

**Monitoring Results
for Natural Gas Wells
Near Project Rulison,
1st Quarter, Fiscal Year 2015**

**U.S. Department of Energy Office of Legacy Management
Grand Junction, Colorado**

Date Sampled: January 7, 2015

Background

Project Rulison was the second Plowshare Program test to stimulate natural gas recovery from deep, low-permeability formations. On September 10, 1969, a 40-kiloton-yield nuclear device was detonated 8,426 feet (1.6 miles) below ground surface in the Williams Fork Formation at what is now the Rulison, Colorado, Site. Following the detonation, a series of production tests were conducted. Afterward, the site was shut down and then remediated, and the emplacement well (R-E) and the reentry well (R-Ex) were plugged.

Purpose

As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM is monitoring natural gas wells that are near the Rulison site for radionuclides associated with the detonation. The very low permeability of the Williams Fork Formation limits contaminant migration, and institutional controls restrict subsurface access in the detonation zone. When companies apply for a permit to drill wells within 3 miles of the site, the Colorado Oil and Gas Conservation Commission notifies DOE, and the State of Colorado and DOE have an opportunity to review and comment on drilling permits and gas well development practices to help protect human health and the environment from the Rulison-related contaminants. The DOE *Rulison Monitoring Plan* (LMS/RUL/S06178) provides guidance for sample collection frequency based on distance from the Rulison detonation point, the types of analyses, and the reporting thresholds.

Summary of Results

Due to operational issues at several well heads and bad weather causing safety concerns, the sampling planned for mid-October of 2014 was delayed several times. The natural gas and production water sampling occurred on January 7, 2015. Analytical results of production water samples and natural gas samples collected in January 2015 were all below the screening levels specified in the *Rulison Monitoring Plan*.

The January sampling effort consisted of sampling a total of 13 natural gas wells. Seven wells (Battlement Mesa [BM] 26-34B, 26-22C, 26-22D, 35-32A, 36-13B, 36-13, and a duplicate from 36-13) produced enough production water volume to conduct all scheduled analyses. At all wells, natural gas was collected and analyzed for tritium and carbon-14. Due to operational issues, a bailer was brought to the 26N to collect downhole production water samples. In well BM 26-33C the production water return lines had an obstruction that limited the potential to bail

production water for sampling. The natural gas temperatures and pressures were lower than normal during this sampling event (Table 2). The well operator was unaware of any operational processes that would cause the lower temperature and pressure to occur.

Table 1 lists the 13 wells, and Table 2 lists the sequential sample collection information.

Table 1. Sample Collection Locations

Pad	Collection Location	Well Name
26N	Wellhead separator	BM 26-33B–D, BM 26-34A–D
26K	Wellhead separator	BM 26-22B–D
35C	Wellhead separator	BM 35-32A
36L	Wellhead separator	BM36-13B
36B	Wellhead separator	BM36-13

Table 2. Samples Collected

Sequence	Pad	Well Name	Location			Sample Phase		Well	
			API # 05-045-	Type	Subtype	Gas	Liquid	T (°F)	P (psi)
1	26N	BM 26-33B	15743	WL	NGSA	Yes	No	84	264
2	26N	BM 26-33C	15742	WL	NGSA	Yes	No	85	260
3	26N	BM 26-33D	15739	WL	NGSA	Yes	No	84.9	261
4	26N	BM 26-34A	15744	WL	NGSA	Yes	No	83.9	263
5	26N	BM 26-34B	15745	WL	NGSA	Yes	Yes	80.1	258
6	26N	BM 26-34C	15741	WL	NGSA	Yes	No	88.8	256
7	26N	BM 26-34D	15748	WL	NGSA	Yes	Yes	81	259
8	26K	BM 26-22B	16086	WL	NGSA	Yes	No	91.8	239
9	26K	BM 26-22C	16087	WL	NGSA	Yes	Yes	89.1	234
10	26K	BM 26-22D	16074	WL	NGSA	Yes	Yes	83.1	240
11	35C	BM 35-32A	10919	WL	NGSA	Yes	Yes	65.3	270
12	36L	BM 36-13B	15469	WL	NGSV	Yes	Yes	67.7	223
13	36B	BM 36-13	10840	WL	NGSV	Yes	Yes	76.7	287
Duplicate	36B	BM 36-13	10840	WL	NGSV	No	Yes	76.7	279

Abbreviations:

API American Petroleum Institute
 NGSA natural gas well—angle
 NGSV natural gas well—vertical
 P (psi) pressure in pounds per square inch
 T (°F) temperature in degrees Fahrenheit
 WL well

Sample Locations

The bottom-hole locations of the 13 gas wells planned for sample collection are between 0.75 mile and 1.07 miles from the Project Rulison detonation point. All gas wells sampled are producing gas from the Williams Fork Formation at a depth near that of the Rulison detonation point.

