from June 2102 to September 2014 at various intervals. A fifth location (UAMS-5) was added in May 2013.	Cerium, lanthanum, U-nat, and Th-nat (ICP-MS); Ra-226 (gas proportional counting), and Th-230 (alpha spectroscopy)

Notes:
cm = centimeters
ERG = Environmental Restoration Group
HPIC = High Pressure Ion Chamber
ICP-MS = Inductively Coupled Plasma-Mass Spectroscopy
in. = inch
m = meter
m s^{-1} = meters per second
Ra-226 = radium-226
Ra-228 = radium-228
RER = Rare Element Resources
Rn-222 = radon-222
Th-230 = thorium-230
Th-nat = natural thorium
U-nat = natural uranium

2.2 Deviations from the SAP

No deviations from the SAP were identified.

2.3 Future Work

The scope of work addressed in the SAP is ongoing. Baseline monitoring of air (ambient radon and particulates) will continue through 2015. Sampling of groundwater and surface water was performed in 2012, 2013, and 2014; and will continue throughout 2015.

3.0 GPS-BASED GAMMA (DIRECT RADIATION) SURVEY

This section documents the results of the baseline gamma radiation survey of the Upton Plant conducted in June 2012. The findings discussed in this section are reflected largely in the supporting figures; the text is limited to a discussion of trends and salient findings.

3.1 GPS Survey Methods

A GPS-based gamma survey was conducted at the Upton Plant on three days, between June 11 and 13, 2012. The detection systems were unshielded 2-in. by 2-in. sodium iodide detectors (Ludlum Model 44-10), each of which was coupled to a ratemeter/scaler (Ludlum Model 2221, set in ratemeter mode) and, in turn, a Trimble Pro XRS GPS Receiver with Trimble TSCe datalogger. Scanning was performed on north-south transects spaced at 100 m, at a speed less than 1.5 m s^{-1} with differentially corrected x- and y-coordinates and gamma count rates recorded every second. The survey was conducted on foot while carrying the requisite equipment in backpacks. The detectors were held at approximately 0.5 m above ground surface in the walking survey.

The survey instruments were in calibration and function checked daily, before and after use. Calibration and function forms are provided in Appendix A.

3.2 Results of GPS-Based Gamma Survey

Data presented in the following sections indicate that the distribution of the Upton Plant gamma count rates is non-parametric. The data also indicate two statistically distinct populations. The data are first summarized collectively.

The gamma count rates were converted into exposure rates, using the method and linear correlations described in Section 3.3. The gamma count rates are displayed as exposure rates in Figure 3.3. All of the statistical analyses and summaries presented henceforth, including the illustrations, were developed using Minitab 15: a statistical software.

3.2.1 Upton Plant-Wide Gamma Count Rates

Table 3.1 provides a statistical summary of the gamma count rates recorded in the Upton Plant area.

Table 3.1. Statistical Summary of Gamma Count Rates

Estimator/Endpoint	Gamma Data (cpm)
Mean (arithmetic)	**15,910**
Standard Deviation	1,854
Median	**16,091**
1st quartile	14,687
3rd quartile	17,092
IQR	2,405
Minimum	8,637
Maximum	27,148
Counts	38,023

Notes:
cpm = counts per minute
IQR = interquartile range

Illustration 3.1 is a histogram of the frequency distribution of the gamma count rate data collected within the Upton Plant. A theoretical lognormal distribution is plotted as the smooth line on the illustration, for the purpose of reference. The distribution peaks at approximately 16,000 cpm and tails off at approximately 11,000 (low end) and 20,000 cpm (high end). In addition, the distribution appears to be bimodal and fails to approximate normal and/or lognormal statistical tests.

Illustration 3.2 is a probability distribution plot, with the theoretical distribution (blue line) set as normal. Approximately 99 percent of the points align with the theoretical normal distribution; however, it cannot be described as normal because 1) there is a discrepancy between the theoretical and actual distributions on the tails and 2) the data set does not pass the Anderson-Darling Normality Test at a 95 percent level of significance.

Illustration 3.3 is a probability distribution plot, with the theoretical distribution set as lognormal. The majority of points (approximately 99.5 percent) align with the theoretical lognormal distribution; however, the distribution of gamma count rates cannot be described as lognormal because there is a statistical discrepancy between the theoretical and actual distributions on the tails.

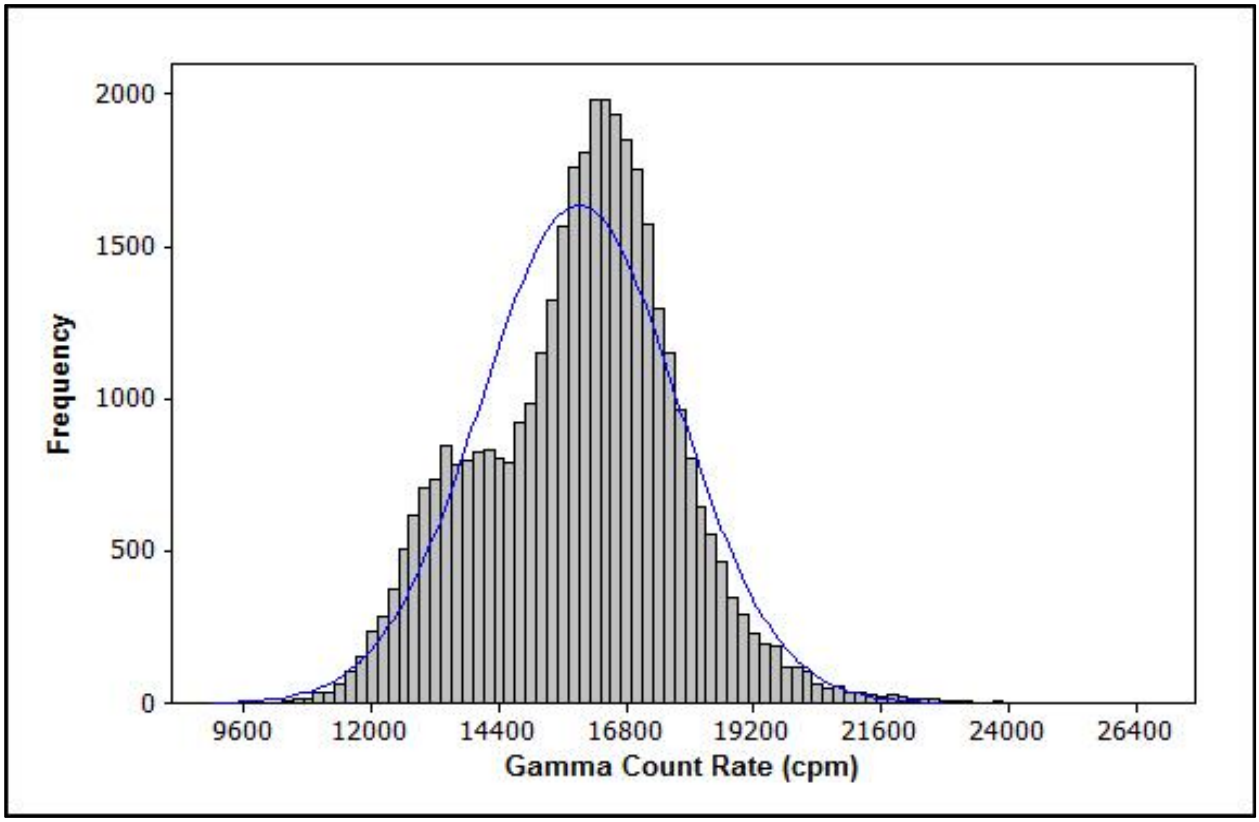

Illustration 3.1. Histogram of Gamma Count Rates

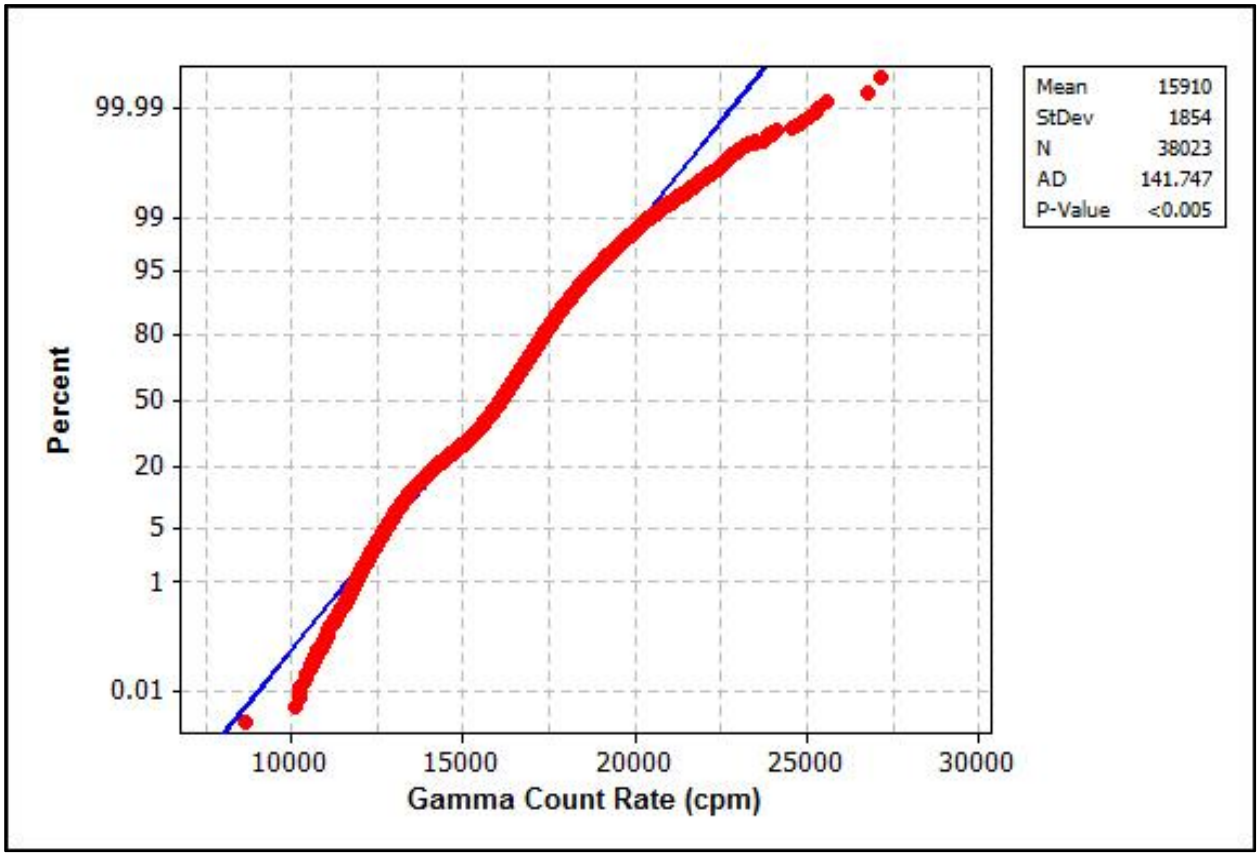

Illustration 3.2. Normal Probability Plot of Gamma Count Rates

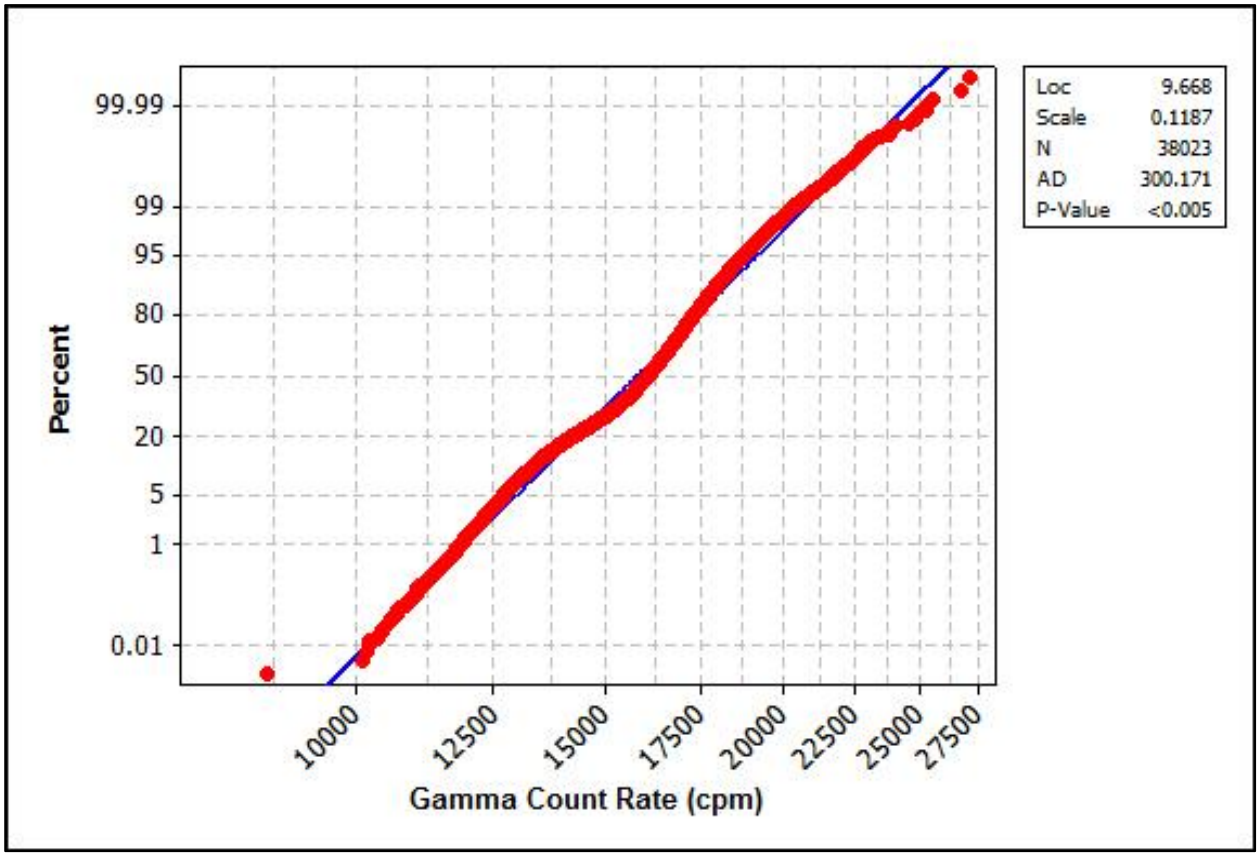

Illustration 3.3. Lognormal Probability Plot of Gamma Count Rates

Additional tests of the data sets (results not reported herein) indicated that none of them followed a parametric distribution. Because no underlying distribution could be defined, data analysis and summaries were performed using non-parametric statistical methods, which are less sensitive to extreme observations typical of skewed data distributions and assume no underlying distribution.

The central tendency and variability of non-parametric data can be described by the median and the interquartile range (IQR), respectively. The median of the population is 16,091 cpm. The IQR encompasses the range between the 1st quartile (the first 25 percent of ascending, ranked values) and 3rd quartile (the first 75 percent of ascending, ranked values). The IQR is 2,405 cpm (or 17,092 less 14,687 cpm).

3.2.1 Area-Specific Gamma Count Rates

A visual observation of the gamma count rates indicates that the data can be apportioned to two areas: 1) those west of a north-south trending ridge and 2) the remainder. The distributions of these data sets —each tested for normality and lognormality—are nonparametric. A Mann-Whitney test indicates that the distributions are statistically different, at a confidence level of 95 percent.

Gamma count rates west of the ridge average 13,583 cpm, with a median and standard deviation of 13,521 and 1,035 cpm, respectively. Those in the remainder of the Upton Plant average 16,604 cpm, with a median and standard deviation of 16,529 and 1,430 cpm, respectively.

3.3 Derivation of Exposure Rates Based on HPIC Correlation

One-minute integrated counts made using the sodium iodide detector were correlated to exposure rate measurements, made with a High Pressure Ion Chamber (HPIC) at eleven locations. Figure 3.1 shows the locations of the measurements. Table 3.2 presents the results of the paired measurements. Exposure rates are reported in microRoentgens per hour (µR hr^{-1}). Gamma measurements are reported as cpm.

The HPIC was in current calibration and function checked daily, before and after use. Calibration and function forms for the HPIC are provided in Appendix A.

The linear regression model for the eleven pairs of measurements is:

$$\text{Exposure rate } (\mu R\ hr^{-1}) = 5x10^{-4} \text{ x cpm} + 5.76$$

Plotting of the data from the HPIC and sodium iodide detector indicates that, with a correlation coefficient, R^2, of 0.99, the sodium iodide detector response explains 99 percent of the variance in the exposure rate; thus, the model strongly fits the data.

Figure 3.2 is a plot of the linear regression. This model was used to convert the gamma count rate data to exposure rates. Table 3.3 presents summary statistics for the exposure rates that are predicted from the population of scanning gamma count rates observed in the Upton Plant. Figure 3.3 presents the exposure rates predicted from all of the scanning gamma count rates observed within the Upton Plant. This figure also shows the two areas of differing gamma count rates. As stated in Section 2.1, the gamma survey results are expressed as exposure rates to allow a more meaningful context for interpretation than the relative magnitude of individual gamma readings. Each datum is assigned to one of three colors —from dark blue to green— based on its value.

Table 3.2. Integrated Gamma Count Rates and High Pressure Ion Chamber Measurements

Measurement Location	Easting[a]	Northing[a]	Sodium Iodide Detector Response (cpm)	HPIC Response (µR hr^{-1})
PIC-01	526635.3	4883935.2	15958	14.4
PIC-02	525096.5	4883855.1	13915	13.2
PIC-03	525987.9	4882773.8	13950	13.2
PIC-04	527194.8	4883317.2	18367	15.6
PIC-05	527179.8	4884002.4	22100	17.6

Notes:
[a] Coordinate system is NAD 1983, UTM Zone 13N, meters.
cpm = counts per minute
µR hr^{-1} = microRoentgens per hour

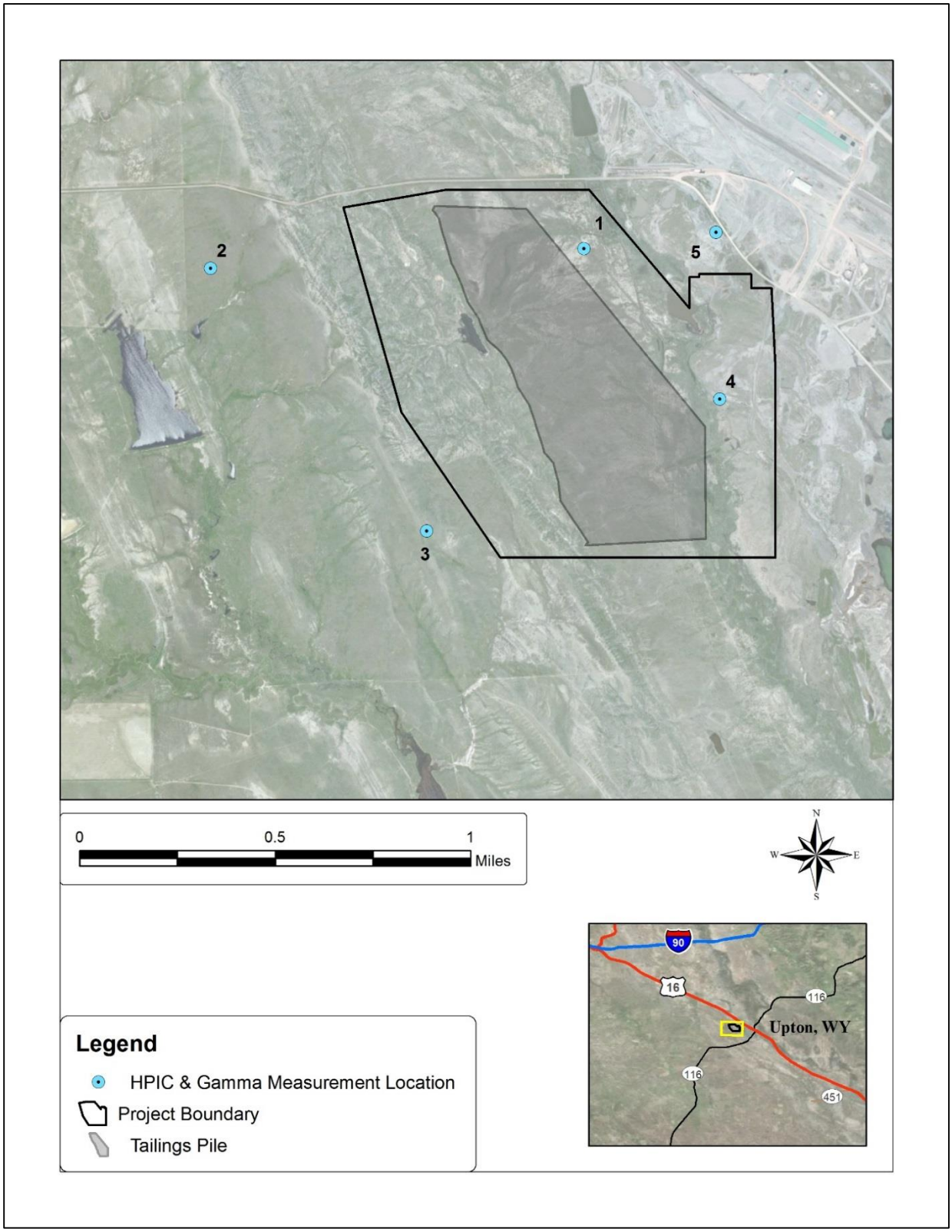

Figure 3.1. High Pressure Ion Chamber and Gamma Count Rate Measurement Locations

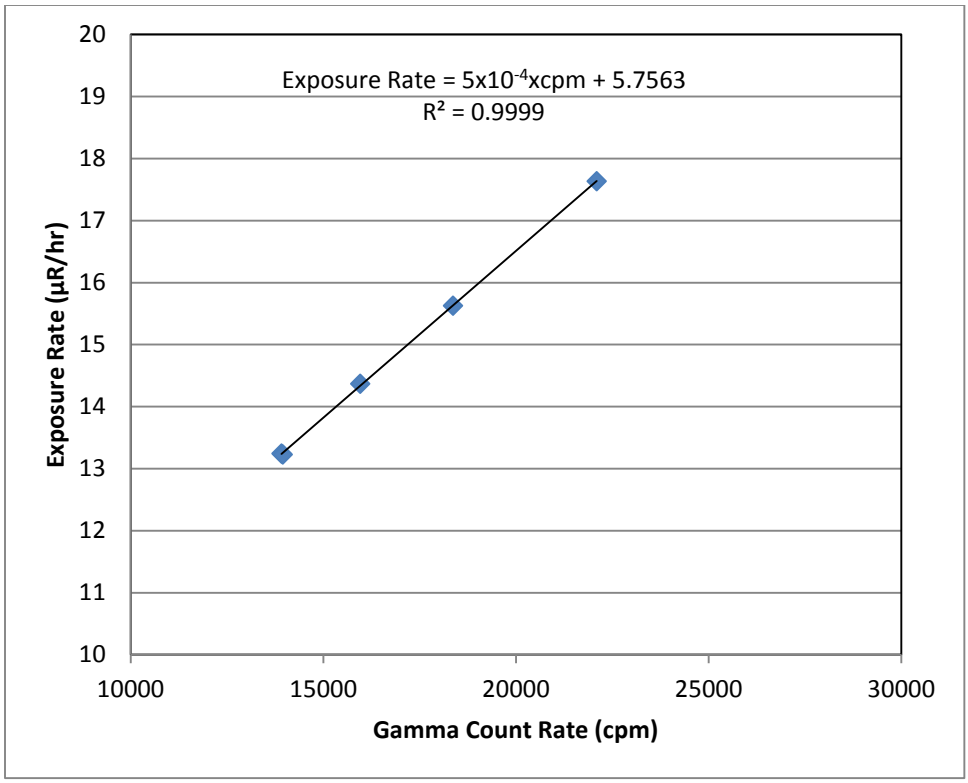

Figure 3.2. High Pressure Ion Chamber and Gamma Count Rate Measurement Linear Regression Model

Table 3.3. Statistical Summary of Predicted Exposure Rates

Estimator/Endpoint	Exposure Rate ($\mu R\ hr^{-1}$)
Mean (arithmetic)	**13.7**
Standard Deviation	0.9
Median	**13.8**
1st quartile	13.1
3rd quartile	14.3
IQR	1.2
Minimum	10.1
Maximum	19.3
Count	38,023

Notes:
cpm = counts per minute
IQR = interquartile range
$\mu R\ hr^{-1}$ = microRoentgens per hour

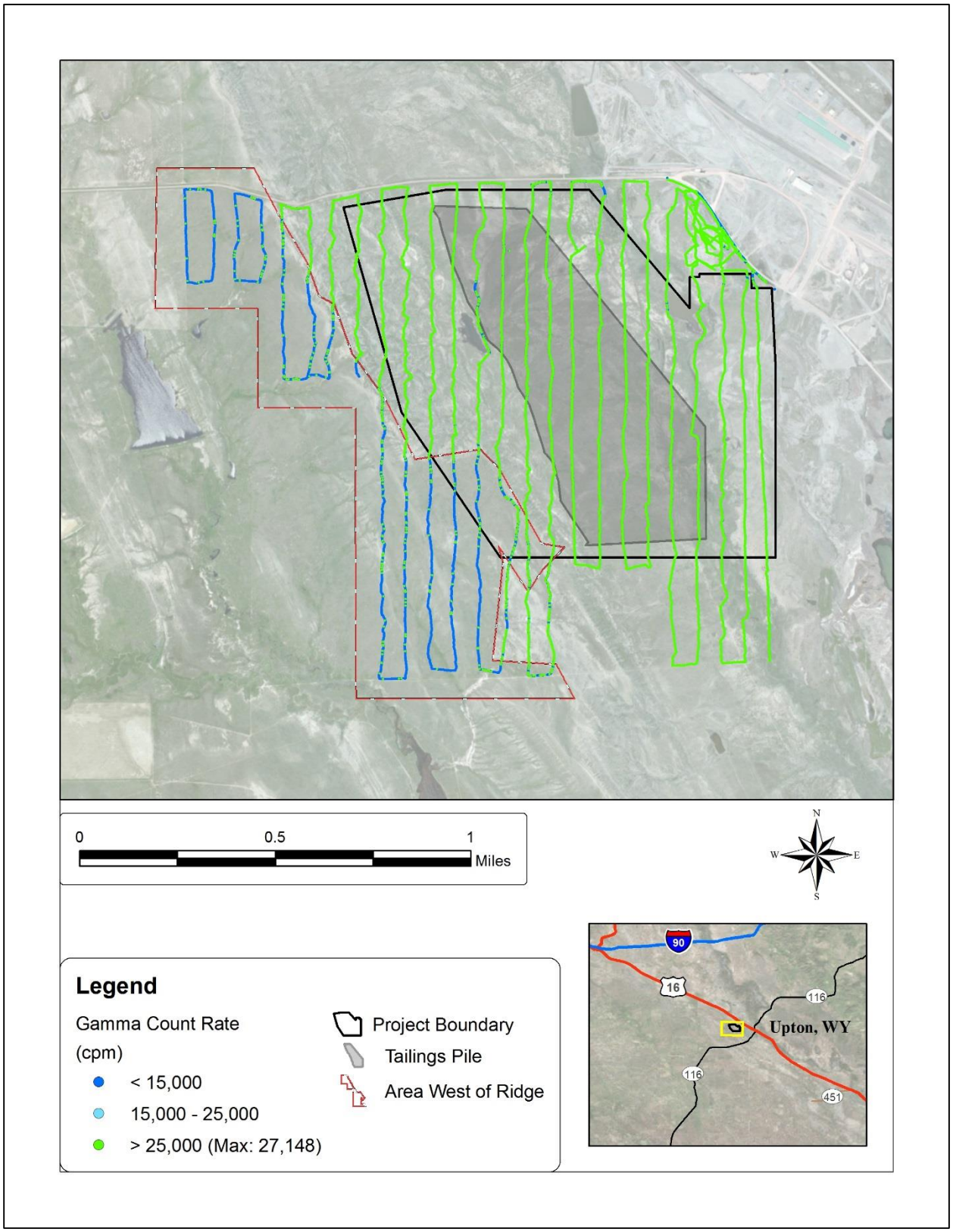

Figure 3.3 Exposure Rates Predicted from Gamma Count Rates

The predicted exposure rates at the Upton Plant can be summarized as follows:

- The range is 10.1 to 19.3 µR hr^{-1}. The IQR is 1.2 µR hr^{-1} (14.3 less 13.1 µR hr^{-1}).
- There appear to be no elevated levels of radioactivity.
- There are two statistically distinct areas of exposure rates.

4.0 BASELINE RADIOLOGICAL INVESTIGATION SOIL SAMPLING

This section presents the results of the baseline soil sampling conducted in June 2012. Section 4.1 summarizes the soil sampling field approach, scope, and analytes. Section 4.2 discusses the results obtained for radium-226, the focus of the baseline soil sampling program. Section 4.3 addresses results for other radiological parameters. Section 4.5 discusses the correlation between radium-226 and natural thorium concentrations in soil and gamma count rates. The laboratory analytical reports for the soil analyses are provided in Appendix B.

4.1 Sampling Strategy and Approach

The soil sampling strategy for the Upton Plant consisted of random sampling at the 16 locations shown in Figure 4.1, in accordance with the strategy in the SAP. The identifiers in Figure 4.1 were truncated to facilitate presentation; e.g., Sample SS-05-SS-061412 was changed to 5. Table 4.1 lists the coordinates of the sample locations. Radon flux measurements were taken at five of the sample locations, as noted in Table 4.1.

The number and types of analytes for the surface soil samples were based on obtaining general knowledge of the distribution of the primary long-lived radionuclides in the uranium and thorium natural decay series. The sample locations were determined using Equation 4 of Section 2.3.3.4 in the SAP, which is:

$$N > \left(\frac{t}{r} cv \right)^2$$

Where:

N = number of samples
t = the t-statistic (1.645)
r = 0.2, the relative fraction error, or the mean minus the true mean, divided by the true mean
cv = coefficient of variation, or the standard deviation of the population divided by the mean

The coefficient of variation (standard deviation/mean= 0.67) was determined from the gamma survey data (see Table 3.1). In this case, N=16 samples, which were spaced on a systematic, triangular grid with a random start location, using Visual Sampling Plan Version 6.2d.

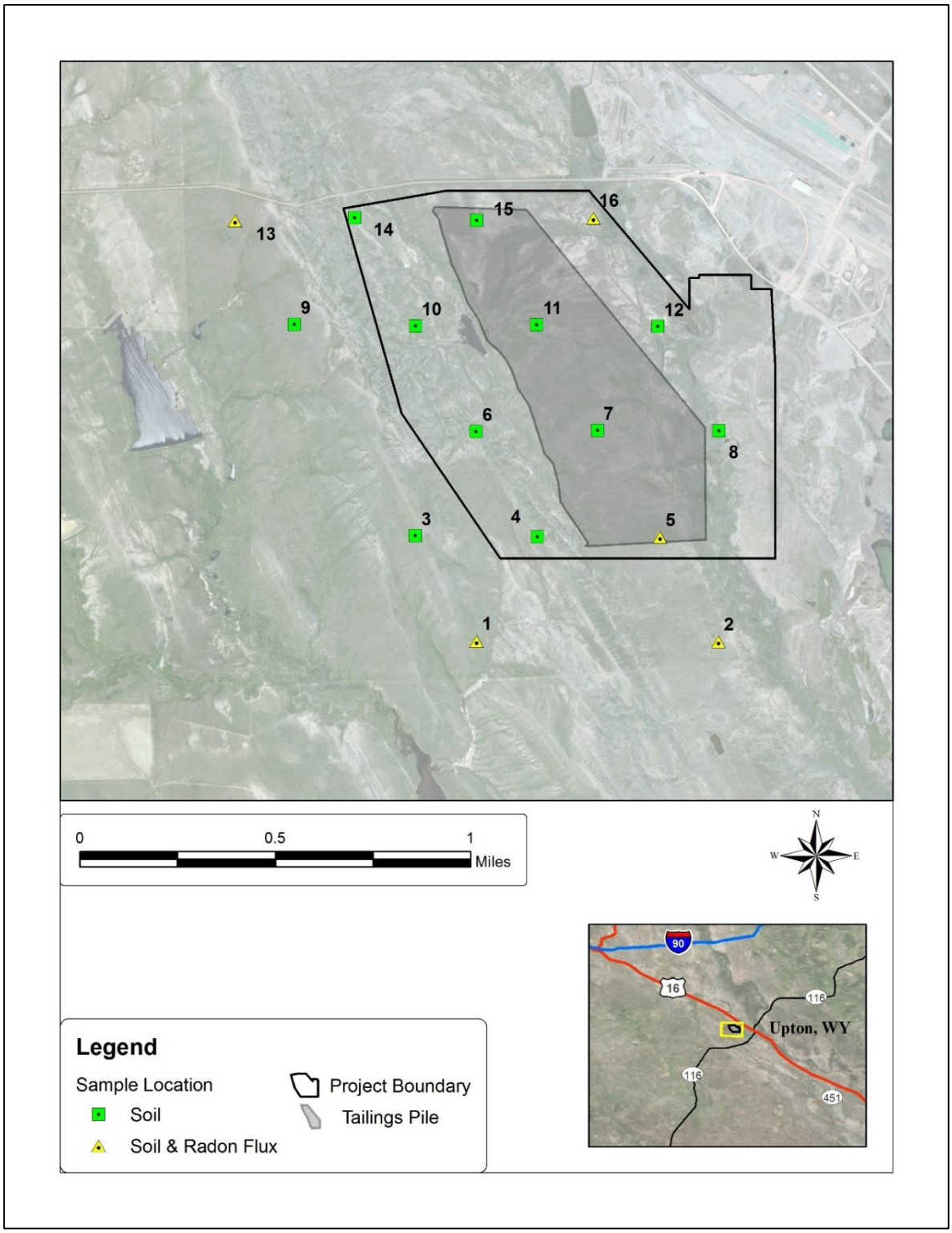

Figure 4.1. Soil Sample and Radon Flux Locations

Table 4.1. Sample Location Coordinates

Sample Location	Easting	Northing
SS-01-SS-061412[a]	526190.2	4882324.4
SS-02-SS-061412[a]	527186.7	4882322.7
SS-03-SS-061412	525939.6	4882758.9
SS-04-SS-061412	526442.5	4882754.4
SS-05-SS-061412	526946.2	4882752.2
SS-06-SS-061412	526190.6	4883187.8
SS-07-SS-061412[a]	526692.0	4883192.3
SS-08-SS-061412	527191.1	4883190.4
SS-09-SS-061412	525442.2	4883628.2
SS-10-SS-061412	525941.4	4883622.4
SS-11-SS-061412	526440.8	4883626.8
SS-12-SS-061412	526940.4	4883619.6
SS-13-SS-061412[a]	525195.1	4884054.9
SS-14-SS-061412	525690.7	4884066.1
SS-15-SS-061412	526193.0	4884056.2
SS-16-SS-061412[a]	526671.0	4884065.0

Notes:
[a]Radon flux location.
[b]Coordinate system is NAD 1983, UTM Zone 13N, meters.

In accordance with the SAP, the baseline soil samples were collected from 0-15 cm and analyzed for radium-226 and -228, natural uranium and natural thorium. The corresponding U.S. Environmental Protection Agency (EPA) analytical methods are EPA M901.1 for the two radiums and EPA M 6020 (Inductively Coupled-Mass Spectroscopy) for natural uranium and thorium.

4.2 Radionuclide Concentrations in Surface Soils

Table 4.2 documents the results of the soil sampling. The soil sample results represent a baseline to compare results for soil samples collected at similar locations and depth during the construction, operational, and closure phases of the Upton Plant. It is recognized that topography and other features may change over time; however, some of the sample locations are expected to remain intact.

Table 4.2. Laboratory Analytical Results for Soil Samples

	Radium-226 (pCi g^{-1})			Radium-228 (pCi g^{-1})			U-nat (mg kg^{-1})		Th-nat (mg kg^{-1})	
Sample Location	**Result**	**Error ± 1σ**	**RL**	**Result**	**Error ± 1σ**	**RL**	**Result**	**MDL**	**Result**	**MDL**
SS-01-SS-061412	1.4	0.4	0.3	0.0U	0.5	0.3	1	0.01	7	0.02
SS-02-SS-061412	1.6	0.4	0.3	2.1	0.5	0.3	1	0.01	12	0.02
SS-03-SS-061412	1.5	0.5	0.3	0.0U	0.5	0.3	2	0.02	9	0.02
SS-04-SS-061412	1.5	0.5	0.3	0.0U	0.5	0.3	ND	0.01	8	0.02
SS-05-SS-061412	1.6	0.6	0.3	1.9	0.7	0.3	2	0.01	12	0.02
SS-06-SS-061412	1.6	0.4	0.3	2.3	0.8	0.3	2	0.01	13	0.02
SS-07-SS-061412	1.8	0.5	0.3	0.0U	0.5	0.3	2	0.01	13	0.02
SS-08-SS-061412	2.3	0.5	0.3	2.4	0.8	0.3	2	0.01	14	0.02
SS-09-SS-061412	1.5	0.6	0.3	0.0U	0.5	0.3	1	0.01	8	0.02
SS-10-SS-061412	1.8	0.6	0.3	0.0U	0.5	0.3	3	0.01	15	0.02
SS-11-SS-061412	1.9	0.6	0.3	2.4	0.6	0.3	2	0.01	10	0.02
SS-12-SS-061412	1.0	0.3	0.3	2.2	0.6	0.3	2	0.01	11	0.02
SS-13-SS-061412	1.0	0.3	0.3	0.0U	0.5	0.3	1	0.01	6	0.02
SS-14-SS-061412	2.2	0.7	0.3	0.0U	0.5	0.3	2	0.01	13	0.02
SS-15-SS-061412	1.6	0.5	0.3	0.0U	0.5	0.3	2	0.01	13	0.02
SS-16-SS-061412	2.3	0.6	0.3	0.0U	0.5	0.3	2	0.01	10	0.02
SS-17-SS-061412[a]	1.4	0.5	0.3	2.4	0.9	0.3	2	0.01	11	0.02
SS-18-SS-061412[a]	1.8	0.5	0.3	2.3	0.7	0.3	3	0.01	14	0.02
SS-19-SS-061412[a]	1.5	0.5	0.3	0.0U	0.5	0.3	3	0.01	14	0.02
SS-20-SS-061412[a]	1.6	0.5	0.3	0.0U	0.5	0.3	2	0.01	7	0.02

Notes:
[a]Duplicate sample.
MDL = method detection limit
mg kg^{-1} = milligrams per kilogram
pCi g^{-1} = picocuries per gram
RL = reporting limit
σ = standard deviation
U = undetected
ND = not detected

4.3 Summary of Radium-226 Results

The following discussion is based largely upon the results and spatial distributions reflected in the supporting figures and tabular summaries.

Table 4.3 presents the summary statistics for radium-226 concentrations in surface soil.

Table 4.3. Summary Statistics for Radium-226 Concentrations in Soil Samples

Estimator/Endpoint	Ra-226 (pCi g^{-1})
Mean (arithmetic)	1.7
Mean (geometric)	1.7
Standard deviation	0.3
Median	1.6
Minimum	1.3
Maximum	2.3
1st quartile	1.5
3rd quartile	1.8
IQR	0.3
Count	16

Notes:
IQR = interquartile range
pCi g^{-1} = picocuries per gram

Statistical tests (results not shown) indicate that the distribution of the radium-226 concentrations is lognormal. The central tendency of a lognormal distribution is best described by a geometric mean, which in this case is 1.7 pCi g^{-1}. This result in central tendency is consistent with both the arithmetic mean and median.

4.4 Other Radionuclides

Table 4.4 presents summary statistics for radium-228, natural uranium, and natural thorium. Natural uranium and thorium results are reported in pCi g^{-1}, although the laboratory reported the results in (milligrams per kilogram) mg kg^{-1}. The conversion to activity concentrations (pCi g^{-1}=0.667 x mg kg^{-1} for natural uranium and 0.22 x mg kg^{-1} for natural thorium) was performed to provide a basis of directly comparing natural uranium and thorium to the other concentrations of long-lived radionuclides in the uranium and thorium series.

Trends in the radium-228 concentrations cannot be discussed, because detections are reported by the laboratory in 6 of 16 samples.

The distribution of natural thorium concentrations is normal, with a central tendency (mean) and standard deviation of 2.4 and 0.6 pCi g^{-1}, respectively. The range of natural thorium concentrations is 1.4 to 3.2 pCi g^{-1}.

The distribution of natural uranium concentrations is nonparametric, with a central tendency (median) and IQR of 1.4 and 0.1 pCi g^{-1}, respectively. The range of natural thorium concentrations is 0.7 to 2.0 pCi g^{-1}.

According to the laboratory results, the radium-226 concentrations are higher to those of natural uranium. However, assuming there is secular equilibrium in the uranium decay series, radium-226 concentrations should be about 48 percent of those of natural uranium (the concentration of uranium-238 based on the natural abundance of uranium isotopes). Thus, the laboratory results for radium-226 and/or natural uranium may be biased.

The laboratory results indicate that natural thorium concentrations are higher than those of the other primary radionuclides in soils at the Upton Plant.

Table 4.4. Summary Statistics for Other Radionuclide Concentrations in Soil Samples

Estimator/Endpoint	Ra-228 (pCi g^{-1})[a]	Th-nat (pCi g^{-1})[a]	U-nat (pCi g^{-1})[a]
Mean (arithmetic)	0.9	2.4	1.3
Standard deviation	1.1	0.6	0.4
Median	0.0	2.5	1.4
Minimum	0.0	1.4	0.7
Maximum	2.4	3.2	2.0
1st quartile	0.0	1.9	1.2
3rd quartile	2.2	2.9	1.4
IQR	2.2	0.9	0.1
Count	16	16	16

Notes:
[a]Sample and duplicate results averaged.
IQR = interquartile range
pCi g^{-1} = picocuries per gram

4.5 Surface Soil Radium-226 and Natural Thorium Estimates Based on Gamma-Soil Radium Correlation

Gamma-soil radium-226 and natural thorium correlations were established using the surface soil analytical results documented in Section 4.2 for all random soil sample locations where integrated gamma measurements were taken (n=16). The data were collected to estimate radium-226 and natural thorium concentrations corresponding to each of the gamma survey points shown in Figure 3.3.

One-minute integrated direct radiation measurements were collected at each of these 16 locations, using the same radiation detection equipment used in the GPS gamma survey. These measurements then were correlated to radium-226 and natural thorium concentrations in soil, as discussed below. Table 4.5 lists the observations.

Regression methods were employed to derive the correlations. It will be shown that radium-226 concentrations in soil do not reliably predict gamma count rates. However, natural thorium concentrations provide a reasonable prediction of gamma count rates.

The relationship between the entire data set (n=16) of radium-226 concentrations and gamma count rates yields a poor correlation coefficient (R^2 = 0.35) with poor residuals (i.e., predicted minus observed radium-226 concentrations). An iteration in which one of the observations (2.3 pCi g^{-1}/15,652 cpm [SS-16-SS-061412]) was omitted from the regression yielded an improved correlation coefficient (R^2 =0.45) with poor residuals. Average residuals did not exhibit a bias (indicating a tendency to over- or under-estimate soil radium-226 concentrations).

Table 4.5. Radium-226 Concentrations and Integrated Gamma Count Rates

Sample Location	Radium-226 (pCi g^{-1})	Th-Nat (pCi g^{-1})	Gamma Count Rate (cpm)
SS-01-SS-061412	1.4	1.5	13740
SS-02-SS-061412	1.6	2.6	16634
SS-03-SS-061412	1.5	2.0	13336
SS-04-SS-061412	1.5	1.8	14519
SS-05-SS-061412	1.6	2.6	16443
SS-06-SS-061412	1.6	2.9	17727
SS-07-SS-061412[a]	1.8	3.0	16553
SS-08-SS-061412	2.3	3.1	17833
SS-09-SS-061412	1.5	1.8	12819
SS-10-SS-061412[a]	1.7	3.2	17388
SS-11-SS-061412	1.9	2.2	16259
SS-12-SS-061412[a]	1.4	2.4	16056
SS-13-SS-061412[a]	1.3	1.4	12147
SS-14-SS-061412	2.2	2.9	17463
SS-15-SS-061412	1.6	2.9	15955
SS-16-SS-061412	2.3	2.2	15652

Notes:
[a]Duplicate sample collected at this location. Ra-226 and Th-nat concentrations averaged for the calculation.
cpm = counts per minute
pCi g^{-1} = picocuries per gram

The linear regression model for this iteration, which has the higher correlation coefficient of the two and was used to estimate radium-226 concentrations from the gamma survey data for the Upton Plant is:

$$\text{Concentration}_{\text{Ra-226}} = 1*10^{-4} \text{ x cpm} + 0.0221$$

A stepwise approach was not taken because it was clear, on cursory evaluation of the correlation plot of all observations, that the data were too few and variable from which to draw salient trends.