Sample Collection

A produced-water sample is collected at the wellhead from a tap on the common line connecting two gas-liquid separators and the accumulation tank. The produced water collected from one well separator is isolated from the other well separator by valves. Lines from each of the two separators are purged of produced water and condensate prior to sample collection. Each sample is collected in a new, 1-gallon plastic container. Due to operational issues on the 26N (wells BM 26-33C and 34D), an operator-provided bailer was used to collect production water from the downhole water return line. An obstruction in the production water return line at well BM 26-33C prohibited lowering of the bailer to the water level and the collection of a production water sample.

Gas samples are collected from a tap on the gas line at the separator output. The line between the tap and the sample bottle is purged before sample collection. Each gas sample is collected in an evacuated 18-liter bottle furnished by the laboratory.

Monitoring Protocol

The *Rulison Monitoring Plan* provides guidance regarding the type and frequency of sample collection as a function of distance and heading from the Rulison detonation point; it also specifies the types of analyses. A copy of the monitoring plan is available at <http://www.lm.doe.gov/Rulison/Documents.aspx>. Table 3a lists gas-phase screening concentrations for tritium and carbon-14, and Table 3b lists liquid-phase screening concentrations for tritium, gross alpha, gross beta, and the suite of radionuclides identified by high-resolution gamma spectrometry.

Table 3a. Gas-Phase Concentrations for Tritium Sample Results

Analyte	Reporting Units	Screening Concentration	Action Concentration	Comment
Tritium	TU	19,293	TBD	5.183×10^{-6} pCi/cc ⁻¹ TU ⁻¹
¹⁴ Carbon	pMC	2 pMC	5 pMC	6.54×10^{-5} pCi/cc and 16.4×10^{-5} pCi/cc, respectively

Abbreviations:

pCi/cc	picocuries per cubic centimeter
pCi/cc ⁻¹ TU ⁻¹	picocuries per cubic centimeter of methane gas per tritium unit
pMC	percent modern carbon
TBD	to be determined
TU	tritium unit

Table 3b. Liquid-Phase Screening Concentrations for Tritium and Other Radionuclides

Analyte	Reporting Units	Screening Concentration	Action Concentration	Comment
Tritium	pCi/L	800	TBD	20,000 pCi/L = EPA drinking water standard
Lab Method				
Gross alpha	pCi/L	3× background	TBD	
Gross beta	pCi/L	3× background	TBD	
High-resolution gamma spectrometry	pCi/L	20	TBD	Based on cesium-137

Notes:

See the *Rulison Monitoring Plan*, Table 2, for response scenarios to use when the screening concentrations, action concentrations, or both, are exceeded.

The derived air effluent concentration for a 50 millirem per year dose from tritium exposure is 0.10 pCi (tritium)/cc (methane).

Abbreviations:

EPA U.S. Environmental Protection Agency
 pCi/L picocuries per liter
 TBD to be determined

Results

Seven of the total 13 sampling locations plus a duplicate at BM 36-13 produced enough production water to analyze for some or all of the Rulison-related contaminants.

Production water analytical results are tabulated by well in Appendix A.

Laboratory Qualifiers

A “detect” is a result greater than the laboratory’s reporting threshold or minimum detectable concentration (MDC).

A “nondetect” is a result that is less than the laboratory’s MDC for that sample. The laboratory assigns the qualifier “U” to a nondetect result.

Data Validation Qualifiers

A detect result less than 3 times the sample MDC is assigned the data validation qualifier “J” (estimated quantity).

A laboratory detect result less than 3 times the 1-sigma total propagated uncertainty is considered a nondetect. Data validation assigns the qualifier “U” to this result.

Results Summaries

Table 4a is a summary of analytical results for liquid-phase tritium, Table 4b is a summary of results for liquid-phase gross alpha and gross beta, and Table 4c shows results for potassium-40 analyses. Sample volumes not adequate for laboratory analysis are counted as not applicable (NA).