It is important to acknowledge that discrepancies between measured soil radium-226 concentrations reported by the laboratory and corresponding radium-226 concentrations estimated by gamma surveys are inevitable in a characterization survey of this nature and magnitude, given the heterogeneity of the site (at least in some areas), differing detector-source geometry at various sample/survey locations, prominent gamma-ray emitters from the thorium decay series contributing to the instrument response, and uncertainty in the laboratory analytical results, especially at low concentrations.

The relationship between the entire data set (n=16) of natural thorium concentrations and gamma count rates yields a strong correlation coefficient ($R^2 = 0.83$) with no unusual observations; that is, observations imparting large leverage on the analysis. The linear regression model for this iteration, which was used to estimate natural thorium concentrations from the gamma survey data for the Upton Plant is:

$$\text{Concentration}_{\text{Th-nat}} = 3*10^{-4} \text{ x cpm} - 2.17$$

Using these equations, radium-226 and natural thorium concentrations in soil were estimated for each discrete gamma survey measurement. Table 4.6 presents the resulting summary statistics for the radium-226 and natural thorium concentrations predicted by the linear regression model from the scanning gamma count rates observed in the Upton Plant.

Table 4.6. Statistical Summary of Radium-226 and Natural Thorium Concentrations Predicted from Gamma Count Rates

Estimator/Endpoint	Radium-226, predicted (pCi g^{-1})[a]	Th-nat, predicted (pCi g^{-1})[a]
Mean (arithmetic)	**1.6**	**2.6**
Standard Deviation	0.2	0.6
Median	**1.6**	**2.7**
1st quartile	1.5	2.2
3rd quartile	1.7	3.0
IQR	0.2	0.8
Minimum	0.9	0.4
Maximum	2.7	6.0
Count (n)	38,023	38,023

Notes:
[a] Measurements only within the Upton Plant.
IQR = interquartile range
pCi g^{-1} = picocuries per gram

The median of the predicted concentrations of radium-226 is 1.6 pCi g^{-1} and its IQR is 0.2 pCi g^{-1} (1.7 less 1.5 pCi g^{-1}). This is equal to the median of the laboratory results.

The median of the predicted concentrations of natural thorium is 2.7 pCi g^{-1} and IQR is 0.8 pCi g^{-1} (3.0 less 2.2 pCi g^{-1}). The median of the predicted concentration of natural thorium is also in good agreement with the median of the laboratory results (2.4 pCi g^{-1}).

These observations indicate that gamma surveys can be an effective tool to predict radium-226 and natural thorium concentrations in soil at the Upton Plant.

5.0 DATA QUALITY ASSESSMENT

This section briefly summarizes the results of the quality control (QC) samples collected for the baseline soil sampling program. As indicated in Table 2.1, 25 percent of the soil samples were duplicated for QC purposes. The results of this QC effort are documented in Table 5.1, which lists the analytical results for each duplicate pair along with corresponding errors and reporting limits (RLs). Table 5.2 documents associated comparisons, presenting the corresponding Replicate Error Ratio (RER) or Relative Percent Difference (RPD), in the cases of Th-nat and U-nat) for each QC pair.

QC trends in the radium-228 concentrations cannot be discussed, because apparently erroneous non-detections are reported by the laboratory in 12 of 20 samples.

Examination of the results provided in Table 5.1 indicates that, in general, there is close agreement in the analytical results reported for each duplicate pair collected for all parameters. Because duplicate results are generally comparable for the majority of QC samples collected and the other parameters for this pair of soil samples were within acceptable ranges, no request to re-analyze the samples were made.

Table 5.2 presents the corresponding RER and, in the cases of Th-nat and U-nat, RPDs calculated for each duplicate pair. The calculation of RER and RPDs is a standard technique used to evaluate QC samples. Typically, an RER of < 2 and an RPD of <20 percent is used as a guideline in many data quality objective evaluations. This data set reveals no cases where either the RER or RPD was greater than 2 and 20, respectively. Thus, the laboratory performance on blind duplicates is satisfactory.

Table 5.1. QA-QC Comparison Results

		Radium-226 (pCi g^{-1})			U-nat (mg kg^{-1})		Th-nat (mg kg^{-1})	
Sample Pair	**Sample Location**	**Result**	**Error ± 1σ**	**RL**	**Result**	**MDL**	**Result**	**MDL**
1	SS-07-SS-061412	1.8	0.5	0.3	2	0.01	13	0.02
	SS-18-SS-081311	1.8	0.5	0.3	3	0.01	14	0.02
2	SS-10-SS-061412	1.8	0.6	0.3	3	0.01	15	0.02
	SS-19-SS-081311	1.5	0.5	0.3	3	0.01	14	0.02
3	SS-12-SS-081311	1.0	0.3	0.3	2	0.01	11	0.02
	SS-17-SS-081311	1.4	0.5	0.3	2	0.01	11	0.02
4	SS-13-SS-081311	1.0	0.3	0.3	1	0.01	6	0.02
	SS-20-SS-061412	1.6	0.5	0.3	2	0.01	7	0.02

Notes:

MDL = method detection limit
mg kg^{-1} = milligrams per kilogram
pCi g^{-1} = picocuries per gram
σ = standard deviation

Table 5.2. QA-QC Comparisons: RPD and RER Summary

		Radionuclide Concentrations			
Sample ID	**Type**	**Ra-226 (pCi g^{-1})**	**Ra-226 Error ± 1σ**	**Uranium (mg kg^{-1})**	**Thorium (mg kg^{-1})**
SS-12-SS-061412	Sample	1	0.3	2	11
SS-17-SS-061412	Replicate	1.4	0.5	2	11
	RER	**0.7**	-	-	-
	RPD	**-**	-	**0**	**0**
SS-07-SS-061412	Sample	1.8	0.5	2	13
SS-18-SS-061412	Replicate	1.8	0.5	3	14
	RER	**0.0**			
	RPD			**10**	**1.9**
SS-10-SS-061412	Sample	1.8	0.6	3	15
SS-19-SS-061412	Replicate	1.5	0.5	3	14
	RER	**0.4**			
	RPD			**0**	**1.7**
SS-13-SS-061412	Sample	1	0.3	1	6
SS-20-SS-061412	Replicate	1.6	0.5	2	7
	RER	**1.0**			
	RPD			**16.7**	**3.8**

In this table, RER corresponds to the Replicate Error Ratio and RPD corresponds to the relative percent difference, which is derived by dividing the difference between the two results by the average result.
mg kg^{-1} = milligrams per kilogram
pCi g^{-1} = picocuries per gram
σ = standard deviation

6.0 RADON FLUX MEASUREMENTS

This section summarizes the results of baseline radon-222 (Rn-222) flux measurements conducted in accordance with Section 2.3.5 of the SAP. Field data and analytical results supporting the Rn-222 flux data are contained in Appendix C.

In accordance with the SAP, radon flux rates were measured at five locations, which coincided with sample locations as shown on Figure 4.1. Five, plus two duplicate canisters were deployed and retrieved on June 13 and 14, 2012, respectively. These canisters were analyzed using EPA Test Method 115, *Monitoring for Radon-222 Emissions*.

Table 4.1 notes the five radon flux locations, all of which coincided with those for soil samples. Table 6.1 documents the results, and lists Ra-226 concentrations in corresponding soil samples. Radon flux rates ranged between 0.20 and 1.22 picocuries per meter squared second (pCi m^{-2} s^{-1}). These values are below the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) requirement of 20 pCi m^{-2} s^{-1} prescribed in 10 *Code of Federal Regulations* 40, Appendix A, Criterion 6. Although the latter requirement applies to tailings and thus is not directly germane to this characterization, it is useful as a context to demonstrate the relative magnitude of baseline radon flux levels measured in the areas where construction and mining activities are anticipated to occur. There are to be no trends in the radon fluxes, as compared to radium-226 concentrations in associated soil samples.

Table 6.1. Radon Flux Results

	Radon-222 (pCi m^{-2} s^{-1})				
Sample Location	**Flux**	**Flux Error (±1σ)**	**LLD**	**Average Flux**	**Ra-226 Concentration (pCi g^{-1})**
SS-01-SS-061412	1.22	0.05	0.1	1.22	1.4
SS-02-SS-061412	0.20	0.04	0.1	0.20	1.6
SS-07-SS-061412[a]	0.48	0.04	0.1	0.42	1.8
	0.35	0.05	0.1		
SS-13-SS-061412[b]	0.93	0.05	0.1	0.93	1.4
SS-16-SS-061412[a]	0.57	0.04	0.1	0.66	2.3
	0.74	0.05	0.1		

Notes:
[a]Duplicate canister deployed
[b]Duplicate sample collected. Radium-226 result is the average of the sample and duplicate results.

LLD = lower limit of detection
pCi g^{-1} = picocuries per gram
pCi m^{-2}-s = picocuries per meter squared second
Ra-226 = radium-226
Rn-222 = radon-222
σ = standard deviation

7.0 AMBIENT RADON MEASUREMENTS

This section describes the placement of and data collection for the ambient radon track etch detectors.

7.1 Measurement Locations

Figure 7.1 and Table 7.1, respectively, show and list the locations of the track etch detectors. Five of the locations are air monitoring stations. One of the locations is in Upton.

Data collection at the Upton Plant started in February 2013 at will continue minimally in quarters: during plant construction, operation, and closure.

Table 7.1. Ambient Radon Track Etch Detector Locations

Track Etch Location	Easting[a]	Northing[a]
1[b] (UAMS-1)	529472.7	4883375.4
2	526137.5	4883685.7
3[b] (UAMS-3)	527044.4	4882981.1
4	527289.2	4882295.0
5	525942.1	4882349.1
6	525574.9	4883670.0
7[b] (UAMS-4)	525027.1	4884122.5
8[b] (UAMS-2)	526940.0	4884102.8
9	527236.6	4883434.9
10[b] (UAMS-5)	529039.8	4882599.6

Notes:
[a]Coordinate systems is NAD1983, UTM Zone 13N, meters.
[b]Air monitoring station at this location, provided in parentheses.

7.2 Measurement Results

Table 7.2 lists the results obtained quarterly by location, between February 2013 and January 2015. Quarterly radon measurements ranged on average by location from 0.7 (Location 7) to 1.6 picocuries per liter (pCi L^{-1}: Locations 2, 4, and 9).

The laboratory analytical reports for the ambient radon analyses are provided in Appendix D.

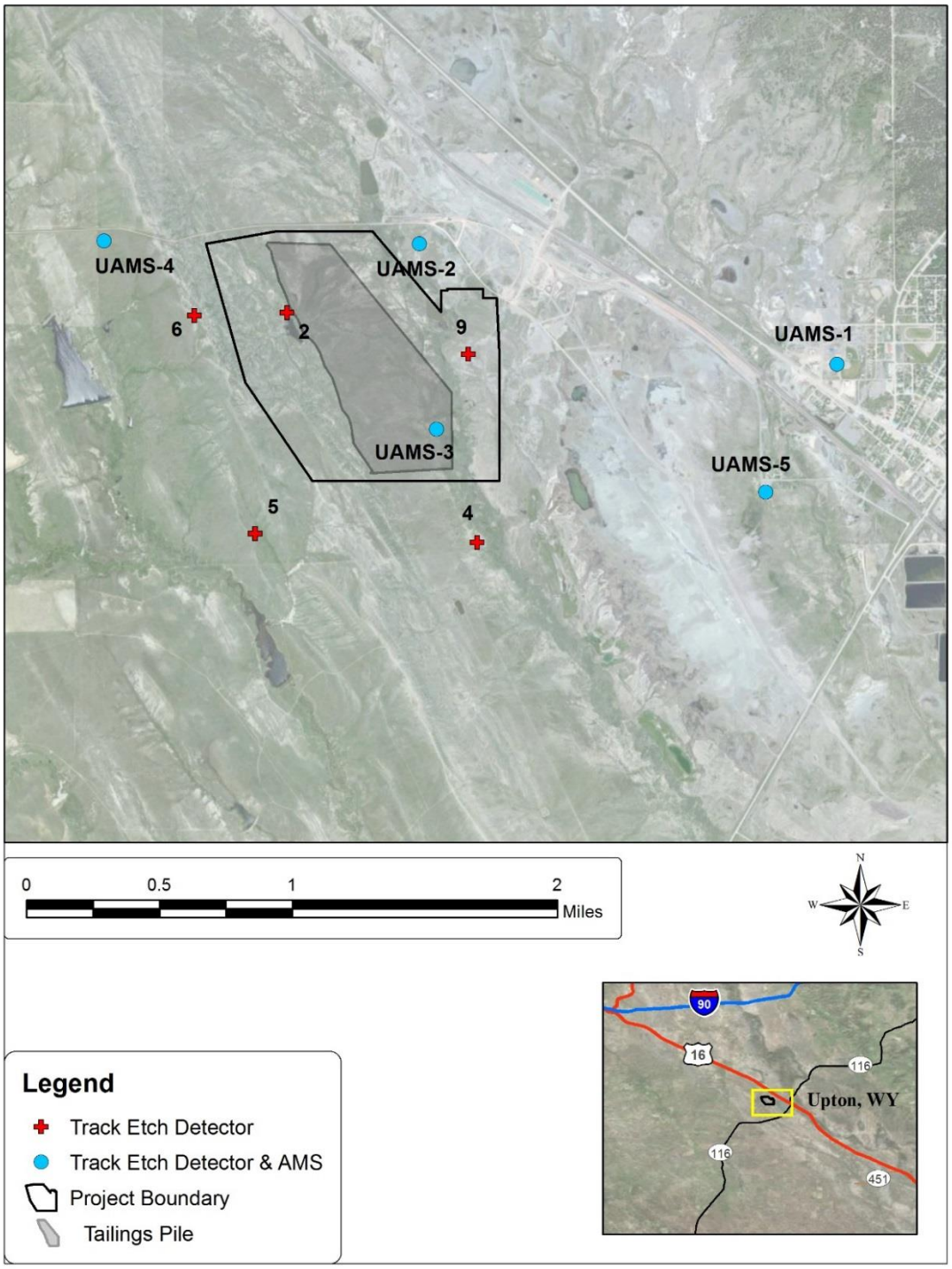

Figure 7.1. Ambient Radon Track Etch Detector and Air Monitoring Station Locations

Table 7.2. Ambient Radon Track Etch Detector Results

Location Number	Start Date	End Date	Radon Concentration (pCi L^{-1})	Radon Error (± pCi L^{-1})	Mean Concentration at Location (pCi L^{-1})
1 (UAMS-1)	2/5/2013	3/25/2013	0.13	0.01	0.9
	3/25/2013	7/11/2013	0.8	0.05	
	7/11/2013	9/30/2013	0.4	0.03	
	9/30/2013	1/10/2014	0.5	0.04	
	1/10/2014	3/26/2014	0.3	0.02	
	3/26/2014	7/23/2014	0.6	0.04	
	7/23/14	10/28/14	3.2	0.13	
	10/28/14	1/4/15	1.1	0.08	
2	2/7/2013	3/25/2013	1	0.08	1.6
	3/23/2013	7/11/2013	1.4	0.07	
	7/11/2013	9/30/2013	1.8	0.1	
	9/30/2013	1/10/2014	2.7	0.11	
	1/10/2014	3/26/2014	0.1	0.01	
	3/26/2014	7/18/2014	0.8	0.05	
	7/18/14	10/28/14	4.3	0.15	
	10/28/14	1/4/15	1.0	0.07	
3 (UAMS-3)	2/5/2013	3/25/2013	0.3[a]	0.03[a]	1.2
	3/25/2013	7/11/2013	1.3[a]	0.07[a]	
	7/11/2013	9/30/2013	1.1[a]	0.07[a]	
	9/30/2013	1/10/2014	1.0[a]	0.06[a]	
	1/10/2014	3/26/2014	0.1[a]	0.01[a]	
	3/26/2014	7/18/2014	0.9[a]	0.06[a]	
	7/18/14	10/28/14	3.7	0.14	
	10/28/14	1/4/15	1.1[a]	0.08[a]	

Table 7.2. Ambient Radon Track Etch Detector Results (continued)

Location Number	Start Date	End Date	Radon Concentration (pCi L^{-1})	Radon Error (± pCi L^{-1})	Mean Concentration at Location (pCi L^{-1})
4	2/5/2013	3/25/2013	0.13	0.01	1.6
	3/25/2013	7/11/2013	1.4	0.08	
	7/11/2013	9/30/2013	1.4	NA	
	9/30/2013	1/10/2014	1.3	0.07	
	3/26/2014	7/18/2014	1.1	0.06	
	7/18/14	10/28/14	4.8	0.16	
	10/28/14	1/4/15	1.3	0.09	
5	2/7/2013	3/26/2013	1	0.08	1.1
	3/26/2013	7/11/2013	0.9	0.06	
	7/11/2013	9/30/2013	1.1	0.07	
	9/30/2013	1/10/2014	0.7	0.05	
	1/10/2014	3/26/2014	0.08	0.01	
	3/26/2014	7/18/2014	0.6	0.04	
	7/18/14	10/28/14	3.7	0.14	
	10/28/14	1/4/15	1.0	0.07	
6	2/5/13	3/25/13	0.5	0.04	1.3
	3/25/2013	7/11/2013	0.7	0.05	
	7/11/2013	9/30/2013	0.6	0.04	
	9/30/2013	1/10/2014	0.9	0.05	
	3/26/2014	7/18/2014	0.6	0.04	
	7/18/14	10/28/14	4.3	0.15	
	10/28/14	1/4/15	1.7	0.1	
7 (UAMS-4)	2/5/2013	3/26/2013	0.6	0.05	0.7
	3/26/2013	7/11/2013	0.8	0.05	
	7/11/2013	9/30/2013	0.8	0.06	
	9/30/2013	1/10/2014	1	0.06	
	1/10/2014	3/26/2014	0.08	0.01	
	3/26/2014	7/18/2014	0.7	0.04	
	10/28/14	1/4/15	1.2	0.08	
8 (UAMS-2)	2/5/2013	3/25/2013	0.13	0.01	0.9
	3/25/2013	7/11/2013	1.2	0.07	
	7/11/2013	9/30/2013	1.1	0.07	
	1/10/2014	3/26/2014	0.3	0.02	
	3/26/2014	7/23/2014	1.1	0.06	
	10/28/14	1/4/15	1.6	0.09	

Table 7.2. Ambient Radon Track Etch Detector Results (concluded)

Location Number	Start Date	End Date	Radon Concentration (pCi L^{-1})	Radon Error (± pCi L^{-1})	Mean Concentration at Location (pCi L^{-1})
9	2/5/2013	3/25/2013	0.13	0.01	1.6
	3/25/2013	7/17/2013	1.6	0.08	
	7/17/2013	9/30/2013	1.5	0.09	
	9/30/2013	1/10/2014	1.5	0.08	
	1/10/2014	3/26/2014	0.4	0.03	
	3/26/2014	7/18/2014	1.3	0.07	
	7/18/14	10/28/14	4.6	0.15	

Notes:
[a]Average of sample and duplicate result
pCi L^{-1} = picocuries per liter

8.0 ENVIRONMENTAL DOSIMETER MEASUREMENTS

This section describes the placement of and data collection for the environmental dosimeters.

8.1 Measurement Locations

Environmental dosimeters were placed at Locations 1, 3, 7, 8 and 10 shown on Figure 7.1 and listed in Table 7.1. A dosimeter also was placed in the RER office in Sundance, Wyoming.

Data collection at the Upton Plant started in April 2013 and continued through December 2014.

8.2 Measurement Results

Table 8.1 lists the results obtained quarterly by location, between February 2013 and March 2014. Quarterly dosimetry measurements ranged on average from 23.9 (Location 7) to 29.5 millirem (mrem) (Location 8).

The quarterly response at each location was calculated as follows:

$$X = \frac{R}{T} \times 90$$

Where:

X= Quarterly exposure rate (mrem per quarter)
R= Dosimeter response (mrem)
T= time between shipment and receipt by dosimeter provider (days)
90= average number of days in quarter

The laboratory analytical reports for the environmental dosimeter analyses are provided in Appendix E.

Table 8.1. Environmental Dosimeter Results

Location	Year	Quarter	Dose for Quarter (mrem)	Average Dose per Quarter (mrem)
1 (UAMS-1)	2013	2	27.4[a]	24.3
		3	22.8[a]	
		4	21.3[a]	
	2014	1	30.7[a]	
		3	21.8[a]	
		4	21.9[a]	
3 (UAMS-3)	2013	2	26.5	25.6
		3	24.8	
		4	21.9	
	2014	1	35.6	
		3	21.9	
		4	23.0	
7 (UAMS-4)	2013	2	27.2[a]	23.9
		3	22.1[a]	
		4	20.7[a]	
	2014	1	29.2	
		3	21.0	
		4	23.3	
8 (UAMS-2)	2013	2	30.0	29.5
		3	28.3	
	2014	1	38.2	
		3	24.0	
		4	27.2	
10 (UAMS-5)	2013	3	25.1	25.0
		4	22.5	
	2014	1	34.2[a]	
		3	21.5[a]	
		4	21.8[a]	

Notes:
[a]Average of sample and duplicate result
mrem = millirem

9.0 AIRBORNE PARTICULATES

RER collected samples of airborne particulates at five locations (UAMS-1 through UAMS-5) using high volume air samplers. The samplers were operated at various intervals, depending on the parameter of interest and field or sampler conditions. The samples were analyzed for total particulates (long-lived radionuclides and lanthanides) and particle size fractions.

9.1 Total Particulates

The samplers were used periodically, from June 2012 to December 2014 to collect total particulates. The locations of the air samplers are shown on Figure 7.1, as UAMS-1 through UAMS-5.

Each high volume air sampler was equipped with an 8-in. by 10-in. 0.8 micron glass fiber filter paper. The air filters were collected at various intervals, prior to saturation. Sample collection periods lasted from 3 to 49 days, averaging 30 days. Flow rate and total flow data were recorded at the time of sample collection.

The filters were sent to and digested by the external analytical laboratory. The samples were analyzed for cerium, lanthanum; natural thorium and uranium, thorium-230, and radium-226 using EPA Methods 200.8 (cerium, lanthanum, natural thorium and uranium), 908.0 (thorium-230) and 903.0 (radium-226).

The laboratory data were reported in units of picocuries per filter (pC f^{-1}) or micrograms per filter (µg f^{-1}, for natural thorium and uranium; cerium, and lanthanum). The radiological data were converted to units of microcuries per milliliter (µCi ml^{-1}), as follows:

$$Concentration,\ \mu Ci\ \ ml^{-1} = \frac{Filter\ \ Concentration}{Total\ \ Flow}(10^{-12})$$

The units of total flow and filter concentration in the equation are cubic meters (m^3) and pCi f^{-1}, respectively. The laboratory-reported concentrations of natural thorium and uranium were converted to pCi g^{-1} by multiplying the value in µg f^{-1} by their respective specific activities (2.22×10^{-7} and 6.77×10^{-7} Ci g^{-1}, respectively) and 1×10^{6}.

Airborne concentrations of cerium and lanthanum were determined by dividing the laboratory reported concentration (in µg f^{-1}) by the volume of air sampled (in standard cubic meters).

Appendix F presents the laboratory analytical reports for particulates.

9.1.1 Radioactive Particulates

The resulting concentrations for each radionuclide and high volume sampler were compared to effluent concentrations listed in Table 2 of 10 CFR 20 Appendix B and reported in Table 9.1 as percentages of the respective effluent concentrations. The most conservative effluent concentration was applied to thorium-230 ($2x10^{-14}$ µCi ml^{-1}). The Class D and W effluent concentrations were applied to natural uranium ($3x10^{-12}$ µCi ml^{-1}) and radium-226 ($9x10^{-13}$ µCi ml^{-1}), respectively. There is no 10 CFR 20 concentration for natural thorium; thus one was calculated for this baseline investigation, by assuming equal activities of the constituents of natural thorium (thorium-228 and thorium-232) and Class W effluent concentrations for thorium-228 ($3x10^{-14}$ µCi ml^{-1}) and thorium-232 ($4x10^{-15}$ µCi ml^{-1}). The unity rule is $1/((0.5/(3x10^{-14})+ 0.5/4x10^{-15})) = 7x10^{-15}$ µCi ml^{-1}.

To date, there have been 12 to 16 effective monitoring events at UAMS-1, UAMS-2, UAMS-3, and UAMS-4. There were seven events at UAMS-5. The data are summarized in Table 9.2, according to location, averages, standard deviations and ranges.

Site-wide, the data can be summarized as follows:

- Natural uranium concentrations ranged from not detected to $1.2x10^{-16}$ µCi ml^{-1} and averaged $3.6x10^{-17}$ µCi ml^{-1}.
- Thorium-230 concentrations ranged from not detected to $1.7x10^{-16}$ µCi ml^{-1} and averaged $2.6x10^{-17}$ µCi ml^{-1}.
- Radium-226 concentrations ranged from not detected to $3.5x10^{-15}$ µCi ml^{-1} and averaged $1.0x10^{-16}$ µCi ml^{-1}.
- Natural thorium concentrations ranged from not detected to $2.4x10^{-16}$ µCi ml^{-1} and averaged $4.1x10^{-17}$ µCi ml^{-1}.

Table 9.1. Radionuclide Concentrations in Air

			Concentration (µCi ml^{-1})				% Effluent Concentration				Lower Limit of Detection (µCi ml^{-1})			
Location	**Start Date**	**Stop Date**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**
UAMS-1	12-Jun-12	15-Jun-12	1.2E-16	1.7E-16	1.8E-16	2.4E-16	4.1E-03	5.7E-03	2.0E-02	3.0E-02	1.2E-16	9.9E-17	9.0E-17	4.0E-17
	21-Jun-12	05-Jul-12	1.1E-16	1.2E-16	1.6E-16	1.3E-16	3.6E-03	4.1E-03	1.7E-02	1.6E-02	3.6E-17	3.5E-17	3.2E-17	1.2E-17
	12-Jul-12	26-Jul-12	6.3E-17	6.0E-17	9.7E-17	6.1E-17	2.1E-03	2.0E-03	1.1E-02	7.6E-03	3.1E-17	2.3E-17	3.2E-17	1.0E-17
	31-Aug-12	04-Oct-12	2.5E-18	2.3E-18	2.4E-18	2.4E-18	8.3E-05	7.7E-05	2.7E-04	3.0E-04	6.2E-19	4.7E-19	1.3E-18	2.0E-19
	11-Oct-12	07-Nov-12	6.6E-17	4.9E-17	8.7E-17	7.5E-17	2.2E-03	1.6E-03	9.7E-03	9.3E-03	1.6E-17	1.4E-18	5.2E-18	5.3E-18
	16-Nov-12	03-Jan-13	ND	2.9E-18	1.3E-16	ND	NA	9.8E-05	1.4E-02	NA	2.2E-16	1.0E-16	1.0E-16	7.7E-17
	10-Jan-13	05-Feb-13	ND	4.9E-17	7.3E-18	ND	NA	1.6E-03	8.1E-04	NA	3.1E-16	1.0E-16	1.0E-16	1.1E-16
	12-Feb-13	15-Mar-13	ND	2.3E-17	7.6E-18	ND	NA	7.6E-04	8.4E-04	NA	2.6E-16	1.0E-16	1.0E-16	9.1E-17
	21-Mar-13	18-Apr-13	ND	ND	1.9E-17	ND	NA	NA	2.1E-03	NA	2.9E-16	1.0E-16	1.0E-16	1.0E-16
	21-Nov-13	07-Jan-14	ND	ND	ND	ND	NA	NA	NA	NA	2.9E-16	1.0E-16	1.0E-16	1.0E-16
	04-Mar-14	07-Apr-14	ND	ND	2.1E-17	ND	NA	NA	2.4E-03	NA	2.1E-16	1.0E-16	1.0E-16	7.2E-17
	14-Apr-14	16-May-14	ND	5.8E-17	4.5E-17	ND	NA	1.9E-03	5.0E-03	NA	2.8E-16	1.0E-16	1.0E-16	9.7E-17
	22-May-14	27-Jun-14	ND	1.3E-17	2.5E-17	ND	NA	4.2E-04	2.8E-03	NA	2.4E-16	1.0E-16	1.0E-16	8.4E-17
	09-Jul-14	18-Aug-14	ND	1.1E-17	9.8E-17	ND	NA	3.6E-04	1.1E-02	NA	2.4E-16	1.0E-16	1.0E-16	8.1E-17
	26-Aug-14	01-Oct-14	ND	2.0E-17	6.6E-17	ND	NA	6.6E-04	7.3E-03	NA	2.4E-16	1.0E-16	1.0E-16	8.5E-17
	13-Oct-14	12-Dec-14	ND	7.2E-17	3.5E-15	ND	NA	2.4E-03	3.9E-01	NA	1.0E-11	1.0E-16	1.0E-16	3.5E-12

Table 9.1. Radionuclide Concentrations in Air (continued)

			Concentration (µCi ml^{-1})				% Effluent Concentration				Lower Limit of Detection (µCi ml^{-1})			
Location	**Start Date**	**Stop Date**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**
UAMS-2	12-Jun-12	21-Jun-12	4.6E-17	8.1E-17	7.4E-17	4.5E-17	1.5E-03	2.7E-03	8.3E-03	5.6E-03	4.6E-17	4.4E-17	3.4E-17	1.5E-17
	28-Jun-12	12-Jul-12	5.9E-17	5.7E-17	5.3E-17	5.8E-17	2.0E-03	1.9E-03	5.8E-03	7.2E-03	3.0E-17	2.3E-17	2.6E-17	9.6E-18
	09-Aug-12	02-Sep-12	1.0E-18	1.5E-18	9.0E-19	9.8E-19	3.4E-05	5.0E-05	9.9E-05	1.2E-04	5.0E-19	4.8E-19	9.0E-19	1.6E-19
	19-Jul-12	02-Aug-12	8.4E-19	8.4E-19	7.4E-19	8.2E-19	2.8E-05	2.8E-05	8.2E-05	1.0E-04	8.4E-19	6.9E-19	1.5E-18	2.7E-19
	09-Sep-12	11-Oct-12	4.9E-17	3.9E-17	2.2E-17	3.7E-17	1.6E-03	1.3E-03	2.4E-03	4.7E-03	1.6E-17	3.2E-19	9.7E-19	5.3E-18
	16-Oct-12	16-Nov-12	7.6E-19	6.7E-19	1.9E-18	6.2E-19	2.5E-05	2.2E-05	2.1E-04	7.7E-05	3.8E-19	3.2E-19	1.7E-18	1.2E-19
	28-Nov-12	10-Jan-13	2.7E-19	4.8E-19	6.5E-19	7.1E-19	9.1E-06	1.6E-05	7.2E-05	8.9E-05	2.7E-19	1.9E-19	3.2E-19	8.9E-20
	16-Jan-13	19-Feb-13	ND	5.6E-18	2.3E-18	ND	NA	1.9E-04	2.5E-04	NA	1.8E-16	1.0E-16	1.0E-16	6.4E-17
	26-Feb-13	21-Mar-13	ND	7.8E-18	ND	ND	NA	2.6E-04	NA	NA	2.7E-16	1.0E-16	1.0E-16	9.4E-17
	27-Mar-13	25-Apr-13	ND	2.7E-18	1.1E-17	ND	NA	9.0E-05	1.3E-03	NA	2.1E-16	1.0E-16	1.0E-16	7.4E-17
	03-Dec-13	10-Jan-14	ND	ND	ND	ND	NA	NA	NA	NA	1.6E-16	1.0E-16	1.0E-16	5.7E-17
	20-Jan-14	25-Feb-14	ND	1.6E-18	5.3E-18	ND	NA	5.3E-05	5.9E-04	NA	1.7E-16	1.0E-16	1.0E-16	6.0E-17
	11-Mar-14	14-Apr-14	ND	ND	ND	ND	NA	NA	NA	NA	1.8E-16	1.0E-16	1.0E-16	6.3E-17
	22-Apr-14	22-May-14	ND	ND	ND	ND	NA	NA	NA	NA	2.1E-16	1.0E-16	1.0E-16	7.1E-17

Table 9.1. Radionuclide Concentrations in Air (continued)

			Concentration (µCi ml^{-1})				% Effluent Concentration				Lower Limit of Detection (µCi ml^{-1})			
Location	**Start Date**	**Stop Date**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**
UAMS-3	24-Jul-12	09-Aug-12	2.2E-18	3.2E-18	3.2E-18	2.1E-18	7.3E-05	1.1E-04	3.6E-04	2.7E-04	2.2E-18	2.1E-18	3.6E-18	7.1E-19
	17-Sep-12	19-Oct-12	1.6E-17	2.3E-17	5.6E-17	2.7E-17	5.5E-04	7.7E-04	6.2E-03	3.3E-03	1.6E-17	3.1E-19	1.1E-18	5.3E-18
	30-Oct-12	28-Nov-12	ND	1.5E-18	2.2E-18	8.2E-19	NA	5.0E-05	2.5E-04	1.0E-04	6.3E-19	4.8E-19	2.8E-18	2.1E-19
	28-Jan-13	26-Feb-13	ND	5.3E-18	3.1E-18	ND	NA	1.8E-04	3.5E-04	NA	2.2E-16	1.0E-16	1.0E-16	7.5E-17
	10-Mar-13	27-Mar-13	ND	ND	2.1E-17	ND	NA	NA	2.3E-03	NA	3.7E-16	1.0E-16	1.0E-16	1.3E-16
	20-Dec-13	20-Jan-14	ND	7.6E-18	6.5E-18	ND	NA	2.5E-04	7.2E-04	NA	3.9E-16	1.0E-16	1.0E-16	1.4E-16
	03-Feb-14	19-Mar-14	ND	7.0E-18	1.1E-17	ND	NA	2.3E-04	1.2E-03	NA	2.2E-16	1.0E-16	1.0E-16	7.7E-17
	26-Mar-14	02-May-14	ND	2.0E-17	0.0E+00	ND	NA	6.5E-04	NA	NA	2.3E-16	1.0E-16	1.0E-16	7.9E-17
	13-May-14	13-Jun-14	ND	2.5E-17	0.0E+00	ND	NA	8.5E-04	NA	NA	2.2E-16	1.0E-16	1.0E-16	7.6E-17
	20-Jun-14	04-Aug-14	ND	5.7E-18	3.2E-17	ND	NA	1.9E-04	3.6E-03	NA	1.6E-16	1.0E-16	1.0E-16	5.4E-17
	12-Aug-14	12-Sep-14	ND	ND	2.8E-17	ND	NA	NA	3.1E-03	NA	2.4E-16	1.0E-16	1.0E-16	8.3E-17
	19-Sep-14	07-Nov-14	ND	4.0E-18	5.9E-17	ND	NA	1.3E-04	6.6E-03	NA	1.0E-11	1.0E-16	1.0E-16	3.5E-12

Table 9.1. Radionuclide Concentrations in Air (concluded)

			Concentration (µCi ml^{-1})				% Effluent Concentration				Lower Limit of Detection (µCi ml^{-1})			
Location	**Start Date**	**Stop Date**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**	**U-nat**	**Th-230**	**Ra-226**	**Th-nat**
UAMS-4	12-Jun-12	28-Jun-12	5.2E-17	2.8E-17	6.1E-17	3.4E-17	1.7E-03	9.3E-04	6.8E-03	4.2E-03	2.6E-17	2.4E-17	2.3E-17	8.4E-18
	05-Jul-12	19-Jul-12	3.0E-17	5.3E-17	5.7E-17	2.9E-17	9.9E-04	1.8E-03	6.3E-03	3.6E-03	3.0E-17	2.0E-17	2.6E-17	9.7E-18
	26-Aug-12	27-Sep-12	9.3E-19	1.2E-18	6.1E-19	1.2E-18	3.1E-05	4.1E-05	6.8E-05	1.5E-04	4.6E-19	5.4E-19	9.6E-19	1.5E-19
	28-Nov-12	16-Jan-13	ND	1.3E-18	1.5E-18	ND	NA	4.4E-05	1.7E-04	NA	1.3E-16	1.0E-16	1.0E-16	4.4E-17
	24-Jan-13	08-Mar-13	ND	1.6E-18	2.7E-18	ND	NA	5.3E-05	3.0E-04	NA	1.4E-16	1.0E-16	1.0E-16	5.0E-17
	15-Mar-13	12-Apr-13	ND	3.7E-17	1.8E-16	ND	NA	1.2E-03	2.0E-02	NA	2.2E-15	1.0E-16	1.0E-16	7.7E-16
	30-Dec-13	03-Feb-14	ND	3.8E-18	1.7E-17	ND	NA	1.3E-04	1.9E-03	NA	1.8E-16	1.0E-16	1.0E-16	6.2E-17
	17-Feb-14	11-Mar-14	ND	2.9E-18	1.3E-17	ND	NA	9.5E-05	1.5E-03	NA	2.9E-16	1.0E-16	1.0E-16	9.9E-17
	19-Mar-14	22-Apr-14	ND	ND	1.9E-17	ND	NA	NA	2.1E-03	NA	1.9E-16	1.0E-16	1.0E-16	6.5E-17
	02-May-14	03-Jun-14	ND	ND	1.7E-17	ND	NA	NA	1.9E-03	NA	1.9E-16	1.0E-16	1.0E-16	6.7E-17
	13-Jun-14	18-Jul-14	ND	1.3E-16	1.8E-16	ND	NA	4.5E-03	2.0E-02	NA	1.9E-16	1.0E-16	1.0E-16	6.5E-17
	04-Aug-14	29-Aug-14	ND	1.5E-17	4.2E-17	ND	NA	5.0E-04	4.7E-03	NA	2.6E-16	1.0E-16	1.0E-16	9.0E-17
	09-Sep-14	09-Sep-14	ND	5.4E-18	6.2E-17	ND	NA	1.8E-04	6.8E-03	NA	1.0E-11	1.0E-16	1.0E-16	3.5E-12
	04-Nov-14	04-Nov-14	ND	9.1E-19	1.5E-17	ND	NA	3.0E-05	1.7E-03	NA	1.0E-11	1.0E-16	1.0E-16	3.5E-12
UAMS-5	07-Jan-14	17-Feb-14	ND	4.4E-18	3.8E-17	ND	NA	1.5E-04	4.3E-03	NA	1.5E-16	1.0E-16	1.0E-16	5.3E-17
	25-Feb-14	26-Mar-14	ND	1.0E-17	2.2E-17	ND	NA	3.5E-04	2.5E-03	NA	2.1E-16	1.0E-16	1.0E-16	7.4E-17
	07-Apr-14	13-May-14	ND	1.1E-17	4.1E-17	ND	NA	3.6E-04	4.6E-03	NA	1.8E-16	1.0E-16	1.0E-16	6.3E-17
	16-May-14	20-Jun-14	ND	4.3E-17	4.3E-17	ND	NA	1.4E-03	4.8E-03	NA	1.8E-16	1.0E-16	1.0E-16	6.1E-17
	27-Jun-14	12-Aug-14	ND	2.0E-17	1.0E-16	ND	NA	6.5E-04	1.2E-02	NA	1.6E-16	1.0E-16	1.0E-16	5.6E-17
	18-Aug-14	19-Sep-14	ND	1.7E-17	6.9E-17	ND	NA	5.8E-04	7.7E-03	NA	2.1E-16	1.0E-16	1.0E-16	7.3E-17
	01-Oct-14	01-Oct-14	ND	1.3E-17	1.1E-16	ND	NA	4.4E-04	1.2E-02	NA	1.0E-11	1.0E-16	1.0E-16	3.5E-12

Notes:
[a]Reporting limit not reported by analytical laboratory
[b]Volume not reported. Calculation not performed.
NA = Not applicable
ND = Result below detection limit
NR = not reported
Ra-226 = radium-226
Th-230 = thorium-230
Th-nat = natural thorium
U-nat = natural uranium
µCi ml^{-1} = microcuries per milliliter

Table 9.2. Summary Statistics for Radionuclide Concentrations in Air

Location	U-nat Concentration (µC ml^{-1})					Th-230 Concentration (µC ml^{-1})				Ra-226 Concentration (µC ml^{-1})				Th-nat Concentration (µC ml^{-1})			
	N	Avg	σ	Min	Max	Avg	σ	Min	Max	Avg	σ	Min	Max	Avg	σ	Min	Max
UAMS-1	16	7.2E-17	4.7E-17	2.5E-18	1.2E-16	5.0E-17	5.0E-17	2.3E-18	1.7E-16	3.0E-16	9.0E-16	2.4E-18	3.5E-15	1.0E-16	8.8E-17	2.4E-18	2.4E-16
UAMS-2	14	2.2E-17	2.7E-17	2.7E-19	5.9E-17	1.8E-17	2.8E-17	4.8E-19	8.1E-17	1.7E-17	2.6E-17	6.5E-19	7.4E-17	2.0E-17	2.5E-17	6.2E-19	5.8E-17
UAMS-3	12	9.3E-18	1.0E-17	2.2E-18	1.6E-17	1.0E-17	8.9E-18	1.5E-18	2.5E-17	2.2E-17	2.1E-17	2.2E-18	5.9E-17	9.9E-18	1.5E-17	8.2E-19	2.7E-17
UAMS-4	14	2.7E-17	2.5E-17	9.3E-19	5.2E-17	2.4E-17	3.9E-17	9.1E-19	1.3E-16	4.7E-17	5.9E-17	6.1E-19	1.8E-16	2.1E-17	1.8E-17	1.2E-18	3.4E-17
UAMS-5	7	A	NA	NA	NA	1.7E-17	1.3E-17	4.4E-18	4.3E-17	6.2E-17	3.5E-17	2.2E-17	1.1E-16	NA	NA	NA	NA
Site Wide	63	3.6E-17	3.9E-17	2.7E-19	1.2E-16	2.7E-17	3.8E-17	4.8E-19	1.7E-16	1.2E-16	5.1E-16	6.1E-19	3.5E-15	4.1E-17	6.0E-17	6.2E-19	2.4E-16

Notes:
NA = not applicable
Ra-226 = radium-226
σ = standard deviation
Th-230 = thorium-230
Th-nat = natural thorium
U-nat = natural uranium
µCi ml^{-1} = microcuries per milliliter

The values determined above are similar to U.S. background concentrations reported in the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex B (UNSCEAR, 2000). The regional concentrations reported in this reference document are: uranium-238 ($2.4x10^{-17}$ to $1.4x10^{-16}$ µCi ml^{-1}), natural thorium ($1.9x10^{-17}$µCi ml^{-1} based on an average of thorium-228 and thorium-232 regional concentrations), thorium-230 ($1.6x10^{-17}$ µCi ml^{-1}), and radium-226 ($1.6x10^{-17}$ µCi ml^{-1}).

The ranges of airborne radioactive particulate concentrations were the following percentages of their respective 10 CFR 20 Appendix B effluent concentrations:

- Natural uranium: not detected to 0.004 percent.
- Natural thorium: not detected to 0.009 percent.
- Thorium-230: not detected to 0.4 percent.
- Radium-226: not detected to 0.03 percent.

9.1.2 Lanthanide Particulates

Table 9.3 presents the concentrations of lanthanides in sample filters and in air. Table 9.4 lists summary statistics for the lanthanides.

Site-wide average cerium and lanthanum particulate concentrations in air are $9.0x10^{-4}$ and $4.5x10^{-4}$ µg m^{-3}, respectively. The range of cerium concentrations is $6.5x10^{-6}$ to $4.0x10^{-3}$ µg m^{-3}. The range of lanthanum concentrations is $3.6x10^{-6}$ to $2.0x10^{-3}$ µg m^{-3}.