Table 4a. Summary of Tritium Samples Based on Laboratory-Assigned Qualifiers

Collection Location	Total Samples (gas/liquid) Collected	Tritium Results (gas phase)			Tritium Results (liquid phase)			Carbon-14 (gas phase)		
		Detect	Nondetect	NA	Detect	Nondetect	NA	Detect	Nondetect	NA
Natural gas wells	13/8	0	13	0	0	8	6	0	13	0

Notes:

Natural gas samples were successfully collected from all 13 wells associated with the sampling plan. Well BM 36-13 was selected as a duplicate sampling location where duplicate production water was collected but no natural gas sample was collected.

At wells BM 26-33B, 26-33C, 26-33D, 26-34A, 26-34C, and 26-22B, no production water was produced during sampling operations. Historically, BM 26-33D and BM 26-22B have typically produced no or very small amounts of production water. At BM 26-33C and BM 26-34D the operator utilized a bailer to collect production water from the wells' water return lines. An obstruction in the water return line was encountered in well BM 26-33C so no production water was collected using the bailer.

Table 4b. Summary of Gross Alpha and Gross Beta Liquid-Phase Samples Based on Laboratory-Assigned Qualifiers

Collection Location	Total Liquid Samples Collected	Gross Alpha Results			Gross Beta Results		
		Detect	Nondetect	NA	Detect	Nondetect	NA
Natural gas wells	8	3	5	6	8	0	6

Notes:

Data validation assigned a J qualifier to three gross-alpha detect results.

Data validation assigned a J qualifier to two gross-beta detect results.

No production water was collected from wells BM 26-33B, 26-33C, 26-33D, 26-34A, 26-34C, and 26-22B.

Table 4c. Summary of Potassium-40 Liquid-Phase Samples Based on Laboratory-Assigned Qualifiers

Collection Location	Total Liquid Samples Collected	Potassium-40 Results		
		Detect	Nondetect	NA
Natural gas wells	8	2	6	6

Notes:

Data validation assigned a J qualifier to both potassium-40 detect results.

No production water was collected from wells BM 26-33B, 26-33C, 26-33D, 26-34A, 26-34C, and 26-22B.

This page intentionally left blank

Data Review and Validation Report

This page intentionally left blank

Data Validation Package

January 2015
Produced Water Sampling at the
Rulison, Colorado, Site

May 2015



U.S. DEPARTMENT OF
ENERGY

Legacy
Management

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
Telephone: 800.553.6847
Fax: 703.605.6900
E-mail: orders@ntis.gov
Online Ordering: <http://www.ntis.gov/help/ordermethods.aspx>

Available electronically at <http://www.osti.gov/scitech/>

Available for a processing fee to U.S. Department of Energy and its contractors,
in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Phone: 865.576.8401
Fax: 865.576.5728
Email: reports@adonis.osti.gov

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Contents

Sampling Event Summary	1
Rulison, Colorado, Site Sample Location Map	2
Data Assessment Summary.....	3
Water Sampling Field Activities Verification Checklist	5
Laboratory Performance Assessment	7
Sampling Quality Control Assessment	18
Certification	20

Attachment 1—Data Presentation

Produced Water Data

Natural Gas Data

Attachment 2—Trip Report

This page intentionally left blank

Sampling Event Summary

Site: Rulison, Colorado, Site

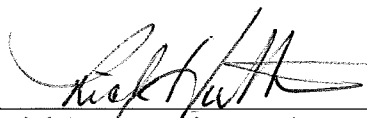
Sampling Period: January 7, 2015

The U.S. Department of Energy Office of Legacy Management conducted sampling at the Rulison, Colorado, Site on January 7, 2015, in accordance with the 2010 *Rulison Monitoring Plan*. The Monitoring Plan provides guidance regarding the type and frequency of sample collection as a function of distance and heading from the Rulison detonation point; it also specifies the types of analyses. Natural gas and produced water samples are analyzed for radionuclides to determine if contamination is migrating from the Rulison detonation zone to producing gas wells. Samples were submitted for analysis as follows:

- Natural gas samples were submitted under requisition 14126698 to Isotech Laboratories in Champaign, Illinois, for the determination of carbon-14 and tritium.
- Produced water samples were submitted under requisition 14126699 to ALS Laboratory Group in Fort Collins, Colorado, for the determination of chloride, gross alpha/beta, gamma-emitting nuclides, and tritium.

Sampling and analyses were conducted as specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351, continually updated). A duplicate sample of produced water was collected at location 05-045-10840.

Sample radionuclide results are compared to the screening levels listed in the Monitoring Plan to determine if any further action is merited. None of the results for the 13 wells sampled during this event exceeded the screening levels specified in the Monitoring Plan. The natural gas and produced water sample results are presented in Attachment 1.