Table 9.3. Lanthanide Concentrations in Air

			Lanthanum ($\mu g\ m^{-3}$)		Cerium ($\mu g\ m^{-3}$)	
Location	**Start Date**	**Stop Date**	**Result**	**Reporting Limit**	**Result**	**Reporting Limit**
UAMS-1	12-Jun-12	15-Jun-12	2.0E-03	1.8E-04	4.0E-03	1.8E-04
	21-Jun-12	05-Jul-12	1.6E-03	5.4E-05	3.3E-03	5.4E-05
	12-Jul-12	26-Jul-12	8.8E-04	4.6E-05	1.8E-03	4.6E-05
	31-Aug-12	04-Oct-12	3.1E-05	9.2E-07	6.3E-05	9.2E-07
	11-Oct-12	07-Nov-12	7.3E-04	2.4E-05	1.5E-03	2.4E-05
	16-Nov-12	03-Jan-13	5.4E-04	3.5E-04	1.0E-03	3.5E-04
	10-Jan-13	05-Feb-13	ND	4.9E-04	ND	4.9E-04
	12-Feb-13	15-Mar-13	ND	4.1E-04	4.6E-04	4.1E-04
	21-Mar-13	18-Apr-13	ND	4.5E-04	ND	4.5E-04
	21-Nov-13	07-Jan-14	ND	4.6E-04	ND	4.6E-04
	04-Mar-14	07-Apr-14	ND	3.3E-04	ND	3.3E-04
	14-Apr-14	16-May-14	ND	4.4E-04	ND	4.4E-04
	22-May-14	27-Jun-14	ND	3.8E-04	ND	3.8E-04
	09-Jul-14	18-Aug-14	ND	3.7E-04	ND	3.7E-04
	26-Aug-14	01-Oct-14	ND	3.8E-04	ND	3.8E-04
	13-Oct-14	13-Oct-14	ND	1.6E+01	ND	1.6E+01
UAMS-2	12-Jun-12	21-Jun-12	6.1E-04	6.8E-05	1.2E-03	6.8E-05
	28-Jun-12	12-Jul-12	7.4E-04	4.4E-05	1.5E-03	4.4E-05
	19-Jul-12	02-Aug-12	1.1E-05	1.2E-06	2.3E-05	1.2E-06
	09-Aug-12	02-Sep-12	1.3E-05	7.5E-07	2.5E-05	7.5E-07
	09-Sep-12	11-Oct-12	3.9E-04	2.4E-05	7.8E-04	2.4E-05
	16-Oct-12	16-Nov-12	5.6E-06	5.6E-07	1.1E-05	5.6E-07
	28-Nov-12	10-Jan-13	3.6E-06	4.0E-07	6.5E-06	4.0E-07
	16-Jan-13	19-Feb-13	ND	2.9E-04	ND	2.9E-04
	26-Feb-13	21-Mar-13	ND	4.3E-04	ND	4.3E-04
	27-Mar-13	25-Apr-13	ND	3.4E-04	ND	3.4E-04
	03-Dec-13	10-Jan-14	ND	2.6E-04	ND	2.6E-04
	20-Jan-14	25-Feb-14	ND	2.7E-04	ND	2.7E-04
	11-Mar-14	14-Apr-14	ND	2.9E-04	ND	2.9E-04
	22-Apr-14	22-May-14	ND	3.2E-04	ND	3.2E-04

Table 9.3. Lanthanide Concentrations in Air (concluded)

			Lanthanum ($\mu g\ m^{-3}$)		Cerium ($\mu g\ m^{-3}$)	
Location	**Start Date**	**Stop Date**	**Result**	**Reporting Limit**	**Result**	**Reporting Limit**
UAMS-3	24-Jul-12	09-Aug-12	2.9E-05	3.2E-06	6.2E-05	3.2E-06
	17-Sep-12	19-Oct-12	2.7E-04	2.4E-05	5.6E-04	2.4E-05
	30-Oct-12	28-Nov-12	4.7E-06	9.3E-07	9.3E-06	9.3E-07
	28-Jan-13	26-Feb-13	ND	3.4E-04	ND	3.4E-04
	10-Mar-13	27-Mar-13	ND	5.8E-04	ND	5.8E-04
	20-Dec-13	20-Jan-14	ND	6.2E-04	ND	6.2E-04
	03-Feb-14	19-Mar-14	ND	3.5E-04	ND	3.5E-04
	26-Mar-14	02-May-14	ND	3.6E-04	ND	3.6E-04
	13-May-14	13-Jun-14	ND	3.4E-04	ND	3.4E-04
	20-Jun-14	04-Aug-14	ND	2.5E-04	ND	2.5E-04
	12-Aug-14	12-Sep-14	ND	3.8E-04	ND	3.8E-04
	19-Sep-14	19-Sep-14	ND	1.6E+01	ND	1.6E+01
UAMS-4	12-Jun-12	28-Jun-12	5.7E-04	3.8E-05	1.2E-03	3.8E-05
	05-Jul-12	19-Jul-12	4.4E-04	4.4E-05	9.2E-04	4.4E-05
	26-Aug-12	27-Sep-12	1.6E-05	6.8E-07	3.4E-05	6.8E-07
	28-Nov-12	16-Jan-13	2.0E-04	2.0E-04	5.0E-04	2.0E-04
	24-Jan-13	08-Mar-13	ND	2.3E-04	ND	2.3E-04
	15-Mar-13	12-Apr-13	ND	3.5E-03	ND	3.5E-03
	30-Dec-13	03-Feb-14	ND	2.8E-04	ND	2.8E-04
	17-Feb-14	11-Mar-14	ND	4.5E-04	ND	4.5E-04
	13-Jun-14	18-Jul-14	ND	3.0E-04	ND	3.0E-04
	04-Aug-14	29-Aug-14	ND	4.1E-04	ND	4.1E-04
	09-Sep-14	09-Sep-14	ND	1.6E+01	ND	1.6E+01
	04-Nov-14	04-Nov-14	ND	1.6E+01	ND	1.6E+01
UAMS-5	07-Jan-14	17-Feb-14	ND	2.4E-04	ND	2.4E-04
	25-Feb-14	26-Mar-14	ND	3.4E-04	ND	3.4E-04
	07-Apr-14	13-May-14	ND	2.9E-04	ND	2.9E-04
	16-May-14	20-Jun-14	ND	2.8E-04	ND	2.8E-04
	27-Jun-14	12-Aug-14	ND	2.6E-04	ND	2.6E-04
	18-Aug-14	19-Sep-14	ND	3.3E-04	ND	3.3E-04
	01-Oct-14	01-Oct-14	ND	1.6E+01	ND	1.6E+01

Notes:
Ce = cerium
La = lanthanum
ND = not detected
NA = not applicable
$\mu g\ m^{-3}$ = micrograms per cubic meter

Table 9.4. Summary Statistics for Lanthanide Concentrations in Air

		Lanthanide Concentration ($\mu g\ m^{-3}$)							
		Average		Standard Deviation		Minimum		Maximum	
Location	n	Lanthanum	Cerium	Lanthanum	Cerium	Lanthanum	Cerium	Lanthanum	Cerium
UAMS-1	16	9.6E-04	1.7E-03	7.1E-04	1.8E+00	3.1E-05	6.3E-05	2.0E-03	5.0E+00
UAMS-2	14	2.5E-04	5.1E-04	3.2E-04	6.5E-04	3.6E-06	6.5E-06	7.4E-04	1.5E-03
UAMS-3	12	1.0E-04	2.1E-04	1.4E-04	3.0E-04	4.7E-06	9.3E-06	2.7E-04	5.6E-04
UAMS-4	12	3.1E-04	6.6E-04	2.5E-04	5.0E-04	1.6E-05	3.4E-05	5.7E-04	1.2E-03
UAMS-5	7	NA	NA	NA	NA	NA	NA	NA	NA
Site-Wide	61	4.5E-04	9.0E-04	5.5E-04	1.1E-03	3.6E-06	6.5E-06	2.0E-03	4.0E-03

Notes:
Ce = cerium
La = lanthanum
$\mu g\ m^{-3}$ = micrograms per cubic meter

9.2 Particulate Matter Fractions

RER conducted Particulate Matter 2.5 ($PM_{2.5}$: particles with a nominal diameter less than 2.5 microns) and Particulate Matter 10 (PM_{10}: particles with a nominal diameter less than 10 microns) measurements for 24 hours at each of the four AMS locations, to further characterize particulates in air.

Tables 9.5 and 9.6 list the individual concentrations of the PM_{10} and $PM_{2.5}$ filters, respectively. PM_{10} and $PM_{2.5}$ concentrations were determined by dividing the laboratory-reported mass by the volume of air sampled in the 24-hr period. The concentrations are compared there to their respective 40 CFR 50 standards.

For the purpose of reference, the PM_{10} standard is met when the expected number of days per calendar year with a 24-hr average concentration above 150 µg m^{-3} is equal to or less than one.

The PM_{10} standard has been meet at each of the five air monitoring stations. The concentrations range from 7.4 (UAMS-3) to 17.4 percent (UAMS-1) of the PM_{10} standard.

The $PM_{2.5}$ standard is met when:

- The annual arithmetic mean concentration (averaged over three years) is less than or equal to 15 µg m^{-3}, or

- The 98th percentile 24-hr concentration is less than or equal to 65 µg m^{-3}.

The 98th percentile is defined in 40 CFR 50 Appendix N as the daily value out of a year of $PM_{2.5}$ monitoring data below which 98 percent of all daily values fall.

Three years of data are needed to compare site measurements to applicable $PM_{2.5}$ standards.

Table 9.5. PM_{10} Concentrations Measured at Upton Air Monitoring Stations

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-1	17-Jun-12	18-Jun-12	58683	0.0293	1115	26	26	78	17.4
	10-Jul-12	11-Jul-12	58697	0.084	1076	78			
	29-Jul-12	30-Jul-12	58757	0.0242	1042	23			
	29-Aug-12	30-Aug-12	58776	0.0758	1089	70			
	08-Oct-12	09-Oct-12	58784	0.0172	1344	13			
	07-Nov-12	08-Nov-12	58790	0.0546	1300	42			
	07-Jan-13	08-Jan-13	58794	0.0279	1363	20			
	06-Feb-13	07-Feb-13	514597	0.012	1470	8			
	16-Mar-13	17-Mar-13	514605	0.0088	1475	6			
	18-Apr-13	19-Apr-13	514613	0.0174	1415	12			
	14-Jun-13	15-Jun-13	514622	0.0319	1394	23			
	25-Jul-13	26-Jul-13	514633	0.0197	1434	14			
	12-Nov-13	13-Nov-13	515959	0.0268	1559	17			
	07-Apr-14	08-Apr-14	515986	0.0512	1573	33			
	20-May-14	21-May-14	515997	0.0183	1537	12			
	27-Jun-14	28-Jun-14	516006	0.0235	1499	16			
	18-Aug-14	19-Aug-14	516015	0.0755	1531	49			
	01-Oct-14	02-Oct-14	516023	0.0124	1867	7			

Table 9.5. PM_{10} Concentrations Measured at Upton Air Monitoring Stations (continued)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-2	26-May-12	27-May-12	58688	0.0515	1343	38	12	38	8.1
	07-Aug-12	08-Aug-12	58699	0.0307	1528	20			
	07-Aug-12	08-Aug-12	58765	0.0116	1623	7			
	02-Sep-12	03-Sep-12	58777	0.0552	1639	34			
	11-Oct-12	12-Oct-12	58785	0.0245	1633	15			
	21-Nov-12	22-Nov-12	58793	0.0077	1636	5			
	10-Jan-13	11-Jan-13	58795	0.0468	1633	29			
	22-Feb-13	23-Feb-13	514600	0.0167	2668	6			
	26-Mar-13	27-Mar-13	514608	0.0333	2429	14			
	29-Apr-13	29-Apr-13	514618	0.0175	1855	9			
	21-Jun-13	22-Jun-13	514623	0.0237	1947	12			
	09-Aug-13	10-Aug-13	514637	0.0163	1954	8			
	30-Sep-13	02-Oct-13	514646	0.0045	3687	1			
	25-Nov-13	26-Nov-13	515962	0.0207	3432	6			
	12-Jan-14	13-Jan-14	515970	0.0063	1965	3			
	25-Feb-14	26-Feb-14	515978	0.0045	3205	1			
	17-Apr-14	18-Apr-14	515989	0.0073	1852	4			
	22-May-14	23-May-14	515998	0.011	1921	6			

Table 9.5. PM_{10} Concentrations Measured at Upton Air Monitoring Stations (continued)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-3	12-Aug-12	13-Aug-12	58767	0.0231	1386	17	11	42	7.4
	11-Sep-12	12-Sep-12	58779	0.062	1464	42			
	28-Oct-12	29-Oct-12	58789	0.0146	1609	9			
	28-Nov-12	28-Nov-12	58772	0.0122	1433	9			
	27-Feb-13	28-Feb-13	514601	0.0071	2061	3			
	28-Mar-13	29-Mar-13	514609	0.0107	1795	6			
	30-Apr-13	01-May-13	514619	0.0094	1750	5			
	02-Jul-13	03-Jul-13	514628	0.031	1547	20			
	19-Aug-13	20-Aug-13	514638	0.0495	1661	30			
	18-Oct-13	19-Oct-13	515954	0.0099	1833	5			
	11-Dec-13	12-Dec-13	515964	0.0265	2738	10			
	27-Jan-14	28-Jan-14	515973	0.0096	2962	3			
	19-Mar-14	20-Mar-14	515982	0.0114	1788	6			
	06-May-14	07-May-14	515993	0.0032	1800	2			
	13-Jun-14	14-Jun-14	516002	0.0099	1867	5			
	04-Aug-14	05-Aug-14	516011	0.045	1768	25			
	18-Nov-14	18-Nov-14	516029	0.0064	1730	4			

Table 9.5. PM_{10} Concentrations Measured at Upton Air Monitoring Stations (continued)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-4	01-Jul-12	02-Jul-12	58691	0.1417	1502	94	21	94	13.9
	24-Jul-12	25-Jul-12	58755	0.0193	1634	12			
	22-Aug-12	23-Aug-12	58771	0.0456	1631	28			
	27-Sep-12	28-Sep-12	58781	0.0357	1633	22			
	21-Jan-13	22-Jan-13	58798	0.0217	1632	13			
	15-Mar-13	16-Mar-13	514604	0.0219	1829	12			
	16-Apr-13	17-Apr-13	514612	0.0175	1681	10			
	14-May-13	15-May-13	514624	0.0607	1760	34			
	12-Jul-13	13-Jul-13	514629	0.0319	1790	18			
	03-Sep-13	04-Sep-13	514641	0.0437	1809	24			
	22-Oct-13	23-Oct-13	515955	0.0133	1797	7			
	23-Dec-13	24-Dec-13	515967	0.0085	1966	4			
	03-Feb-14	04-Feb-14	515974	0.0141	4308	3			
	17-Mar-14	18-Mar-14	515981	0.0065	1730	4			
	22-Apr-14	23-Apr-14	515990	0.0352	1853	19			
	10-Jun-14	11-Jun-14	516001	0.0135	1817	7			
	04-Sep-14	05-Sep-14	516018	0.019	1626	12			
	28-Oct-14	29-Oct-14	516027	0.1282	1749	73			

Table 9.5. PM_{10} Concentrations Measured at Upton Air Monitoring Stations (concluded)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-5	25-May-13	27-May-13	513262	0.0453	3767	12	17	48	11.0
	23-Jul-13	24-Jul-13	514632	0.0633	1938	33			
	10-Sep-13	11-Sep-13	514642	0.091	1879	48			
	05-Nov-13	06-Nov-13	515958	0.0083	1745	5			
	30-Dec-13	31-Dec-13	515968	0.0068	1863	4			
	21-Feb-14	22-Feb-14	515977	0.0094	2209	4			
	04-Apr-14	05-Apr-14	515985	0.0386	1820	21			
	13-May-14	14-May-14	515994	0.0416	1798	23			
	24-Jun-14	25-Jun-14	516005	0.0254	1914	13			
	09-Dec-14	10-Dec-14	519703	0.0625	1778	35			

Notes:
[a]PM_{10} standard is met when the expected number of days per calendar year with a 24-hr average concentration above 150 µg m^{-3} is equal to or less than one.
g = grams
NA = not applicable
NR = not reported
PM_{10} = particulate matter, diameter less than 10 microns
scm = standard cubic meters
µg m^{-3} = micrograms per cubic meter

Table 9.6. $PM_{2.5}$ Concentrations Measured at Upton Air Monitoring Stations

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-1	19-Jun-12	20-Jun-12	58685	0.0038	795.1	4.8	10	47	64.2
	08-Jul-12	09-Jul-12	58694	0.0509	1088.0	46.8			
	31-Jul-12	01-Aug-12	58761	0.0138	1014.3	13.6			
	26-Aug-12	27-Aug-12	58775	0.0146	1095.0	13.3			
	04-Oct-12	05-Oct-12	58783	0.0097	1302.7	7.4			
	12-Nov-12	13-Nov-12	58791	0.0151	1323.5	11.4			
	03-Jan-13	04-Jan-13	58774	0.0139	1300.2	10.7			
	08-Feb-13	09-Feb-13	514598	0.0054	1324.0	4.0			
	19-Mar-13	20-Mar-13	514606	0.0029	1307.0	2.0			
	23-Apr-13	24-Apr-13	514614	0.0099	1294.0	8.0			
	11-Jun-13	12-Jun-13	513265	0.0167	1446.0	12.0			
	05-Aug-13	06-Aug-13	514635	0.0105		0.0			
	18-Sep-13	19-Sep-13	514644	0.0107	1329.0	8.0			
	15-Nov-13	16-Nov-13	515960	0.016	1384.0	12.0			
	10-Apr-14	11-Apr-14	515987	0.0132	1462.0	9.0			
	16-May-14	17-May-14	515996	0.022	1571.0	14.0			
	08-Jul-14		516008	0		0.0			
	22-Aug-14		516016	0		0.0			
	06-Oct-14	07-Oct-14	516024	0.0108	1795.0	6.0			

Table 9.6. $PM_{2.5}$ Concentrations Measured at Upton Air Monitoring Stations (continued)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-2	24-Jun-12	25-Jun-12	58686	0.0179	1252.3	14.3	5	14	36.1
	17-Jul-12	18-Jul-12	58752	0.0113	1639.3	6.9			
	05-Aug-12	06-Aug-12	58763	0.0125	1359.8	9.2			
	05-Sep-12	06-Sep-12	58778	0.0186	1635.2	11.4			
	13-Oct-12	14-Oct-12	58786	0.0137	1634.6	8.4			
	16-Nov-12	17-Nov-12	58792	0.011	1636.0	6.7			
	14-Jan-13	15-Jan-13	58796	0.0057	1634.2	3.5			
	21-Feb-13	22-Feb-13	514599	0.0053	1964.0	3.0			
	22-Mar-13	22-Mar-13	514607	0.0019	1774.0	1.0			
	25-Apr-13	26-Apr-13	514616	0.0106	1880.0	6.0			
	24-Jun-13	25-Jun-13	514626	0.0107	1957.0	5.0			
	07-Aug-13	08-Aug-13	514636	0.0109	1971.0	6.0			
	09-Oct-13	10-Oct-13	515952	0.008	1818.0	4.0			
	21-Nov-13	22-Nov-13	515961	0.007	3150.0	2.0			
	16-Jan-14	17-Jan-14	515971	0.0034	2052.0	2.0			
	04-Mar-14	05-Mar-14	515979	0.0044	1759.0	3.0			
	14-Apr-14	15-Apr-14	515988	0.0041	1803.0	2.0			
	27-May-14	28-May-14	515999	0.006	1950.0	3.0			

Table 9.6. $PM_{2.5}$ Concentrations Measured at Upton Air Monitoring Stations (continued)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-3	15-Aug-12	16-Aug-12	58789	0.0065	1279.2	5.1	6	13	40.0
	13-Sep-12	14-Sep-12	58780	0.0162	1361.9	11.9			
	16-Oct-12	17-Oct-12	58787	0.009	1480.3	6.1			
	07-Dec-12	08-Dec-12	58773	NR	1038.3	NA			
	06-Mar-13	07-Mar-13	514602	0.0041	1728.0	2.0			
	01-Apr-13	02-Apr-13	514610	0.0094	1724.0	5.0			
	07-May-13	08-May-13	514620	0.0109	1549.0	7.0			
	27-Jun-13	28-Jun-13	514627	0.0085	1655.0	5.0			
	22-Aug-13	23-Aug-13	514639	0.0152	1440.0	11.0			
	16-Oct-13	17-Oct-13	515953	0.0116	1765.0	7.0			
	16-Dec-13	17-Dec-13	515965	0.0077	2825.0	3.0			
	20-Jan-14	21-Jan-14	515972	0.0036	2415.0	1.0			
	24-Mar-14	25-Mar-14	515983	0.0077	1747.0	4.0			
	06-May-14	07-May-14	515992	0.0081	1766.0	5.0			
	17-Jun-14	18-Jun-14	516003	0.0082	1794.0	5.0			
	08-Aug-14	09-Aug-14	516012	0.0155	1640.0	9.0			
	16-Sep-14	17-Sep-14	516020	0.021	1665.0	13.0			
	02-Dec-14	03-Dec-14	516031	0.0039	2541.0	2.0			

Table 9.6. $PM_{2.5}$ Concentrations Measured at Upton Air Monitoring Stations (continued)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-4	03-Jul-12	04-Jul-12	58693	0.0269	1478.6	18.2	6	18	43.2
	22-Jul-12	23-Jul-12	58754	0.0142	1464.7	9.7			
	20-Aug-12	21-Aug-12	58770	0.0143	1584.5	9.0			
	30-Sep-12	01-Oct-12	58782	0.0265	1632.9	16.2			
	16-Jan-13	17-Jan-13	58797	0.0078	1598.4	4.9			
	09-Mar-13	10-Mar-13	514603	0.0075	1726.0	4.0			
	12-Apr-13	13-Apr-13	514611	0.0107	1721.0	6.0			
	09-May-13	10-May-13	514621	0.0103	1799.0	6.0			
	16-Jul-13	17-Jul-13	514630	0.0109	1734.0	6.0			
	28-Aug-13	29-Aug-13	514640	0.0186	1792.0	10.0			
	28-Oct-13	29-Oct-13	515956	0.0039	1725.0	2.0			
	20-Dec-13	21-Dec-13	515966	0.0075	2319.0	3.0			
	06-Feb-14	07-Feb-14	515975	0.0142	3705.0	4.0			
	11-Mar-14	12-Mar-14	515980	0.0012	1745.0	1.0			
	25-Apr-14	26-Apr-14	515991	0.0071	1766.0	4.0			
	03-Jun-14	04-Jun-14	516000	0.0102	1819.0	6.0			
	18-Jul-14	NR	516009	NR	NA	NA			
	29-Aug-14	30-Aug-14	516017	0.015	1721.0	9.0			
	13-Oct-14	14-Oct-14	516025	0.0073	1810.0	4.0			

Table 9.6. $PM_{2.5}$ Concentrations Measured at Upton Air Monitoring Stations (concluded)

Location	Start Date	End Date	Filter No.	Filter Weight (g)	Volume (scm)	Concentration (µg m-3)	Mean (µg m^{-3})	Maximum (µg m^{-3})	% of Standard (Mean)[a]
UAMS-5	11-Jun-13	12-Jun-13	513264	0.0144	1841.0	8.0	7	15	45.6
	18-Jul-13	19-Jul-13	514631	0.0142	1936.0	7.0			
	12-Sep-13	13-Sep-13	514643	0.0123	1869.0	7.0			
	31-Oct-13	01-Nov-13	515957	0.0079	1785.0	4.0			
	02-Jan-14	03-Jan-14	515969	0.0037	2099.0	2.0			
	17-Feb-14	18-Feb-14	515976	0.0037	1785.0	2.0			
	26-Mar-14	27-Mar-14	515984	0.0116	1798.0	6.0			
	14-May-14	15-May-14	515995	0.0205	1828.0	11.0			
	20-Jun-14	21-Jun-14	516004	0.0233	1921.0	12.0			
	13-Aug-14	14-Aug-14	516013	0.0265	1791.0	15.0			
	19-Sep-14		516021	0		0.0			
	04-Dec-14	05-Dec-14	516032	0.0135	1763.0	8.0			

Notes:
[a]$PM_{2.5}$ standard is less than or equal to 15 µg m^{-3}, as an annual arithmetic mean concentration averaged over three years.
g = grams
$PM_{2.5}$ = particulate matter, diameter less than 2.5 microns
scm = standard cubic meters
µg m^{-3} = micrograms per cubic meter

10.0 SUMMARY AND CONCLUSIONS

The baseline information presented in this report, coupled with environmental data collected once the mine is operational, will be used as a basis to evaluate its potential environmental impacts. The results of the baseline field investigation documented herein indicate the following at the Upton Plant:

- The central tendency and variability of measured gamma count rates can be described non-parametrically by the median and the interquartile range (IQR), respectively. The median of the population is 16,091 cpm. The IQR encompasses the range between the 1st quartile (the first 25 percent of ascending, ranked values) and 3rd quartile (the first 75 percent of ascending, ranked values). The IQR is 2,405 cpm (or 17,092 less 14,687 cpm).

- The relationship between gamma count and exposure rates is highly predictable. The range of predicted exposure rates is 10.1 and 19.3 µR hr^{-1}, with a central tendency of 13.8 µR hr^{-1}.

- The medians of the predicted concentrations (1.6 pCi g^{-1}) of radium-226 and natural thorium (2.7 pCi g^{-1}) are in good agreement with the median of the laboratory results (1.6 and 2.4 pCi g^{-1}, respectively). This indicates that gamma surveys can effectively predict radium-226 and natural thorium concentrations in soil.

- The largely homogeneous distribution of radium-226 and natural thorium concentrations is indicated by the low variability in gamma count rates at the Upton Plant.

- Because applicable NRC soil cleanup criteria are likely to be based both on radium-226 and radium-228, both radionuclides should be considered in investigations conducted during operation and closure.

- The measured radon flux rates range from 0.20 to 1.22 pCi m^{-2} s^{-1}. For comparison purposes, these values are below the NESHAPS requirement of 20 pCi m^{-2} s^{-1} specified in 10 CFR 40, Appendix A, Criterion 6. Although the requirement applies to uranium mill tailings and thus is not directly germane to this characterization, it is useful as a context to demonstrate the magnitude of baseline radon flux levels measured at the Site.

- Quarterly dosimetry measurements ranged on average from 23.9 to 29.5 mrem.

- Quarterly radon measurements ranged on average from 0.7 to 1.6 pCi L^{-1}.

- Particulate radionuclide concentrations in air across the site are consistently low and at levels at least 99 % below their respective 10 CFR 20 Appendix B effluent concentrations.

- Site-wide average cerium and lanthanum particulate concentrations in air are 9.0×10^{-4} and 4.5×10^{-4} µg m^{-3}, respectively. The range of cerium concentrations is 6.5×10^{-6} to 4.0×10^{-3} µg m^{-3}. The range of lanthanum concentrations is 3.6×10^{-6} to 2.0×10^{-3} µg m^{-3}.

- PM_{10} and $PM_{2.5}$ measurements continue to be collected at the Upton Plant. PM_{10} concentrations range from 7.4 (UAMS-3) to 17.4 percent (UAMS-1) of the respective standard. Three years of data are needed to compare site measurements to the applicable $PM_{2.5}$ standard.

- Radiological impacts incurred during the development and operation of the Plant and TSF, if any, will be determined by comparing the data sets of this baseline and future surveys.

11.0 REFERENCES

Knight Piésold, 2011. *Bear Lodge Project Upton Project/TSF Environmental Sampling and Analysis and Quality Assurance Plans*, December.

Rare Element Resources, Inc. (RER), 2015. *Environmental Report in Support of the Radioactive Materials License Application for the Upton Plant Site*. Anticipated publication in May.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000. *UNSCEAR Report to the General Assembly, Sources and Effects of Ionizing Radiation, Annex B.*

U.S. Environmental Protection Agency (EPA), Test Method 115: *Monitoring for Radon-222 Emissions*.

Baseline Soil Sampling 2022

Pace Analytical
1673 Terra Avenue Sheridan, WY 82801 ph: (307) 672-8945

Date: 4/15/2022

CLIENT: Tetra Tech
Project: RER Upton Project
Lab Order: S2203106

CASE NARRATIVE

Report ID: S2203106001

Entire Report Reviewed by: Crystal Herman

Crystal Herman, Mining Supervisor

Samples #1 BH3 (0-18), #1 BH3 (18-30), #1 BH3 (30-60), #2 BH5 (0-18), #2 BH5 (18-30), #2 BH5 (30-60), #3 BH4 (0-18), #3 BH4 (18-30), #3 BH4 (30-60), #4 BH6 (0-18), #4 BH6 (18-30), #4 BH6 (30-60), #5 BH1 (0-18), #5 BH1 (18-30), #5 BH1 (30-60), #6 BH2 (0-18), #6 BH2 (18-30) and #6 BH2 (30-60) were received on March 7, 2022.

Samples were analyzed using the methods outlined in the following references:

U.S.E.P.A. 600/2-78-054 "Field and Laboratory Methods Applicable to Overburden and Mining Soils", 1978
American Society of Agronomy, Number 9, Part 2, 1982
USDA Handbook 60 "Diagnosis and Improvement of Saline and Alkali Soils", 1969
Wyoming Department of Environmental Quality, Land Quality Division, Guideline No. 1, 1984
New Mexico Overburden and Soils Inventory and Handling Guideline, March 1987
State of Utah, Division of Oil, Gas, and Mining: Guidelines for Management of Topsoil and Overburden for Underground and Surface Coal Mining, April 1988
Montana Department of State Lands, Reclamation Division: Soil, Overburden, and Regraded Spoil Guidelines, December 1994
State of Nevada Modified Sobek Procedure
Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846, 3rd Edition

All Quality Control parameters met the acceptance criteria defined by EPA and Pace Analytical (Formerly Inter-Mountain Laboratories) except as indicated in this case narrative.

Qualifiers by sample

S2203106-001 - Total (3050) Metals by ICP - 6010C/Boron - RPD outside accepted recovery limits
S2203106-001 - Total (3050) Metals by ICP - 6010C/Cadmium - RPD outside accepted recovery limits
S2203106-002 - Total (3050) Metals by ICP - 6010C/Boron - Spike Recovery outside accepted recovery limits
S2203106-002 - Total (3050) Metals by ICP - 6010C/Iron - Spike Recovery outside accepted recovery limits
S2203106-002 - Total (3050) Metals by ICP - 6010C/Molybdenum - Spike Recovery outside accepted recovery limits
S2203106-002 - Total (3050) Metals by ICP - 6010C/Thorium - RPD outside accepted recovery limits
S2203106-002 - Total (3050) Metals by ICP - 6010C/Boron - Spike Recovery outside accepted recovery limits
S2203106-002 - Total (3050) Metals by ICP - 6010C/Molybdenum - Spike Recovery outside accepted recovery limits
S2203106-003 - Total (3050) Metals by ICP - 6010C/Calcium - Spike Recovery outside accepted recovery limits
S2203106-003 - Total (3050) Metals by ICP - 6010C/Magnesium - Spike Recovery outside accepted recovery limits
S2203106-003 - Total (3050) Metals by ICP - 6010C/Potassium - Spike Recovery outside accepted recovery limits
S2203106-003 - Total (3050) Metals by ICP - 6010C/Calcium - Spike Recovery outside accepted recovery limits
S2203106-003 - Total (3050) Metals by ICP - 6010C/Magnesium - Spike Recovery outside accepted recovery limits
S2203106-003 - Total (3050) Metals by ICP - 6010C/Potassium - Spike Recovery outside accepted recovery limits
S2203106-011 - Total (3050) Metals by ICP - 6010C/Calcium - RPD outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Aluminum - Spike Recovery outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Boron - Spike Recovery outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Molybdenum - Spike Recovery outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Sodium - Spike Recovery outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Sodium - RPD outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Thorium - RPD outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Vanadium - Spike Recovery outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Aluminum - Spike Recovery outside accepted recovery limits

Pace Analytical
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Date: 4/15/2022

S2203106-012 - Total (3050) Metals by ICP - 6010C/Boron - Spike Recovery outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Molybdenum - Spike Recovery outside accepted recovery limits
S2203106-012 - Total (3050) Metals by ICP - 6010C/Vanadium - Spike Recovery outside accepted recovery limits
S2203106-013 - Total (3050) Metals by ICP - 6010C/Magnesium - Spike Recovery outside accepted recovery limits
S2203106-013 - Total (3050) Metals by ICP - 6010C/Potassium - Spike Recovery outside accepted recovery limits
S2203106-013 - Total (3050) Metals by ICP - 6010C/Magnesium - Spike Recovery outside accepted recovery limits
S2203106-013 - Total (3050) Metals by ICP - 6010C/Potassium - Spike Recovery outside accepted recovery limits

Pace Analytical
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Date: 4/15/2022

Definitions

RL	Reporting Limit

Qualifiers

*	Value exceeds Maximum Contaminant Level
A	Check MSA specifications
B	Analyte detected in the associated Method Blank
C	Calculated Value
D	Report limit raised due to dilution
E	Value above quantitation range
G	Analyzed at Pace Gillette, WY laboratory
H	Holding times for preparation or analysis exceeded
J	Analyte detected below quantitation limits
L	Analyzed by another laboratory
M	Value exceeds Monthly Ave or MCL or is less than LCL
ND	Not Detected at the Reporting Limit
O	Outside the Range of Dilutions
R	RPD outside accepted recovery limits
S	Spike Recovery outside accepted recovery limits
U	Analyte below method detection limit
X	Matrix Effect

Pace Analytical
1673 Terra Avenue Sheridan, WY 82801 ph: (307) 672-8945

Soil Analysis Report

Tetra Tech
2525 Palmer Street, Suite 2
Missoula, MT 59808

Report ID: S2203106001

Project: RER Upton Project
Date Received: 3/7/2022

Date Reported: 4/15/2022
Work Order: S2203106

Lab ID	Sample ID	Radium 226 pCi/g	Radium 228 pCi/g	Nitrate ppm	Ammonia ppm
S2203106-001	#1 BH3 (0-18)	1.3 ± 0.3	1.4 ± 0.5	3.2	11
S2203106-002	#1 BH3 (18-30)	1.1 ± 0.3	0.6 ± 0.5	0.5	12
S2203106-003	#1 BH3 (30-60)	1.1 ± 0.3	1.1 ± 0.5	0.6	10
S2203106-004	#2 BH5 (0-18)	0.8 ± 0.3	0.9 ± 0.5	1.0	6
S2203106-005	#2 BH5 (18-30)	1.1 ± 0.3	1.2 ± 0.5	33.8	8
S2203106-006	#2 BH5 (30-60)	1.0 ± 0.3	0.7 ± 0.6	6.6	8
S2203106-007	#3 BH4 (0-18)	1.1 ± 0.3	1.2 ± 0.5	2.7	7
S2203106-008	#3 BH4 (18-30)	0.9 ± 0.3	1.7 ± 0.5	3.4	10
S2203106-009	#3 BH4 (30-60)	1.0 ± 0.4	1.0 ± 0.6	3.8	8
S2203106-010	#4 BH6 (0-18)	1.3 ± 0.3	0.3 ± 0.5	0.3	5
S2203106-011	#4 BH6 (18-30)	0.9 ± 0.3	1.3 ± 0.5	0.8	7
S2203106-012	#4 BH6 (30-60)	1.1 ± 0.3	0.9 ± 0.6	1.1	7
S2203106-013	#5 BH1 (0-18)	0.6 ± 0.3	0.5 ± 0.5	<0.1	7
S2203106-014	#5 BH1 (18-30)	1.4 ± 0.3	0.6 ± 0.5	<0.1	10
S2203106-015	#5 BH1 (30-60)	1.1 ± 0.4	0.9 ± 0.6	<0.1	9
S2203106-016	#6 BH2 (0-18)	0.7 ± 0.3	0.6 ± 0.5	<0.1	6
S2203106-017	#6 BH2 (18-30)	1.1 ± 0.3	1.1 ± 0.6	4.6	7
S2203106-018	#6 BH2 (30-60)	0.8 ± 0.3	0.7 ± 0.5	12.1	7

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage, TOC=Total Organic Carbon

Reviewed by: Crystal Herman
Crystal Herman, Mining Supervisor

Pace Analytical
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Soil Analysis Report

Tetra Tech

2525 Palmer Street, Suite 2
Missoula, MT 59808

Report ID: S2203106001

Project: RER Upton Project

Date Received: 3/7/2022

Date Reported: 4/15/2022

Work Order: S2203106

Lab ID	Sample ID	Total Aluminum mg/Kg	Total Barium mg/Kg	Total Beryllium mg/Kg	Total Boron mg/Kg	Total Cadmium mg/Kg	Total Calcium mg/Kg	Total Chromium mg/Kg	Total Cobalt mg/Kg	Total Copper mg/Kg	Total Iron mg/Kg
S2203106-001	#1 BH3 (0-18)	13800	93	<0.7	9	2	18800	12	3	24	15900
S2203106-002	#1 BH3 (18-30)	15200	93	<0.7	8	<1	9820	12	4	23	16000
S2203106-003	#1 BH3 (30-60)	14500	99	<0.7	6	<1	8690	12	4	23	16700
S2203106-004	#2 BH5 (0-18)	12100	80	<0.7	8	<1	42000	11	4	20	14900
S2203106-005	#2 BH5 (18-30)	15300	83	<0.7	11	<1	35200	12	3	21	17100
S2203106-006	#2 BH5 (30-60)	15400	122	<0.7	8	1	19600	12	4	23	18600
S2203106-007	#3 BH4 (0-18)	14100	89	<0.7	8	<1	44700	12	4	22	13900
S2203106-008	#3 BH4 (18-30)	13100	96	<0.7	6	1	8390	10	5	23	22100
S2203106-009	#3 BH4 (30-60)	13000	89	<0.7	7	<1	4110	10	4	23	14900
S2203106-010	#4 BH6 (0-18)	10400	90	<0.7	6	<1	16700	8	4	21	13700
S2203106-011	#4 BH6 (18-30)	13100	78	<0.7	7	<1	2560	10	4	24	13100
S2203106-012	#4 BH6 (30-60)	14200	84	<0.7	6	<1	3120	11	5	24	14800
S2203106-013	#5 BH1 (0-18)	11600	70	<0.7	6	<1	84000	10	3	18	12500
S2203106-014	#5 BH1 (18-30)	13800	87	<0.7	9	<1	33700	11	4	22	15500
S2203106-015	#5 BH1 (30-60)	15300	101	<0.7	6	<1	12200	11	4	23	15700
S2203106-016	#6 BH2 (0-18)	13800	91	<0.7	7	<1	38300	11	4	21	14900
S2203106-017	#6 BH2 (18-30)	13900	86	<0.7	6	<1	22600	11	4	23	15300
S2203106-018	#6 BH2 (30-60)	13200	84	<0.7	7	<1	1020	10	4	24	16300

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage, TOC=Total Organic Carbon

Reviewed by: Crystal Herman

Crystal Herman, Mining Supervisor

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Soil Analysis Report

Tetra Tech

2525 Palmer Street, Suite 2
Missoula, MT 59808

Report ID: S2203106001

Project: RER Upton Project

Date Received: 3/7/2022

Date Reported: 4/15/2022

Work Order: S2203106

Lab ID	Sample ID	Total Lead mg/Kg	Total Lithium mg/Kg	Total Magnesium mg/Kg	Total Manganese mg/Kg	Total Molybdenum mg/Kg	Total Nickel mg/Kg	Total Potassium mg/Kg	Total Silver mg/Kg	Total Sodium mg/Kg	Total Thorium mg/Kg
S2203106-001	#1 BH3 (0-18)	<10	4	1980	69	<5	8	2500	<5	430	19.8
S2203106-002	#1 BH3 (18-30)	<10	5	2010	67	<5	8	2610	<5	410	20.3
S2203106-003	#1 BH3 (30-60)	10	4	1950	68	<5	9	2490	<5	380	21.0
S2203106-004	#2 BH5 (0-18)	<10	4	3100	85	<5	7	2580	<5	250	18.9
S2203106-005	#2 BH5 (18-30)	<10	6	3940	163	<5	7	2770	<5	320	18.8
S2203106-006	#2 BH5 (30-60)	10	5	2580	89	<5	9	2810	<5	340	23.4
S2203106-007	#3 BH4 (0-18)	<10	5	2250	79	<5	8	2740	<5	540	19.4
S2203106-008	#3 BH4 (18-30)	<10	5	2350	161	<5	9	2250	<5	320	25.5
S2203106-009	#3 BH4 (30-60)	10	4	1640	60	<5	9	2220	<5	310	20.5
S2203106-010	#4 BH6 (0-18)	10	4	1810	68	<5	8	3640	<5	280	18.4
S2203106-011	#4 BH6 (18-30)	<10	4	1700	38	<5	8	2550	<5	220	18.9
S2203106-012	#4 BH6 (30-60)	<10	5	1800	46	<5	10	2420	<5	370	19.9
S2203106-013	#5 BH1 (0-18)	<10	4	1850	50	<5	6	2670	<5	320	16.4
S2203106-014	#5 BH1 (18-30)	10	4	1870	64	<5	8	2740	<5	310	20.3
S2203106-015	#5 BH1 (30-60)	10	5	1980	77	<5	10	2650	<5	360	21.3
S2203106-016	#6 BH2 (0-18)	10	5	1900	69	<5	8	2730	<5	260	19.5
S2203106-017	#6 BH2 (18-30)	<10	4	1790	64	<5	8	2610	<5	240	20.4
S2203106-018	#6 BH2 (30-60)	10	4	1590	66	<5	8	2240	<5	270	21.3

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage, TOC=Total Organic Carbon

Reviewed by: Crystal Herman

Crystal Herman, Mining Supervisor

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Soil Analysis Report

Tetra Tech

2525 Palmer Street, Suite 2
Missoula, MT 59808

Report ID: S2203106001

Project: RER Upton Project

Date Received: 3/7/2022

Date Reported: 4/15/2022

Work Order: S2203106

Lab ID	Sample ID	Total Vanadium mg/Kg	Total Zinc mg/Kg	Total Mercury mg/Kg	Total Antimony mg/Kg	Total Arsenic mg/Kg	Total Selenium mg/Kg	Total Uranium mg/Kg
S2203106-001	#1 BH3 (0-18)	15	53	<0.2	<3	8.6	1	2.7
S2203106-002	#1 BH3 (18-30)	17	54	<0.2	<3	9.1	1	2.7
S2203106-003	#1 BH3 (30-60)	14	63	<0.2	<3	31.7	1	2.7
S2203106-004	#2 BH5 (0-18)	14	47	<0.2	<3	9.3	1	2.6
S2203106-005	#2 BH5 (18-30)	19	53	<0.2	<3	10.6	1	2.8
S2203106-006	#2 BH5 (30-60)	17	61	<0.2	<3	11.6	1	2.7
S2203106-007	#3 BH4 (0-18)	16	55	<0.2	<3	7.4	<1	2.7
S2203106-008	#3 BH4 (18-30)	14	58	<0.2	<3	9.3	1	2.9
S2203106-009	#3 BH4 (30-60)	12	60	<0.2	<3	9.5	1	2.8
S2203106-010	#4 BH6 (0-18)	10	57	<0.2	<3	9.3	1	2.5
S2203106-011	#4 BH6 (18-30)	12	61	<0.2	<3	8.9	1	2.8
S2203106-012	#4 BH6 (30-60)	13	67	<0.2	<3	11.9	1	2.8
S2203106-013	#5 BH1 (0-18)	13	43	<0.2	<3	7.6	1	2.5
S2203106-014	#5 BH1 (18-30)	14	54	<0.2	<3	10.4	1	2.6
S2203106-015	#5 BH1 (30-60)	15	63	<0.2	<3	10.5	1	2.6
S2203106-016	#6 BH2 (0-18)	15	52	<0.2	<3	9.2	1	2.7
S2203106-017	#6 BH2 (18-30)	14	56	<0.2	<3	9.4	1	2.6
S2203106-018	#6 BH2 (30-60)	13	58	<0.2	<3	11.0	1	2.6

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage, TOC=Total Organic Carbon

Reviewed by: Crystal Herman

Crystal Herman, Mining Supervisor

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech
Work Order: S2203106
Project: RER Upton Project

Date: 4/15/2022
Report ID: S2203106001

Total Mercury in Soils Sample Type **MBLK** Units: mg/Kg

MB (03/18/22 12:19) RunNo: 198126

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Mercury	ND	0.2					

MB (03/18/22 13:37) RunNo: 198126

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Mercury	ND	0.2					

Total Mercury in Soils Sample Type **LCS** Units: mg/Kg

LCS (03/18/22 12:16) RunNo: 198126

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Mercury	5.0	0.2	5		100	80 - 120	

LCS (03/18/22 13:34) RunNo: 198126

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Mercury	5.0	0.2	5		101	80 - 120	

Total Mercury in Soils Sample Type **MS** Units: mg/Kg

S2203106-001AS (03/18/22 12:28) RunNo: 198126

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Mercury	0.8	0.2	0.833	ND	100	80 - 120	

S2203106-010AS (03/18/22 13:07) RunNo: 198126

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Mercury	0.8	0.2	0.833	ND	99.2	80 - 120	

Total Mercury in Soils Sample Type **MSD** Units: mg/Kg

S2203106-001ASD (03/18/22 12:30) RunNo: 198126

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Mercury	0.8	0.2	0.8	1.29	99.2	20	

S2203106-010ASD (03/18/22 13:09) RunNo: 198126

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Mercury	0.8	0.2	0.8	1.99	97.2	20	

Total Mercury in Soils Sample Type **DUP** Units: mg/Kg

S2203106-001AD (03/18/22 12:26) RunNo: 198126

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Mercury	ND	0.2	ND			20	

S2203106-010AD (03/18/22 13:05) RunNo: 198126

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Mercury	ND	0.2	ND			20	

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech
Work Order: S2203106
Project: RER Upton Project

Date: 4/15/2022
Report ID: S2203106001

Nitrogen-Ammonia - Soil Sample Type **MBLK** Units: ppm

WCB (03/17/22 10:04) RunNo: 198057

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Ammonia	ND	1					

SOILS-BLK (03/17/22 10:35) RunNo: 198057

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Ammonia	1	1					

MBLK (03/17/22 11:14) RunNo: 198135

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Nitrate	ND	0.1					

Nitrogen-Ammonia - Soil Sample Type **LCS** Units: ppm

ICV1 (03/17/22 10:01) RunNo: 198057

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Ammonia	26	1	20.8		123	70 - 130	

ICV1 (03/17/22 10:29) RunNo: 198057

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Ammonia	26	1	20.8		126	70 - 130	

SOILS-QC (03/17/22 10:34) RunNo: 198057

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Ammonia	18	1	20.8		86.6	70 - 130	

ICV1 (03/17/22 10:38) RunNo: 198057

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Ammonia	26	1	20.8		124	70 - 130	

SOILS-QC (03/17/22 12:05) RunNo: 198135

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Nitrogen-Nitrate	13.2	0.1	10.3		129	70 - 130	

Nitrogen-Ammonia - Soil Sample Type **DUP** Units: ppm

S2203106-006A (03/17/22 10:12) RunNo: 198057

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Nitrogen-Ammonia	8	1	8	0.317		20	

S2203106-016A (03/17/22 10:26) RunNo: 198057

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Nitrogen-Ammonia	6	1	6	5.12		20	

S2203106-006A (03/17/22 11:35) RunNo: 198135

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Nitrogen-Nitrate	6.9	0.1	6.6	3.26		0	

S2203106-016A (03/17/22 12:00) RunNo: 198135

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Nitrogen-Nitrate	ND	0.1	ND			0	

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech **Date:** 4/15/2022
Work Order: S2203106 **Report ID:** S2203106001
Project: RER Upton Project

Radium By Gamma Spectroscopy in Soil Sample Type **MBLK** Units: pCi/g

MB-22-11 (04/01/22 08:47) RunNo: 198720 PrepDate: 03/11/22 0:00 BatchID: 19368

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Radium 226	ND	0.2					
Radium 228	ND	0.2					

Radium By Gamma Spectroscopy in Soil Sample Type **LCS** Units: pCi/g

LCS-22-11 (04/01/22 09:18) RunNo: 198720 PrepDate: 03/11/22 0:00 BatchID: 19368

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Radium 226	37.9	0.2	37.9		100	70 - 130	
Radium 228	8.9	0.2	8.36		106	70 - 130	

Radium By Gamma Spectroscopy in Soil Sample Type **DUP** Units: pCi/g

S2203106-001AD (04/01/22 11:22) RunNo: 198720 PrepDate: 03/11/22 0:00 BatchID: 19368

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Radium 226	1.3	0.2	1.3	1.73		30	
Radium 228	1.2	0.2	1.4	10.9		30	

Total (3050) Metals by EPA 200.8-Soil Sample Type **MBLK** Units: mg/Kg

MB-19379 (04/12/22 16:49) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Antimony	ND	5					
Arsenic	ND	1.5					
Selenium	ND	5					
Uranium	ND	0.3					

Total (3050) Metals by EPA 200.8-Soil Sample Type **LCS** Units: mg/Kg

LCS-19379 (04/12/22 17:03) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Antimony	53	5	50		105	85 - 115	
Arsenic	54.1	1.5	50		108	85 - 115	
Selenium	103	5	100		103	85 - 115	
Uranium	52.6	0.3	50		105	85 - 115	

Total (3050) Metals by EPA 200.8-Soil Sample Type **MS** Units: mg/Kg

S2203106-002AS (04/12/22 17:51) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Antimony	ND	3	50	ND	0.931	70 - 130	S
Arsenic	65.4	1.5	50	9.1	113	70 - 130	
Selenium	110	1	100	1	108	70 - 130	
Uranium	54.1	0.3	50	2.7	103	70 - 130	

S2203106-012AS (04/12/22 19:35) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Antimony	ND	3	50	ND	0.653	70 - 130	S
Arsenic	63.5	1.5	50	11.9	103	70 - 130	
Selenium	105	1	100	1	103	70 - 130	
Uranium	54.7	0.3	50	2.8	104	70 - 130	

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech
Work Order: S2203106
Project: RER Upton Project

Date: 4/15/2022
Report ID: S2203106001

Total (3050) Metals by EPA 200.8-Soil Sample Type **MSD** Units: mg/Kg

S2203106-002AMSD (04/12/22 17:58) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Antimony	ND	3	ND		0.890	20	S
Arsenic	66.3	1.5	65.4	1.29	114	20	
Selenium	106	1	110	3.18	105	20	
Uranium	54.3	0.3	54.1	0.439	103	20	

S2203106-012AMSD (04/12/22 19:42) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Antimony	ND	3	ND		0.625	20	S
Arsenic	64.2	1.5	63.5	0.994	105	20	
Selenium	116	1	105	10.3	115	20	
Uranium	55.2	0.3	54.7	0.842	105	20	

Total (3050) Metals by EPA 200.8-Soil Sample Type **DUP** Units: mg/Kg

S2203106-001AD (04/12/22 17:38) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Antimony	ND	3	ND			20	
Arsenic	8.8	1.5	8.6	2.81		20	
Selenium	1	1	1	11.5		20	
Uranium	2.7	0.3	2.7	0.247		20	

S2203106-011AD (04/12/22 19:21) RunNo: 198865 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Antimony	ND	3	ND			20	
Arsenic	9.0	1.5	8.9	1.65		20	
Selenium	1	1	1	1.45		20	
Uranium	2.8	0.3	2.8	0.493		20	

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech
Work Order: S2203106
Project: RER Upton Project

Date: 4/15/2022
Report ID: S2203106001

Total (3050) Metals by ICP - 6010C Sample Type **MBLK** Units: mg/Kg

MB-19379 (04/11/22 15:01) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Aluminum	ND	10					
Barium	ND	0.5					
Beryllium	ND	0.7					
Boron	ND	5					
Cadmium	ND	0.2					
Calcium	ND	50					
Chromium	ND	3					
Cobalt	ND	1					
Copper	ND	1					
Iron	ND	10					
Lead	ND	15					
Lithium	ND	0.2					
Magnesium	ND	50					
Manganese	ND	1					
Molybdenum	ND	5					
Nickel	ND	1					
Potassium	ND	50					
Silver	ND	5					
Sodium	ND	50					
Thorium	ND	2.7					
Vanadium	ND	5					
Zinc	ND	15					

Total (3050) Metals by ICP - 6010C Sample Type **LCS** Units: mg/Kg

LCS-19379 (04/11/22 15:07) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Aluminum	120	10	125		99.5	80 - 120	
Barium	50.6	0.5	50		101	80 - 120	
Beryllium	48.9	0.7	50		97.8	80 - 120	
Boron	125	5	125		99.9	80 - 120	
Cadmium	55.4	0.2	50		111	80 - 120	
Chromium	50	3	50		100	80 - 120	
Cobalt	50	1	50		101	80 - 120	
Copper	52	1	50		103	80 - 120	
Iron	130	10	125		102	80 - 120	
Lead	50	15	50		100	80 - 120	
Lithium	124	0.2	125		99.2	80 - 120	
Manganese	51	1	50		101	80 - 120	
Molybdenum	56	5	50		112	80 - 120	
Nickel	126	1	125		101	80 - 120	
Silver	24	5	25		94.7	80 - 120	
Vanadium	49	5	50		97.2	80 - 120	
Zinc	48	15	50		96.5	80 - 120	

LCS-19379 (04/11/22 15:09) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Calcium	970	50	1000		96.5	80 - 120	
Magnesium	1090	50	1000		109	80 - 120	

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech
Work Order: S2203106
Project: RER Upton Project

Date: 4/15/2022
Report ID: S2203106001

Total (3050) Metals by ICP - 6010C Sample Type **LCS** Units: mg/Kg

LCS-19379 (04/11/22 15:09) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Potassium	940	50	1000		93.5	80 - 120	
Sodium	940	50	1000		94.4	80 - 120	
Thorium	46.9	2.7	50		93.8	80 - 120	

Total (3050) Metals by ICP - 6010C Sample Type **MS** Units: mg/Kg

S2203106-002AS (04/11/22 15:27) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Aluminum	18600	10	125	15200	2690	75 - 125	S
Barium	132	1	50	93	79.6	75 - 125	
Beryllium	42.2	0.7	50	ND	84.4	75 - 125	
Boron	75	5	125	8	53.3	75 - 125	S
Cadmium	50	1	50	ND	98.0	75 - 125	
Chromium	58	3	50	12	92.2	75 - 125	
Cobalt	47	1	50	4	86.0	75 - 125	
Copper	68	1	50	23	90.2	75 - 125	
Lead	50	10	50	ND	85.6	75 - 125	
Lithium	120	1	125	5	92.7	75 - 125	
Manganese	105	1	50	67	77.3	75 - 125	
Molybdenum	29	5	50	ND	54.8	75 - 125	S
Nickel	116	1	125	8	86.2	75 - 125	
Silver	20	5	25	ND	79.1	75 - 125	
Vanadium	58	5	50	17	82.1	75 - 125	
Zinc	103	15	50	54	98.0	75 - 125	

S2203106-002AS (04/11/22 15:39) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Iron	16000	10	125	16000	14.1	75 - 125	S

S2203106-003AS (04/11/22 15:45) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Calcium	8380	50	1000	8690	-30.7	75 - 125	S
Magnesium	3830	50	1000	1950	188	75 - 125	S
Potassium	4020	50	1000	2490	153	75 - 125	S
Sodium	1340	50	1000	380	95.9	75 - 125	

S2203106-012AS (04/11/22 16:49) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Aluminum	14000	10	125	14200	-179	75 - 125	S
Barium	131	1	50	84	94.3	75 - 125	
Beryllium	43.9	0.7	50	ND	87.7	75 - 125	
Boron	48	5	125	6	33.2	75 - 125	S
Cadmium	53	1	50	ND	103	75 - 125	
Chromium	55	3	50	11	89.3	75 - 125	
Cobalt	50	1	50	5	90.2	75 - 125	
Copper	69	1	50	24	91.0	75 - 125	
Lead	50	10	50	ND	89.7	75 - 125	
Lithium	123	1	125	5	94.6	75 - 125	
Manganese	88	1	50	46	84.1	75 - 125	

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech **Date:** 4/15/2022
Work Order: S2203106 **Report ID:** S2203106001
Project: RER Upton Project

Total (3050) Metals by ICP - 6010C Sample Type **MS** Units: mg/Kg

S2203106-012AS (04/11/22 16:49) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Molybdenum	23	5	50	ND	42.9	75 - 125	S
Nickel	121	1	125	10	89.0	75 - 125	
Silver	20	5	25	ND	78.9	75 - 125	
Vanadium	45	5	50	13	65.7	75 - 125	S
Zinc	115	15	50	67	96.5	75 - 125	

S2203106-012AS (04/11/22 17:00) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Iron	14200	10	125	14800	-514	75 - 125	S

S2203106-013AS (04/11/22 17:07) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Spike	Ref Samp	%REC	% Rec Limits	Qual
Calcium	71500	50	1000	84000	-1250	75 - 125	S
Magnesium	3290	50	1000	1850	144	75 - 125	S
Potassium	4010	50	1000	2670	135	75 - 125	S
Sodium	1300	50	1000	320	97.9	75 - 125	

Total (3050) Metals by ICP - 6010C Sample Type **MSD** Units: mg/Kg

S2203106-002AMSD (04/11/22 15:34) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Aluminum	17700	10	18600	4.82	1990	20	S
Barium	132	1	132	0.188	79.1	20	
Beryllium	43.1	0.7	42.2	2.22	86.3	20	
Boron	68	5	75	9.59	47.8	20	S
Cadmium	51	1	50	1.87	99.9	20	
Chromium	58	3	58	1.29	90.7	20	
Cobalt	48	1	47	2.11	88.0	20	
Copper	68	1	68	0.542	90.9	20	
Lead	50	10	50	2.16	87.9	20	
Lithium	122	1	120	1.55	94.2	20	
Manganese	106	1	105	0.994	79.4	20	
Molybdenum	29	5	29	0.206	54.9	20	S
Nickel	119	1	116	2.80	88.8	20	
Silver	20	5	20	0.0663	79.0	20	
Thorium	22.3	2.7	ND			20	R
Vanadium	56	5	58	3.41	78.2	20	
Zinc	103	15	103	0.318	98.7	20	

S2203106-002AMSD (04/11/22 15:41) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Iron	16100	10	16000	0.267	48.4	20	S

S2203106-003AMSD (04/11/22 15:48) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Calcium	9110	50	8380	8.37	42.5	20	S
Magnesium	3710	50	3830	3.30	176	20	S
Potassium	3930	50	4020	2.36	144	20	S
Sodium	1330	50	1340	0.784	94.9	20	

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ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech
Work Order: S2203106
Project: RER Upton Project

Date: 4/15/2022
Report ID: S2203106001

Total (3050) Metals by ICP - 6010C Sample Type **MSD** Units: mg/Kg

S2203106-003AMSD (04/11/22 15:48) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Thorium	66.6	2.7	67.1	0.802		20	

S2203106-012AMSD (04/11/22 16:56) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Aluminum	14700	10	14000	4.75	366	20	S
Barium	123	1	131	6.15	78.7	20	
Beryllium	42.5	0.7	43.9	3.27	84.9	20	
Boron	53	5	48	10.8	37.5	20	S
Cadmium	52	1	53	1.48	102	20	
Chromium	55	3	55	1.00	88.2	20	
Cobalt	48	1	50	3.02	87.2	20	
Copper	69	1	69	0.278	90.7	20	
Lead	50	10	50	3.05	86.5	20	
Lithium	121	1	123	1.06	93.5	20	
Manganese	87	1	88	1.13	82.1	20	
Molybdenum	25	5	23	6.25	46.0	20	S
Nickel	119	1	121	1.76	87.3	20	
Silver	19	5	20	3.42	76.2	20	
Sodium	270	50	ND		-9.19	20	SR
Thorium	20.4	2.7	ND			20	R
Vanadium	46	5	45	2.12	67.7	20	S
Zinc	114	15	115	1.35	93.4	20	

S2203106-012AMSD (04/11/22 17:03) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Iron	13200	10	14200	6.92	-1270	20	S

S2203106-013AMSD (04/11/22 17:09) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Conc	%RPD	%REC	% RPD Limits	Qual
Calcium	76700	50	71500	7.01	-728	20	S
Magnesium	3470	50	3290	5.44	162	20	S
Potassium	4290	50	4010	6.80	163	20	S
Sodium	1340	50	1300	3.09	102	20	
Thorium	61.8	2.7	59.7	3.55		20	

Total (3050) Metals by ICP - 6010C Sample Type **DUP** Units: mg/Kg

S2203106-001AD (04/11/22 15:18) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Aluminum	12700	10	13800	8.83		20	
Barium	82	1	93	12.9		20	
Beryllium	ND	0.7	ND			20	
Boron	6	5	9	35.3		20	R
Cadmium	6	1	2	87.1		20	R
Calcium	15800	50	18800	17.7		20	
Chromium	11	3	12	8.55		20	
Cobalt	3	1	3	4.18		20	
Copper	22	1	24	7.76		20	
Lead	ND	10	ND			20	

Pace Analytical
1673 Terra Avenue Sheridan, WY 82801 ph: (307) 672-8945

ANALYTICAL QC SUMMARY REPORT

CLIENT: Tetra Tech
Work Order: S2203106
Project: RER Upton Project

Date: 4/15/2022
Report ID: S2203106001

Total (3050) Metals by ICP - 6010C Sample Type **DUP** Units: mg/Kg

S2203106-001AD (04/11/22 15:18) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Lithium	4	1	4	9.63		20	
Magnesium	1790	50	1980	9.93		20	
Manganese	62	1	69	10.3		20	
Molybdenum	ND	5	ND			20	
Nickel	7	1	8	4.76		20	
Potassium	2350	50	2500	6.19		20	
Silver	ND	5	ND			20	
Sodium	420	50	430	4.13		20	
Thorium	18.9	2.7	19.8	4.50		20	
Vanadium	13	5	15	15.8		20	
Zinc	56	15	53	5.64		20	

S2203106-001AD (04/11/22 15:23) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Iron	15000	10	15900	5.55		20	

S2203106-011AD (04/11/22 16:40) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Aluminum	12900	10	13100	1.39		20	
Barium	79	1	78	1.70		20	
Beryllium	ND	0.7	ND			20	
Boron	7	5	7	0.0146		20	
Cadmium	ND	1	ND			20	
Calcium	3560	50	2560	32.5		20	R
Chromium	10	3	10	0.434		20	
Cobalt	4	1	4	0.227		20	
Copper	23	1	24	2.19		20	
Lead	ND	10	ND			20	
Lithium	4	1	4	3.76		20	
Magnesium	1720	50	1700	1.29		20	
Manganese	39	1	38	3.88		20	
Molybdenum	ND	5	ND			20	
Nickel	8	1	8	1.47		20	
Potassium	2530	50	2550	0.611		20	
Silver	ND	5	ND			20	
Sodium	220	50	220	1.46		20	
Thorium	18.6	2.7	18.9	1.21		20	
Vanadium	12	5	12	0.562		20	
Zinc	61	15	61	0.204		20	

S2203106-011AD (04/11/22 16:44) RunNo: 198821 PrepDate: 04/06/22 0:00 BatchID: 19379

Analyte	Result	RL	Ref Samp	%RPD	%REC	% RPD Limits	Qual
Iron	14800	10	13100	12.3		20	

Appendix I: Air Quality Permit Application and Approval

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

DEQ

Mark Gordon, Governor

Todd Parfitt, Director

August 11, 2022

Mr. Randall Scott
President & Chief Executive Officer
Rare Element Resources, Inc.
P.O. Box 271049
Littleton, CO 80127

Re: Authorization Letter P0035643
(Temporary REE Demonstration Plant)

Dear Mr. Scott:

The Division of Air Quality of the Wyoming Department of Environmental Quality has completed final review of Rare Element Resources, Incorporated's (CMP100752) application to construct the REE Demonstration Plant (F030920) located at 131 Buffalo Creek Road, Upton, Weston County Wyoming. The separation and processing demonstration project equipment includes:

- One (1) 2.1 MMBtu/hr Steam Plant Boiler (BOL001)
- One (1) Primary Processing Calciner With Scrubber (CKD001)
- One (1) Pug Primary Crusher With Dust Collector (CSH001)
- One (1) Primary Screening With Dust Collector (CSH002)
- One (1) Secondary Crusher With Dust Collector (CSH003)
- One (1) Secondary Screening With Dust Collector (CSH004)
- One (1) Bulk Bag Filler Hopper With Dust Collector (CSH005)
- One (1) Primary Process Exploration Sample Feed Hopper With Dust Collector (CSH006)
- One (1) Oxalic Acid Feed Hopper With Dust Collector (CSH007)
- One (1) Oxalic Acid Feed Hopper With Dust Collector (CSH008)
- One (1) Lime Feed Hopper With Dust Collector (CSH009)
- One (1) Haul Roads (FUG001)
- One (1) Exploration Sample Stockpile (FUG002)
- One (1) Exploration Sample Pre-Crusher Mixing (FUG003)
- One (1) Batch Drop Dump (FUG004)
- One (1) Exploration Sample Post-Crusher Mixing (FUG005)
- One (1) Bentonite Batch Drop (FUG006)
- One (1) 1.6 MMBtu/hr Primary Process Building Furnace (HET001)
- One (1) Batch Drop Loadout of Exploration Sample (LUD001)
- One (1) 8,500 Gallon Hydrochloric Acid Storage Tank With Scrubber (TNK001)
- One (1) 1,400 Gallon Recycled Hydrochloric Acid Storage Tank With Scrubber (TNK002)
- One (1) 10,000 Gallon Nitric Acid Storage tank With Scrubber (TNK003)
- One (1) 12,250 Gallon Ammonia Water Storage Tank With Scrubber (TNK004)
- One (1) Main Processing Facility Vent With Scrubber (VNT001)

Emissions for the crushing/screening equipment were estimated using a maximum production rate of 1,000 tons. The Division estimated emissions associated with the crushing/screening equipment to be 3.1 tpy of TSP, 1.0 tpy of PM_{10}, 1.8 tpy of NO_x, 5.4 tpy of CO, 0.4 tpy of VOC's, and 0.11 tpy HAP'S. Emissions were estimated using Table 11.24-2 – Emission Factors for Metallic Mineral Processing. Unpaved roads – Chapter 13, Section 13.2.2. Paved roads – Chapter 13, Section 13.2.1. Material handling – Chapter 13, Section 13.2.4. Wind erosion – Chapter 13, Section 13.2.5. Solids mixing – Chapter 13, Section 13.2.4 and Chapter 11, Section 11.9, Table 11.9-1. Crushing and screening – Chapter 11, Section 11.24, Table 11.24-2. Oxalic acid handling – Chapter 6, Section 6.2, Table 6.2-2. Lime handling – Chapter 11, Section 11.17, Table 11.17-4. Boiler and heater – Chapter 1, Section 1.4, Tables 1.4-1 through 1.4-4. Calciner – Chapter 8, Section 8.12, Tables 8.12-3 and 8.12-4 .

The Division has determined the temporary REE Demonstration Plant to be insignificant in emission rate and ambient air quality impact, and will issue an authorization letter under Chapter 6, Section 2(k)(viii) of the Wyoming Air Quality Standards and Regulations with the following conditions:

1. That authorized representatives of the Division of Air Quality be given permission to enter and inspect any property, premise or place on or at which an air pollution source is located or is being constructed or installed for the purpose of investigating actual or potential sources of air pollution and for determining compliance or non-compliance with any rules, standards, permits or orders.

2. That all substantive commitments and descriptions set forth in the application for this permit, unless superseded by a specific condition of this permit, are incorporated herein by this reference and are enforceable as conditions of this permit.

3. That the date of commencement of construction shall be reported to the Administrator within thirty (30) days of commencement. In accordance with Chapter 6, Section 2(h) of the WAQSR, approval to construct or modify shall become invalid if construction is not commenced within twenty-four (24) months after receipt of such approval or if construction is discontinued for a period of twenty-four (24) months or more. The Administrator may extend the period based on satisfactory justification of the requested extension.

4. Notification shall be submitted to the Division, within fifteen (15) days of startup and shutdown of the REE Demonstration Plant.

5. All notifications, reports and correspondence required by this authorization letter shall be submitted to the Stationary Source Compliance Program Manager. Submissions may be done electronically through https://airimpact.wyo.gov to satisfy requirements of this authorization letter.

6. That the allowable opacity for fugitive emissions associated with the crushing/screening equipment shall be limited to twelve percent (12%), the allowable opacity for screens, conveyor transfer points and other fugitive emission points shall be limited to seven percent (7%) as determined by 40 CFR part 60, appendix A, Method 9.

7. That the crushing/screening equipment shall be equipped with dust collectors to control fugitive emissions from the crushing/screening operations.

8. This authorization letter shall expire 25 months after initial startup of the REE Demonstration Plant.

The Division is issuing this authorization based on the information submitted in the application. Any deviation in the construction or operation of this facility from that represented in your application which could result in significant pollutant emissions and impact will be a violation of the Wyoming Environmental Quality Act and the Wyoming Air Quality Standards & Regulations. Violations could result in enforcement actions and penalties under the law. Any appeal of this authorization letter as a final action of the Department must be made to the Environmental Quality Council within thirty (30) days of authorization letter issuance per Chapter 1, Section 8, General Rules of Practice and Procedure, Department of Environmental Quality.

If you have any questions, please contact this office.

Sincerely,

for Nancy E. Vehr
Administrator
Air Quality Division

Air Quality Permit Application — Rare Earth Element Separation and Processing Demonstration Project

117-8541002
July 2022

PREPARED FOR:

Rare Element Resources, Inc.
P.O. Box 271049
Littleton, CO 80127

PREPARED BY:

Tetra Tech, Inc.
2525 Palmer St., Ste. 2
Missoula, MT 59808

P +1-406-543-0000
tetratech.com

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 APPICATION FORM 3

3.0 PROJECT DESCRIPTION 6

3.1 Project Schedule 6

3.2 Emission Sources and Timing 6

3.3 Facilities 6

3.4 Process Description 8

3.4.1 Physical Upgrading (PUG) 10

3.4.2 Primary Processing (PP) 10

3.4.3 Thorium-Cerium Separation (TCS) 10

3.4.4 Neodymium/Praseodymium Separation (NPS) 10

3.4.5 Chemical Recycling and Waste Facilities 11

4.0 EMISSION SOURCES AND RATES 11

4.1 Facility Processes and Emission Controls Affected 11

4.2 Emisison Factors Used to Calculate Potential Emissions 11

4.3 Potential Emissions 13

4.3.1 Fugitive Particulate Emissions 13

4.3.2 Tailpipe Emissions 13

4.3.3 Stationary Equipment Emissions 13

5.0 AMBIENT COMPLIANCE DEMONSTRATION 16

6.0 REFERENCES 17

LIST OF TABLES

Table 1. Anticipated Demonstration Project Schedule 6
Table 2. Demonstration Project Chemical Consumption, Delivery, and Storage Summary 7
Table 3. Potential Fugitive Emissions by Phase 13
Table 4. Potential Tailpipe Emissions by Phase 13
Table 5. Potential Stationary Source Emissions in PUG/Sample Storage Facility 14
Table 6. Potential Feed Hopper Emissions in Main Process Facility 14
Table 7. Potential Calciner Emissions in Main Process Facility 14
Table 8. Potential Combustion Emissions from Main Process Facility 14
Table 9. Potential Emissions from Main Process Facility Scrubber Vents 15
Table 10. Potential Emissions from Bulk Chemical Storage Tanks 15
Table 11. Potential Emissions from Stationary Sources 15
Table 12. Comparison of Western Biomass Plant and REE Demonstration Plant Potential Emissions 16

LIST OF FIGURES

Figure 1. Demonstration Plant Site....1
Figure 2. Demonstration Plant Permit Boundary....2
Figure 3. Demonstration Plant Site Plan....7
Figure 4. Areal Imagery of Demonstration Plant Site in November 2021....8
Figure 5. Demonstration Project Flow Diagram....9

APPENDICES

APPENDIX A – DEMONSTRATION PROJECT EMISSION CALCULATIONS 18

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
BSFC	brake specific fuel consumption
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
GHG	greenhouse gasses
HAPs	hazardous air pollutants
HEPA	High efficiency particulate air [filter]
HREE	Heavy rare earth elements
HVAC	heating, ventilation, air conditioning
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NdPr	neodymium-praseodymium
NO_x	nitrogen oxides
NPS	neodymium/praseodymium separation
PM	particulate matter
PM_{10}	particulate matter smaller than 10 micrometers
$PM_{2.5}$	particulate matter smaller than 2.5 micrometers
PP	primary processing
PUG	physical upgrading
REE	rare earth element
REOs	rare earth oxides
RER	Rare Element Resources, Inc.
SEG	samarium, europium, gadolinium
SO_2	sulfur dioxide
SX	solvent extraction
TCS	thorium-cerium separation
TREO/TREO(Th)	total rare earth oxide
WAQSR	Wyoming Air Quality Standards and Regulations
WDEQ	Wyoming Department of Environmental Quality
WDEQ-AQD	Wyoming Department of Environmental Quality Air Quality Division
WRAP	Western Regional Air Partnership

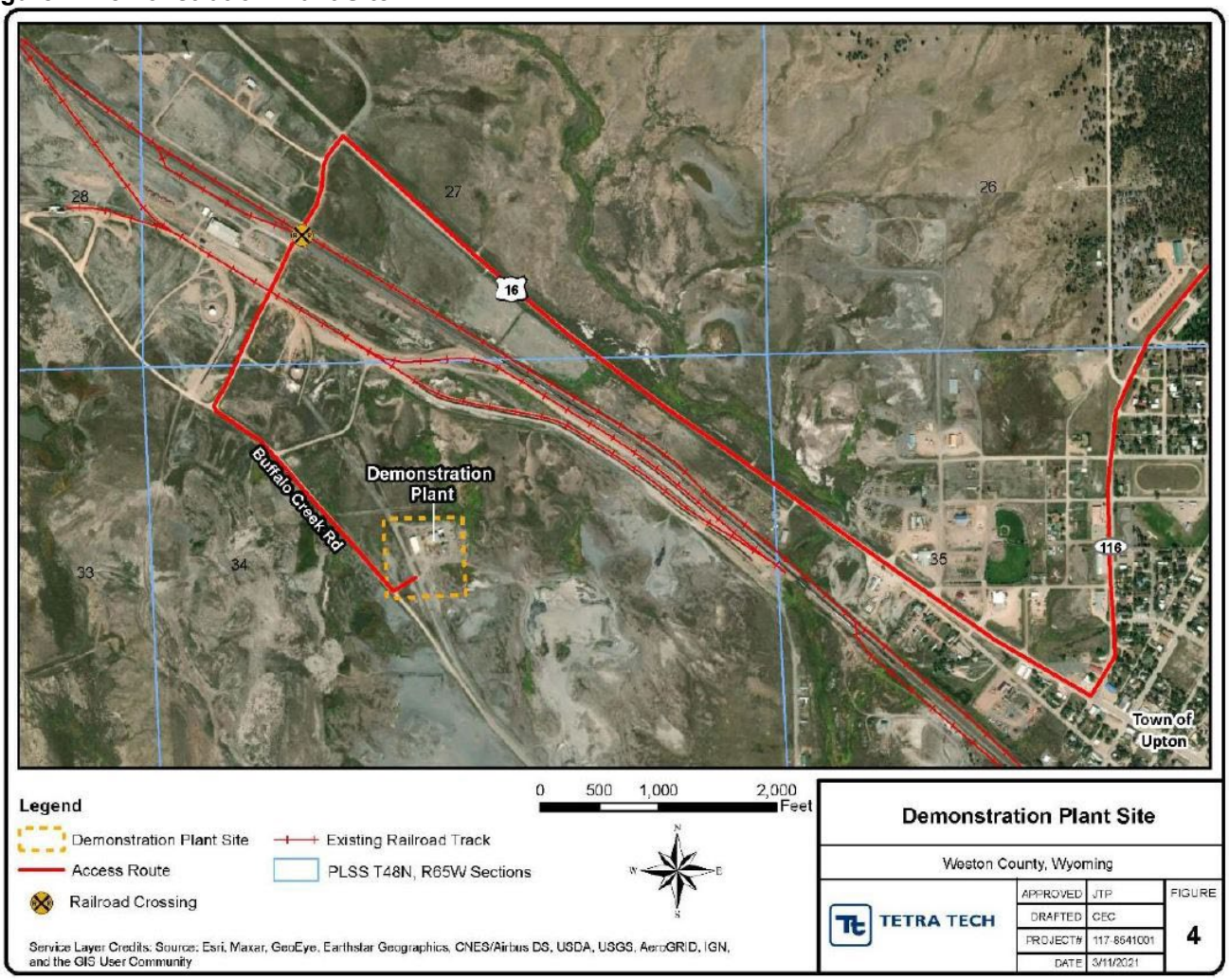
1.0 INTRODUCTION

This air quality permit application is submitted in support of a new Rare Earth Element (REE) Separation and Processing Demonstration Project (Demonstration Project) in northeastern Wyoming. The application is submitted pursuant to Wyoming Air Quality Standards and Regulations (WAQSR), Section 6, Chapter 2 which defines construction permit application requirements. Tetra Tech, Inc. was retained by Rare Element Resources, Inc. (RER), to prepare this permit application. The application is for a new minor source air quality construction permit from the Air Quality Division of the Wyoming Department of Environmental Quality (WDEQ-AQD).

The Demonstration Project proposes to demonstrate the domestic production of neodymium-praseodymium (NdPr) and other rare earth oxides (REOs). Approximately 1,000 tons of exploration sample removed previously from the Bear Lodge project in Wyoming are available for processing. The demonstration-scale hydrometallurgical, separation, and refining plant will process up to 3 tons of feed material per day as a research and development scale-up. The Demonstration Plant is planned to operate for approximately one year.

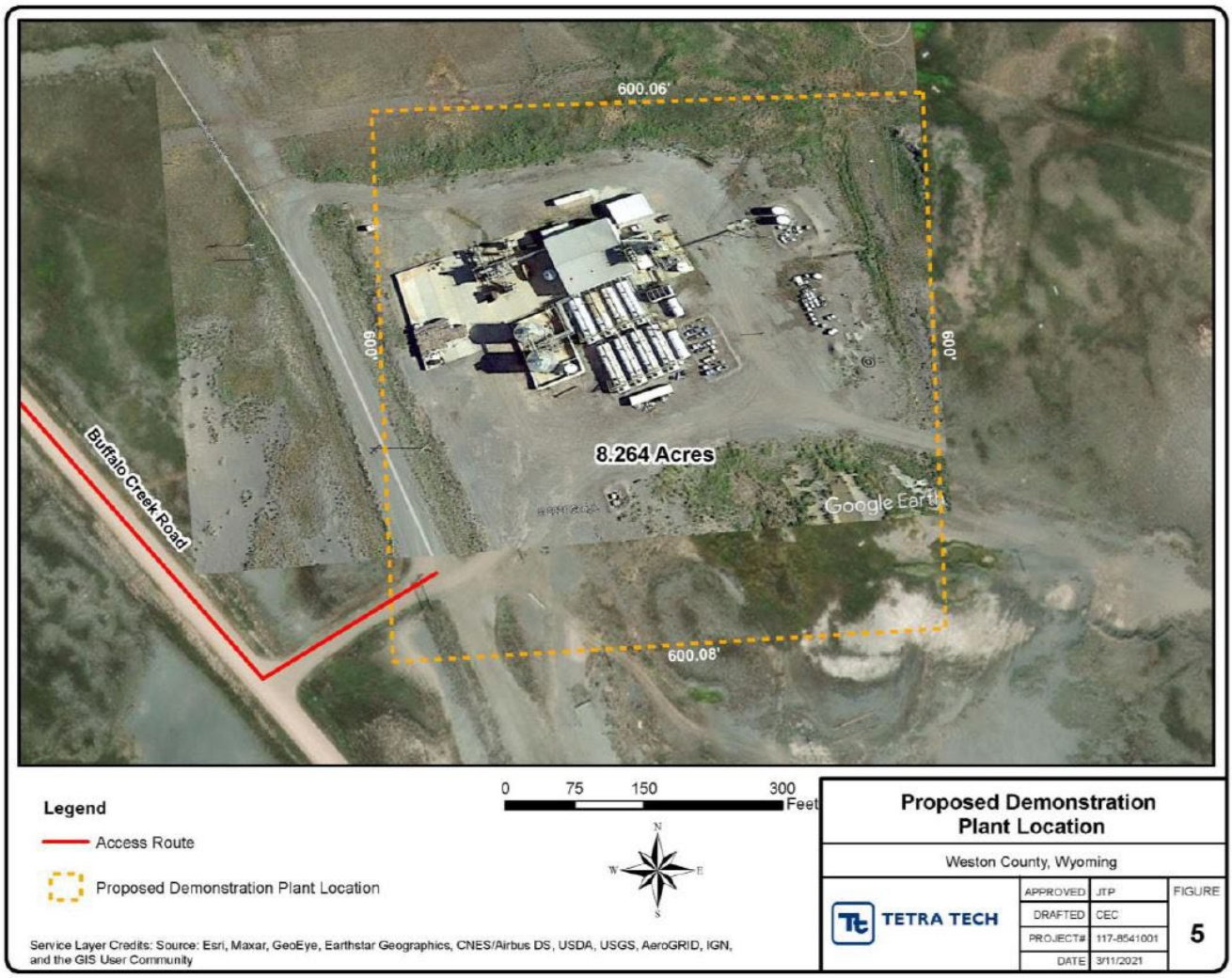
The demonstration plant will be located at a brownfields site within the Upton Logistics Center Industrial Park. The location is an 8.2-acre site at 131 Buffalo Creek Road, Upton, Wyoming, 82730 and has the necessary utility infrastructure (water, sewer, natural gas) to support the plant. (see **Figure 1** and **Figure 2** below)

Figure 1. Demonstration Plant Site



The Demonstration Project site and surrounding area lie within a Class II airshed under the Clean Air Act. There are no Class I areas within 50 kilometers of the Demonstration Plant site. The nearest Class I area is Wind Cave National Park, approximately 70 miles southeast of the Upton site. The second nearest is Badlands National Park, 115 miles to the east. The Northern Cheyenne Indian Reservation is approximately 140 miles to the northwest. Sensitive Class II areas within 100 km of the Upton site include Devils Tower National Monument, Jewell Cave National Monument, Black Elk Wilderness Area and Mount Rushmore National Memorial. (IML Air Science, 2014)

Figure 2. Demonstration Plant Permit Boundary



2.0 APPICATION FORM

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Air Quality Division

New Source Review Permit Application Form Cover Sheet

Is this supplemental information to an application currenlty under review?

Yes _____ No _____

Previous Application #: _____

Date of Application: _____

COMPANY INFORMATION:

Company Name: Rare Element Resources, Inc.
Address: P.O. Box 271049
City: Littleton State: Colorado Zip Code: 80127
Country: USA Phone Number: 720-278-2460

FACILITY INFORMATION:

Facility Name: REE Demonstration Plant
New Facility or Existing Facility: New
Facility Description: Rare Earth Element Separation and Processing Demonstration Project
Facility Class: Minor Operating Status: Not Yet Installed
Facility Type: Unknown

For Oil & Gas Production Sites ONLY:
First Date of Production (FDOP)/Date of Modification: _____
Single well or multiple well facility? _____
Does production at this facility contain H2S?* _____
If yes, contact the Division.
API Number(s): _____

NAICS Code: 212299 All Other Metal Ore Mining

FACILITY LOCATION:

***Enter the facility location in either the latitude/longitude area or section/township/range area. Both are not required.**
Physical Address: 131 Buffalo Creek Rd.
City: Upton Zip Code: 82730
State: WY County: Weston

OR

Latitude: _____ Longitude: _____ County: _____
Quarter Quarter: _____ Quarter: _____
Section: _____ Township: _____ Range: _____

For longitude and latitude, use NAD 83/WGS84 datum and 5 digits after the decimal (i.e. 41.12345, -107.56789)

CONTACT INFORMATION:

***Note that an Environmental AND NSR Permitting Contact is required for your application to be deemed complete by the agency.**
Title: Mr. First Name: Randall
Last Name: Scott
Company Name: Rare Element Resources, Inc.
Job Title: President & Chief Executive Officer
Address: P.O. Box 271049
City: Littleton State: Colorado
Zip Code: 80127
Primary Phone No.: 720-278-2460 E-mail: rscott@rareelementresources.com
Mobile Phone No.: 303-521-5810 Fax No.: 720-278-2490
Contact Type: Responsible Official Start Date: 12/1/11

***Name of the contact to whom the permit will be issued:**
Additional Contact Type (if needed): _____
Title: _____ First Name: _____
Last Name: _____
Company Name: _____
Job Title: _____
Address: _____
City: _____ State: _____

Zip Code:
Primary Phone No.:
Mobile Phone No.:
Contact Type:

E-mail:
Fax No.:
Start Date:

FACILITY APPLICATION INFORMATION:

General Info:

Has the facility changed location or is it a new/ greenfield facility?	Yes
Has a Land Use Planning document been included in this application?	Yes
Is the facility located in a sage grouse core area?*	No
If the facility is in a sage grouse core area, what is the WER number?	

** For questions about sage grouse core area, contact WY Game & Fish Department.*

Federal Rules Applicability - Facility Level:

Prevention of Significant Deterioration (PSD):	No
Non-Attainment New Source Review:	No

Modeling Section:

Has the Air Quality Division been contacted to determine if modeling is required?	Yes
Is a modeling analysis part of this application?	No
Is the proposed project subject to Prevention of Significant Deterioration (PSD) requirements?	No
Has the Air Quality Division been notified to schedule a pre-application meeting?	Yes
Has a modeling protocol been submitted to and approved by the Air Quality Division?	No
Has the Air Quality Division received a Q/D analysis to submit to the respective FLMs to determine the need for an AQRV analysis?	No

Required Attachments:

Facility Map	✓
Process Flow Diagram	✓
Modeling Analysis (if applicable)	
Land Use Planning Document	✓
Detailed Project Description	✓
Emissions Calculations	✓

I, Randall Scott (Responsible Official (Printed Name)) President & Chief Executive Officer (Title)

an Official Representative of the Company, state that I have knowledge of the facts herein set forth and that the same are true and correct to the best of my knowledge and belief. I further certify that the operational information provided and emission rates listed on this application reflect the anticipated emissions due to the operation of this facility. The facility will operate in compliance with all applicable Wyoming Air Quality Standards and Regulations.

Signature: Randall J. Scott (ink) Date: 7/20/22

3.0 PROJECT DESCRIPTION

3.1 PROJECT SCHEDULE

The total project lifespan is expected to be approximately 25 months, including the site grading and earthworks period. **Table 1** shows the tentative project schedule.

Table 1. Anticipated Demonstration Project Schedule

	Month																								
Phase	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Construction																									
Sample Delivery[a]																									
Operation																									
Decommissioning																									

a. Delivery is anticipated to occur over a 20-30 day period within this timeframe.

3.2 EMISSION SOURCES AND TIMING

Fugitive emission sources of particulate matter (PM, PM_{10}, $PM_{2.5}$) include construction activities, heavy duty diesel trucks, pickup traffic, delivery trucks, and passenger vehicles. Particulates (PM, PM_{10}, $PM_{2.5}$), carbon monoxide (CO), oxides of nitrogen and sulfur (NO_x and SO_2), a small amount of hazardous air pollutants (HAPs), and greenhouse gasses (GHG) carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) will be emitted by mobile equipment engine exhaust and by stationary sources such as a boiler, heater, and control equipment stacks.

Section 4.0 details the Project air emission inventory based on three project phases:

- Construction of Demonstration Plant (including site preparation);
- Operation of Demonstration Plant (including sample delivery); and
- Decommissioning of the Demonstration Plant.

Maximum emissions are anticipated to occur during construction of the Demonstration Plant.

3.3 FACILITIES

Facilities at the project will include the physical upgrading (PUG) building, main process building, chemical containment area, equipment/storage area, electrical control room, clean room, office trailer, and parking area (see **Figure 3**). The existing facilities include the PUG building, main process building, chemical containment area, and equipment/storage area. **Figure 4** shows areal imagery of the Demonstration Plant site in November 2021 after landowner cleanup.

The PUG/Sample Storage Facility will be used to receive and store the exploration sample prior to crushing, and will house the jaw crusher, cone crusher, and coarse vibrating screen units while onsite. The final comminuted product will be stored in super sacks within the covered PUG/Sample Storage Facility.

The Main Process Facility will house the process units, which will be built on modular, self-contained skids using multiple levels of steel platforms.

A covered chemical storage area located within a concrete containment structure will be used to house process feed chemicals. A process chemicals summary is provided in **Table 2**.