Rick Hufton, Site Lead
Stoller Newport News Nuclear, Inc.,
a wholly owned subsidiary of
Huntington Ingalls Industries, Inc.

05-29-15
Date



M:\LT5\111\0082\03\000\S09396\S0939600.mxd smithw 09/26/2012 3:10:22 PM

Rulison, Colorado, Site Sample Location Map

Data Assessment Summary

This page intentionally left blank

Water Sampling Field Activities Verification Checklist

Project	Rulison, Colorado	Date(s) of Water Sampling	January 7, 2015
Date(s) of Verification	April 2, 2015	Name of Verifier	Stephen Donovan

	Response (Yes, No, NA)	Comments
1. Is the SAP the primary document directing field procedures? List any Program Directives or other documents, SOPs, instructions.	Yes	Program Directive RUL-2015-01.
2. Were the sampling locations specified in the planning documents sampled?	No	Limited volume of produced water was available from eight of the wells.
3. Were calibrations conducted as specified in the above-named documents?	NA	Field measurements were not required.
4. Was an operational check of the field equipment conducted daily? Did the operational checks meet criteria?		
5. Were the number and types (alkalinity, temperature, specific conductance, pH, turbidity, DO, ORP) of field measurements taken as specified?		
6. Were wells categorized correctly?	NA	This sampling event did not include ground water.
7. Were the following conditions met when purging a Category I well: Was one pump/tubing volume purged prior to sampling? Did the water level stabilize prior to sampling? Did pH, specific conductance, and turbidity measurements meet criteria prior to sampling? Was the flow rate less than 500 mL/min?	NA	This sampling event did not include ground water.

Water Sampling Field Activities Verification Checklist (continued)

	Response (Yes, No, NA)	Comments
8. Were the following conditions met when purging a Category II well: Was the flow rate less than 500 mL/min? Was one pump/tubing volume removed prior to sampling?	NA	This sampling event did not include groundwater.
9. Were duplicates taken at a frequency of one per 20 samples?	Yes	A duplicate sample was collected at location 05-045-10840.
10. Were equipment blanks taken at a frequency of one per 20 samples that were collected with non-dedicated equipment?	NA	An equipment blank was not required.
11. Were trip blanks prepared and included with each shipment of VOC samples?	NA	
12. Were the true identities of the QC samples documented?	Yes	
13. Were samples collected in the containers specified?	Yes	
14. Were samples filtered and preserved as specified?	Yes	
15. Were the number and types of samples collected as specified?	Yes	Limited volume of produced water was available.
16. Were chain of custody records completed and was sample custody maintained?	Yes	
17. Was all pertinent information documented on the field data sheets?	Yes	
18. Was the presence or absence of ice in the cooler documented at every sample location?	NA	Sample cooling was not required.
19. Were water levels measured at the locations specified in the planning documents?	NA	

Laboratory Performance Assessment

General Information

Requisition No. (RIN): 14126699
 Sample Event: January 7, 2015
 Site(s): Rulison, Colorado, Site
 Laboratory: ALS Laboratory Group, Fort Collins, Colorado
 Work Order No.: 1501106
 Analysis: Radiochemistry and Wet Chemistry
 Validator: Stephen Donovan
 Review Date: April 2, 2015

This validation was performed according to the *Environmental Procedures Catalog*, (LMS/POL/S04325, continually updated) “Standard Practice for Validation of Environmental Data.” The procedure was applied at Level 3, Data Validation. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Chloride	WCH-B-011	EPA 300.0	EPA 300.0
Gamma Spectrometry	GAM-A-001	PA SOP713R11	PA SOP713R11
Gross Alpha/Beta	GPC-A-001	PA SOP702R19	PA SOP724R10
Tritium	LCS-A-001	PA SOP700R10	PA SOP704R9

Data Qualifier Summary

Analytical results were qualified as listed in Table 2. Refer to the sections below for an explanation of the data qualifiers applied.