Table 2. Demonstration Project Chemical Consumption, Delivery, and Storage Summary

Process Feed Material	Delivery Schedule	Storage Location	Total Inventory (tons)
Exploration Sample	20-day period prior to operations	PUG/Sample Storage Facility	1,000
Hydrochloric Acid	Every 14 days	Chemical Containment Area	300
Oxalic Acid	Every 21 days (bags)	Chemical Containment Area	400
Sulfuric Acid	Once prior to operations (tote)	Chemical Containment Area	2
Nitric Acid	Every 14 days	Chemical Containment Area	600
Ammonia Water	Every 14 days	Chemical Containment Area	150
Lime	Once prior to operations (bags)	Main Process Facility	80
Organic Reactants	Every 4 months	Chemical Containment Area	200

Figure 3. Demonstration Plant Site Plan

Figure 4. Areal Imagery of Demonstration Plant Site in November 2021

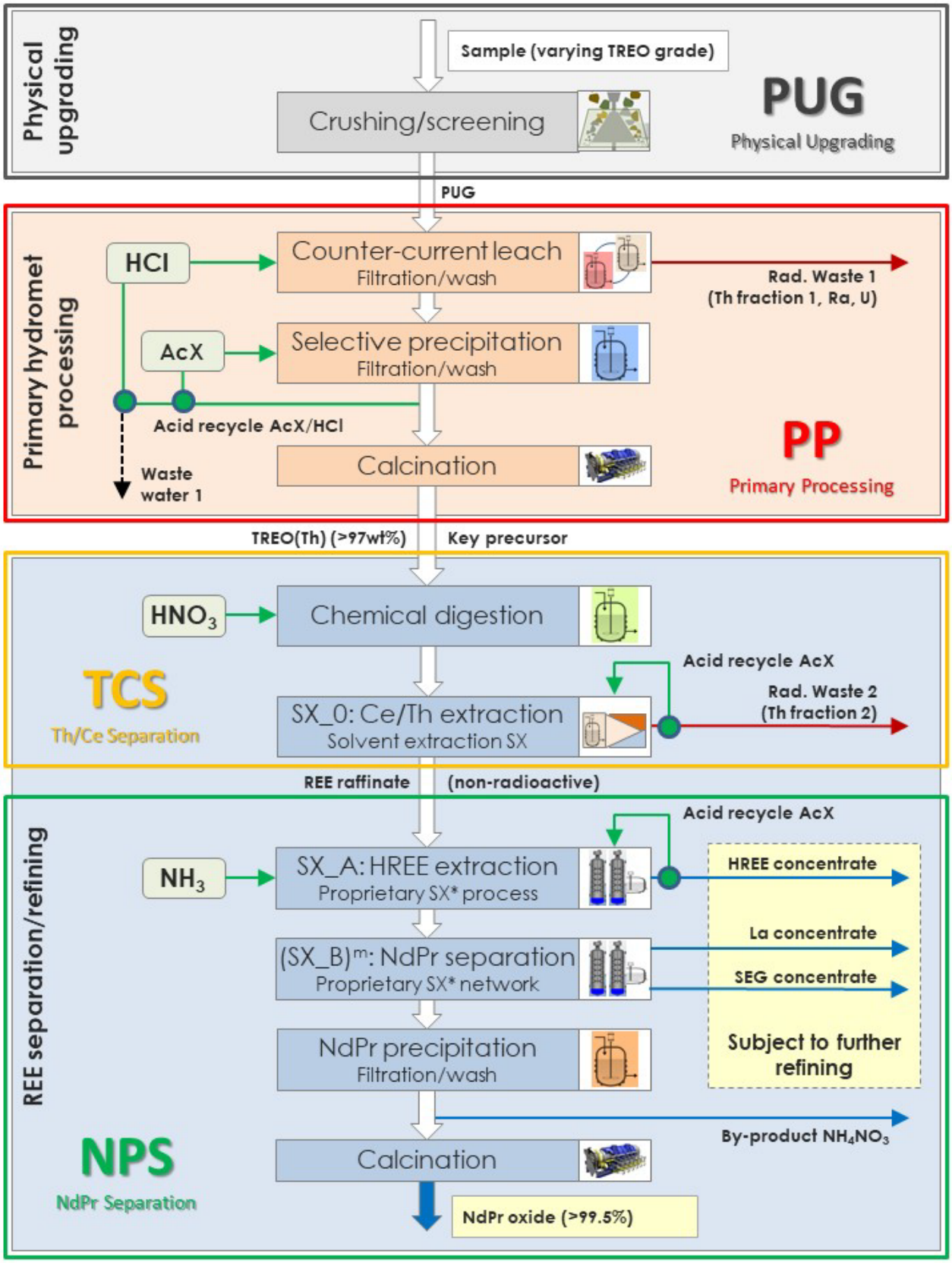
3.4 PROCESS DESCRIPTION

The Demonstration Plant will consist of four main process stages shown in **Figure 5**. These include:

1. Physical upgrade (PUG): comminution and screening of the extracted exploration sample containing source material.
2. Primary processing (PP): primary hydrometallurgical processing of the comminuted exploration sample to produce a highly pure total rare earth oxide (TREO), referred to as TREO(Th), concentrate (the precursor), which separates out a significant portion of the natural radioactivity contained in the exploration sample.
3. Thorium-cerium separation (TCS): removal of radioactivity, mainly thorium and its decay products, together with cerium, which is not currently considered to be a marketable REO product. An innovative technology allows the effectively complete removal of the source material. It allows for a high recycling rate of process streams and reduces the production of waste significantly.
4. Neodymium/praseodymium separation (NPS) and refining of REE groups including high purity neodymium/praseodymium oxide (the primary product), a lanthanum, cerium concentrate, a samarium, europium, gadolinium (SEG) concentrate, and a heavy rare earth elements (HREE) concentrate. The innovative technology applies multifunctional separators in a network for the recycling of valuable product streams to optimize the product quality and yield. The network is controlled by proprietary software combining real-time monitoring data of critical process streams with a unique process simulation software.

The process will produce these primary products and byproducts and implement extensive materials recycling to reduce waste as much as possible. All waste materials will be neutralized and shipped off-site to a licensed storage facility.

Figure 5. Demonstration Project Flow Diagram



3.4.1 Physical Upgrading (PUG)

The PUG plant is designed to use a combination of crushing and screening to reduce the grain size of the feed material and physically liberate the rare earth-bearing fines for processing in the Demonstration Plant.

Once delivered, the exploration sample will be stored in the PUG building, for up to two months, until it can be processed. The sample will then be re-handled by a front-end loader, mixed and homogenized by a front-end loader and dozer, and loaded into a hopper which feeds a jaw crusher. Secondary crushing with a cone crusher will supplement the jaw crusher for harder material as needed. The sample from the jaw crusher is then sized through a screen and with the oversize being fed into a cone crusher. All of the sample is then sized again through a screen and mixed and homogenized again to produce the final comminuted product which will be stored in super sacks within the covered PUG/Sample Storage Facility. During Demonstration Plant operations, the sample will be transported from the PUG/Sample Storage Facility to the Main Process Facility via forklift in a super sack approximately twice per day.

3.4.2 Primary Processing (PP)

The sample will be discharged into the PP stage feed hopper via a standalone bag breaker system with local dust collection to capture any residual dust from discharging the sample. PP includes primary hydrometallurgical processing of the comminuted and homogenized sample to produce a TREO(Th) concentrate, which is an intermediate product with a purity of >97 weight percent TREO. PP consists of three main processes:

1. A leach circuit, including the wash of the leached residue;
2. Selective REE precipitation, including the wash, drying, and calcining of the precipitate; and
3. Recovery of acids and water from the barren leach solution.

PP will occur in the Main Process Facility.

3.4.3 Thorium-Cerium Separation (TCS)

In the TCS stage, the TREO(Th) concentrate, the intermediate product of the PP, is further refined to an REE raffinate, effectively free of thorium and depleted in cerium. The TCS process consists of the digestion of the TREO(Th) concentrate, a solvent extraction (SX) cycle including extraction of thorium and cerium from aqueous phase to organic phase, stripping of the organic phase by precipitation strip, and washing of the organic phase. The SX cycle produces REE-bearing, non-radioactive raffinate for further separation of specific REEs and thorium/cerium-bearing radioactive waste that is treated in the solid waste treatment process. TCS will occur in the Main Process Facility.

3.4.4 Neodymium/Praseodymium Separation (NPS)

In the NPS stage, the effectively thorium-free and cerium-depleted extraction raffinate from the SX process in TCS is processed further in subsequent SX cycles to separate:

- Raffinate mainly containing HREE, and SEG in SX_A
- Raffinate mainly containing SEG in SX_B1
- Raffinate mainly containing lanthanum, cerium, and metal impurities in SX_B2
- Highly pure raffinate containing neodymium and praseodymium in SX_B3

From the four different raffinates, solid products of mixed REEs are produced by precipitation and dependent on the product specifications. NPS will occur in the Main Process Facility.

3.4.5 Chemical Recycling and Waste Facilities

In the waste treatment process, all waste and wastewater streams are combined and neutralized for disposal. There will be no discharge of wastewater. The produced solid waste streams are:

- Washed leach residue from the PP containing the non-dissolved fraction of the source material and most of the radium originating from the exploration sample which is immobilized in the leach residue via coprecipitation.
- Thorium-bearing oxalate from the precipitation strip of the TCS process containing all remaining residual thorium originating from the exploration sample.

The produced wastewater streams are:

- Strongly acidic metal chloride concentrate from the PP acid recovery plant containing the mobilized, but not precipitated, uranium, daughter products fraction of the exploration sample.
- Acidic bleed streams from the precipitation strip and wash of the TCS process.

All four streams are considered as radioactive waste streams.

Within a mixing tank, the radioactive wastewater stream forms a hydrous ferric oxide sludge during neutralization with burnt lime and the radioactivity concentration is reduced below the feed concentration due to the increased mass from neutralization. The bleed streams are neutralized by burnt lime to form calcium precipitates.

The solid waste streams are neutralized and immobilized by burnt lime to a pH range of 6-9 in a pug mill where they are also combined with the neutralized liquid waste streams in a batched process. Bentonite is added to the total tailings if needed to adsorb excess liquid. The total tailings waste, which contains nearly 100% of the radioactive material, is transferred to a roll-off bin and stored prior to periodic waste shipments.

Additionally, organic liquid wastes are produced from TCS and NPS. The organic waste of the TCS might be contain a small concentration of thorium and will be conditioned with a hydrocarbon adsorber and mixed with the other radioactive waste streams and disposed together as solid radioactive waste. All waste materials will be shipped off-site to a licensed storage facility. The non-radioactive organic waste from NPS is disposed of separately.

4.0 EMISSION SOURCES AND RATES

4.1 FACILITY PROCESSES AND EMISSION CONTROLS AFFECTED

The demonstration project involves the physical processing of this already extracted exploration sample followed by chemical processing to produce a pure TREO concentrate followed by the separation of NdPr oxide. Facility processes and emission controls planned for the Demonstration Plant include cyclones and dust collectors to minimize dust generation from material handling systems, and wet scrubbers to eliminate vapor emissions from the chemical storage tanks, calciner, and leaching and precipitation circuits. Additionally, the PUG/Sample Storage Facility is enclosed on three sides and the Main Process Facility is fully enclosed and the heating, ventilation, air conditioning (HVAC) system will be equipped with a high-efficiency particulate air filtration (HEPA) system.

4.2 EMISISON FACTORS USED TO CALCULATE POTENTIAL EMISSIONS

The Demonstration Plant will generate stationary source, fugitive dust, and tailpipe emissions. In general, fugitive dust emissions will include traffic on unpaved roads (including haulage of exploration sample, waste, and chemical supplies), traffic on paved areas, exploration sample unloading, wind erosion on exploration sample

stockpile, and exploration sample mixing. Emission factors for these sources are provided in EPA's AP-42, Compilation of Air Pollutant Emission Factors (EPA, 1995) as listed below:

- Unpaved roads – Chapter 13, Section 13.2.2
- Paved roads – Chapter 13, Section 13.2.1
- Material handling – Chapter 13, Section 13.2.4
- Wind erosion – Chapter 13, Section 13.2.5
- Solids mixing – Chapter 13, Section 13.2.4 and Chapter 11, Section 11.9, Table 11.9-1
- Crushing and screening – Chapter 11, Section 11.24, Table 11.24-2
- Oxalic acid handling – Chapter 6, Section 6.2, Table 6.2-2
- Lime handling – Chapter 11, Section 11.17, Table 11.17-4
- Boiler and heater – Chapter 1, Section 1.4, Tables 1.4-1 through 1.4-4
- Calciner – Chapter 8, Section 8.12, Tables 8.12-3 and 8.12-4

In some cases, fugitive PM_{10} and $PM_{2.5}$ emission factors were not available in AP-42 and the particle size multipliers from Section 13.2.4 were used to estimate PM_{10} and $PM_{2.5}$ emission factors.

Published fugitive dust emission factors are modified by specific control measures. EPA guidance provided in AP-42 allows for natural mitigation of fugitive dust emissions based on days of precipitation per year (page 13.2.2-7, Equation 2). For the Demonstration Project, a value of 100 days per year was used, based on WDEQ Powder River Basin Coal Mine Permitting Guidance (WDEQ, 2018). A precipitation day is defined in Section 13.2 of AP-42 as any day measuring precipitation of 0.01" or more. The emission factor correction for precipitation days applies to all unpaved roads. A control efficiency of 75% was assumed for the activities that occur within the PUG/ Sample Storage Facility, which is enclosed on three sides, based on the Western Regional Air Partnership's (WRAP) Fugitive Dust Handbook (Countess Environmental, 2006).

Gasoline and diesel equipment tailpipe emissions were calculated using emission factors from several sources. With the exception of SO_2 and aldehydes for diesel equipment, emission factors are based on EPA standards for various engine tier ratings and model years (EPA, 2016a; 2016b; 2016c; 2017). Heavy equipment was assumed to have Tier 4 engines and passenger vehicles were assumed to have Tier 2, Bin 8 engines. Delivery trucks were assumed to be model year 2007+ and pickup trucks were assumed to be model year 2008+. SO_2 emission factors calculated from fuel sulfur content and brake specific fuel consumption (BSFC) and aldehyde emission factors for diesel equipment is from AP-42, Chapter 3, Table 3.3-1.

In most cases, equipment activity levels used to calculate emissions were based on available hours and typical load factors. Nonroad load factors taken from EPA's Nonroad model (EPA, 2010). Load factors for pickup trucks, and passenger vehicles were assumed to be 25% of scheduled hours, due to low throttle settings and/or intermittent operation and load factors for delivery trucks were assumed to be 40%.

Comparable emission factors were used for oxalic acid handling and calciner emissions since emission factors specific to these processes are not provided in AP-42.

EPA's TANKS 4.09d was used to calculate emissions from chemical storage tanks and one turnover was assumed to be the maximum hourly emissions which would occur during tank filling.

Emissions that are directed to the main facility scrubbers are based on emissions test data collected from a bench scale model.

Additionally, potential GHG emissions were calculated for mobile and stationary combustion sources, although there are no NAAQS for GHGs. EPAs GHG Emission Factors Hub (EPA, 2022) was used for mobile sources and AP-42, Section 1.4, Table 1.4-2 was used for stationary sources. GHG emissions are in metric tons as is industry standard and tons per year for consistency with IMPACT forms.

4.3 POTENTIAL EMISSIONS

This section summarizes the potential emissions for the proposed Demonstration Plant. Detailed emission calculations for the proposed project are provided in **Appendix A**.

4.3.1 Fugitive Particulate Emissions

The potential fugitive emission rates for the Project by phase are summarized in **Table 3**. Fugitive dust emissions are highest during the construction phase and lowest during operation since the majority of the fugitive dust activities take place in the PUG/Sample Storage Facility which is enclosed on three sides. Exploration sample truck loadout was included in the operational fugitive emissions.

Table 3. Potential Fugitive Emissions by Phase

Phase	Duration	PM (tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)
Construction	10 months	56.48	14.26	4.00
Operation	12 months	2.55	0.71	0.10
Decommissioning	3 months	17.01	4.30	1.20
Total	25 months	76.04	19.27	5.30

4.3.2 Tailpipe Emissions

Table 4 summarizes potential combustion emissions from equipment and vehicle tailpipes. Tailpipe emissions are highest during the construction and decommissioning phases and lowest during operation due to the use of heavy equipment during construction and decommissioning. Additionally, potential GHG emissions were calculated although there are no NAAQS for GHGs.

Table 4. Potential Tailpipe Emissions by Phase

Pollutant	Construction	Operation	Decommissioning
PM (tons)	0.04	0.01	0.01
PM10 (tons)	0.04	0.01	0.01
PM2.5 (tons)	0.04	0.01	0.01
SO_2 (tons)	0.01	0.005	0.004
NO_x (tons)	0.87	0.33	0.26
CO (tons)	5.80	4.20	1.85
VOC (tons)	0.57	0.32	0.17
HAPs (tons)	0.44	0.08	0.13
CO2 (metric tons)	1,115.18	324.11	337.90
CH4 (metric tons)	0.02	0.002	0.01
N2O (metric tons)	0.02	0.002	0.01

4.3.3 Stationary Equipment Emissions

Table 5 through **Table 11** summarize emissions from stationary equipment all of which are equipped with emission control devices with the exception of the boiler and heater. Stationary sources will only emit once the Demonstration Plant becomes operational.

Stationary equipment located in the PUG/Sample Storage Facility are summarized in **Table 5**, all of these sources are controlled by a single cyclone dust collector. Additionally, all are located within the PUG/Sample Storage Facility which is enclosed on three sides; however, to be conservative the 75% control efficiency for a 3-sided enclosure was not used.

Table 5. Potential Stationary Source Emissions in PUG/Sample Storage Facility

Source	PM (tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)
Primary Crusher & Screen	0.003	0.0003	0.00004
Secondary Crusher & Screen	0.006	0.003	0.00043
Bulk Bag Filler	0.00002	0.00001	0.000001
Total	0.009	0.0031	0.0005

Emissions from feed hoppers located in the Main Process Facility are presented in **Table 6** below. As discussed in Section 3.4.2 the sample will be discharged into the PP Feed Hopper (110FH-101) via a standalone bag breaker system equipped with a dust collector. The Oxalic Acid Feed Hoppers (560FH-101 and 560FH-102) and Lime Feed Hopper (540FH-101) will also each use a standalone bag breaker system equipped with a dust collector. Emissions from the dust collectors is discharged to the fully enclosed Main Process Facility and will be filtered again through the HVAC equipped with a HEPA system prior to discharging to the atmosphere. To be conservative no additional emission controls were assumed for the enclosed building or HVAC system.

Table 6. Potential Feed Hopper Emissions in Main Process Facility

Source	PM (tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)
110FH-101	0.0006	0.0003	0.00005
560FH-101	0.0011	0.0005	0.00008
560FH-102	0.0005	0.0002	0.00003
540FH-101	0.0009	0.0004	0.00006
Total	0.0031	0.0015	0.00022

Table 7 presents the potential emissions from the calciner which is equipped with a venturi scrubber and electrically heated; therefore, there are no combustion emissions associated with the calciner.

Table 7. Potential Calciner Emissions in Main Process Facility

PM (tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)	CO_2 (metric tons)
0.45	0.21	0.03	18.33

Table 8 summarizes stationary equipment emissions for the heater and boiler from the combustion of natural gas. Both are located in the Main Process Facility.

Table 8. Potential Combustion Emissions from Main Process Facility

Pollutant	Boiler	Heater	Total
PM (tons)	0.07	0.04	0.11
PM_{10} (tons)	0.07	0.04	0.11
$PM_{2.5}$ (tons)	0.07	0.04	0.11
SO_2 (tons)	0.01	0.003	0.01
NO_x (tons)	0.90	0.52	1.42
CO (tons)	0.76	0.43	1.19
VOC (tons)	0.05	0.03	0.08
HAPs (tons)	0.02	0.01	0.03
CO_2 (metric tons)	981.68	560.96	1,542.64
CH_4 (metric tons)	0.02	0.01	0.03
N_2O (metric tons)	0.02	0.01	0.03

Emissions from PP, TCS, and NPS process stages are collected and neutralized by two packed bed scrubbers operating in parallel prior to being discharged to the atmosphere. Emissions from these Main Process Facility scrubber vents are presented in **Table 9**.

Table 9. Potential Emissions from Main Process Facility Scrubber Vents

Pollutant	PTE (tons)
NO_x	0.01
VOC	0.004
HAPs	0.0012
HCl	0.00001
Cl_2	0.00001
AsH_3	0.001
NH_3	0.00004

The liquid chemical storage tanks will be housed in the Chemical Containment Area which will be covered and located within a concrete containment structure. Each tank will be heated and equipped with its own scrubber. **Table 10** presents the potential emissions from the bulk chemical storage tanks.

Table 10. Potential Emissions from Bulk Chemical Storage Tanks

Source	Source Description	Pollutant	PTE (tons)
510TK-101	Hydrochloric Acid Storage Tank	HCl	0.0013
511TK-101	Recovered Hydrochloric Acid Storage Tank	HCl	0.0006
520TK-101	Nitric Acid Storage Tank	HNO_3	0.00008
540TK-101	Ammonium Hydroxide Storage Tank	NH_3	0.06

The total emissions from stationary sources are presented in **Table 11**.

Table 11. Potential Emissions from Stationary Sources

Pollutant	PTE
PM (tons)	0.57
PM_{10} (tons)	0.33
$PM_{2.5}$ (tons)	0.14
SO_2 (tons)	0.01
NO_x (tons)	1.43
CO (tons)	1.19
VOC (tons)	0.08
Pb (tons)	0.00001
HAPs (tons)	0.03
HCl (tons)	0.002
HNO_3 (tons)	0.0001
NH_3 (tons)	0.06
CO_2 (metric tons)	1,560.97
CH_4 (metric tons)	0.03
N_2O (metric tons)	0.03

5.0 AMBIENT COMPLIANCE DEMONSTRATION

The Demonstration Plant site was previously occupied by a wood chip to ethanol pilot production facility (IMPACT Facility ID: F019488, Facility Name: Upton Plant) operated by Western Biomass Energy, LLC. On October 19, 2006, Western Biomass Energy, LLC submitted an application to construct the Upton Plant. Based on the information provided in the permit application (AP 5280) WDEQ-AQD determined that ambient air quality standards will be maintained (WDEQ-AQD, 2006). When compared to the proposed Demonstration Plant the total proposed emissions for the Western Biomass Energy Upton Plant were higher than what is proposed for the Demonstration Plant. Therefor it is not anticipated that the ambient air quality standards would be maintained during construction, operation, and decommissioning of the REE Demonstration Plant. A comparison of the proposed emissions for the Western Biomass Energy Upton Plant and REE Demonstration Plant are provided in **Table 12** below.

Table 12. Comparison of Western Biomass Plant and REE Demonstration Plant Potential Emissions

Pollutant	Western Biomass Plant[a]	REE Demonstration Plant[b]
PM (tons)	5.8	3.13
PM_{10} (tons)	2.6	1.04
$PM_{2.5}$ (tons)	NA	0.25
SO_2 (tons)	NA	0.01
NO_x (tons)	5.6	1.76
CO (tons)	4.7	5.39
VOC (tons)	17.4	0.4
HAPs (tons)	3.0	0.11

a. Does not include vehicle tailpipe emissions. Reference: Table 1 (WDEQ-AQD, 2006)
b. Includes vehicle tailpipe emissions from operational phase (see Table 4 above)

Although the CO emissions at the REE Demonstration Plant are shown to be higher than the Western Biomass Plant in **Table 12**, the REE Demonstration Plant emissions include tail pipe emissions from vehicles and the Western Biomass Plant emissions do not. When the CO tailpipe emissions (4.2 tons) are excluded the CO emissions for the REE Demonstration Plant are 1.19 tons, which is lower than the CO emissions for the Western Biomass Plant.

6.0 REFERENCES

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APPENDIX A – DEMONSTRATION PROJECT EMISSION CALCULATIONS

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

Emissions Summary

AQD ID	Company EU ID	Description	Control	PTE (tpy)														
				PM	PM_{10}	$PM_{2.5}$	SO_2	NO_x	CO	VOC	Pb	HAPs	HCl	HNO_3	NH_3	CO_2	CH_4	N_2O
BOL001	Steam Plant Boiler		None	0.07	0.07	0.07	0.01	0.9	0.76	0.05	0.000005	0.02	-	-	-	1,082.12	0.02	0.02
CKD001	140RK-101	Primary Processing Calciner	Scrubber	0.45	0.21	0.03	-	-	-	-	-	-	-	-	-	20.20	-	-
CSH001	PUG Primary Crusher		Dust Collector	0.003	0.0003	0.00004	-	-	-	-	-	-	-	-	-	-	-	-
CSH003	PUG Secondary Crusher		Dust Collector	0.006	0.0028	0.00043	-	-	-	-	-	-	-	-	-	-	-	-
CSH005	Bulk Bag Filler		Dust Collector	0.00002	0.00001	0.000001	-	-	-	-	-	-	-	-	-	-	-	-
CSH006	110FH-101	PP Feed Hopper	Dust Collector	0.0006	0.0003	0.00005	-	-	-	-	-	-	-	-	-	-	-	-
CSH007	560FH-101	Oxalic Acid Feed Hopper	Dust Collector	0.0011	0.0005	0.00008	-	-	-	-	-	-	-	-	-	-	-	-
CSH008	560FH-102	Oxalic Acid Feed Hopper	Dust Collector	0.0005	0.0002	0.00003	-	-	-	-	-	-	-	-	-	-	-	-
CSH009	540FH-101	Lime Feed Hopper	Dust Collector	0.001	0.0004	0.00006	-	-	-	-	-	-	-	-	-	-	-	-
FUG001	Haul Roads	Tailpipe Emissions	None	0.01	0.01	0.01	0.00474	0.33	4.2	0.32	-	0.08	-	-	-	294.03	0.001	0.001
FUG001	Haul Roads	Fugitive Dust	None	2.17	0.62	0.06	-	-	-	-	-	-	-	-	-	-	-	-
FUG002	Exploration Sample Stockpile		3-Sided Enclosure	0.009	0.004	0.001	-	-	-	-	-	-	-	-	-	-	-	-
FUG003	Exploration Sample Pre-crushing Mixing		3-Sided Enclosure	0.18	0.04	0.02	-	-	-	-	-	-	-	-	-	-	-	-
FUG004	Transfer to Solids Mixing		3-Sided Enclosure	0.0004	0.0002	0.00003	-	-	-	-	-	-	-	-	-	-	-	-
FUG005	Exploration Sample Post-crusher mixing		3-Sided Enclosure	0.18	0.04	0.02	-	-	-	-	-	-	-	-	-	-	-	-
FUG006	Bentonite Batch Drop		None	0.00000058	0.00000027	0.00000004	-	-	-	-	-	-	-	-	-	-	-	-
HET001	PP Building Furnace		None	0.04	0.04	0.04	0.003	0.52	0.43	0.03	0.000003	0.01	-	-	-	618.35	0.01	0.01
LUD001	Exploration Sample Truck Loadout		None	0.0015	0.0007	0.0001	-	-	-	-	-	-	-	-	-	-	-	-
TNK001	510TK-101	HCl Storage Tank	Scrubber	-	-	-	-	-	-	-	-	0.0013	0.0013	-	-	-	-	-
TNK002	511TK-101	Recovered HCl Storage Tank	Scrubber	-	-	-	-	-	-	-	-	0.0006	0.0006	-	-	-	-	-
TNK003	520TK-101	Nitric Acid Storage Tank	Scrubber	-	-	-	-	-	-	-	-	-	-	0.0001	-	-	-	-
TNK004	540TK-101	Ammonium Hydroxide Storage Tank	Scrubber	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-
VNT001	Main Processing Facility Scrubber Vents		Scrubber	-	-	-	-	0.01	-	0.004	-	0.0012	0.00001	-	0.00004	-	-	-
N/A	Tailpipe Emissions	Construction	None	0.04	0.04	0.04	0.01	0.87	5.80	0.57	-	0.44	-	-	-	1,011.68	0.02	0.02
N/A	Tailpipe Emissions	Decomissioning	None	0.01	0.01	0.01	0.004	0.26	1.85	0.17	-	0.13	-	-	-	306.54	0.01	0.01
N/A	Fugitive Dust	Construction	None	56.48	14.26	4.00	-	-	-	-	-	-	-	-	-	-	-	-
N/A	Fugitive Dust	Decomissioning	None	17.01	4.30	1.20	-	-	-	-	-	-	-	-	-	-	-	-
			Fugitive Total	2.56	0.72	0.11	0.00	0.33	4.20	0.32	-	0.08	-	-	-	294.03	0.00	0.00
			Point Source Total	0.57	0.33	0.14	0.01	1.43	1.19	0.08	0.00001	0.03	0.002	0.0001	0.06	1,720.67	0.03	0.03
			Facility Total	3.13	1.04	0.25	0.01	1.76	5.39	0.40	0.00	0.11	0.002	0.00	0.06	2,014.70	0.03	0.03

AQD ID	Company EU ID	Description	Control	Pre-Controlled Potential Emissions (tpy)											
				PM	PM_{10}	$PM_{2.5}$	SO_2	NO_x	CO	VOC	Pb	HAPs	HCl	HNO_3	NH_3
BOL001	Steam Plant Boiler		None	0.07	0.07	0.07	0.01	0.9	0.76	0.05	0.000005	0.02	-	-	-
CKD001	140RK-101	Primary Processing Calciner	Scrubber	9.09	4.3	0.65	-	-	-	-	-	-	-	-	-
CSH001	PUG Primary Crusher		Dust Collector	0.25	0.025	0.0038	-	-	-	-	-	-	-	-	-
CSH003	PUG Secondary Crusher		Dust Collector	0.6	0.28	0.043	-	-	-	-	-	-	-	-	-
CSH005	Bulk Bag Filler		Dust Collector	0.002	0.0007	0.0001	-	-	-	-	-	-	-	-	-
CSH006	110FH-101	PP Feed Hopper	Dust Collector	0.06	0.03	0.0045	-	-	-	-	-	-	-	-	-
CSH007	560FH-101	Oxalic Acid Feed Hopper	Dust Collector	0.11	0.05	0.008	-	-	-	-	-	-	-	-	-
CSH008	560FH-102	Oxalic Acid Feed Hopper	Dust Collector	0.05	0.02	0.003	-	-	-	-	-	-	-	-	-
CSH009	540FH-101	Lime Feed Hopper	Dust Collector	0.09	0.04	0.01	-	-	-	-	-	-	-	-	-
FUG001	Haul Roads	Tailpipe Emissions	None	0.01	0.01	0.01	0.00474	0.33	4.2	0.32	-	0.08			
FUG001	Haul Roads	Fugitive Dust	None	2.17	0.62	0.06	-	-	-	-	-	-	-	-	-
FUG002	Exploration Sample Stockpile		3-Sided Enclosure	0.04	0.02	0.003	-	-	-	-	-	-	-	-	-
FUG003	Exploration Sample Pre-crushing Mixing		3-Sided Enclosure	0.72	0.16	0.08	-	-	-	-	-	-	-	-	-
FUG004	Transfer to Solids Mixing		3-Sided Enclosure	0.002	0.001	0.0001	-	-	-	-	-	-	-	-	-
FUG005	Exploration Sample Post-crusher mixing		3-Sided Enclosure	0.72	0.16	0.08	-	-	-	-	-	-	-	-	-
FUG006	Bentonite Batch Drop		None	0.00000229	0.00000108	0.00000016	-	-	-	-	-	-	-	-	-
HET001	PP Building Furnace		None	0.04	0.04	0.04	0.003	0.52	0.43	0.03	0.000003	0.01	-	-	-
LUD001	Exploration Sample Truck Loadout		None	0.0015	0.0007	0.0001	-	-	-	-	-	-	-	-	-
TNK001	510TK-101	HCl Storage Tank	Scrubber	-	-	-	-	-	-	-	-	0.013	0.013	-	-
TNK002	511TK-101	Recovered HCl Storage Tank	Scrubber	-	-	-	-	-	-	-	-	0.006	0.006	-	-
TNK003	520TK-101	Nitric Acid Storage Tank	Scrubber	-	-	-	-	-	-	-	-	-	-	0.001	-
TNK004	540TK-101	Ammonium Hydroxide Storage Tank	Scrubber	-	-	-	-	-	-	-	-	-	-	-	0.56
VNT001	Main Processing Facility Scrubber Vents		Scrubber	-	-	-	-	0.01	-	0.004	-	0.0014	0.0001	-	0.0004
N/A	Tailpipe Emissions	Construction	None	0.04	0.04	0.04	0.01	0.87	5.80	0.57	-	0.44	-	-	-
N/A	Tailpipe Emissions	Decomissioning	None	0.01	0.01	0.01	0.00	0.26	1.85	0.17	-	0.13	-	-	-
N/A	Fugitive Dust	Construction	None	56.48	14.26	4.00	-	-	-	-	-	-	-	-	-
N/A	Fugitive Dust	Decomissioning	None	17.01	4.30	1.20	-	-	-	-	-	-	-	-	-
			Fugitive Total	3.67	0.97	0.23	0.00	0.33	4.20	0.32	-	0.08	-	-	-
			Point Source Total	10.36	4.86	0.83	0.01	1.43	1.19	0.08	0.00	0.05	0.02	0.00	0.56
			Facility Total	14.03	5.84	1.06	0.01	1.76	5.39	0.40	0.00	0.13	0.02	0.00	0.56

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

Emissions Summary Cont.

AQD ID	Company EU ID	Description	Control	PTE (lb/hr)											
				PM	PM_{10}	$PM_{2.5}$	SO_2	NO_x	CO	VOC	Pb	HAPs	HCl	HNO_3	NH_3
BOL001	Steam Plant Boiler		None	0.02	0.02	0.02	0.001	0.21	0.17	0.01	0.000001	0.004	-	-	-
CKD001	140RK-101	Primary Processing Calciner	Scrubber	0.11	0.05	0.01	-	-	-	-	-	-	-	-	-
CSH001	PUG Primary Crusher		Dust Collector	0.07	0.01	0.001	-	-	-	-	-	-	-	-	-
CSH003	PUG Secondary Crusher		Dust Collector	0.16	0.074	0.011	-	-	-	-	-	-	-	-	-
CSH005	Bulk Bag Filler		Dust Collector	0.004	0.0019	0.0003	-	-	-	-	-	-	-	-	-
CSH006	110FH-101	PP Feed Hopper	Dust Collector	0.0018	0.0009	0.00014	-	-	-	-	-	-	-	-	-
CSH007	560FH-101	Oxalic Acid Feed Hopper	Dust Collector	0.000004	0.000002	0.00000029	-	-	-	-	-	-	-	-	-
CSH008	560FH-102	Oxalic Acid Feed Hopper	Dust Collector	0.000004	0.000002	0.00000029	-	-	-	-	-	-	-	-	-
CSH009	540FH-101	Lime Feed Hopper	Dust Collector	0.00001	0.000005	0.000001	-	-	-	-	-	-	-	-	-
FUG001	Haul Roads	Tailpipe Emissions	None	0.004	0.004	0.004	0.03	0.17	6.15	0.17	-	0.08	-	-	-
FUG001	Haul Roads	Fugitive Dust	None	7.04	2.02	0.20	-	-	-	-	-	-	-	-	-
FUG002	Exploration Sample Stockpile		3-Sided Enclosure	2.01	1.01	0.15	-	-	-	-	-	-	-	-	-
FUG003	Exploration Sample Pre-crushing Mixing		3-Sided Enclosure	4.67	1.08	0.49	-	-	-	-	-	-	-	-	-
FUG004	Transfer to Solids Mixing		3-Sided Enclosure	0.1	0.05	0.01	-	-	-	-	-	-	-	-	-
FUG005	Exploration Sample Post-crusher mixing		3-Sided Enclosure	4.67	1.08	0.49	-	-	-	-	-	-	-	-	-
FUG006	Bentonite Batch Drop		None	0.000126	0.0000594	0.00000899	-	-	-	-	-	-	-	-	-
HET001	PP Building Furnace		None	0.01	0.01	0.01	0.001	0.16	0.13	0.01	0.000001	0.003	-	-	-
LUD001	Exploration Sample Truck Loadout		None	0.40	0.19	0.03	-	-	-	-	-	-	-	-	-
TNK001	510TK-101	HCl Storage Tank	Scrubber	-	-	-	-	-	-	-	-	0.14	0.14	-	-
TNK002	511TK-101	Recovered HCl Storage Tank	Scrubber	-	-	-	-	-	-	-	-	0.01	0.01	-	-
TNK003	520TK-101	Nitric Acid Storage Tank	Scrubber	-	-	-	-	-	-	-	-	-	-	0.01	-
TNK004	540TK-101	Ammonium Hydroxide Storage Tank	Scrubber	-	-	-	-	-	-	-	-	-	-	-	4.69
VNT001	Main Processing Facility Scrubber Vents		Scrubber	-	-	-	-	0.002	-	0.001	-	0.0003	0.000002	-	0.00001
N/A	Tailpipe Emissions	Construction	None	0.04	0.04	0.04	0.05	0.95	11.85	0.63	-	0.52	-	-	-
N/A	Tailpipe Emissions	Decomissioning	None	0.04	0.04	0.04	0.05	0.95	11.85	0.63	-	0.13	-	-	-
N/A	Fugitive Dust	Construction	None	287.49	80.42	10.61	-	-	-	-	-	-	-	-	-
N/A	Fugitive Dust	Decomissioning	None	287.49	80.42	10.61	-	-	-	-	-	-	-	-	-
			Fugitive Total	18.91	5.41	1.37	0.03	0.17	6.15	0.17	-	0.08	-	-	-
			Point Source Total	0.37	0.16	0.05	0.00	0.36	0.30	0.02	0.00	0.16	0.15	0.01	4.69
			Facility Total	19.27	5.58	1.42	0.04	0.53	6.46	0.19	0.00	0.24	0.15	0.01	4.69

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project
Emission Calculations

Equipment ID:	Boiler 1	
Equipment Description:	50 HP Parker Industrial 104 Steam Plant Boiler	
Heat Input Rating:	2.1	MMBtu/hr
Fuel Type:	Natural Gas	
Heating Value:	1,020	Btu/scf
Operating Hours:	8,760	hr/year

Criteria Pollutants	Emission Factor ($lb/10^6$ scf)	Emission Factor Reference	SCC	Emission Factor (lb/MMBtu)	PTE (lbs/hr)	PTE (tpy)
NO_X	100	AP-42 Table 1.4-1	1-02-006-03	9.80E-02	0.21	0.90
CO	84			8.24E-02	0.17	0.76
PM, PM_{10}, $PM_{2.5}$	7.6	AP-42 Table 1.4-2		7.45E-03	0.02	0.07
SO_2	0.6			5.88E-04	0.001	0.01
VOC	5.5			5.39E-03	0.01	0.05
Pb	0.0005			4.90E-07	0.000001	0.000005
GHG Pollutants						
CO_2	120000	AP-42 Table 1.4-2	1-02-006-03	118	247	1,082
CH_4	2.3			2.25E-03	0.005	0.02
N_2O	2.2			2.16E-03	0.005	0.02
HAPs/TAPs						
Dichlorobenzene	1.2E-03	AP-42 Table 1.4-3	1-02-006-03	1.18E-06	2.47E-06	1.08E-05
Toluene	3.4E-03	AP-42 Table 1.4-3		3.33E-06	7.00E-06	3.07E-05
Hexane	1.8E+00	AP-42 Table 1.4-3		1.76E-03	3.71E-03	1.62E-02
Anthracene	2.4E-06	AP-42 Table 1.4-3		2.35E-09	4.94E-09	2.16E-08
Pyrene	5.0E-06	AP-42 Table 1.4-3		4.90E-09	1.03E-08	4.51E-08
Benzo(g,h,i)perylene	1.2E-06	AP-42 Table 1.4-3		1.18E-09	2.47E-09	1.08E-08
Indeno(1,2,3-cd)pyrene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
Benzo(b)fluoranthene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
Fluoranthene	3.0E-06	AP-42 Table 1.4-3		2.94E-09	6.18E-09	2.71E-08
Benzo(k)fluoranthene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
Acenaphthylene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
Chrysene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
Formaldehyde	7.5E-02	AP-42 Table 1.4-3		7.35E-05	1.54E-04	6.76E-04
Benzo(a)pyrene	1.2E-06	AP-42 Table 1.4-3		1.18E-09	2.47E-09	1.08E-08
Dibenzo(a,h)anthracene	1.2E-06	AP-42 Table 1.4-3		1.18E-09	2.47E-09	1.08E-08
3-Methylchloranthrene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
Benz(a)anthracene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
7,12-Dimethylbenz(a)anth	1.6E-05	AP-42 Table 1.4-3		1.57E-08	3.29E-08	1.44E-07
Benzene	2.1E-03	AP-42 Table 1.4-3		2.06E-06	4.32E-06	1.89E-05
Manganese	3.8E-04	AP-42 Table 1.4-4		3.73E-07	7.82E-07	3.43E-06
Mercury	2.6E-04	AP-42 Table 1.4-4		2.55E-07	5.35E-07	2.34E-06
Nickel	2.1E-03	AP-42 Table 1.4-4		2.06E-06	4.32E-06	1.89E-05
Arsenic	2.0E-04	AP-42 Table 1.4-4		1.96E-07	4.12E-07	1.80E-06
Beryllium	1.2E-05	AP-42 Table 1.4-4		1.18E-08	2.47E-08	1.08E-07
Cadmium	1.1E-03	AP-42 Table 1.4-4		1.08E-06	2.26E-06	9.92E-06
Chromium	1.4E-03	AP-42 Table 1.4-4		1.37E-06	2.88E-06	1.26E-05
Cobalt	8.4E-05	AP-42 Table 1.4-4		8.24E-08	1.73E-07	7.57E-07
Selenium	2.4E-05	AP-42 Table 1.4-4		2.35E-08	4.94E-08	2.16E-07
Acenaphthene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	3.71E-09	1.62E-08
Phenanthrene	1.7E-05	AP-42 Table 1.4-3		1.67E-08	3.50E-08	1.53E-07
Fluorene	2.8E-06	AP-42 Table 1.4-3		2.75E-09	5.76E-09	2.52E-08
Naphthalene	6.1E-04	AP-42 Table 1.4-3		5.98E-07	1.26E-06	5.50E-06
2-Methylnaphthalene	2.4E-05	AP-42 Table 1.4-3		2.35E-08	4.94E-08	2.16E-07
				TOTAL HAPs/TAPs	0.004	0.02

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	140RK-101		
Equipment Description:	Primary Processing Calciner		
Maximum Annual Plant Throughput:	1000	tons/year	
Maximum Daily Throughput:	3	tons/day	
% TREO	10.1%		
Product:	101	tons/year	
	0.3	tons/day	
Control:	Sly Venturi Scrubber		
Control Efficiency:	95%		
	0.74	PM	
Particle Size Multipliers (k):	0.35	PM_{10}	AP-42 Section 13.2.4
	0.05	$PM_{2.5}$	

Pollutant	Emission Factor	Units	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lbs/hr)	PTE (tpy)
PM	180.00	lb/ton proc	AP-42, Table 8.12-3	3-05-150-02	9.09	0.11	0.45
PM_{10}	85.14	lb/ton proc	PM Emission Factor * (0.35/0.74)		4.30	0.05	0.21
$PM_{2.5}$	12.89	lb/ton proc	PM Emission Factor * (0.053/0.74)		0.65	0.01	0.03
CO2	400	lb/ton proc	AP-42, Table 8.12-4		20.2	5.05	20.2

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	PrimCrusher		
Equipment Description:	Physical Upgrading Primary Crusher		
Maximum Annual Throughput:	1000	tons/year	
Maximum Daily Throughput:	100	tons/day	
Max Crusher Capacity:	13	tons/hr	
Exploration Sample Moisture Content:	3	wt %	Personal communication with Jaye Pickarts 5/23/2022
Control:	Series 2000 CycloPlus Dust Collector		
Control Efficiency:	99%		
	0.74	PM	
Particle Size Multipliers (k):	0.35	PM_{10}	AP-42 Section 13.2.4
	0.053	$PM_{2.5}$	

	Low-moisture[a]					
Pollutant	Emission Factor (lb/ton)	Emission Factor Reference[b]	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lbs/hr)	PTE (tpy)
PM	0.5	AP-42 Table 11.24-2	3-03-024-01	0.25	0.07	0.003
PM10	0.05	AP-42 Table 11.24-2		0.03	0.01	0.0003
$PM_{2.5}$	0.008	PM_{10} Emission Factor * (0.053/0.35)		0.004	0.001	0.00004

a. High-moisture > 4% wt; low-moisture < 4% wt

b. Emission factors in Tables 11.24-1 and 11.24-2 for primary, secondary, and tertiary crushing operations are for process units that are typical arrangements (includes a hopper or ore dump, screen(s), crusher, surge bin, apron feeder, and conveyor belt transfer points).

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	SecCrusher		
Equipment Description:	Physical Upgrading Secondary Crusher		
Maximum Annual Throughput:	1000	tons/year	
Maximum Daily Throughput:	100	tons/day	
Max Crusher Capacity:	13	tons/hr	
Exploration Sample Moisture Content:	3	wt %	high-moisture > 4% wt; low-moisture < 4% wt
Control:	Series 2000 CycloPlus Dust Collector		
Control Efficiency:	99%		
	0.74	PM	
Particle Size Multipliers (k):	0.35	PM_{10}	AP-42 Section 13.2.4
	0.053	$PM_{2.5}$	

	Low-moisture						
Pollutant	Emission Factor	Units	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lbs/hr)	PTE (tpy)
PM	1.2	lb/ton	AP-42 Table 11.24-2	3-03-024-02	0.6	0.16	0.01
PM_{10}	0.57	lb/ton	PM Emission Factor * (0.35/0.74)		0.28	0.074	0.003
$PM_{2.5}$	0.09	lb/ton	PM Emission Factor * (0.053/0.74)		0.043	0.011	0.00043

a. High-moisture > 4% wt; low-moisture < 4% wt

b. Emission factors in Tables 11.24-1 and 11.24-2 for primary, secondary, and tertiary crushing operations are for process units that are typical arrangements (includes a hopper or ore dump, screen(s), crusher, surge bin, apron feeder, and conveyor belt transfer points).

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	BagFiller		
Equipment Description:	Bulk Bag Filler Hopper		
Maximum Annual Throughput:	1,000	tons/year	
Maximum Hourly Throughput:	20	tons/hour	Section 2.1.2.6 (RER, 2022a)
Mean Wind Speed (U):	9.4	mph	Met Data Summary (IML, 2021)
Maximum Wind Speed (U):	39.7	mph	Met Data Summary (IML, 2021)
Exploration Sample Moisture Content:	3	wt %	Personal communication with Jaye Pickarts 5/23/2022
Control:	Series 2000 CycloPlus Dust Collector		
Control efficiecy:	99%		

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/ton) at Max Wind Speed	Emission Factor (lb/ton) at Mean Wind Speed	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
PM	0.74	0.0198	0.0030	AP-42, 13.2.4, Equation 1	3-05-888-01	0.002	0.004	0.00002
PM_{10}	0.35	0.0094	0.0014			0.0007	0.0019	0.00001
$PM_{2.5}$	0.053	0.0014	0.0002			0.0001	0.0003	0.000001

$$E = k(0.0032) \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)}$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	110FH-101		
Equipment Description:	Primary Process Exploration Sample Feed Hopper		
Maximum Annual Throughput:	1000	tons/year	
Maximum Daily Throughput:	3	tons/day	
Max Hourly Throughput:	1.5	tons/hr	
Exploration Sample Moisture Content:	3	wt %	high-moisture > 4% wt; low-moisture < 4% wt
Control:	Flexicon Bulk Bag Station Dust Collector		
Control Efficiency:	99%		
	0.74	PM	
Particle Size Multipliers (k):	0.35	PM_{10}	AP-42 Section 13.2.4
	0.053	$PM_{2.5}$	

	Low-moisture						
Pollutant	Emission Factor	Units	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lbs/hr)	PTE (tpy)
PM	0.12	lb/ton	AP-42 Table 11.24-2	3-003-024-04	0.06	0.0018	0.0006
PM_{10}	0.06	lb/ton	AP-42 Table 11.24-2	3-003-024-04	0.03	0.0009	0.0003
$PM_{2.5}$	0.009	lb/ton	PM10 Emission Factor * (0.053/0.35)	3-003-024-04	0.0045	0.00014	0.00005

a. High-moisture > 4% wt; low-moisture < 4% wt

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:			
CSH007	560FH-101		
CSH008	560FH-102		
Equipment Description:	Oxalic Acid Feed Hoppers		
Maximum Annual Throughput:	400	tons/year	
560FH-101	280	tons/year	
560FH-102	120	tons/year	
Maximum Hourly Throughput:			
560FH-101	1	tons/hr	
560FH-102	1	tons/hr	
Control:	Flexicon Bulk Bag Station Dust Collector		
Control Efficiency:	99%		
Particle Size Multipliers (k):	0.74	PM	AP-42 Section 13.2.4
	0.35	PM_{10}	
	0.053	$PM_{2.5}$	
Emission Factors:			
PM	0.80	lb/ton	AP-42 Table 6.2-2
PM_{10}	0.38	lb/ton	PM Emission Factor * (0.35/0.74)
$PM_{2.5}$	0.06	lb/ton	PM Emission Factor * (0.053/0.74)

	Pre-Controlled Potential Emissions (tpy)			PTE (lbs/hr)			PTE (tpy)		
Unit	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
560FH-101	0.11	0.05	0.008	0.000004	0.000002	2.86E-07	0.001	0.0005	0.00008
560FH-102	0.05	0.02	0.003	0.000004	0.000002	2.86E-07	0.0005	0.0002	0.00003

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	540FH-101	
Equipment Description:	Lime Feed Hopper	
Maximum Annual Throughput:	80	tons/year
Maximum Hourly Throughput:	1	tons/hour
Control:	Flexicon Bulk Bag Station Dust Collector	
Control Efficiency:	99%	

Particle Size Multipliers (k):	0.74	PM	AP-42 Section 13.2.4
	0.35	PM_{10}	
	0.053	$PM_{2.5}$	

Emission Factors:

PM	2.2	lb/ton	AP-42 Table 11.17-4
PM_{10}	1.04	lb/ton	PM Emission Factor * (0.35/0.74)
$PM_{2.5}$	0.16	lb/ton	PM Emission Factor * (0.053/0.74)

	Pre-Controlled Potential Emissions (tpy)			PTE (lbs/hr)			PTE (tpy)		
Unit	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
540FH-101	0.09	0.04	0.01	0.00001	0.000005	0.000001	0.001	0.0004	0.00006

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Tailpipe Emissions		
Equipment Description:	Tailpipe Emissions		
Operating Schedule:	25	days/month	
Construction	10	months	
Operation	12	months	
Decomissioning	3	months	
BSFC for < 100 hp:	0.408	lb/hp-hr	EPA-420-R-21-021
BSFC for ≥ 100 hp:	0.367	lb/hp-hr	EPA-420-R-21-021
Density of Distillate Oil:	7.05	lb/gal	AP-42, Appendix A
Density of Gasoline:	6.17	lb/gal	AP-42, Appendix A
Diesel Fuel Sulfur Standard:	15	ppm	EPA-420-B-16-005
Gasoline Sulfur Standard:	30	ppm	EPA-420-B-16-004

Notes:
a. Nonroad I EPA-420-R-10-016, NR-005d
For highway vehicles diesel assumed to be 40% and gasoline 25%
b. NMOG is for passenger vehicles only.
c. With the exception of SO_2 and Aldehydes emission factors are taken from:
EPA-420-B-16-022 for nonroad equipment;
EPA-420-B-16-018 for heavy-duty highway compression-ignition engines;
EPA-420-B-16-019 for heavy-duty highway spark-ignition engines; and
EPA-420-B-17-028 for light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles.
d. SO2 emission factors calculated from fuel sulfur content and BSFC.
e. Aldehydes emission factor for diesel equipment is from AP-42 Table 3.3-1.
f. Total hourly emissions are overestimated since not all equipment will be running at the same time.
g. GHG emission factors from EPA's GHG Emission Factors Hub

	Construction PTE (lb/hr)								Construction PTE (tons)								Construction PTE (metric tons)			Construction PTE (tons)		
Source	VOC	NO_x	CO	SO_2	PM	PM_{10}	$PM_{2.5}$	HAPs	VOC	NO_x	CO	SO_2	PM	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Excavator	0.07	0.16	1.36	2.61E-03	7.80E-03	7.80E-03	7.80E-03	0.11	0.07	0.16	1.36	2.61E-03	7.80E-03	7.80E-03	7.80E-03	0.11	252.12	4.94E-03	4.94E-03	228.72	4.48E-03	4.48E-03
Front end loader	0.05	0.10	0.85	1.62E-03	4.85E-03	4.85E-03	4.85E-03	0.07	0.05	0.10	0.85	1.62E-03	4.85E-03	4.85E-03	4.85E-03	0.07	156.79	3.07E-03	3.07E-03	142.24	2.79E-03	2.79E-03
Backhoe	0.01	0.02	0.20	2.66E-04	7.94E-04	7.94E-04	7.94E-04	0.01	0.01	0.02	0.20	2.66E-04	7.94E-04	7.94E-04	7.94E-04	0.01	25.67	5.03E-04	5.03E-04	23.29	4.56E-04	4.56E-04
Skid steer	0.06	0.06	0.13	1.91E-04	7.70E-04	7.70E-04	7.70E-04	0.01	0.06	0.06	0.13	1.91E-04	7.70E-04	7.70E-04	7.70E-04	0.01	18.44	3.61E-04	3.61E-04	16.73	3.28E-04	3.28E-04
Crane	0.07	0.15	1.29	2.46E-03	7.35E-03	7.35E-03	7.35E-03	0.10	0.07	0.15	1.29	2.46E-03	7.35E-03	7.35E-03	7.35E-03	0.10	237.69	4.66E-03	4.66E-03	215.63	4.22E-03	4.22E-03
Dozer	0.04	0.08	0.73	1.40E-03	4.17E-03	4.17E-03	4.17E-03	0.06	0.04	0.08	0.73	1.40E-03	4.17E-03	4.17E-03	4.17E-03	0.06	134.84	2.64E-03	2.64E-03	122.33	2.40E-03	2.40E-03
Forklift	0.17	0.17	0.35	5.27E-04	2.12E-03	2.12E-03	2.12E-03	0.02	0.17	0.17	0.35	5.27E-04	2.12E-03	2.12E-03	2.12E-03	0.02	50.90	9.97E-04	9.97E-04	46.17	9.04E-04	9.04E-04
Manlift	0.04	0.04	0.09	1.26E-04	5.07E-04	5.07E-04	5.07E-04	0.005	0.04	0.04	0.09	1.26E-04	5.07E-04	5.07E-04	5.07E-04	0.005	12.16	2.38E-04	2.38E-04	11.03	2.16E-04	2.16E-04
Scissor Lift	0.03	0.03	0.06	6.43E-05	3.45E-03	3.45E-03	3.45E-03	0.002	0.03	0.03	0.06	6.43E-05	3.45E-03	3.45E-03	3.45E-03	0.002	6.20	1.22E-04	1.22E-04	5.63	1.10E-04	1.10E-04
Grader	0.03	0.07	0.58	1.12E-03	3.34E-03	3.34E-03	3.34E-03	0.05	0.03	0.07	0.58	1.12E-03	3.34E-03	3.34E-03	3.34E-03	0.05	107.87	2.11E-03	2.11E-03	97.86	1.92E-03	1.92E-03
Equipment Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	0.001	0.002	0.15	4.95E-05	9.92E-05	9.92E-05	9.92E-05	0.002	4.78	3.25E-07	3.25E-07	4.34	2.95E-07	2.95E-07
Exploration Sample Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrochloric Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitric Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonia Water Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxalic Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic Reactants Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfuric Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lime Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste Hauling Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pickup Truck	1.43E-04	1.47E-04	0.01	3.30E-03	1.47E-05	1.47E-05	1.47E-05	2.35E-05	1.79E-05	1.84E-05	6.71E-04	2.06E-04	1.84E-06	1.84E-06	1.84E-06	2.94E-06	9.79	1.00E-06	1.00E-06	8.88	9.07E-07	9.07E-07
Passenger Vehicle	1.72E-03	2.20E-03	0.05	3.30E-02	2.20E-04	2.20E-04	2.20E-04	1.98E-04	2.15E-04	2.76E-04	5.79E-03	2.06E-03	2.76E-05	2.76E-05	2.76E-05	2.48E-05	97.92	1.13E-05	1.13E-05	88.83	1.02E-05	1.02E-05
TOTAL	**0.63**	**0.95**	**11.85**	**0.05**	**0.04**	**0.04**	**0.04**	**0.52**	**0.57**	**0.87**	**5.80**	**0.01**	**0.04**	**0.04**	**0.04**	**0.44**	**1,115.18**	**0.02**	**0.02**	**1,011.68**	**0.02**	**0.02**

	Operation PTE (lb/hr)								Operation PTE (tons)								Operation PTE (metric tons)			Operation PTE (tons)		
Source	VOC	NO_x	CO	SO_2	PM	PM_{10}	$PM_{2.5}$	HAPs	VOC	NO_x	CO	SO_2	PM	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Excavator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Front end loader	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Backhoe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skid steer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dozer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forklift	0.17	0.17	0.35	5.27E-04	2.12E-03	2.12E-03	2.12E-03	1.99E-02	0.20	0.20	0.42	6.33E-04	2.55E-03	2.55E-03	2.55E-03	2.39E-02	61.08	1.20E-03	1.20E-03	55.41	1.09E-03	1.09E-03
Manlift	0.04	0.04	0.09	1.26E-04	5.07E-04	5.07E-04	5.07E-04	4.76E-03	0.05	0.05	0.11	1.51E-04	6.09E-04	6.09E-04	6.09E-04	5.72E-03	14.59	2.86E-04	2.86E-04	13.24	2.59E-04	2.59E-04
Scissor Lift	0.03	0.03	0.06	6.43E-05	3.45E-03	3.45E-03	3.45E-03	2.43E-03	0.04	0.04	0.07	7.71E-05	4.14E-03	4.14E-03	4.14E-03	2.92E-03	7.45	1.46E-04	1.46E-04	6.75	1.32E-04	1.32E-04
Grader	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exploration Sample Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	5.56E-03	7.94E-03	0.62	1.98E-04	3.97E-04	3.97E-04	3.97E-04	8.33E-03	19.13	8.99E-08	8.99E-08	17.36	8.15E-08	8.15E-08
Hydrochloric Acid Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	1.67E-03	2.38E-03	0.18	5.95E-05	1.19E-04	1.19E-04	1.19E-04	2.50E-03	5.74	4.80E-08	4.80E-08	5.21	4.36E-08	4.36E-08
Nitric Acid Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	3.33E-03	4.76E-03	0.37	1.19E-04	2.38E-04	2.38E-04	2.38E-04	5.00E-03	11.48	9.60E-08	9.60E-08	10.41	8.71E-08	8.71E-08
Ammonia Water Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	3.33E-03	4.76E-03	0.37	1.19E-04	2.38E-04	2.38E-04	2.38E-04	5.00E-03	11.48	9.60E-08	9.60E-08	10.41	8.71E-08	8.71E-08
Oxalic Acid Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	1.11E-03	1.59E-03	0.12	3.96E-05	7.94E-05	7.94E-05	7.94E-05	1.67E-03	3.83	3.32E-08	3.32E-08	3.47	3.02E-08	3.02E-08
Organic Reactants Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	5.00E-04	7.14E-04	0.06	1.78E-05	3.57E-05	3.57E-05	3.57E-05	7.50E-04	1.72	1.66E-08	1.66E-08	1.56	1.51E-08	1.51E-08
Sulfuric Acid Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	5.56E-05	7.94E-05	0.01	1.98E-06	3.97E-06	3.97E-06	3.97E-06	8.33E-05	0.19	1.85E-09	1.85E-09	0.17	1.68E-09	1.68E-09
Lime Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	2.22E-04	3.17E-04	0.02	7.93E-06	1.59E-05	1.59E-05	1.59E-05	3.33E-04	0.77	1.01E-08	1.01E-08	0.69	9.20E-09	9.20E-09
Waste Hauling Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	1.67E-02	2.38E-02	1.85	5.95E-04	1.19E-03	1.19E-03	1.19E-03	2.50E-02	57.40	9.60E-08	9.60E-08	52.07	8.71E-08	8.71E-08
Pickup Truck	1.43E-04	1.47E-04	0.01	3.30E-03	1.47E-05	1.47E-05	1.47E-05	2.35E-05	1.86E-05	1.91E-05	6.97E-04	2.48E-04	1.91E-06	1.91E-06	1.91E-06	3.06E-06	11.75	1.04E-06	1.04E-06	10.66	9.43E-07	9.43E-07
Passenger Vehicle	1.72E-03	2.20E-03	0.05	3.30E-02	2.20E-04	2.20E-04	2.20E-04	1.98E-04	2.24E-04	2.87E-04	6.02E-03	2.48E-03	2.87E-05	2.87E-05	2.87E-05	2.58E-05	117.51	1.17E-05	1.17E-05	106.60	1.06E-05	1.06E-05
MAX (hourly) TOTAL (annually)	**0.17**	**0.17**	**6.15**	**0.03**	**0.004**	**0.004**	**0.004**	**0.08**	**0.32**	**0.33**	**4.20**	**0.005**	**0.01**	**0.01**	**0.01**	**0.08**	**324.11**	**0.00**	**0.00**	**294.03**	**0.001**	**0.001**

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

Tailpipe Emission Calculations Cont.

	Decommissioning PTE (lb/hr)								Decommissioning PTE (tons)								Decommissioning PTE (metric tons)			Decommissioning PTE (tons)		
Source	VOC	NO_x	CO	SO_2	PM	PM_{10}	$PM_{2.5}$	HAPs	VOC	NO_x	CO	SO_2	PM	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Excavator	0.07	0.16	1.36	2.61E-03	7.80E-03	7.80E-03	7.80E-03	0.11	0.02	0.05	0.41	7.83E-04	2.34E-03	2.34E-03	2.34E-03	3.29E-02	75.64	1.48E-03	1.48E-03	68.62	1.34E-03	1.34E-03
Front end loader	0.05	0.10	0.85	1.62E-03	4.85E-03	4.85E-03	4.85E-03	0.07	0.01	0.03	0.25	4.87E-04	1.45E-03	1.45E-03	1.45E-03	2.05E-02	47.04	9.21E-04	9.21E-04	42.67	8.36E-04	8.36E-04
Backhoe	0.01	0.02	0.20	2.66E-04	7.94E-04	7.94E-04	7.94E-04	0.01	0.00	0.00	0.06	7.98E-05	2.38E-04	2.38E-04	2.38E-04	3.35E-03	7.70	1.51E-04	1.51E-04	6.99	1.37E-04	1.37E-04
Skid steer	0.06	0.06	0.13	1.91E-04	7.70E-04	7.70E-04	7.70E-04	0.01	0.02	0.02	0.04	5.73E-05	2.31E-04	2.31E-04	2.31E-04	2.17E-03	5.53	1.08E-04	1.08E-04	5.02	9.83E-05	9.83E-05
Crane	0.07	0.15	1.29	2.46E-03	7.35E-03	7.35E-03	7.35E-03	0.10	0.02	0.04	0.39	7.39E-04	2.21E-03	2.21E-03	2.21E-03	3.11E-02	71.31	1.40E-03	1.40E-03	64.69	1.27E-03	1.27E-03
Dozer	0.04	0.08	0.73	1.40E-03	4.17E-03	4.17E-03	4.17E-03	0.06	0.01	0.03	0.22	4.19E-04	1.25E-03	1.25E-03	1.25E-03	1.76E-02	40.45	7.92E-04	7.92E-04	36.70	7.19E-04	7.19E-04
Forklift	0.17	0.17	0.35	5.27E-04	2.12E-03	2.12E-03	2.12E-03	0.02	0.05	0.05	0.11	1.58E-04	6.37E-04	6.37E-04	6.37E-04	5.98E-03	15.27	2.99E-04	2.99E-04	13.85	2.71E-04	2.71E-04
Manlift	0.04	0.04	0.09	1.26E-04	5.07E-04	5.07E-04	5.07E-04	0.005	0.01	0.01	0.03	3.78E-05	1.52E-04	1.52E-04	1.52E-04	1.43E-03	3.65	7.15E-05	7.15E-05	3.31	6.48E-05	6.48E-05
Scissor Lift	0.03	0.03	0.06	6.43E-05	3.45E-03	3.45E-03	3.45E-03	0.002	0.01	0.01	0.02	1.93E-05	1.04E-03	1.04E-03	1.04E-03	7.29E-04	1.86	3.65E-05	3.65E-05	1.69	3.31E-05	3.31E-05
Grader	0.03	0.07	0.58	1.12E-03	3.34E-03	3.34E-03	3.34E-03	0.05	0.01	0.02	0.18	3.35E-04	1.00E-03	1.00E-03	1.00E-03	1.41E-02	32.36	6.34E-04	6.34E-04	29.36	5.75E-04	5.75E-04
Equipment Delivery Trucks	0.06	0.08	6.15	1.98E-03	3.97E-03	3.97E-03	3.97E-03	0.08	0.00	0.00	0.15	4.95E-05	9.92E-05	9.92E-05	9.92E-05	2.08E-03	4.78	3.25E-07	3.25E-07	4.34	2.95E-07	2.95E-07
Exploration Sample Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrochloric Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitric Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonia Water Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxalic Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic Reactants Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfuric Acid Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lime Delivery Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste Hauling Trucks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pickup Truck	1.43E-04	1.47E-04	0.01	3.30E-03	1.47E-05	1.47E-05	1.47E-05	2.35E-05	5.37E-06	5.51E-06	2.01E-04	6.19E-05	5.51E-07	5.51E-07	5.51E-07	8.82E-07	2.94	3.00E-07	3.00E-07	2.66	2.72E-07	2.72E-07
Passenger Vehicle	1.72E-03	2.20E-03	0.05	3.30E-02	2.20E-04	2.20E-04	2.20E-04	1.98E-04	6.45E-05	8.27E-05	1.74E-03	6.19E-04	8.27E-06	8.27E-06	8.27E-06	7.44E-06	29.38	3.38E-06	3.38E-06	26.65	3.06E-06	3.06E-06
TOTAL	**0.63**	**0.95**	**11.85**	**0.05**	**0.04**	**0.04**	**0.04**	**0.52**	**0.17**	**0.26**	**1.85**	**0.004**	**0.01**	**0.01**	**0.01**	**0.13**	**337.90**	**0.01**	**0.01**	**306.54**	**0.01**	**0.01**

										Operating Schedule (hrs/day)			Total Operating Hours				Total VMT			Fuel Consumption (gallons)		
Source	Brand	Model	HP	kW	Model Year	Load Factor[a]	Fuel	Tier	Number of Units	Const.	Op.	Decom.	Const.	Op.	Decom.	mi/unit-trip	Const.	Op.	Decom.	Const.	Op.	Decom.
Excavator	CAT	326 Hydrau	201	150	2014+	59%	Diesel	Tier 4	2	8	-	8	4,000	-	1,200		-	-	-	24,694	-	7,408
Front end loader	CAT	950M	250	186	2014+	59%	Diesel	Tier 4	1	8	-	8	2,000	-	600		-	-	-	15,357	-	4,607
Backhoe	CAT	430	115	86	2014+	21%	Diesel	Tier 4	1	8	-	8	2,000	-	600		-	-	-	2,514	-	754
Skid steer	CAT	246D3	74.3	55	2013+	21%	Diesel	Tier 4	1	8	-	8	2,000	-	600		-	-	-	1,806	-	542
Crane	Grove	RT765E-2	260	194	2014+	43%	Diesel	Tier 4	2	8	-	8	4,000	-	1,200		800	-	240	23,280	-	6,984
Dozer	CAT	D6	215	160	2014+	59%	Diesel	Tier 4	1	8	-	8	2,000	-	600		-	-	-	13,207	-	3,962
Forklift	CAT	DP40N3	73	54	2013+	59%	Diesel	Tier 4	1	8	8	8	2,000	2,400	600		4,000	75	1,200	4,985	5,982	1,496
Manlift	JLG	450A	49	37	2013+	21%	Diesel	Tier 4	1	8	8	8	2,000	2,400	600		400	48	120	1,191	1,429	357
Scissor Lift	JLG	RT3369	25	19	2008+	21%	Diesel	Tier 4	1	8	8	8	2,000	2,400	600		400	48	120	608	729	182
Grader	CAT	120GC	172	128	2014+	59%	Diesel	Tier 4	1	8	-	8	2,000	-	600		10,000	-	3,000	10,565	-	3,170
Equipment Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	25	2	-	2	50	-	50		25	-	25	469	-	469
Exploration Sample Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	4	-	2	-	-	200	-		-	7	-	-	1,874	-
Hydrochloric Acid Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	1	-	2	-	-	60	-		-	4	-	-	562	-
Nitric Acid Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	2	-	2	-	-	120	-		-	7	-	-	1,124	-
Ammonia Water Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	2	-	2	-	-	120	-		-	7	-	-	1,124	-
Oxalic Acid Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	1	-	2	-	-	40	-		-	3	-	-	375	-
Organic Reactants Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	3	-	2	-	-	18	-		-	1	-	-	169	-
Sulfuric Acid Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	1	-	2	-	-	2	-		-	0	-	-	19	-
Lime Delivery Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	4	-	2	-	-	8	-		-	1	-	-	75	-
Waste Hauling Trucks	N/A	N/A	450	336	2007+	40%	Diesel	N/A	1	-	2	-	-	600	-		-	7	-	-	5,622	-
Pickup Truck	N/A	N/A	300	224	2008+	25%	Gasoline	N/A	2	0.5	0.5	0.5	250	300	75	0.17	83	87	25	1,115	1,338	335
Passenger Vehicle	N/A	N/A	200	149	Bin 8	25%	Gasoline	Tier 2	30	0.5	0.5	0.5	3,750	4,500	1,125	0.17	1,250	1,300	375	11,153	13,383	3,346

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

Source	Emission Factor (s)				Emissions (lb/hr)			Emissions (tons)		
	NMHC/ NMOG[a]	NMHC + NO_x	VOC[b]	Units	Const.	Op.	Decom.	Const.	Op.	Decom.
Excavator	0.19	-	0.19	g/kW-hr	0.07	-	0.07	0.07	-	0.02
Front end loader	0.19	-	0.19	g/kW-hr	0.05	-	0.05	0.05	-	0.01
Backhoe	0.19	-	0.19	g/kW-hr	0.01	-	0.01	0.01	-	0.002
Skid steer	-	4.7	2.35	g/kW-hr	0.06	-	0.06	0.06	-	0.02
Crane	0.19	-	0.19	g/kW-hr	0.07	-	0.07	0.07	-	0.02
Dozer	0.19	-	0.19	g/kW-hr	0.04	-	0.04	0.04	-	0.01
Forklift	-	4.7	2.35	g/kW-hr	0.17	0.17	0.17	0.17	0.20	0.05
Manlift	-	4.7	2.35	g/kW-hr	0.04	0.04	0.04	0.04	0.05	0.01
Scissor Lift	-	7.5	3.75	g/kW-hr	0.03	0.03	0.03	0.03	0.04	0.01
Grader	0.19	-	0.19	g/kW-hr	0.03	-	0.03	0.03	-	0.01
Equipment Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	0.06	-	0.06	0.001	-	0.001
Exploration Sample Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.01	-
Hydrochloric Acid Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.002	-
Nitric Acid Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.003	-
Ammonia Water Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.003	-
Oxalic Acid Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.001	-
Organic Reactants Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.001	-
Sulfuric Acid Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.0001	-
Lime Delivery Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.0002	-
Waste Hauling Trucks	0.14	2.4	0.14	g/bhp-hr	-	0.06	-	-	0.02	-
Pickup Truck	0.195	-	0.195	g/VMT	1.43E-04	1.43E-04	1.43E-04	1.79E-05	1.86E-05	5.37E-06
Passenger Vehicle	0.156	-	0.156	g/VMT	1.72E-03	1.72E-03	1.72E-03	2.15E-04	2.24E-04	6.45E-05

a. NMOG is for passenger vehicles only.
b. All NMHC and NMOG assumed to be VOC. Where NMHC/NMOG emission factor was unavailable VOC emission factor assumed to be one half of NMHC + NO_x emission factor.

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

Source	Emission Factor(s)			Emissions (lb/hr)			Emissions (tons)		
	NMHC + NO_x	NO_x[a]	Units	Const.	Op.	Decom.	Const.	Op.	Decom.
Excavator	-	0.40	g/kW-hr	0.16	-	0.16	0.16	-	0.05
Front end loader	-	0.40	g/kW-hr	0.10	-	0.10	0.10	-	0.03
Backhoe	-	0.40	g/kW-hr	0.02	-	0.02	0.02	-	0.00
Skid steer	4.7	2.35	g/kW-hr	0.06	-	0.06	0.06	-	0.02
Crane	-	0.40	g/kW-hr	0.15	-	0.15	0.15	-	0.04
Dozer	-	0.40	g/kW-hr	0.08	-	0.08	0.08	-	0.03
Forklift	4.7	2.35	g/kW-hr	0.17	0.17	0.17	0.17	0.20	0.05
Manlift	4.7	2.35	g/kW-hr	0.04	0.04	0.04	0.04	0.05	0.01
Scissor Lift	7.5	3.75	g/kW-hr	0.03	0.03	0.03	0.03	0.04	0.01
Grader	-	0.40	g/kW-hr	0.07	-	0.07	0.07	-	0.02
Equipment Delivery Trucks	2.4	0.20	g/bhp-hr	0.08	-	0.08	0.002	-	0.002
Exploration Sample Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.008	-
Hydrochloric Acid Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.002	-
Nitric Acid Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.005	-
Ammonia Water Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.005	-
Oxalic Acid Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.002	-
Organic Reactants Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.001	-
Sulfuric Acid Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.0001	-
Lime Delivery Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.0003	-
Waste Hauling Trucks	2.4	0.20	g/bhp-hr	-	0.08	-	-	0.024	-
Pickup Truck	-	0.20	g/VMT	1.47E-04	1.47E-04	1.47E-04	1.84E-05	1.91E-05	5.51E-06
Passenger Vehicle	-	0.20	g/VMT	2.20E-03	2.20E-03	2.20E-03	2.76E-04	2.87E-04	8.27E-05

a. Where NO_x emission factor was unavailable NO_x emission factor assumed to be one half of NMHC + NOx emission factor.

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

	Emission Factor(s)		Emissions (lb/hr)			Emissions (tons)		
Source	CO	Units	Const.	Op.	Decom.	Const.	Op.	Decom.
Excavator	3.5	g/kW-hr	1.36	-	1.36	1.36	-	0.41
Front end loader	3.5	g/kW-hr	0.85	-	0.85	0.85	-	0.25
Backhoe	5.0	g/kW-hr	0.20	-	0.20	0.20	-	0.06
Skid steer	5.0	g/kW-hr	0.13	-	0.13	0.13	-	0.04
Crane	3.5	g/kW-hr	1.29	-	1.29	1.29	-	0.39
Dozer	3.5	g/kW-hr	0.73	-	0.73	0.73	-	0.22
Forklift	5.0	g/kW-hr	0.35	0.35	0.35	0.35	0.42	0.11
Manlift	5.5	g/kW-hr	0.09	0.09	0.09	0.09	0.11	0.03
Scissor Lift	6.6	g/kW-hr	0.06	0.06	0.06	0.06	0.07	0.02
Grader	3.5	g/kW-hr	0.58	-	0.58	0.58	-	0.18
Equipment Delivery Trucks	15.5	g/bhp-hr	6.15	-	6.15	0.154	-	0.154
Exploration Sample Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.615	-
Hydrochloric Acid Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.185	-
Nitric Acid Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.369	-
Ammonia Water Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.369	-
Oxalic Acid Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.123	-
Organic Reactants Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.055	-
Sulfuric Acid Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.006	-
Lime Delivery Trucks	15.5	g/bhp-hr	-	6.15	-	-	0.025	-
Waste Hauling Trucks	15.5	g/bhp-hr	-	6.15	-	-	1.845	-
Pickup Truck	7.3	g/VMT	5.36E-03	5.36E-03	5.36E-03	6.71E-04	6.97E-04	2.01E-04
Passenger Vehicle	4.2	g/VMT	4.63E-02	4.63E-02	4.63E-02	5.79E-03	6.02E-03	1.74E-03

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

	Emission Factor(s)		Emissions (lb/hr)			Emissions (tons)		
Source	SO_2	Units	Const.	Op.	Decom.	Const.	Op.	Decom.
Excavator	0.005	g/hp-hr	2.61E-03	-	2.61E-03	2.61E-03	-	7.83E-04
Front end loader	0.005	g/hp-hr	1.62E-03	-	1.62E-03	1.62E-03	-	4.87E-04
Backhoe	0.005	g/hp-hr	2.66E-04	-	2.66E-04	2.66E-04	-	7.98E-05
Skid steer	0.006	g/hp-hr	1.91E-04	-	1.91E-04	1.91E-04	-	5.73E-05
Crane	0.005	g/hp-hr	2.46E-03	-	2.46E-03	2.46E-03	-	7.39E-04
Dozer	0.005	g/hp-hr	1.40E-03	-	1.40E-03	1.40E-03	-	4.19E-04
Forklift	0.006	g/hp-hr	5.27E-04	5.27E-04	5.27E-04	5.27E-04	6.33E-04	1.58E-04
Manlift	0.006	g/hp-hr	1.26E-04	1.26E-04	1.26E-04	1.26E-04	1.51E-04	3.78E-05
Scissor Lift	0.006	g/hp-hr	6.43E-05	6.43E-05	6.43E-05	6.43E-05	7.71E-05	1.93E-05
Grader	0.005	g/hp-hr	1.12E-03	-	1.12E-03	1.12E-03	-	3.35E-04
Equipment Delivery Trucks	0.005	g/hp-hr	1.98E-03	-	1.98E-03	4.95E-05	-	4.95E-05
Exploration Sample Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	1.98E-04	-
Hydrochloric Acid Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	5.95E-05	-
Nitric Acid Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	1.19E-04	-
Ammonia Water Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	1.19E-04	-
Oxalic Acid Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	3.96E-05	-
Organic Reactants Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	1.78E-05	-
Sulfuric Acid Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	1.98E-06	-
Lime Delivery Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	7.93E-06	-
Waste Hauling Trucks	0.005	g/hp-hr	-	1.98E-03	-	-	5.95E-04	-
Pickup Truck	0.010	g/hp-hr	3.30E-03	3.30E-03	3.30E-03	2.06E-04	2.48E-04	6.19E-05
Passenger Vehicle	0.010	g/hp-hr	3.30E-02	3.30E-02	3.30E-02	2.06E-03	2.48E-03	6.19E-04

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

	Emission Factor(s)		Emissions (lb/hr)			Emissions (tons)		
Source	PM	Units	Const.	Op.	Decom.	Const.	Op.	Decom.
Excavator	0.02	g/kW-hr	7.80E-03	-	7.80E-03	7.80E-03	-	2.34E-03
Front end loader	0.02	g/kW-hr	4.85E-03	-	4.85E-03	4.85E-03	-	1.45E-03
Backhoe	0.02	g/kW-hr	7.94E-04	-	7.94E-04	7.94E-04	-	2.38E-04
Skid steer	0.03	g/kW-hr	7.70E-04	-	7.70E-04	7.70E-04	-	2.31E-04
Crane	0.02	g/kW-hr	7.35E-03	-	7.35E-03	7.35E-03	-	2.21E-03
Dozer	0.02	g/kW-hr	4.17E-03	-	4.17E-03	4.17E-03	-	1.25E-03
Forklift	0.03	g/kW-hr	2.12E-03	2.12E-03	2.12E-03	2.12E-03	2.55E-03	6.37E-04
Manlift	0.03	g/kW-hr	5.07E-04	5.07E-04	5.07E-04	5.07E-04	6.09E-04	1.52E-04
Scissor Lift	0.40	g/kW-hr	3.45E-03	3.45E-03	3.45E-03	3.45E-03	4.14E-03	1.04E-03
Grader	0.02	g/kW-hr	3.34E-03	-	3.34E-03	3.34E-03	-	1.00E-03
Equipment Delivery Trucks	0.01	g/bhp-hr	3.97E-03	-	3.97E-03	9.92E-05	-	9.92E-05
Exploration Sample Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	3.97E-04	-
Hydrochloric Acid Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	1.19E-04	-
Nitric Acid Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	2.38E-04	-
Ammonia Water Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	2.38E-04	-
Oxalic Acid Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	7.94E-05	-
Organic Reactants Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	3.57E-05	-
Sulfuric Acid Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	3.97E-06	-
Lime Delivery Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	1.59E-05	-
Waste Hauling Trucks	0.01	g/bhp-hr	-	3.97E-03	-	-	1.19E-03	-
Pickup Truck	0.02	g/VMT	1.47E-05	1.47E-05	1.47E-05	1.84E-06	1.91E-06	5.51E-07
Passenger Vehicle	0.02	g/VMT	2.20E-04	2.20E-04	2.20E-04	2.76E-05	2.87E-05	8.27E-06

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

	Emission Factor(s)		Emissions (lb/hr)			Emissions (tons)		
Source	Formaldehyde	Units	Const.	Op.	Decom.	Const.	Op.	Decom.
Excavator	4.63E-04	lb/hp-hr	0.11	-	0.11	0.11	-	0.03
Front end loader	4.63E-04	lb/hp-hr	0.07	-	0.07	0.07	-	0.02
Backhoe	4.63E-04	lb/hp-hr	0.01	-	0.01	0.01	-	0.003
Skid steer	4.63E-04	lb/hp-hr	0.01	-	0.01	0.01	-	0.002
Crane	4.63E-04	lb/hp-hr	0.10	-	0.10	0.10	-	0.03
Dozer	4.63E-04	lb/hp-hr	0.06	-	0.06	0.06	-	0.02
Forklift	4.63E-04	lb/hp-hr	0.02	0.02	0.02	0.02	0.02	0.01
Manlift	4.63E-04	lb/hp-hr	0.005	0.005	0.005	0.005	0.01	0.001
Scissor Lift	4.63E-04	lb/hp-hr	0.002	0.002	0.002	0.002	0.003	0.001
Grader	4.63E-04	lb/hp-hr	0.05	-	0.05	0.05	-	0.01
Equipment Delivery Trucks	4.63E-04	lb/hp-hr	0.08	-	0.08	0.00	-	0.002
Exploration Sample Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.01	-
Hydrochloric Acid Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.003	-
Nitric Acid Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.01	-
Ammonia Water Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.01	-
Oxalic Acid Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.002	-
Organic Reactants Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.001	-
Sulfuric Acid Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.0001	-
Lime Delivery Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.0003	-
Waste Hauling Trucks	4.63E-04	lb/hp-hr	-	0.08	-	-	0.03	-
Pickup Truck	0.032	g/VMT	2.35E-05	2.35E-05	2.35E-05	2.94E-06	3.06E-06	8.82E-07
Passenger Vehicle	0.018	g/VMT	1.98E-04	1.98E-04	1.98E-04	2.48E-05	2.58E-05	7.44E-06

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

Source	Emission Factor(s)		Emissions (metric tons)		
	CO_2	Units	Const.	Op.	Decom.
Excavator	10.21	kg/gallon	252.12	-	75.64
Front end loader	10.21	kg/gallon	156.79	-	47.04
Backhoe	10.21	kg/gallon	25.67	-	7.70
Skid steer	10.21	kg/gallon	18.44	-	5.53
Crane	10.21	kg/gallon	237.69	-	71.31
Dozer	10.21	kg/gallon	134.84	-	40.45
Forklift	10.21	kg/gallon	50.90	61.08	15.27
Manlift	10.21	kg/gallon	12.16	14.59	3.65
Scissor Lift	10.21	kg/gallon	6.20	7.45	1.86
Grader	10.21	kg/gallon	107.87	-	32.36
Equipment Delivery Trucks	10.21	kg/gallon	4.78	-	4.78
Exploration Sample Delivery Trucks	10.21	kg/gallon	-	19.13	-
Hydrochloric Acid Delivery Trucks	10.21	kg/gallon	-	5.74	-
Nitric Acid Delivery Trucks	10.21	kg/gallon	-	11.48	-
Ammonia Water Delivery Trucks	10.21	kg/gallon	-	11.48	-
Oxalic Acid Delivery Trucks	10.21	kg/gallon	-	3.83	-
Organic Reactants Delivery Trucks	10.21	kg/gallon	-	1.72	-
Sulfuric Acid Delivery Trucks	10.21	kg/gallon	-	0.19	-
Lime Delivery Trucks	10.21	kg/gallon	-	0.77	-
Waste Hauling Trucks	10.21	kg/gallon	-	57.40	-
Pickup Truck	8.78	kg/gallon	9.79	11.75	2.94
Passenger Vehicle	8.78	kg/gallon	97.92	117.51	29.38

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

Source	Emission Factor(s)		Emissions (metric tons)		
	CH_4	Units	Const.	Op.	Decom.
Excavator	0.20	g/gallon	4.94E-03	-	1.48E-03
Front end loader	0.20	g/gallon	3.07E-03	-	9.21E-04
Backhoe	0.20	g/gallon	5.03E-04	-	1.51E-04
Skid steer	0.20	g/gallon	3.61E-04	-	1.08E-04
Crane	0.20	g/gallon	4.66E-03	-	1.40E-03
Dozer	0.20	g/gallon	2.64E-03	-	7.92E-04
Forklift	0.20	g/gallon	9.97E-04	1.20E-03	2.99E-04
Manlift	0.20	g/gallon	2.38E-04	2.86E-04	7.15E-05
Scissor Lift	0.20	g/gallon	1.22E-04	1.46E-04	3.65E-05
Grader	0.20	g/gallon	2.11E-03	-	6.34E-04
Equipment Delivery Trucks	0.013	g/VMT	3.25E-07	-	3.25E-07
Exploration Sample Delivery Trucks	0.013	g/VMT	-	8.99E-08	-
Hydrochloric Acid Delivery Trucks	0.013	g/VMT	-	4.80E-08	-
Nitric Acid Delivery Trucks	0.013	g/VMT	-	9.60E-08	-
Ammonia Water Delivery Trucks	0.013	g/VMT	-	9.60E-08	-
Oxalic Acid Delivery Trucks	0.013	g/VMT	-	3.32E-08	-
Organic Reactants Delivery Trucks	0.013	g/VMT	-	1.66E-08	-
Sulfuric Acid Delivery Trucks	0.013	g/VMT	-	1.85E-09	-
Lime Delivery Trucks	0.013	g/VMT	-	1.01E-08	-
Waste Hauling Trucks	0.013	g/VMT	-	9.60E-08	-
Pickup Truck	0.012	g/VMT	1.00E-06	1.04E-06	3.00E-07
Passenger Vehicle	0.009	g/VMT	1.13E-05	1.17E-05	3.38E-06

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project
Tailpipe Emission Calculations Cont.