Table 2. Data Qualifier Summary

Sample Number	Location	Analyte	Flag	Reason
1501106-2	BM 26-22C	Gross Alpha	J	Less than the determination limit
1501106-3	BM 26-22D	Actinium-228	U	Nuclide identification criteria
1501106-3	BM 26-22D	Gross Alpha	J	Less than the determination limit
1501106-3	BM 26-22D	Potassium-40	J	Less than the determination limit
1501106-4	BM 26-34B	Gross Beta	J	Less than the determination limit
1501106-5	BM 26-34D	Gross Beta	J	Less than the determination limit
1501106-6	BM 35-32A	Actinium-228	U	Nuclide identification criteria
1501106-7	BM 36-13	Potassium-40	J	Less than the determination limit
1501106-8	BM 36-13B	Gross Alpha	J	Less than the determination limit

Sample Shipping/Receiving

ALS Laboratory Group in Fort Collins, Colorado, received eight water samples on January 9, 2015, accompanied by a Chain of Custody form. The Chain of Custody form was checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. Copies of the shipping labels were included in the receiving documentation. The Chain of Custody form was complete with no errors or omissions.

Preservation and Holding Times

The sample shipment was received intact at ambient temperature which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all metal, organic, and wet chemical analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL.

For radiochemical analytes (those measured by radiometric counting) the MDL and PQL are not applicable, and these results are evaluated using the minimum detectable concentration (MDC), Decision Level Concentration (DLC), and Determination Limit (DL). The MDC is a measure of radiochemical method performance and was calculated and reported as specified in *Quality Systems for Analytical Services*. The DLC is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, and is estimated as 3 times the one-sigma total propagated uncertainty. Results that are greater than the MDC, but less than the DLC are qualified with a “U” flag (not detected). The DL for radiochemical results is the lowest concentration that can be reliably measured, and is defined as 3 times the MDC. Results not previously “U” qualified that are less than the DL are qualified with a “J” flag as estimated values.

The reported MDLs for the wet chemical analyte and MDCs for radiochemical analytes met the detection limits requirements with the following exceptions. The required detection limits were not met for gross alpha and gross beta samples because of the elevated levels of dissolved solids in the samples.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing a linear curve. Compliance requirements for

continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

Method EPA 300.0, Chloride

Calibration for chloride was performed using five calibration standards on January 2, 2015. The calibration curve correlation coefficient values were greater than 0.995 and the absolute values of the intercepts were less than 3 times the MDL. Initial and continuing calibration verification checks were made at the required frequency with all calibration checks meeting the laboratory's acceptance criteria.

Gamma Spectrometry

Activity concentrations above the MDC were reported in some instances where minimum nuclide identification criteria were not met. Such tentative identifications result when the software attempts to calculate net activity concentrations for analytes where either one or both of the following criteria are not satisfied: one or more characteristic peaks for a nuclide must be identified above the critical level, or the minimum library peak abundance must be attained. Sample results for gamma-emitting radionuclides that do not meet the identification criteria are qualified with a "U" flag as not detected.

Method and Calibration Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. Calibration blanks are analyzed to assess instrument contamination prior to and during sample analysis. All radiochemical method blank results were below the Decision Level Concentration.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Laboratory Replicate Analysis

Laboratory replicate sample results demonstrate acceptable laboratory precision. The relative percent difference value for the chloride matrix spike replicate met the acceptance criteria. The radiochemical relative error ratio (calculated using the one-sigma total propagated uncertainty) for the sample replicates was less than three for all duplicates.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The MS/MSD data are not evaluated when the concentration of the unspiked sample is greater than 4 times the spike concentration. The spike recoveries met the recovery and precision criteria for all analytes evaluated.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on February 2, 2015. The Sample Management System EDD validation module was used to verify that the EDD files were complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

SAMPLE MANAGEMENT SYSTEM

General Data Validation Report

RIN: 14126699 Lab Code: PAR Validator: Stephen Donovan Validation Date: 04/02/2015
Project: Rulison Site Analysis Type: Metals General Chem Rad Organics
of Samples: 8 Matrix: WATER Requested Analysis Completed: Yes

Chain of Custody

Present: OK Signed: OK Dated: OK

Sample

Integrity: OK Preservation: OK Temperature: OK

Select Quality Parameters

- Holding Times
- Detection Limits
- Field/Trip Blanks
- Field Duplicates

All analyses were completed within the applicable holding times.

There are 16 detection limit failures.