Source	Emission Factor(s)		Emissions (metric tons)		
	N_2O	Units	Const.	Op.	Decom.
Excavator	0.20	g/gallon	4.94E-03	-	1.48E-03
Front end loader	0.20	g/gallon	3.07E-03	-	9.21E-04
Backhoe	0.20	g/gallon	5.03E-04	-	1.51E-04
Skid steer	0.20	g/gallon	3.61E-04	-	1.08E-04
Crane	0.20	g/gallon	4.66E-03	-	1.40E-03
Dozer	0.20	g/gallon	2.64E-03	-	7.92E-04
Forklift	0.20	g/gallon	9.97E-04	1.20E-03	2.99E-04
Manlift	0.20	g/gallon	2.38E-04	2.86E-04	7.15E-05
Scissor Lift	0.20	g/gallon	1.22E-04	1.46E-04	3.65E-05
Grader	0.20	g/gallon	2.11E-03	-	6.34E-04
Equipment Delivery Trucks	0.013	g/VMT	3.25E-07	-	3.25E-07
Exploration Sample Delivery Trucks	0.013	g/VMT	-	8.99E-08	-
Hydrochloric Acid Delivery Trucks	0.013	g/VMT	-	4.80E-08	-
Nitric Acid Delivery Trucks	0.013	g/VMT	-	9.60E-08	-
Ammonia Water Delivery Trucks	0.013	g/VMT	-	9.60E-08	-
Oxalic Acid Delivery Trucks	0.013	g/VMT	-	3.32E-08	-
Organic Reactants Delivery Trucks	0.013	g/VMT	-	1.66E-08	-
Sulfuric Acid Delivery Trucks	0.013	g/VMT	-	1.85E-09	-
Lime Delivery Trucks	0.013	g/VMT	-	1.01E-08	-
Waste Hauling Trucks	0.013	g/VMT	-	9.60E-08	-
Pickup Truck	0.012	g/VMT	1.00E-06	1.04E-06	3.00E-07
Passenger Vehicle	0.009	g/VMT	1.13E-05	1.17E-05	3.38E-06

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Haul Roads		Precipitation Days (P)	100	WY-AQD PRB Permitting Guidance (February 2018) - Typical for PRB
Equipment Description:	Haul Roads		Silt Content of Road (s)	8.6	WY-AQD PRB Permitting Guidance (February 2018) - Typical for PRB
Operating Schedule	25	days/month	N	365	
Construction	7	months			
Operation	12	months			
Decomissioning	3	months			

Equipment	One-way Distance (ft) Unpaved	One-way Distance (ft) Paved	Mean Vehicle Weight (tons)	Number of Units	Roundtrip Distance (mi) Unpaved	Roundtrip Distance (mi) Paved	Throughput	Load Size	Units	vehicle trips/ year	Annual VMT Unpaved	Annual VMT Paved	Emission Factors (lb/VMT) Unpaved PM	Unpaved PM_{10}	Unpaved $PM_{2.5}$	Paved PM	Paved PM_{10}	Paved $PM_{2.5}$
Exploration Sample Delivery Trucks	365	0	30	4	0.14	-	1,000	20	Tons	50	7	-	7.94	2.27	0.23	2.33	0.47	0.11
Hydrochloric Acid Delivery Trucks	375	0	30	1	0.14	-	162,396	6,246	gallons	26	4	-	7.94	2.27	0.23	2.33	0.47	0.11
Nitric Acid Delivery Trucks	375	0	30	2	0.14	-	241,693	4,648	gallons	52	7	-	7.94	2.27	0.23	2.33	0.47	0.11
Ammonia Water Delivery Trucks	375	0	30	2	0.14	-	301,650	5,801	gallons	52	7	-	7.94	2.27	0.23	2.33	0.47	0.11
Oxalic Acid Delivery Trucks	375	0	30	1	0.14	-	400	23	Tons	18	3	-	7.94	2.27	0.23	2.33	0.47	0.11
Organic Reactants Delivery Trucks	375	0	30	3	0.14	-	N/A	N/A	N/A	9	1	-	7.94	2.27	0.23	2.33	0.47	0.11
Sulfuric Acid Delivery Trucks	375	0	30	1	0.14	-	N/A	N/A	N/A	1	0	-	7.94	2.27	0.23	2.33	0.47	0.11
Lime Delivery Trucks	380	135	30	4	0.14	0.05	80	20	tons	4	1	0.20	7.94	2.27	0.23	2.33	0.47	0.11
Waste Hauling Trucks	375	0	40	1	0.14	-	N/A	30	Tons	52	7	-	9.04	2.59	0.26	3.13	0.63	0.15
Pickup Truck	440	0	5	2	0.17	-	N/A	N/A	N/A	520	87	-	3.55	1.02	0.10	0.37	0.07	0.02
Passenger Vehicle	440	0	3	30	0.17	-	N/A	N/A	N/A	7,800	1,300	-	2.82	0.81	0.08	0.22	0.04	0.01
Forklift	0	165	5	1	-	0.06	N/A	N/A	N/A	1,200	-	75	3.55	1.02	0.10	0.37	0.07	0.02
Manlift	N/A	N/A	7	1	N/A	N/A	2,400	1%	mi/transit duty	N/A	-	48	4.15	1.19	0.12	0.53	0.11	0.03
Scissor Lift	N/A	N/A	5	1	N/A	N/A	2,400	1%	mi/transit duty	N/A	-	48	3.46	0.99	0.10	0.35	0.07	0.02

Equipment	Max PTE (lb/hr) Unpaved PM	Unpaved PM_{10}	Unpaved $PM_{2.5}$	Paved PM	Paved PM_{10}	Paved $PM_{2.5}$	Total PM	Total PM_{10}	Total $PM_{2.5}$	PTE (tons/yr) Unpaved PM	Unpaved PM_{10}	Unpaved $PM_{2.5}$	Paved PM	Paved PM_{10}	Paved $PM_{2.5}$	Total PM	Total PM_{10}	Total $PM_{2.5}$
Exploration Sample Delivery Trucks	0.55	0.16	0.02	-	-	-	0.55	0.16	0.02	2.74E-02	7.86E-03	7.86E-04	-	-	-	2.74E-02	7.86E-03	7.86E-04
Hydrochloric Acid Delivery Trucks	0.56	0.16	0.02	-	-	-	0.56	0.16	0.02	1.47E-02	4.20E-03	4.20E-04	-	-	-	1.47E-02	4.20E-03	4.20E-04
Nitric Acid Delivery Trucks	0.56	0.16	0.02	-	-	-	0.56	0.16	0.02	2.93E-02	8.40E-03	8.40E-04	-	-	-	2.93E-02	8.40E-03	8.40E-04
Ammonia Water Delivery Trucks	0.56	0.16	0.02	-	-	-	0.56	0.16	0.02	2.93E-02	8.40E-03	8.40E-04	-	-	-	2.93E-02	8.40E-03	8.40E-04
Oxalic Acid Delivery Trucks	0.56	0.16	0.02	-	-	-	0.56	0.16	0.02	1.02E-02	2.91E-03	2.91E-04	-	-	-	1.02E-02	2.91E-03	2.91E-04
Organic Reactants Delivery Trucks	0.56	0.16	0.02	-	-	-	0.56	0.16	0.02	5.08E-03	1.45E-03	1.45E-04	-	-	-	5.08E-03	1.45E-03	1.45E-04
Sulfuric Acid Delivery Trucks	0.56	0.16	0.02	-	-	-	0.56	0.16	0.02	5.64E-04	1.62E-04	1.62E-05	-	-	-	5.64E-04	1.62E-04	1.62E-05
Lime Delivery Trucks	0.57	0.16	0.02	0.06	0.01	0.003	0.63	0.18	0.02	2.29E-03	6.55E-04	6.55E-05	2.38E-04	4.77E-05	1.17E-05	2.52E-03	7.02E-04	7.72E-05
Waste Hauling Trucks	0.64	0.18	0.02	-	-	-	0.64	0.18	0.02	3.34E-02	9.56E-03	9.56E-04	-	-	-	3.34E-02	9.56E-03	9.56E-04
Pickup Truck	0.59	0.17	0.02	-	-	-	0.59	0.17	0.02	0.15	0.04	0.00	-	-	-	0.15	0.04	0.00
Passenger Vehicle	7.04	2.02	0.20	-	-	-	7.04	2.02	0.20	1.83	0.52	0.05	-	-	-	1.83	0.52	0.05
Forklift	-	-	-	2.34E-02	4.69E-03	1.15E-03	2.34E-02	4.69E-03	1.15E-03	-	-	-	1.41E-02	2.81E-03	6.90E-04	1.41E-02	2.81E-03	6.90E-04
Manlift	-	-	-	2.93E-03	5.85E-04	1.44E-04	2.93E-03	5.85E-04	1.44E-04	-	-	-	1.28E-02	2.56E-03	6.29E-04	1.28E-02	2.56E-03	6.29E-04
Scissor Lift	-	-	-	1.94E-03	3.88E-04	9.53E-05	1.94E-03	3.88E-04	9.53E-05	-	-	-	8.50E-03	1.70E-03	4.17E-04	8.50E-03	1.70E-03	4.17E-04
MAX (hourly) TOTAL (annually)	**7.04**	**2.02**	**0.20**	**0.06**	**0.01**	**0.00**	**7.04**	**2.02**	**0.20**	**2.14**	**0.61**	**0.06**	**0.04**	**0.01**	**0.002**	**2.17**	**0.62**	**0.06**

Unpaved Roads — AP-42 13.2.2 Equation 1a and 2

$E = k (s/12)^a (W/3)^b [(365-P)/365]$

Where:

k = particle size multiplier

E = size-specific emission factor (lb/VMT)

s = surface material silt content %

W = mean vehicle weight (tons)

P = number of days in a year with at least 0.01 in of precipitation

Pollutant	PM	PM_{10}	$PM_{2.5}$
k (lb/VMT)	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

Source: AP-42 Table 13.2.2-2 Industrial Roads

Paved Roads

$E = [k (sL)^{0.91} \times$ AP-42 13.2.1 Equation 2

Where:

E = particulate emission factor (lb/VMT)

k = particle size multiplier

sL = road surface silt loading (g/m^3)

W = average vehicle weight (tons)

P = number of days in a year with at least 0.01 in of precipitation

N = number of days in the averaging period

Pollutant	PM	PM_{10}	$PM_{2.5}$
k (lb/VMT)	0.011	0.0022	0.00054

Source: AP-42 Table 13.2.1-1

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Stockpile		
Equipment Description:	Exploration Sample Storage Pile		
Maximum Annual Throughput:	1,000	tons/year	
	574.71	yd^3/year	
	439.40	m^3/year	
Density:	1.74	tons/yd^3	WY-AQD PRB Permitting Guidance (February 2018) - Overburden Density Typical for PRB
Threshold friction velocity (u_t*):	1.02	m/s	AP-42, Table 13.2.5-2
Storage pile radius:	6	m	Note: PUG building width = 50 ft = 15.24 m
Storage pile height:	6	m	Note: Approx 20 ft
Storage pile volume:	457	m^3	
Surface area:	159.86	m^2	$S = \pi r \sqrt{r^2 + h^2}$
Control:	3-sided Enclosure		
Control Efficiency:	75%	WRAP Fugitive Dust Handbook Table 9-4	

Permit Application Values	Pre-Controlled Potential Emissions[a] (tpy)			PTE (lbs/hr)[b]			PTE (tons)[a]		
	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
	0.04	0.02	0.003	2.01	1.01	0.15	0.009	0.004	0.001

a. Annual emissions based on the two months with the highest emissions.
b. Hourly emissions based on maximum hourly data

Area ID	u_s/u_r[a]	Pile Surface	
		%[a]	Area (m^2)
A	0.9	12%	19.18
B	0.6	48%	76.73
$C_1 + C_2$	0.2	40%	63.95

a. AP-42 Table 13.2.5-3

Aerodynamic Particle Size Multipliers (k)			
30 µm	<15 µm	<10 µm	<2.5 µm
1.0	0.6	0.5	0.075

AP-42, Sec. 13.2.5

	PM (g)				Pre-Controlled Potential Emissions (tons)				PTE (lbs/hr)			PTE (tons)		
Month	Area ID: A	Area ID: B	Area ID: C	Total	PM	PM_{10}	$PM_{2.5}$	PM (g/hr)	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Jun-20	10,260.41	4,599.21	-	14,859.62	0.016	0.008	0.001	2,917.84	1.63	0.81	0.12	0.004	0.002	0.0003
Jul-20	9,381.76	2,140.84	-	11,522.59	0.013	0.006	0.001	1,175.68	0.66	0.33	0.05	0.003	0.002	0.0002
Aug-20	6,063.81	1,229.14	-	7,292.95	0.008	0.004	0.001	1,350.78	0.75	0.38	0.06	0.002	0.001	0.0002
Sep-20	5,828.82	1,203.78	-	7,032.59	0.008	0.004	0.001	1,175.68	0.66	0.33	0.05	0.002	0.001	0.0001
Oct-20	8,540.54	3,515.66	-	12,056.20	0.013	0.007	0.001	1,874.76	1.05	0.52	0.08	0.003	0.002	0.0003
Nov-20	4,201.19	896.94	-	5,098.13	0.006	0.003	0.000	1,232.75	0.69	0.34	0.05	0.001	0.001	0.0001
Dec-20	5,414.12	2,902.77	-	8,316.89	0.009	0.005	0.001	2,018.72	1.13	0.56	0.08	0.002	0.001	0.0002
Jan-21	10,120.30	6,972.21	-	17,092.51	0.019	0.009	0.001	3,612.51	2.01	1.01	0.15	0.005	0.002	0.0004
Feb-21	2,436.83	476.46	-	2,913.30	0.003	0.002	0.000	1,038.68	0.58	0.29	0.04	0.001	0.000	0.0001
Mar-21	5,695.73	2,375.78	-	8,071.51	0.009	0.004	0.001	2,522.42	1.41	0.70	0.11	0.002	0.001	0.0002
Apr-21	8,300.52	3,108.25	-	11,408.77	0.013	0.006	0.001	1,851.27	1.03	0.52	0.08	0.003	0.002	0.0002
May-21	8,126.03	2,274.39	-	10,400.42	0.011	0.006	0.001	1,679.69	0.94	0.47	0.07	0.003	0.001	0.0002
Jun-21	2,084.07	655.21	-	2,739.28	0.003	0.002	0.000	1,204.05	0.67	0.34	0.05	0.001	0.000	0.0001

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

Storage Pile Emission Calculations Cont.

Date	Max Wind Gust (mph)	Fastest mile (u^+_{10}) (m/s)	$u^* = 0.1 * u_s/u_r * u_{10}^+$ (m/s) AP-42, Sec. 13.2.5, Eq. 6 & 7			$u^*-u_t^*$ (m/s)			$P = 58(u^*-u_t^*)^2+25(u^*-ut^*)$ (g/m^2) AP-42, Sec. 13.2.5, Eq. 3			kPA (g)		
			Area ID: A	Area ID: B	Area ID: C	Area ID: A	Area ID: B	Area ID: C	Area ID: A	Area ID: B	Area ID: C	Area ID: A	Area ID: B	Area ID: C
6/8/2020	32	14.31	1.29	0.86	0.29	0.27	-	-	10.84	-	-	207.88	-	-
6/9/2020	40.8	18.24	1.64	1.09	0.36	0.62	0.07	-	37.94	2.18	-	727.89	167.24	-
6/10/2020	38.3	17.12	1.54	1.03	0.34	0.52	0.01	-	28.76	0.19	-	551.80	14.24	-
6/11/2020	18.2	8.14	0.73	0.49	0.16	-	-	-	-	-	-	-	-	-
6/12/2020	26.9	12.03	1.08	0.72	0.24	0.06	-	-	1.78	-	-	34.19	-	-
6/13/2020	60.6	27.09	2.44	1.63	0.54	1.42	0.61	-	152.10	36.40	-	2,917.84	2,792.82	-
6/14/2020	48.4	21.64	1.95	1.30	0.43	0.93	0.28	-	73.06	11.44	-	1,401.48	878.16	-
6/15/2020	32.7	14.62	1.32	0.88	0.29	0.30	-	-	12.46	-	-	239.03	-	-
6/16/2020	39.3	17.57	1.58	1.05	0.35	0.56	0.03	-	32.30	0.92	-	619.53	70.64	-
6/17/2020	39	17.43	1.57	1.05	0.35	0.55	0.03	-	31.22	0.69	-	598.83	53.04	-
6/18/2020	28.9	12.92	1.16	0.78	0.26	0.14	-	-	4.75	-	-	91.14	-	-
6/19/2020	33	14.75	1.33	0.89	0.30	0.31	-	-	13.18	-	-	252.92	-	-
6/20/2020	31.7	14.17	1.28	0.85	0.28	0.26	-	-	10.17	-	-	195.07	-	-
6/21/2020	28.9	12.92	1.16	0.78	0.26	0.14	-	-	4.75	-	-	91.14	-	-
6/22/2020	38.4	17.17	1.54	1.03	0.34	0.52	0.01	-	29.11	0.26	-	558.41	19.59	-
6/23/2020	19.6	8.76	0.79	0.53	0.18	-	-	-	-	-	-	-	-	-
6/24/2020	25.2	11.27	1.01	0.68	0.23	-	-	-	-	-	-	-	-	-
6/25/2020	34	15.20	1.37	0.91	0.30	0.35	-	-	15.72	-	-	301.57	-	-
6/26/2020	20.8	9.30	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
6/27/2020	24.3	10.86	0.98	0.65	0.22	-	-	-	-	-	-	-	-	-
6/28/2020	45.9	20.52	1.85	1.23	0.41	0.83	0.21	-	60.31	7.86	-	1,156.94	603.48	-
6/29/2020	32.5	14.53	1.31	0.87	0.29	0.29	-	-	11.99	-	-	229.95	-	-
6/30/2020	28.7	12.83	1.15	0.77	0.26	0.13	-	-	4.42	-	-	84.79	-	-
7/1/2020	46.1	20.61	1.85	1.24	0.41	0.83	0.22	-	61.29	8.13	-	1,175.68	623.98	-
7/2/2020	31.1	13.90	1.25	0.83	0.28	0.23	-	-	8.88	-	-	170.42	-	-
7/3/2020	27	12.07	1.09	0.72	0.24	0.07	-	-	1.91	-	-	36.69	-	-
7/4/2020	35.4	15.83	1.42	0.95	0.32	0.40	-	-	19.59	-	-	375.73	-	-
7/5/2020	46.1	20.61	1.85	1.24	0.41	0.83	0.22	-	61.29	8.13	-	1,175.68	623.98	-
7/6/2020	28	12.52	1.13	0.75	0.25	0.11	-	-	3.32	-	-	63.73	-	-
7/7/2020	38.3	17.12	1.54	1.03	0.34	0.52	0.01	-	28.76	0.19	-	551.80	14.24	-
7/8/2020	41.7	18.64	1.68	1.12	0.37	0.66	0.10	-	41.54	3.03	-	796.80	232.12	-
7/9/2020	38.8	17.35	1.56	1.04	0.35	0.54	0.02	-	30.51	0.54	-	585.21	41.64	-
7/10/2020	36.6	16.36	1.47	0.98	0.33	0.45	-	-	23.19	-	-	444.91	-	-
7/11/2020	24.6	11.00	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
7/12/2020	28.8	12.87	1.16	0.77	0.26	0.14	-	-	4.58	-	-	87.95	-	-
7/13/2020	38.8	17.35	1.56	1.04	0.35	0.54	0.02	-	30.51	0.54	-	585.21	41.64	-
7/14/2020	21	9.39	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
7/15/2020	26.7	11.94	1.07	0.72	0.24	0.05	-	-	1.53	-	-	29.28	-	-
7/16/2020	25	11.18	1.01	0.67	0.22	-	-	-	-	-	-	-	-	-
7/17/2020	24.4	10.91	0.98	0.65	0.22	-	-	-	-	-	-	-	-	-
7/18/2020	35.8	16.00	1.44	0.96	0.32	0.42	-	-	20.76	-	-	398.21	-	-
7/19/2020	36.7	16.41	1.48	0.98	0.33	0.46	-	-	23.50	-	-	450.91	-	-
7/20/2020	31.1	13.90	1.25	0.83	0.28	0.23	-	-	8.88	-	-	170.42	-	-
7/21/2020	29.2	13.05	1.17	0.78	0.26	0.15	-	-	5.26	-	-	100.92	-	-
7/22/2020	24.7	11.04	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
7/23/2020	34.2	15.29	1.38	0.92	0.31	0.36	-	-	16.25	-	-	311.73	-	-
7/24/2020	28.5	12.74	1.15	0.76	0.25	0.13	-	-	4.10	-	-	78.59	-	-
7/25/2020	26.1	11.67	1.05	0.70	0.23	0.03	-	-	0.80	-	-	15.44	-	-
7/26/2020	45.5	20.34	1.83	1.22	0.41	0.81	0.20	-	58.38	7.34	-	1,119.91	563.24	-
7/27/2020	15.5	6.93	0.62	0.42	0.14	-	-	-	-	-	-	-	-	-
7/28/2020	36.1	16.14	1.45	0.97	0.32	0.43	-	-	21.66	-	-	415.45	-	-
7/29/2020	23.7	10.59	0.95	0.64	0.21	-	-	-	-	-	-	-	-	-
7/30/2020	28.5	12.74	1.15	0.76	0.25	0.13	-	-	4.10	-	-	78.59	-	-
7/31/2020	30.9	13.81	1.24	0.83	0.28	0.22	-	-	8.47	-	-	162.49	-	-
8/1/2020	20.4	9.12	0.82	0.55	0.18	-	-	-	-	-	-	-	-	-
8/2/2020	26.8	11.98	1.08	0.72	0.24	0.06	-	-	1.65	-	-	31.72	-	-
8/3/2020	33.6	15.02	1.35	0.90	0.30	0.33	-	-	14.68	-	-	281.68	-	-
8/4/2020	29.6	13.23	1.19	0.79	0.26	0.17	-	-	5.97	-	-	114.47	-	-
8/5/2020	19.8	8.85	0.80	0.53	0.18	-	-	-	-	-	-	-	-	-
8/6/2020	35.8	16.00	1.44	0.96	0.32	0.42	-	-	20.76	-	-	398.21	-	-
8/7/2020	40.9	18.28	1.65	1.10	0.37	0.63	0.08	-	38.34	2.27	-	735.41	174.19	-
8/8/2020	33	14.75	1.33	0.89	0.30	0.31	-	-	13.18	-	-	252.92	-	-
8/9/2020	29.7	13.28	1.19	0.80	0.27	0.17	-	-	6.15	-	-	117.95	-	-
8/10/2020	33.2	14.84	1.34	0.89	0.30	0.32	-	-	13.68	-	-	262.36	-	-
8/11/2020	22.3	9.97	0.90	0.60	0.20	-	-	-	-	-	-	-	-	-
8/12/2020	36.3	16.23	1.46	0.97	0.32	0.44	-	-	22.27	-	-	427.13	-	-
8/13/2020	28	12.52	1.13	0.75	0.25	0.11	-	-	3.32	-	-	63.73	-	-
8/14/2020	47.9	21.41	1.93	1.28	0.43	0.91	0.26	-	70.41	10.69	-	1,350.78	820.02	-
8/15/2020	24.9	11.13	1.00	0.67	0.22	-	-	-	-	-	-	-	-	-
8/16/2020	22.3	9.97	0.90	0.60	0.20	-	-	-	-	-	-	-	-	-
8/17/2020	23.4	10.46	0.94	0.63	0.21	-	-	-	-	-	-	-	-	-
8/18/2020	28.2	12.61	1.13	0.76	0.25	0.11	-	-	3.63	-	-	69.56	-	-
8/19/2020	27.4	12.25	1.10	0.73	0.24	0.08	-	-	2.45	-	-	47.07	-	-
8/20/2020	18.3	8.18	0.74	0.49	0.16	-	-	-	-	-	-	-	-	-
8/21/2020	34	15.20	1.37	0.91	0.30	0.35	-	-	15.72	-	-	301.57	-	-
8/22/2020	18.3	8.18	0.74	0.49	0.16	-	-	-	-	-	-	-	-	-
8/23/2020	24.6	11.00	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
8/24/2020	23.9	10.68	0.96	0.64	0.21	-	-	-	-	-	-	-	-	-
8/25/2020	21.9	9.79	0.88	0.59	0.20	-	-	-	-	-	-	-	-	-
8/26/2020	22.5	10.06	0.91	0.60	0.20	-	-	-	-	-	-	-	-	-
8/27/2020	38.5	17.21	1.55	1.03	0.34	0.53	0.01	-	29.46	0.33	-	565.06	25.00	-
8/28/2020	29.3	13.10	1.18	0.79	0.26	0.16	-	-	5.43	-	-	104.25	-	-
8/29/2020	31	13.86	1.25	0.83	0.28	0.23	-	-	8.68	-	-	166.44	-	-
8/30/2020	41.4	18.51	1.67	1.11	0.37	0.65	0.09	-	40.32	2.74	-	773.51	209.92	-
8/31/2020	14.8	6.62	0.60	0.40	0.13	-	-	-	-	-	-	-	-	-
9/1/2020	34.9	15.60	1.40	0.94	0.31	0.38	-	-	18.16	-	-	348.43	-	-
9/2/2020	40.8	18.24	1.64	1.09	0.36	0.62	0.07	-	37.94	2.18	-	727.89	167.24	-
9/3/2020	20.9	9.34	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
9/4/2020	18.8	8.40	0.76	0.50	0.17	-	-	-	-	-	-	-	-	-

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

9/5/2020	22.7	10.15	0.91	0.61	0.20	-	-	-	-	-	-	-	-	-
9/6/2020	29.6	13.23	1.19	0.79	0.26	0.17	-	-	5.97	-	-	114.47	-	-
9/7/2020	34.4	15.38	1.38	0.92	0.31	0.36	-	-	16.79	-	-	322.04	-	-
9/8/2020	19.7	8.81	0.79	0.53	0.18	-	-	-	-	-	-	-	-	-
9/9/2020	20.1	8.99	0.81	0.54	0.18	-	-	-	-	-	-	-	-	-
9/10/2020	20.9	9.34	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
9/11/2020	17.6	7.87	0.71	0.47	0.16	-	-	-	-	-	-	-	-	-
9/12/2020	21	9.39	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
9/13/2020	14.2	6.35	0.57	0.38	0.13	-	-	-	-	-	-	-	-	-
9/14/2020	23.6	10.55	0.95	0.63	0.21	-	-	-	-	-	-	-	-	-
9/15/2020	23.2	10.37	0.93	0.62	0.21	-	-	-	-	-	-	-	-	-
9/16/2020	29.1	13.01	1.17	0.78	0.26	0.15	-	-	5.09	-	-	97.62	-	-
9/17/2020	23.9	10.68	0.96	0.64	0.21	-	-	-	-	-	-	-	-	-
9/18/2020	32.4	14.48	1.30	0.87	0.29	0.28	-	-	11.75	-	-	225.47	-	-
9/19/2020	31.8	14.22	1.28	0.85	0.28	0.26	-	-	10.39	-	-	199.30	-	-
9/20/2020	29.3	13.10	1.18	0.79	0.26	0.16	-	-	5.43	-	-	104.25	-	-
9/21/2020	14.9	6.66	0.60	0.40	0.13	-	-	-	-	-	-	-	-	-
9/22/2020	27.4	12.25	1.10	0.73	0.24	0.08	-	-	2.45	-	-	47.07	-	-
9/23/2020	34	15.20	1.37	0.91	0.30	0.35	-	-	15.72	-	-	301.57	-	-
9/24/2020	37.3	16.67	1.50	1.00	0.33	0.48	-	-	25.42	-	-	487.66	-	-
9/25/2020	18.1	8.09	0.73	0.49	0.16	-	-	-	-	-	-	-	-	-
9/26/2020	43.9	19.63	1.77	1.18	0.39	0.75	0.16	-	50.96	5.38	-	977.52	412.55	-
9/27/2020	46.1	20.61	1.85	1.24	0.41	0.83	0.22	-	61.29	8.13	-	1,175.68	623.98	-
9/28/2020	30.6	13.68	1.23	0.82	0.27	0.21	-	-	7.86	-	-	150.87	-	-
9/29/2020	33.2	14.84	1.34	0.89	0.30	0.32	-	-	13.68	-	-	262.36	-	-
9/30/2020	33.7	15.07	1.36	0.90	0.30	0.34	-	-	14.94	-	-	286.60	-	-
10/1/2020	16.6	7.42	0.67	0.45	0.15	-	-	-	-	-	-	-	-	-
10/2/2020	34.8	15.56	1.40	0.93	0.31	0.38	-	-	17.88	-	-	343.08	-	-
10/3/2020	25.1	11.22	1.01	0.67	0.22	-	-	-	-	-	-	-	-	-
10/4/2020	20.1	8.99	0.81	0.54	0.18	-	-	-	-	-	-	-	-	-
10/5/2020	31.3	13.99	1.26	0.84	0.28	0.24	-	-	9.30	-	-	178.49	-	-
10/6/2020	24	10.73	0.97	0.64	0.21	-	-	-	-	-	-	-	-	-
10/7/2020	21.6	9.66	0.87	0.58	0.19	-	-	-	-	-	-	-	-	-
10/8/2020	21.6	9.66	0.87	0.58	0.19	-	-	-	-	-	-	-	-	-
10/9/2020	20.2	9.03	0.81	0.54	0.18	-	-	-	-	-	-	-	-	-
10/10/2020	33.5	14.98	1.35	0.90	0.30	0.33	-	-	14.43	-	-	276.80	-	-
10/11/2020	48.5	21.68	1.95	1.30	0.43	0.93	0.28	-	73.59	11.60	-	1,411.73	889.98	-
10/12/2020	34.8	15.56	1.40	0.93	0.31	0.38	-	-	17.88	-	-	343.08	-	-
10/13/2020	38.8	17.35	1.56	1.04	0.35	0.54	0.02	-	30.51	0.54	-	585.21	41.64	-
10/14/2020	52.7	23.56	2.12	1.41	0.47	1.10	0.39	-	97.73	18.82	-	1,874.76	1,444.23	-
10/15/2020	50.5	22.58	2.03	1.35	0.45	1.01	0.33	-	84.67	14.85	-	1,624.30	1,139.82	-
10/16/2020	25.2	11.27	1.01	0.68	0.23	-	-	-	-	-	-	-	-	-
10/17/2020	37.4	16.72	1.50	1.00	0.33	0.48	-	-	25.75	-	-	493.91	-	-
10/18/2020	24.3	10.86	0.98	0.65	0.22	-	-	-	-	-	-	-	-	-
10/19/2020	17.8	7.96	0.72	0.48	0.16	-	-	-	-	-	-	-	-	-
10/20/2020	30.2	13.50	1.22	0.81	0.27	0.20	-	-	7.08	-	-	135.88	-	-
10/21/2020	17.5	7.82	0.70	0.47	0.16	-	-	-	-	-	-	-	-	-
10/22/2020	35.4	15.83	1.42	0.95	0.32	0.40	-	-	19.59	-	-	375.73	-	-
10/23/2020	23.4	10.46	0.94	0.63	0.21	-	-	-	-	-	-	-	-	-
10/24/2020	26.9	12.03	1.08	0.72	0.24	0.06	-	-	1.78	-	-	34.19	-	-
10/25/2020	24.5	10.95	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
10/26/2020	13.5	6.04	0.54	0.36	0.12	-	-	-	-	-	-	-	-	-
10/27/2020	11.9	5.32	0.48	0.32	0.11	-	-	-	-	-	-	-	-	-
10/28/2020	12.3	5.50	0.49	0.33	0.11	-	-	-	-	-	-	-	-	-
10/29/2020	12.4	5.54	0.50	0.33	0.11	-	-	-	-	-	-	-	-	-
10/30/2020	35.4	15.83	1.42	0.95	0.32	0.40	-	-	19.59	-	-	375.73	-	-
10/31/2020	37.3	16.67	1.50	1.00	0.33	0.48	-	-	25.42	-	-	487.66	-	-
11/1/2020	15.9	7.11	0.64	0.43	0.14	-	-	-	-	-	-	-	-	-
11/2/2020	14.5	6.48	0.58	0.39	0.13	-	-	-	-	-	-	-	-	-
11/3/2020	13.3	5.95	0.54	0.36	0.12	-	-	-	-	-	-	-	-	-
11/4/2020	22.7	10.15	0.91	0.61	0.20	-	-	-	-	-	-	-	-	-
11/5/2020	21.6	9.66	0.87	0.58	0.19	-	-	-	-	-	-	-	-	-
11/6/2020	24.5	10.95	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
11/7/2020	34.4	15.38	1.38	0.92	0.31	0.36	-	-	16.79	-	-	322.04	-	-
11/8/2020	36.1	16.14	1.45	0.97	0.32	0.43	-	-	21.66	-	-	415.45	-	-
11/9/2020	26.8	11.98	1.08	0.72	0.24	0.06	-	-	1.65	-	-	31.72	-	-
11/10/2020	26.2	11.71	1.05	0.70	0.23	0.03	-	-	0.92	-	-	17.66	-	-
11/11/2020	27.5	12.29	1.11	0.74	0.25	0.09	-	-	2.59	-	-	49.76	-	-
11/12/2020	17.7	7.91	0.71	0.47	0.16	-	-	-	-	-	-	-	-	-
11/13/2020	41.4	18.51	1.67	1.11	0.37	0.65	0.09	-	40.32	2.74	-	773.51	209.92	-
11/14/2020	46.7	20.88	1.88	1.25	0.42	0.86	0.23	-	64.26	8.95	-	1,232.75	687.02	-
11/15/2020	19.9	8.90	0.80	0.53	0.18	-	-	-	-	-	-	-	-	-
11/16/2020	23.8	10.64	0.96	0.64	0.21	-	-	-	-	-	-	-	-	-
11/17/2020	21.3	9.52	0.86	0.57	0.19	-	-	-	-	-	-	-	-	-
11/18/2020	36.9	16.50	1.48	0.99	0.33	0.46	-	-	24.14	-	-	463.01	-	-
11/19/2020	36.2	16.18	1.46	0.97	0.32	0.44	-	-	21.96	-	-	421.27	-	-
11/20/2020	20.4	9.12	0.82	0.55	0.18	-	-	-	-	-	-	-	-	-
11/21/2020	21	9.39	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
11/22/2020	22.5	10.06	0.91	0.60	0.20	-	-	-	-	-	-	-	-	-
11/23/2020	19.8	8.85	0.80	0.53	0.18	-	-	-	-	-	-	-	-	-
11/24/2020	21	9.39	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
11/25/2020	37	16.54	1.49	0.99	0.33	0.47	-	-	24.45	-	-	469.12	-	-
11/26/2020	25.6	11.44	1.03	0.69	0.23	0.01	-	-	0.26	-	-	4.90	-	-
11/27/2020	15	6.71	0.60	0.40	0.13	-	-	-	-	-	-	-	-	-
11/28/2020	23.4	10.46	0.94	0.63	0.21	-	-	-	-	-	-	-	-	-
11/29/2020	23.2	10.37	0.93	0.62	0.21	-	-	-	-	-	-	-	-	-
11/30/2020	19.1	8.54	0.77	0.51	0.17	-	-	-	-	-	-	-	-	-
12/1/2020	41.5	18.55	1.67	1.11	0.37	0.65	0.09	-	40.72	2.83	-	781.24	217.26	-
12/2/2020	27.5	12.29	1.11	0.74	0.25	0.09	-	-	2.59	-	-	49.76	-	-
12/3/2020	16.8	7.51	0.68	0.45	0.15	-	-	-	-	-	-	-	-	-
12/4/2020	29.8	13.32	1.20	0.80	0.27	0.18	-	-	6.33	-	-	121.46	-	-
12/5/2020	17.7	7.91	0.71	0.47	0.16	-	-	-	-	-	-	-	-	-
12/6/2020	17	7.60	0.68	0.46	0.15	-	-	-	-	-	-	-	-	-
12/7/2020	15.7	7.02	0.63	0.42	0.14	-	-	-	-	-	-	-	-	-

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

12/8/2020	14.2	6.35	0.57	0.38	0.13	-	-	-	-	-	-	-	-	-
12/9/2020	22.6	10.10	0.91	0.61	0.20	-	-	-	-	-	-	-	-	-
12/10/2020	30.2	13.50	1.22	0.81	0.27	0.20	-	-	7.08	-	-	135.88	-	-
12/11/2020	17.9	8.00	0.72	0.48	0.16	-	-	-	-	-	-	-	-	-
12/12/2020	23.8	10.64	0.96	0.64	0.21	-	-	-	-	-	-	-	-	-
12/13/2020	13.4	5.99	0.54	0.36	0.12	-	-	-	-	-	-	-	-	-
12/14/2020	15.5	6.93	0.62	0.42	0.14	-	-	-	-	-	-	-	-	-
12/15/2020	22	9.83	0.89	0.59	0.20	-	-	-	-	-	-	-	-	-
12/16/2020	26.2	11.71	1.05	0.70	0.23	0.03	-	-	0.92	-	-	17.66	-	-
12/17/2020	20.2	9.03	0.81	0.54	0.18	-	-	-	-	-	-	-	-	-
12/18/2020	26.4	11.80	1.06	0.71	0.24	0.04	-	-	1.16	-	-	22.20	-	-
12/19/2020	33.1	14.80	1.33	0.89	0.30	0.31	-	-	13.43	-	-	257.63	-	-
12/20/2020	27.8	12.43	1.12	0.75	0.25	0.10	-	-	3.03	-	-	58.03	-	-
12/21/2020	17.9	8.00	0.72	0.48	0.16	-	-	-	-	-	-	-	-	-
12/22/2020	49.9	22.31	2.01	1.34	0.45	0.99	0.32	-	81.27	13.84	-	1,559.01	1,062.18	-
12/23/2020	53.9	24.10	2.17	1.45	0.48	1.15	0.43	-	105.23	21.16	-	2,018.72	1,623.33	-
12/24/2020	25.2	11.27	1.01	0.68	0.23	-	-	-	-	-	-	-	-	-
12/25/2020	10.5	4.69	0.42	0.28	0.09	-	-	-	-	-	-	-	-	-
12/26/2020	22.7	10.15	0.91	0.61	0.20	-	-	-	-	-	-	-	-	-
12/27/2020	23.1	10.33	0.93	0.62	0.21	-	-	-	-	-	-	-	-	-
12/28/2020	15.1	6.75	0.61	0.41	0.14	-	-	-	-	-	-	-	-	-
12/29/2020	35.7	15.96	1.44	0.96	0.32	0.42	-	-	20.46	-	-	392.54	-	-
12/30/2020	17.6	7.87	0.71	0.47	0.16	-	-	-	-	-	-	-	-	-
12/31/2020	9.3	4.16	0.37	0.25	0.08	-	-	-	-	-	-	-	-	-
1/1/2021	12.4	5.54	0.50	0.33	0.11	-	-	-	-	-	-	-	-	-
1/2/2021	15.2	6.80	0.61	0.41	0.14	-	-	-	-	-	-	-	-	-
1/3/2021	27.2	12.16	1.09	0.73	0.24	0.07	-	-	2.18	-	-	41.81	-	-
1/4/2021	17.3	7.73	0.70	0.46	0.15	-	-	-	-	-	-	-	-	-
1/5/2021	36.7	16.41	1.48	0.98	0.33	0.46	-	-	23.50	-	-	450.91	-	-
1/6/2021	7.7	3.44	0.31	0.21	0.07	-	-	-	-	-	-	-	-	-
1/7/2021	20.8	9.30	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
1/8/2021	15.8	7.06	0.64	0.42	0.14	-	-	-	-	-	-	-	-	-
1/9/2021	14	6.26	0.56	0.38	0.13	-	-	-	-	-	-	-	-	-
1/10/2021	19.5	8.72	0.78	0.52	0.17	-	-	-	-	-	-	-	-	-
1/11/2021	13.1	5.86	0.53	0.35	0.12	-	-	-	-	-	-	-	-	-
1/12/2021	19.4	8.67	0.78	0.52	0.17	-	-	-	-	-	-	-	-	-
1/13/2021	65.1	29.10	2.62	1.75	0.58	1.60	0.73	-	188.31	48.74	-	3,612.51	3,739.68	-
1/14/2021	59.8	26.73	2.41	1.60	0.53	1.39	0.58	-	146.06	34.38	-	2,801.99	2,638.07	-
1/15/2021	38.3	17.12	1.54	1.03	0.34	0.52	0.01	-	28.76	0.19	-	551.80	14.24	-
1/16/2021	38.5	17.21	1.55	1.03	0.34	0.53	0.01	-	29.46	0.33	-	565.06	25.00	-
1/17/2021	40.7	18.19	1.64	1.09	0.36	0.62	0.07	-	37.55	2.09	-	720.42	160.35	-
1/18/2021	43.7	19.54	1.76	1.17	0.39	0.74	0.15	-	50.06	5.15	-	960.37	394.87	-
1/19/2021	28.1	12.56	1.13	0.75	0.25	0.11	-	-	3.47	-	-	66.63	-	-
1/20/2021	20.3	9.07	0.82	0.54	0.18	-	-	-	-	-	-	-	-	-
1/21/2021	17.7	7.91	0.71	0.47	0.16	-	-	-	-	-	-	-	-	-
1/22/2021	23.8	10.64	0.96	0.64	0.21	-	-	-	-	-	-	-	-	-
1/23/2021	23.7	10.59	0.95	0.64	0.21	-	-	-	-	-	-	-	-	-
1/24/2021	29.3	13.10	1.18	0.79	0.26	0.16	-	-	5.43	-	-	104.25	-	-
1/25/2021	14.4	6.44	0.58	0.39	0.13	-	-	-	-	-	-	-	-	-
1/26/2021	24.7	11.04	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
1/27/2021	26.7	11.94	1.07	0.72	0.24	0.05	-	-	1.53	-	-	29.28	-	-
1/28/2021	29.5	13.19	1.19	0.79	0.26	0.17	-	-	5.79	-	-	111.03	-	-
1/29/2021	17.9	8.00	0.72	0.48	0.16	-	-	-	-	-	-	-	-	-
1/30/2021	29.3	13.10	1.18	0.79	0.26	0.16	-	-	5.43	-	-	104.25	-	-
1/31/2021	14.3	6.39	0.58	0.38	0.13	-	-	-	-	-	-	-	-	-
2/1/2021	10	4.47	0.40	0.27	0.09	-	-	-	-	-	-	-	-	-
2/2/2021	15.8	7.06	0.64	0.42	0.14	-	-	-	-	-	-	-	-	-
2/3/2021	35.1	15.69	1.41	0.94	0.31	0.39	-	-	18.73	-	-	359.24	-	-
2/4/2021	37.2	16.63	1.50	1.00	0.33	0.48	-	-	25.10	-	-	481.44	-	-
2/5/2021	22.9	10.24	0.92	0.61	0.20	-	-	-	-	-	-	-	-	-
2/6/2021	23.7	10.59	0.95	0.64	0.21	-	-	-	-	-	-	-	-	-
2/7/2021	34.5	15.42	1.39	0.93	0.31	0.37	-	-	17.06	-	-	327.24	-	-
2/8/2021	20.8	9.30	0.84	0.56	0.19	-	-	-	-	-	-	-	-	-
2/9/2021	17.6	7.87	0.71	0.47	0.16	-	-	-	-	-	-	-	-	-
2/10/2021	14.8	6.62	0.60	0.40	0.13	-	-	-	-	-	-	-	-	-
2/11/2021	27.4	12.25	1.10	0.73	0.24	0.08	-	-	2.45	-	-	47.07	-	-
2/12/2021	17.7	7.91	0.71	0.47	0.16	-	-	-	-	-	-	-	-	-
2/13/2021	18.1	8.09	0.73	0.49	0.16	-	-	-	-	-	-	-	-	-
2/14/2021	22	9.83	0.89	0.59	0.20	-	-	-	-	-	-	-	-	-
2/15/2021	24.6	11.00	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
2/16/2021	18.2	8.14	0.73	0.49	0.16	-	-	-	-	-	-	-	-	-
2/17/2021	19.7	8.81	0.79	0.53	0.18	-	-	-	-	-	-	-	-	-
2/18/2021	17.4	7.78	0.70	0.47	0.16	-	-	-	-	-	-	-	-	-
2/19/2021	11.6	5.19	0.47	0.31	0.10	-	-	-	-	-	-	-	-	-
2/20/2021	19.8	8.85	0.80	0.53	0.18	-	-	-	-	-	-	-	-	-
2/21/2021	23.5	10.51	0.95	0.63	0.21	-	-	-	-	-	-	-	-	-
2/22/2021	29.1	13.01	1.17	0.78	0.26	0.15	-	-	5.09	-	-	97.62	-	-
2/23/2021	44.6	19.94	1.79	1.20	0.40	0.77	0.18	-	54.14	6.21	-	1,038.68	476.46	-
2/24/2021	24.7	11.04	0.99	0.66	0.22	-	-	-	-	-	-	-	-	-
2/25/2021	25.7	11.49	1.03	0.69	0.23	0.01	-	-	0.36	-	-	6.93	-	-
2/26/2021	25.1	11.22	1.01	0.67	0.22	-	-	-	-	-	-	-	-	-
2/27/2021	28.5	12.74	1.15	0.76	0.25	0.13	-	-	4.10	-	-	78.59	-	-
2/28/2021	23	10.28	0.93	0.62	0.21	-	-	-	-	-	-	-	-	-
3/1/2021	18.2	8.14	0.73	0.49	0.16	-	-	-	-	-	-	-	-	-
3/2/2021	13.8	6.17	0.56	0.37	0.12	-	-	-	-	-	-	-	-	-
3/3/2021	12.8	5.72	0.51	0.34	0.11	-	-	-	-	-	-	-	-	-
3/4/2021	17.5	7.82	0.70	0.47	0.16	-	-	-	-	-	-	-	-	-
3/5/2021	9.5	4.25	0.38	0.25	0.08	-	-	-	-	-	-	-	-	-
3/6/2021	32.6	14.57	1.31	0.87	0.29	0.29	-	-	12.22	-	-	234.47	-	-
3/7/2021	21.4	9.57	0.86	0.57	0.19	-	-	-	-	-	-	-	-	-
3/8/2021	24.2	10.82	0.97	0.65	0.22	-	-	-	-	-	-	-	-	-
3/9/2021	30.5	13.63	1.23	0.82	0.27	0.21	-	-	7.67	-	-	147.07	-	-
3/10/2021	22.3	9.97	0.90	0.60	0.20	-	-	-	-	-	-	-	-	-
3/11/2021	20.7	9.25	0.83	0.56	0.19	-	-	-	-	-	-	-	-	-

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

3/12/2021	27.4	12.25	1.10	0.73	0.24	0.08	-	-	2.45	-	-	47.07	-	-
3/13/2021	19.3	8.63	0.78	0.52	0.17	-	-	-	-	-	-	-	-	-
3/14/2021	26.5	11.85	1.07	0.71	0.24	0.05	-	-	1.28	-	-	24.53	-	-
3/15/2021	16	7.15	0.64	0.43	0.14	-	-	-	-	-	-	-	-	-
3/16/2021	23.4	10.46	0.94	0.63	0.21	-	-	-	-	-	-	-	-	-
3/17/2021	26.7	11.94	1.07	0.72	0.24	0.05	-	-	1.53	-	-	29.28	-	-
3/18/2021	26.2	11.71	1.05	0.70	0.23	0.03	-	-	0.92	-	-	17.66	-	-
3/19/2021	20.7	9.25	0.83	0.56	0.19	-	-	-	-	-	-	-	-	-
3/20/2021	38.7	17.30	1.56	1.04	0.35	0.54	0.02	-	30.15	0.47	-	578.46	36.03	-
3/21/2021	28.4	12.70	1.14	0.76	0.25	0.12	-	-	3.94	-	-	75.55	-	-
3/22/2021	28.5	12.74	1.15	0.76	0.25	0.13	-	-	4.10	-	-	78.59	-	-
3/23/2021	36.3	16.23	1.46	0.97	0.32	0.44	-	-	22.27	-	-	427.13	-	-
3/24/2021	25.9	11.58	1.04	0.69	0.23	0.02	-	-	0.58	-	-	11.12	-	-
3/25/2021	35.1	15.69	1.41	0.94	0.31	0.39	-	-	18.73	-	-	359.24	-	-
3/26/2021	18.8	8.40	0.76	0.50	0.17	-	-	-	-	-	-	-	-	-
3/27/2021	34.6	15.47	1.39	0.93	0.31	0.37	-	-	17.33	-	-	332.49	-	-
3/28/2021	30.2	13.50	1.22	0.81	0.27	0.20	-	-	7.08	-	-	135.88	-	-
3/29/2021	57.8	25.84	2.33	1.55	0.52	1.31	0.53	-	131.49	29.57	-	2,522.42	2,269.12	-
3/30/2021	39.3	17.57	1.58	1.05	0.35	0.56	0.03	-	32.30	0.92	-	619.53	70.64	-
3/31/2021	27.7	12.38	1.11	0.74	0.25	0.09	-	-	2.88	-	-	55.24	-	-
4/1/2021	21.9	9.79	0.88	0.59	0.20	-	-	-	-	-	-	-	-	-
4/2/2021	24.1	10.77	0.97	0.65	0.22	-	-	-	-	-	-	-	-	-
4/3/2021	23.7	10.59	0.95	0.64	0.21	-	-	-	-	-	-	-	-	-
4/4/2021	17.4	7.78	0.70	0.47	0.16	-	-	-	-	-	-	-	-	-
4/5/2021	33.8	15.11	1.36	0.91	0.30	0.34	-	-	15.20	-	-	291.55	-	-
4/6/2021	28	12.52	1.13	0.75	0.25	0.11	-	-	3.32	-	-	63.73	-	-
4/7/2021	19.8	8.85	0.80	0.53	0.18	-	-	-	-	-	-	-	-	-
4/8/2021	52.5	23.47	2.11	1.41	0.47	1.09	0.39	-	96.50	18.44	-	1,851.27	1,415.27	-
4/9/2021	40.3	18.02	1.62	1.08	0.36	0.60	0.06	-	36.01	1.74	-	690.87	133.44	-
4/10/2021	48.6	21.73	1.96	1.30	0.43	0.94	0.28	-	74.13	11.75	-	1,422.02	901.86	-
4/11/2021	44.6	19.94	1.79	1.20	0.40	0.77	0.18	-	54.14	6.21	-	1,038.68	476.46	-
4/12/2021	41	18.33	1.65	1.10	0.37	0.63	0.08	-	38.73	2.36	-	742.95	181.21	-
4/13/2021	37.5	16.76	1.51	1.01	0.34	0.49	-	-	26.07	-	-	500.20	-	-
4/14/2021	24	10.73	0.97	0.64	0.21	-	-	-	-	-	-	-	-	-
4/15/2021	11.6	5.19	0.47	0.31	0.10	-	-	-	-	-	-	-	-	-
4/16/2021	26.6	11.89	1.07	0.71	0.24	0.05	-	-	1.40	-	-	26.89	-	-
4/17/2021	29.8	13.32	1.20	0.80	0.27	0.18	-	-	6.33	-	-	121.46	-	-
4/18/2021	33.2	14.84	1.34	0.89	0.30	0.32	-	-	13.68	-	-	262.36	-	-
4/19/2021	28.8	12.87	1.16	0.77	0.26	0.14	-	-	4.58	-	-	87.95	-	-
4/20/2021	34.4	15.38	1.38	0.92	0.31	0.36	-	-	16.79	-	-	322.04	-	-
4/21/2021	16.9	7.55	0.68	0.45	0.15	-	-	-	-	-	-	-	-	-
4/22/2021	25.2	11.27	1.01	0.68	0.23	-	-	-	-	-	-	-	-	-
4/23/2021	28.9	12.92	1.16	0.78	0.26	0.14	-	-	4.75	-	-	91.14	-	-
4/24/2021	30.9	13.81	1.24	0.83	0.28	0.22	-	-	8.47	-	-	162.49	-	-
4/25/2021	28	12.52	1.13	0.75	0.25	0.11	-	-	3.32	-	-	63.73	-	-
4/26/2021	23.6	10.55	0.95	0.63	0.21	-	-	-	-	-	-	-	-	-
4/27/2021	23.7	10.59	0.95	0.64	0.21	-	-	-	-	-	-	-	-	-
4/28/2021	29.3	13.10	1.18	0.79	0.26	0.16	-	-	5.43	-	-	104.25	-	-
4/29/2021	36.8	16.45	1.48	0.99	0.33	0.46	-	-	23.82	-	-	456.94	-	-
4/30/2021	22.2	9.92	0.89	0.60	0.20	-	-	-	-	-	-	-	-	-
5/1/2021	25.2	11.27	1.01	0.68	0.23	-	-	-	-	-	-	-	-	-
5/2/2021	33.7	15.07	1.36	0.90	0.30	0.34	-	-	14.94	-	-	286.60	-	-
5/3/2021	26.7	11.94	1.07	0.72	0.24	0.05	-	-	1.53	-	-	29.28	-	-
5/4/2021	32.8	14.66	1.32	0.88	0.29	0.30	-	-	12.70	-	-	243.63	-	-
5/5/2021	44.1	19.71	1.77	1.18	0.39	0.75	0.16	-	51.86	5.61	-	994.82	430.49	-
5/6/2021	15.4	6.88	0.62	0.41	0.14	-	-	-	-	-	-	-	-	-
5/7/2021	40.9	18.28	1.65	1.10	0.37	0.63	0.08	-	38.34	2.27	-	735.41	174.19	-
5/8/2021	34.2	15.29	1.38	0.92	0.31	0.36	-	-	16.25	-	-	311.73	-	-
5/9/2021	27	12.07	1.09	0.72	0.24	0.07	-	-	1.91	-	-	36.69	-	-
5/10/2021	16.6	7.42	0.67	0.45	0.15	-	-	-	-	-	-	-	-	-
5/11/2021	27	12.07	1.09	0.72	0.24	0.07	-	-	1.91	-	-	36.69	-	-
5/12/2021	35.2	15.74	1.42	0.94	0.31	0.40	-	-	19.01	-	-	364.70	-	-
5/13/2021	35.4	15.83	1.42	0.95	0.32	0.40	-	-	19.59	-	-	375.73	-	-
5/14/2021	19.8	8.85	0.80	0.53	0.18	-	-	-	-	-	-	-	-	-
5/15/2021	20.6	9.21	0.83	0.55	0.18	-	-	-	-	-	-	-	-	-
5/16/2021	26.6	11.89	1.07	0.71	0.24	0.05	-	-	1.40	-	-	26.89	-	-
5/17/2021	26.5	11.85	1.07	0.71	0.24	0.05	-	-	1.28	-	-	24.53	-	-
5/18/2021	28.4	12.70	1.14	0.76	0.25	0.12	-	-	3.94	-	-	75.55	-	-
5/19/2021	27.8	12.43	1.12	0.75	0.25	0.10	-	-	3.03	-	-	58.03	-	-
5/20/2021	42.6	19.04	1.71	1.14	0.38	0.69	0.12	-	45.28	3.94	-	868.63	302.19	-
5/21/2021	32	14.31	1.29	0.86	0.29	0.27	-	-	10.84	-	-	207.88	-	-
5/22/2021	23	10.28	0.93	0.62	0.21	-	-	-	-	-	-	-	-	-
5/23/2021	40	17.88	1.61	1.07	0.36	0.59	0.05	-	34.88	1.48	-	669.09	113.93	-
5/24/2021	38.9	17.39	1.57	1.04	0.35	0.55	0.02	-	30.86	0.62	-	592.01	47.31	-
5/25/2021	27.9	12.47	1.12	0.75	0.25	0.10	-	-	3.17	-	-	60.86	-	-
5/26/2021	51	22.80	2.05	1.37	0.46	1.03	0.35	-	87.56	15.72	-	1,679.69	1,206.28	-
5/27/2021	25.7	11.49	1.03	0.69	0.23	0.01	-	-	0.36	-	-	6.93	-	-
5/28/2021	32.1	14.35	1.29	0.86	0.29	0.27	-	-	11.06	-	-	212.22	-	-
5/29/2021	27.8	12.43	1.12	0.75	0.25	0.10	-	-	3.03	-	-	58.03	-	-
5/30/2021	17.5	7.82	0.70	0.47	0.16	-	-	-	-	-	-	-	-	-
5/31/2021	31.1	13.90	1.25	0.83	0.28	0.23	-	-	8.88	-	-	170.42	-	-
6/1/2021	30	13.41	1.21	0.80	0.27	0.19	-	-	6.70	-	-	128.60	-	-
6/2/2021	18.4	8.23	0.74	0.49	0.16	-	-	-	-	-	-	-	-	-
6/3/2021	20.3	9.07	0.82	0.54	0.18	-	-	-	-	-	-	-	-	-
6/4/2021	26.3	11.76	1.06	0.71	0.24	0.04	-	-	1.04	-	-	19.91	-	-
6/5/2021	46.4	20.74	1.87	1.24	0.41	0.85	0.22	-	62.76	8.54	-	1,204.05	655.21	-
6/6/2021	36.6	16.36	1.47	0.98	0.33	0.45	-	-	23.19	-	-	444.91	-	-
6/7/2021	33.7	15.07	1.36	0.90	0.30	0.34	-	-	14.94	-	-	286.60	-	-

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Exploration Sample Pre-crusher mixing		
Equipment Description:	Exploration Sample Pre-crusher mixing with Front End Loader and Dozer		
Maximum Annual Throughput:	1,000	tons/year	
Maximum Hourly Throughput:	20	tons/hour	Section 2.1.2.6 (RER, 2022a)
Mean Wind Speed (U):	9.4	mph	Met Data Summary (IML, 2021)
Maximum Wind Speed (U):	39.7	mph	Met Data Summary (IML, 2021)
Exploration Sample Moisture Content:	3	wt %	Personal communication with Jaye Pickarts 5/23/2022
Exploration Sample Silt Content:	8.6	wt %	WY-AQD PRB Permitting Guidance (February 2018) - Typical for PRB
Mixing Hours of Operation:	80	hrs/year	8 hrs/day for 2 working weeks (10 days)
Control:	3-sided Enclosure		
Control efficiecy:	75%	WRAP Fugitive Dust Handbook Table 4-2	

Front End Loader Mixing

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/ton) at Max Wind Speed	Emission Factor (lb/ton) at Mean Wind Speed	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
PM	0.74	0.0198	0.0030	AP-42, 13.2.4, Equation 1	3-05-888-01	0.0015	0.10	0.0004
PM_{10}	0.35	0.0094	0.0014			0.0007	0.05	0.0002
$PM_{2.5}$	0.053	0.0014	0.0002			0.0001	0.01	0.0000

Bulldozer Mixing

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/hr)	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
PM	N/A	18.07	AP-42, Table 11.9-1	3-05-888-01	0.7229	4.57	0.1829
PM_{10}[a]	0.75	4.06			0.1625	1.03	0.0411
$PM_{2.5}$[b]	0.105	1.90			0.0759	0.48	0.0192

a. Multipily the ≤ 15 µm equation by k
b. Multiply the TSP equation by k

Total

Pollutant	PM	PM_{10}	$PM_{2.5}$
Pre-Controlled Potential Emissions (tpy)	0.72	0.16	0.08
PTE (lb/hr)	4.67	1.08	0.49
PTE (tpy)	0.18	0.04	0.02

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)}$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

$E = 5.7\,(s)^{1.2} / (M)^{1.3}$ AP-42, Table 11.9-1, TSP < 30 µm, Bulldozing, Overburden

$E = 1.0\,(s)^{1.5} / (M)^{1.4}$ AP-42, Table 11.9-1, < 15 µm, Bulldozing, Overburden

Where:
s = material silt content (%)
M = material moisture content (%)

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Transfer to Solids Mixing		
Equipment Description:	Batch Drop Dump for solids mixing		
Maximum Annual Throughput:	1,000	tons/year	
Maximum Hourly Throughput:	20	tons/hour	Section 2.1.2.6 (RER, 2022a)
Mean Wind Speed (U):	9.4	mph	Met Data Summary (IML, 2021)
Maximum Wind Speed (U):	39.7	mph	Met Data Summary (IML, 2021)
Exploration Sample Moisture Content:	3	wt %	Personal communication with Jaye Pickarts 5/23/2022
Control:	3-sided Enclosure		
Control efficiecy:	75%	WRAP Fugitive Dust Handbook Table 4-2	

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/ton) at Max Wind Speed	Emission Factor (lb/ton) at Mean Wind Speed	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
PM	0.74	0.0198	0.0030	AP-42, 13.2.4, Equation 1	3-05-888-01	0.002	0.10	0.0004
PM_{10}	0.35	0.0094	0.0014			0.001	0.05	0.0002
$PM_{2.5}$	0.053	0.0014	0.0002			0.0001	0.01	0.00003

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)}$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Exploration Sample Post-crusher mixing		
Equipment Description:	Exploration Sample Post-crusher mixing		
Maximum Annual Throughput:	1,000	tons/year	
Maximum Hourly Throughput:	20	tons/hour	Section 2.1.2.6 (RER, 2022a)
Mean Wind Speed (U):	9.4	mph	Met Data Summary (IML, 2021)
Maximum Wind Speed (U):	39.7	mph	Met Data Summary (IML, 2021)
Exploration Sample Moisture Content:	3	wt %	Personal communication with Jaye Pickarts 5/23/2022
Exploration Sample Silt Content:	8.6	wt %	WY-AQD PRB Permitting Guidance (February 2018) - Typical for PRB
Mixing Hours of Operation:	80	hrs/year	8 hrs/day for 2 working weeks (10 days)
Control:	3-sided Enclosure		
Control efficiecy:	75%	WRAP Fugitive Dust Handbook Table 4-2	

Front End Loader Mixing

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/ton) at Max Wind Speed	Emission Factor (lb/ton) at Mean Wind Speed	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
PM	0.74	0.0198	0.0030	AP-42, 13.2.4, Equation 1	3-05-888-01	0.0015	0.10	0.0004
PM_{10}	0.35	0.0094	0.0014			0.0007	0.05	0.0002
$PM_{2.5}$	0.053	0.0014	0.0002			0.0001	0.01	0.0000

Bulldozer Mixing

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/hr)	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
PM	N/A	18.07	AP-42, Table 11.9-1	3-05-888-01	0.7229	4.57	0.1829
PM_{10}[a]	0.75	4.06			0.1625	1.03	0.0411
$PM_{2.5}$[b]	0.105	1.90			0.0759	0.48	0.0192

a. Multipily the ≤ 15 µm equation by k
b. Multiply the TSP equation by k

Total

Pollutant	PM	PM_{10}	$PM_{2.5}$
Pre-Controlled Potential Emissions (tpy)	0.72	0.16	0.08
PTE (lb/hr)	4.67	1.08	0.49
PTE (tpy)	0.18	0.04	0.02

$$E = k(0.0032) \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)}$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

$E = 5.7 (s)^{1.2} / (M)^{1.3}$ AP-42, Table 11.9-1, TSP < 30 µm, Bulldozing, Overburden

$E = 1.0 (s)^{1.5} / (M)^{1.4}$ AP-42, Table 11.9-1, < 15 µm, Bulldozing, Overburden

Where:
s = material silt content (%)
M = material moisture content (%)

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project
Emission Calculations

Equipment ID:	Bentonite Batch Drop		
Equipment Description:	Bentonite Batch Drop		
Maximum Annual Throughput:	1.5	tons/year	
Maximum Hourly Throughput:	0.025	tons/hr	
Mean Wind Speed (U):	9.4	mph	Met Data Summary (IML, 2021)
Maximum Wind Speed (U):	39.7	mph	Met Data Summary (IML, 2021)
Exploration Sample Moisture Content:	3	wt %	Personal communication with Jaye Pickarts 5/23/2022

Control:	3-sided Enclosure	(Bentonite batch drop located within fully enclosed building; 3-Sided Enclosure control effieicncy applied for conservative estimate)
Control efficiecy:	75%	WRAP Fugitive Dust Handbook Table 4-2

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/ton) at Max Wind Speed	Emission Factor (lb/ton) at Mean Wind Speed	Emission Factor Reference	SCC	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
PM	0.74	0.0198	0.0030	AP-42, 13.2.4, Equation 1	3-05-888-01	2.29E-06	1.26E-04	5.79E-07
PM_{10}	0.35	0.0094	0.0014			1.08E-06	5.94E-05	2.74E-07
$PM_{2.5}$	0.053	0.0014	0.0002			1.64E-07	8.99E-06	4.14E-08

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)}$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project
Emission Calculations

Equipment ID:	PP Building Furnace		
Equipment Description:	Primary Processing Building Furnace		
Heat Input Rating:	1.6	MMBtu/hr	
Fuel Type:	Natural Gas		
Heating Value:	1,020	Btu/scf	
Operating Hours:	6,570	hr/year	assumed 9 months/year

Criteria Pollutants	Emission Factor ($lb/10^6$ scf)	Emission Factor Reference	SCC	Emission Factor (lb/MMBtu)	PTE (lbs/hr)	PTE (tpy)
NO_X	100	AP-42 Table 1.4-1	1-02-006-03	9.80E-02	0.16	0.52
CO	84			8.24E-02	0.13	0.43
PM, PM_{10}, $PM_{2.5}$	7.6	AP-42 Table 1.4-2		7.45E-03	0.01	0.04
SO_2	0.6			5.88E-04	0.001	0.003
VOC	5.5			5.39E-03	0.01	0.03
Pb	0.0005			4.90E-07	0.000001	0.000003
GHG Pollutants						
CO_2	120000	AP-42 Table 1.4-2	1-02-006-03	118	188	618
CH_4	2.3			2.25E-03	0.004	0.01
N_2O	2.2			2.16E-03	0.003	0.01
HAPs/TAPs						
Dichlorobenzene	1.2E-03	AP-42 Table 1.4-3	1-02-006-03	1.18E-06	1.88E-06	6.18E-06
Toluene	3.4E-03	AP-42 Table 1.4-3		3.33E-06	5.33E-06	1.75E-05
Hexane	1.8E+00	AP-42 Table 1.4-3		1.76E-03	2.82E-03	9.28E-03
Anthracene	2.4E-06	AP-42 Table 1.4-3		2.35E-09	3.76E-09	1.24E-08
Pyrene	5.0E-06	AP-42 Table 1.4-3		4.90E-09	7.84E-09	2.58E-08
Benzo(g,h,i)perylene	1.2E-06	AP-42 Table 1.4-3		1.18E-09	1.88E-09	6.18E-09
Indeno(1,2,3-cd)pyrene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
Benzo(b)fluoranthene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
Fluoranthene	3.0E-06	AP-42 Table 1.4-3		2.94E-09	4.71E-09	1.55E-08
Benzo(k)fluoranthene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
Acenaphthylene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
Chrysene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
Formaldehyde	7.5E-02	AP-42 Table 1.4-3		7.35E-05	1.18E-04	3.86E-04
Benzo(a)pyrene	1.2E-06	AP-42 Table 1.4-3		1.18E-09	1.88E-09	6.18E-09
Dibenzo(a,h)anthracene	1.2E-06	AP-42 Table 1.4-3		1.18E-09	1.88E-09	6.18E-09
3-Methylchloranthrene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
Benz(a)anthracene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
7,12-Dimethylbenz(a)anth	1.6E-05	AP-42 Table 1.4-3		1.57E-08	2.51E-08	8.24E-08
Benzene	2.1E-03	AP-42 Table 1.4-3		2.06E-06	3.29E-06	1.08E-05
Manganese	3.8E-04	AP-42 Table 1.4-4		3.73E-07	5.96E-07	1.96E-06
Mercury	2.6E-04	AP-42 Table 1.4-4		2.55E-07	4.08E-07	1.34E-06
Nickel	2.1E-03	AP-42 Table 1.4-4		2.06E-06	3.29E-06	1.08E-05
Arsenic	2.0E-04	AP-42 Table 1.4-4		1.96E-07	3.14E-07	1.03E-06
Beryllium	1.2E-05	AP-42 Table 1.4-4		1.18E-08	1.88E-08	6.18E-08
Cadmium	1.1E-03	AP-42 Table 1.4-4		1.08E-06	1.73E-06	5.67E-06
Chromium	1.4E-03	AP-42 Table 1.4-4		1.37E-06	2.20E-06	7.21E-06
Cobalt	8.4E-05	AP-42 Table 1.4-4		8.24E-08	1.32E-07	4.33E-07
Selenium	2.4E-05	AP-42 Table 1.4-4		2.35E-08	3.76E-08	1.24E-07
Acenaphthene	1.8E-06	AP-42 Table 1.4-3		1.76E-09	2.82E-09	9.28E-09
Phenanthrene	1.7E-05	AP-42 Table 1.4-3		1.67E-08	2.67E-08	8.76E-08
Fluorene	2.8E-06	AP-42 Table 1.4-3		2.75E-09	4.39E-09	1.44E-08
Naphthalene	6.1E-04	AP-42 Table 1.4-3		5.98E-07	9.57E-07	3.14E-06
2-Methylnaphthalene	2.4E-05	AP-42 Table 1.4-3		2.35E-08	3.76E-08	1.24E-07
				TOTAL HAPs/TAPs	0.003	0.010

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Exploration Sample Truck Loadout		
Equipment Description:	Batch Drop Loadout of Exploration Sample		
Maximum Annual Throughput:	1,000	tons/year	
Maximum Hourly Throughput:	20	tons/hour	Section 2.1.2.6 (RER, 2022a)
Mean Wind Speed (U):	9.4	mph	Met Data Summary (IML, 2021)
Maximum Wind Speed (U):	39.7	mph	Met Data Summary (IML, 2021)
Exploration Sample Moisture Content:	3	wt %	Personal communication with Jaye Pickarts 5/23/2022

Pollutant	Particle Size Multiplier (k)	Emission Factor (lb/ton) at Max Wind Speed	Emission Factor (lb/ton) at Mean Wind Speed	Emission Factor Reference	SCC	PTE (lb/hr)	PTE (tpy)
PM	0.74	0.0198	0.0030	AP-42, 13.2.4, Equation 1	30510499	0.40	0.0015
PM_{10}	0.35	0.0094	0.0014			0.19	0.0007
$PM_{2.5}$	0.053	0.0014	0.0002			0.03	0.0001

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \text{ (pound [lb]/ton)}$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 µm	< 15 µm	< 10 µm	< 5 µm	< 2.5 µm
0.74	0.48	0.35	0.20	0.053[a]

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	510TK-101		
Equipment Description:	Bulk Storage Tank Hydrochloric Acid		
Mixture/Component:	HCl 28.5 % Concentration		
Shell Height:	16.71	ft	
Shell Diameter:	10	ft	
Maximum Liquid Height:	14.92	ft	
Avgerage Liquid Height:	7.46	ft	
Working Volume:	8,766	gal	
Turnovers per Year:	18.53		
Net Throughput:	162,396	gal/yr	6,246
Heated:	Yes		
Roof Type:	Dome		
Roof Height:	1.79	ft	
Roof Radius:	10	ft	
Control Equipment:	PolyProcessing PolyScrub		
Control Efficiency:	90%		

Pollutant	Pre-Controlled Potential Emissions (lbs/yr)	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
HCl	25.84	0.013	0.14	0.0013

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	510TK-101
City:	Upton
State:	Wyoming
Company:	Rare Element Resources, Inc.
Type of Tank:	Vertical Fixed Roof Tank
Description:	Rare Earth Element Separation and Processing Demonstration Plant Hydrochloric Acid Bulk Storage Tank

Tank Dimensions

Shell Height (ft):	16.71
Diameter (ft):	10.00
Liquid Height (ft) :	14.92
Avg. Liquid Height (ft):	7.46
Volume (gallons):	8,765.81
Turnovers:	19.11
Net Throughput(gal/yr):	162,396.00
Is Tank Heated (y/n):	Y

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition	Good
Roof Color/Shade:	White/White
Roof Condition:	Good

Roof Characteristics

Type:	Dome
Height (ft)	1.79
Radius (ft) (Dome Roof)	10.00

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig)	0.00

Meterological Data used in Emissions Calculations: Rapid City, South Dakota (Avg Atmospheric Pressure = 13.11 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

510TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
HCl (28.5% Conc)	All	77.00	77.00	77.00	77.00	0.1836	0.1836	0.1836	36.4000			36.46	Option 1: VP70 = .136 VP80 = .204

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

510TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

Annual Emission Calcaulations	
Standing Losses (lb):	0.0000
Vapor Space Volume (cu ft):	799.7895
Vapor Density (lb/cu ft):	0.0012
Vapor Space Expansion Factor:	0.0000
Vented Vapor Saturation Factor:	0.9098
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	799.7895
Tank Diameter (ft):	10.0000
Vapor Space Outage (ft):	10.1832
Tank Shell Height (ft):	16.7100
Average Liquid Height (ft):	7.4600
Roof Outage (ft):	0.9332
Roof Outage (Dome Roof)	
Roof Outage (ft):	0.9332
Dome Radius (ft):	10.0000
Shell Radius (ft):	5.0000
Vapor Density	
Vapor Density (lb/cu ft):	0.0012
Vapor Molecular Weight (lb/lb-mole):	36.4000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.1836
Daily Avg. Liquid Surface Temp. (deg. R):	536.6700
Daily Average Ambient Temp. (deg. F):	46.5292
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	536.6700
Tank Paint Solar Absorptance (Shell):	0.1700
Tank Paint Solar Absorptance (Roof):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,348.0802
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0000
Daily Vapor Temperature Range (deg. R):	0.0000
Daily Vapor Pressure Range (psia):	0.0000
Breather Vent Press. Setting Range(psia):	0.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.1836
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.1836
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.1836
Daily Avg. Liquid Surface Temp. (deg R):	536.6700
Daily Min. Liquid Surface Temp. (deg R):	536.6700
Daily Max. Liquid Surface Temp. (deg R):	536.6700
Daily Ambient Temp. Range (deg. R):	25.6417
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9098
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.1836
Vapor Space Outage (ft):	10.1832
Working Losses (lb):	25.8405
Vapor Molecular Weight (lb/lb-mole):	36.4000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.1836
Annual Net Throughput (gal/yr.):	162,396.0000
Annual Turnovers:	19.1054
Turnover Factor:	1.0000
Maximum Liquid Volume (gal):	8,765.8069
Maximum Liquid Height (ft):	14.9200
Tank Diameter (ft):	10.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	25.8405

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

510TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
HCl (28.5% Conc)	25.84	0.00	25.84

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	511TK-102	
Equipment Description:	Bulk Storage Tank Recycled Hydrochloric Acid	
Mixture/Component:	HCl 28.5 % Concentration	
Shell Height:	10	ft
Shell Diameter:	5.3	ft
Maximum Liquid Height:	8.67	ft
Avgerage Liquid Height:	4.33	ft
Working Volume:	1,431	gal
Turnovers per Year:	123.91	
Net Throughput:	177,302	gal/yr
Heated:	Yes	
Roof Type:	Dome	
Roof Height:	1.33	ft
Roof Radius:	5.3	ft
Control Equipment:	PolyProcessing PolyScrub	
Control Efficiency:	90%	

Pollutant	Pre-Controlled Potential Emissions (lbs/yr)	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
HCl	11.53	0.006	0.01	0.0006

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	511TK-102
City:	Upton
State:	Wyoming
Company:	Rare Element Resources, Inc.
Type of Tank:	Vertical Fixed Roof Tank
Description:	Rare Earth Element Separation and Processing Demonstration Plant Recycled Hydrochloric Acid Bulk Storage Tank

Tank Dimensions

Shell Height (ft):	10.00
Diameter (ft):	5.30
Liquid Height (ft) :	8.67
Avg. Liquid Height (ft):	4.33
Volume (gallons):	1,430.85
Turnovers:	123.91
Net Throughput(gal/yr):	177,302.00
Is Tank Heated (y/n):	Y

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition	Good
Roof Color/Shade:	White/White
Roof Condition:	Good

Roof Characteristics

Type:	Dome
Height (ft)	1.33
Radius (ft) (Dome Roof)	5.30

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig)	0.00

Meterological Data used in Emissions Calculations: Rapid City, South Dakota (Avg Atmospheric Pressure = 13.11 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

511TK-102 - Vertical Fixed Roof Tank
Upton, Wyoming

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
HCl (28.5% Conc)	All	77.00	77.00	77.00	77.00	0.1836	0.1836	0.1836	36.4000			36.46	Option 1: VP70 = .136 VP80 = .204

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

511TK-102 - Vertical Fixed Roof Tank
Upton, Wyoming

Annual Emission Calcaulations	
Standing Losses (lb):	0.0000
Vapor Space Volume (cu ft):	140.9936
Vapor Density (lb/cu ft):	0.0012
Vapor Space Expansion Factor:	0.0000
Vented Vapor Saturation Factor:	0.9415
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	140.9936
Tank Diameter (ft):	5.3000
Vapor Space Outage (ft):	6.3908
Tank Shell Height (ft):	10.0000
Average Liquid Height (ft):	4.3300
Roof Outage (ft):	0.7208
Roof Outage (Dome Roof)	
Roof Outage (ft):	0.7208
Dome Radius (ft):	5.3000
Shell Radius (ft):	2.6500
Vapor Density	
Vapor Density (lb/cu ft):	0.0012
Vapor Molecular Weight (lb/lb-mole):	36.4000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.1836
Daily Avg. Liquid Surface Temp. (deg. R):	536.6700
Daily Average Ambient Temp. (deg. F):	46.5292
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	536.6700
Tank Paint Solar Absorptance (Shell):	0.1700
Tank Paint Solar Absorptance (Roof):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,348.0802
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0000
Daily Vapor Temperature Range (deg. R):	0.0000
Daily Vapor Pressure Range (psia):	0.0000
Breather Vent Press. Setting Range(psia):	0.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.1836
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.1836
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.1836
Daily Avg. Liquid Surface Temp. (deg R):	536.6700
Daily Min. Liquid Surface Temp. (deg R):	536.6700
Daily Max. Liquid Surface Temp. (deg R):	536.6700
Daily Ambient Temp. Range (deg. R):	25.6417
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9415
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.1836
Vapor Space Outage (ft):	6.3908
Working Losses (lb):	11.5324
Vapor Molecular Weight (lb/lb-mole):	36.4000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.1836
Annual Net Throughput (gal/yr.):	177,302.0000
Annual Turnovers:	123.9138
Turnover Factor:	0.4088
Maximum Liquid Volume (gal):	1,430.8494
Maximum Liquid Height (ft):	8.6700
Tank Diameter (ft):	5.3000
Working Loss Product Factor:	1.0000
Total Losses (lb):	11.5324

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

511TK-102 - Vertical Fixed Roof Tank
Upton, Wyoming

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
HCl (28.5% Conc)	11.53	0.00	11.53

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	520TK-101	
Equipment Description:	Bulk Storage Tank Nitric Acid	
Mixture/Component:	HNO_3 45% Concentration	
Shell Height:	14.5	ft
Shell Diameter:	11.92	ft
Maximum Liquid Height:	12.50	ft
Avgerage Liquid Height:	6.25	ft
Working Volume:	10,435	gal
Turnovers per Year:	23.16	
Net Throughput:	241,693	gal/yr
Heated:	Yes	
Roof Type:	Dome	
Roof Height:	2.00	ft
Roof Radius:	11.92	ft
Control Equipment:	PolyProcessing PolyScrub	
Control Efficiency:	90%	

Pollutant	Pre-Controlled Potential Emissions (lbs/yr)	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
HNO_3	1.64	0.001	0.01	0.0001

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	520TK-101
City:	Upton
State:	Wyoming
Company:	Rare Element Resources, Inc.
Type of Tank:	Vertical Fixed Roof Tank
Description:	Rare Earth Element Separation and Processing Demonstration Plant Nitric Acid Bulk Storage Tank

Tank Dimensions

Shell Height (ft):	14.50
Diameter (ft):	11.92
Liquid Height (ft) :	12.50
Avg. Liquid Height (ft):	6.25
Volume (gallons):	10,434.84
Turnovers:	23.16
Net Throughput(gal/yr):	241,693.00
Is Tank Heated (y/n):	Y

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition	Good
Roof Color/Shade:	White/White
Roof Condition:	Good

Roof Characteristics

Type:	Dome
Height (ft)	2.00
Radius (ft) (Dome Roof)	11.92

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig)	0.00

Meterological Data used in Emissions Calculations: Rapid City, South Dakota (Avg Atmospheric Pressure = 13.11 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

520TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Nitric Acid (45% Conc)	All	77.00	77.00	77.00	77.00	0.0045	0.0045	0.0045	63.0100			63.01	Option 1: VP70 = .00324 VP80 = .00509

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

520TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

Annual Emission Calcaulations	
Standing Losses (lb):	0.0000
Vapor Space Volume (cu ft):	1,036.4370
Vapor Density (lb/cu ft):	0.0000
Vapor Space Expansion Factor:	0.0000
Vented Vapor Saturation Factor:	0.9978
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	1,036.4370
Tank Diameter (ft):	11.9200
Vapor Space Outage (ft):	9.2875
Tank Shell Height (ft):	14.5000
Average Liquid Height (ft):	6.2500
Roof Outage (ft):	1.0375
Roof Outage (Dome Roof)	
Roof Outage (ft):	1.0375
Dome Radius (ft):	11.9200
Shell Radius (ft):	5.9600
Vapor Density	
Vapor Density (lb/cu ft):	0.0000
Vapor Molecular Weight (lb/lb-mole):	63.0100
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0045
Daily Avg. Liquid Surface Temp. (deg. R):	536.6700
Daily Average Ambient Temp. (deg. F):	46.5292
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	536.6700
Tank Paint Solar Absorptance (Shell):	0.1700
Tank Paint Solar Absorptance (Roof):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,348.0802
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0000
Daily Vapor Temperature Range (deg. R):	0.0000
Daily Vapor Pressure Range (psia):	0.0000
Breather Vent Press. Setting Range(psia):	0.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0045
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0045
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0045
Daily Avg. Liquid Surface Temp. (deg R):	536.6700
Daily Min. Liquid Surface Temp. (deg R):	536.6700
Daily Max. Liquid Surface Temp. (deg R):	536.6700
Daily Ambient Temp. Range (deg. R):	25.6417
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9978
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.0045
Vapor Space Outage (ft):	9.2875
Working Losses (lb):	1.6444
Vapor Molecular Weight (lb/lb-mole):	63.0100
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0045
Annual Net Throughput (gal/yr.):	241,693.0000
Annual Turnovers:	23.1621
Turnover Factor:	1.0000
Maximum Liquid Volume (gal):	10,434.8354
Maximum Liquid Height (ft):	12.5000
Tank Diameter (ft):	11.9200
Working Loss Product Factor:	1.0000
Total Losses (lb):	1.6444

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

520TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Nitric Acid (45% Conc)	1.64	0.00	1.64

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	540TK-101	
Equipment Description:	Bulk Storage Tank Ammonia Water	
Mixture/Component:	Ammonia 25 % Concentration	
Shell Height:	17.083	ft
Shell Diameter:	11.92	ft
Maximum Liquid Height:	15.17	ft
Avgerage Liquid Height:	7.58	ft
Working Volume:	12,664	gal
Turnovers per Year:	24	
Net Throughput:	301,650	gal/yr
Heated:	Yes	
Roof Type:	Dome	
Roof Height:	1.92	ft
Roof Radius:	11.92	ft
Control Equipment:	PolyProcessing PolyScrub	
Control Efficiency:	90%	

Pollutant	Pre-Controlled Potential Emissions (lbs/yr)	Pre-Controlled Potential Emissions (tpy)	PTE (lb/hr)	PTE (tpy)
NH_3	1,117.17	0.56	4.69	0.06

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	540TK-101
City:	Upton
State:	Wyoming
Company:	Rare Element Resources, Inc.
Type of Tank:	Vertical Fixed Roof Tank
Description:	Rare Earth Element Separation and Processing Demonstration Plant Ammonia Water Bulk Storage Tank

Tank Dimensions

Shell Height (ft):	17.08
Diameter (ft):	11.92
Liquid Height (ft) :	15.17
Avg. Liquid Height (ft):	7.58
Volume (gallons):	12,663.72
Turnovers:	24.22
Net Throughput(gal/yr):	301,650.00
Is Tank Heated (y/n):	Y

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition	Good
Roof Color/Shade:	White/White
Roof Condition:	Good

Roof Characteristics

Type:	Dome
Height (ft)	1.92
Radius (ft) (Dome Roof)	11.92

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig)	0.00

Meterological Data used in Emissions Calculations: Rapid City, South Dakota (Avg Atmospheric Pressure = 13.11 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

540TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Ammonia (25% Conc.)	All	77.00	77.00	77.00	77.00	9.1338	9.1338	9.1338	17.0300			17.03	Option 1: VP70 = 7.717 VP80 = 9.741

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

540TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

Annual Emission Calcaulations	
Standing Losses (lb):	0.0000
Vapor Space Volume (cu ft):	1,171.3182
Vapor Density (lb/cu ft):	0.0270
Vapor Space Expansion Factor:	0.0000
Vented Vapor Saturation Factor:	0.1644
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	1,171.3182
Tank Diameter (ft):	11.9200
Vapor Space Outage (ft):	10.4962
Tank Shell Height (ft):	17.0830
Average Liquid Height (ft):	7.5800
Roof Outage (ft):	0.9932
Roof Outage (Dome Roof)	
Roof Outage (ft):	0.9932
Dome Radius (ft):	11.9200
Shell Radius (ft):	5.9600
Vapor Density	
Vapor Density (lb/cu ft):	0.0270
Vapor Molecular Weight (lb/lb-mole):	17.0300
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	9.1338
Daily Avg. Liquid Surface Temp. (deg. R):	536.6700
Daily Average Ambient Temp. (deg. F):	46.5292
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	536.6700
Tank Paint Solar Absorptance (Shell):	0.1700
Tank Paint Solar Absorptance (Roof):	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,348.0802
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0000
Daily Vapor Temperature Range (deg. R):	0.0000
Daily Vapor Pressure Range (psia):	0.0000
Breather Vent Press. Setting Range(psia):	0.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	9.1338
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	9.1338
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	9.1338
Daily Avg. Liquid Surface Temp. (deg R):	536.6700
Daily Min. Liquid Surface Temp. (deg R):	536.6700
Daily Max. Liquid Surface Temp. (deg R):	536.6700
Daily Ambient Temp. Range (deg. R):	25.6417
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.1644
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	9.1338
Vapor Space Outage (ft):	10.4962
Working Losses (lb):	1,117.1724
Vapor Molecular Weight (lb/lb-mole):	17.0300
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	9.1338
Annual Net Throughput (gal/yr.):	301,650.0000
Annual Turnovers:	24.2192
Turnover Factor:	1.0000
Maximum Liquid Volume (gal):	12,663.7162
Maximum Liquid Height (ft):	15.1700
Tank Diameter (ft):	11.9200
Working Loss Product Factor:	1.0000
Total Losses (lb):	1,117.1724

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

540TK-101 - Vertical Fixed Roof Tank
Upton, Wyoming

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Ammonia (25% Conc.)	1,117.17	0.00	1,117.17

Rare Element Resources
Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID: Main Processing Facility Scrubber Vent
Equipment Description: Main Processing Facility Scrubber Vent
Hours of Operation: 8760 hr/yr

Pollutant	Emission Factor	Units	Emission Factor Reference	Emission Factor (lb/hr)	Pre-Controlled Potential Emissions (tpy)	Control Efficiency	PTE (lb/hr)	PTE (tpy)
NO_X	0.001	kg/hr	Emissions Test	2.20E-03	0.01	0%	0.002	0.01
TC	0.0004	kg/hr	Emissions Test	8.82E-04	0.004	0%	0.001	0.004
NH_3	0.039	g/hr	Emissions Test	8.60E-05	0.0004	90%	0.00001	0.00004
HCl	0.00001	kg/hr	Emissions Test	2.20E-05	0.0001	90%	0.000002	0.000010
Cl_2	0.00001	kg/hr	Emissions Test	2.20E-05	0.0001	90%	0.000002	0.000010
AsH_3	0.00012	kg/hr	Emissions Test	2.65E-04	0.0012	0%	0.0003	0.001
HAPs	0.0001	kg/hr	Emissions Test	3.09E-04	0.0014		0.0003	0.0012

Rare Element Resources

Rare Earth Element Separation and Processing Demonstration Project

Emission Calculations

Equipment ID:	Fugutive Dust Const. & Decom.	
Equipment Description:	Fugutive Dust Const. & Decom.	
Material silt content (s):	8.6 %	WY-AQD PRB Permitting Guidance (February 2018) - Typical for PRB
Material moisture content (M):	7.9 %	AP-42, Table 11.9-3, Overburden
Precipitation Days (P)	100 days	WY-AQD PRB Permitting Guidance (February 2018) - Typical for PRB
N	365 days	

Item	Brand	Model	Scaling Factors		EF					Transit Duty	No. of Units	Hours of Operation		Vehicle Speed (S) mph	Vehicle Weight (tons)	VMT		Emission Factor Reference
			PM_{10}	$PM_{2.5}$	TSP < 30 µm	< 15 µm	PM_{10}	$PM_{2.5}$	Units			Const.	Decom.			Const.	Decom.	
Excavator	CAT	326 Hydraulic	0.75	0.105	5.13	1.40	1.05	0.54	lb/hr	100%	2	4,000	1,200	N/A		N/A	N/A	AP-42, Table 11.9-1
Front end loader	CAT	950M	0.75	0.105	5.13	1.40	1.05	0.54	lb/hr	100%	1	2,000	600	N/A		N/A	N/A	AP-42, Table 11.9-1
Backhoe	CAT	430	0.75	0.105	5.13	1.40	1.05	0.54	lb/hr	100%	1	2,000	600	N/A		N/A	N/A	AP-42, Table 11.9-1
Skid steer	CAT	246D3	0.75	0.105	5.13	1.40	1.05	0.54	lb/hr	100%	1	2,000	600	N/A		N/A	N/A	AP-42, Table 11.9-1
Crane	Grove	RT765E-2	N/A	N/A	9.72	N/A	2.78	0.28	lb/VMT	10%	2	4,000	1,200	2	47	800	240	AP-42, 13.2.2
Dozer	CAT	D6	0.75	0.105	5.13	1.40	1.05	0.54	lb/hr	100%	1	2,000	600	N/A		N/A	N/A	AP-42, Table 11.9-1
Forklift	CAT	DP40N3	N/A	N/A	3.55	N/A	1.02	0.10	lb/VMT	40%	1	2,000	600	5	5	4,000	1,200	AP-42, 13.2.3
Manlift	JLG	450A	N/A	N/A	4.15	N/A	1.19	0.12	lb/VMT	10%	1	2,000	600	2	7	400	120	AP-42, 13.2.4
Scissor Lift	JLG	RT3369	N/A	N/A	3.46	N/A	0.99	0.10	lb/VMT	10%	1	2,000	600	2	5	400	120	AP-42, 13.2.5
Grader	CAT	120GC	0.6	0.031	2.24	1.28	0.77	0.07	lb/VMT	100%	1	2,000	600	5	N/A	10,000	3,000	AP-42, Table 11.9-1
Equipment Delivery Trucks	N/A	N/A	N/A	N/A	7.94	N/A	2.27	0.23	lb/VMT	10%	25	50	50	5	30	25	25	AP-42, 13.2.6
Pickup Truck	N/A	N/A	N/A	N/A	3.55	N/A	1.02	0.10	lb/VMT	25%	2	250	75	10	5	83	25	AP-42, 13.2.7
Passenger Vehicle	N/A	N/A	N/A	N/A	2.82	N/A	0.81	0.08	lb/VMT	25%	30	3,750	1,125	10	3	1,250	375	AP-42, 13.2.8

Assumed all vehicle travel was on unpaved industrial roads.

Item	Construction						Decomissioning					
	Emissions (lb/hr)			Emissions (tons)			Emissions (lb/hr)			Emissions (tons)		
	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$	PM	PM_{10}	$PM_{2.5}$
Excavator	10.27	2.09	1.08	10.27	2.09	1.08	10.27	2.09	1.08	3.08	0.63	0.32
Front end loader	5.13	1.05	0.54	5.13	1.05	0.54	5.13	1.05	0.54	1.54	0.31	0.16
Backhoe	5.13	1.05	0.54	5.13	1.05	0.54	5.13	1.05	0.54	1.54	0.31	0.16
Skid steer	5.13	1.05	0.54	5.13	1.05	0.54	5.13	1.05	0.54	1.54	0.31	0.16
Crane	3.89	1.11	0.11	3.89	1.11	0.11	3.89	1.11	0.11	1.17	0.33	0.03
Dozer	5.13	1.05	0.54	5.13	1.05	0.54	5.13	1.05	0.54	1.54	0.31	0.16
Forklift	7.09	2.03	0.20	7.09	2.03	0.20	7.09	2.03	0.20	2.13	0.61	0.06
Manlift	0.83	0.24	0.02	0.83	0.24	0.02	0.83	0.24	0.02	0.25	0.07	0.01
Scissor Lift	0.69	0.20	0.02	0.69	0.20	0.02	0.69	0.20	0.02	0.21	0.06	0.01
Grader	11.18	3.83	0.35	11.18	3.83	0.35	11.18	3.83	0.35	3.35	1.15	0.10
Equipment Delivery Trucks	3.97	1.14	0.11	0.10	0.03	0.00	3.97	1.14	0.11	0.10	0.03	0.00
Pickup Truck	17.73	5.08	0.51	0.15	0.04	0.00	17.73	5.08	0.51	0.04	0.01	0.00
Passenger Vehicle	211.32	60.52	6.05	1.76	0.50	0.05	211.32	60.52	6.05	0.53	0.15	0.02
TOTAL	**287.49**	**80.42**	**10.61**	**56.48**	**14.26**	**4.00**	**287.49**	**80.42**	**10.61**	**17.01**	**4.30**	**1.20**

Pollutant	PM	PM_{10}	$PM_{2.5}$
k (lb/VMT)	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

Source: AP-42 Table 13.2.2-2 Industrial Roads