There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

RIN: 14126699 Lab Code: PAR

Non-Compliance Report: Detection Limits

Project: Rulison Site

Validation Date: 04/02/2015

Ticket	Location	Lab Sample ID	Method Code	Lab Method	Analyte Name	Result	Qualifier	Reported Detection Limit	Required Detection Limit	Units
MNU 712	2657	1501106-1	GPC-A-001	724R11	GROSS BETA	180		44	4	pCi/L
MNU 712	2657	1501106-1	GPC-A-001	724R11	GROSS ALPHA	11.7	U	44	2	pCi/L
MNU 705	BM 26-22C	1501106-2	GPC-A-001	724R11	GROSS BETA	167		43	4	pCi/L
MNU 705	BM 26-22C	1501106-2	GPC-A-001	724R11	GROSS ALPHA	45.6		42	2	pCi/L
MNU 706	BM 26-22D	1501106-3	GPC-A-001	724R11	GROSS BETA	211		45	4	pCi/L
MNU 706	BM 26-22D	1501106-3	GPC-A-001	724R11	GROSS ALPHA	58		47	2	pCi/L
MNU 703	BM 26-34B	1501106-4	GPC-A-001	724R11	GROSS BETA	46.1		23	4	pCi/L
MNU 703	BM 26-34B	1501106-4	GPC-A-001	724R11	GROSS ALPHA	-8.25	U	29	2	pCi/L
MNU 704	BM 26-34D	1501106-5	GPC-A-001	724R11	GROSS BETA	120		45	4	pCi/L
MNU 704	BM 26-34D	1501106-5	GPC-A-001	724R11	GROSS ALPHA	33.5	U	48	2	pCi/L
MNU 707	BM 35-32A	1501106-6	GPC-A-001	724R11	GROSS BETA	143		45	4	pCi/L
MNU 707	BM 35-32A	1501106-6	GPC-A-001	724R11	GROSS ALPHA	18.7	U	41	2	pCi/L
MNU 708	BM 36-13	1501106-7	GPC-A-001	724R11	GROSS ALPHA	24.1	U	39	2	pCi/L
MNU 708	BM 36-13	1501106-7	GPC-A-001	724R11	GROSS BETA	181		43	4	pCi/L
MNU 709	BM 36-13B	1501106-8	GPC-A-001	724R11	GROSS BETA	170		43	4	pCi/L
MNU 709	BM 36-13B	1501106-8	GPC-A-001	724R11	GROSS ALPHA	57.6		45	2	pCi/L

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 14126699 **Lab Code:** PAR **Date Due:** 02/06/2015
Matrix: Water **Site Code:** RUL01 **Date Completed:** 02/03/2015

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
BM 35-32A	Actinium-228	01/29/2015						0.71
BM 35-32A	Americium-241	01/29/2015						0.23
Blank_Spike	Americium-241	01/29/2015				93.20		
BM 35-32A	Antimony-125	01/29/2015						1.24
BM 35-32A	Cerium-144	01/29/2015						0.68
BM 35-32A	Cesium-134	01/29/2015						
BM 35-32A	Cesium-137	01/29/2015						1.71
Blank_Spike	Cesium-137	01/29/2015				97.60		
BM 35-32A	Cobalt-60	01/29/2015						0.30
Blank_Spike	Cobalt-60	01/29/2015				96.10		
BM 35-32A	Europium-152	01/29/2015						0.12
BM 35-32A	Europium-154	01/29/2015						1.25
BM 35-32A	Europium-155	01/29/2015						0.07
Blank_Spike	GROSS ALPHA	01/14/2015				103.00		
BM 36-13B	GROSS ALPHA	01/14/2015					63.0	
Blank	GROSS ALPHA	01/14/2015	-0.0600	U				
BM 35-32A	GROSS ALPHA	01/16/2015						0.43
Blank_Spike	GROSS BETA	01/14/2015				104.00		
BM 36-13B	GROSS BETA	01/14/2015					95.9	
Blank	GROSS BETA	01/14/2015	0.8820	U				
BM 35-32A	GROSS BETA	01/16/2015						1.85
BM 36-13	H-3	01/28/2015						0.22
2657	H-3	01/28/2015					100.0	
Blank_Spike	H-3	01/30/2015				99.30		
Blank	H-3	01/30/2015	58.4000	U				
BM 35-32A	Lead-212	01/29/2015						0.16
BM 35-32A	Potassium-40	01/29/2015						0.32
BM 35-32A	Promethium-144	01/29/2015						0.92
BM 35-32A	Promethium-146	01/29/2015						0.25
BM 35-32A	Ruthenium-106	01/29/2015						1.64
BM 35-32A	Thorium-234	01/29/2015						1.19
BM 35-32A	Uranium-235	01/29/2015						0.18

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 14126699 **Lab Code:** PAR **Date Due:** 02/06/2015
Matrix: Water **Site Code:** RUL01 **Date Completed:** 02/03/2015

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
BM 35-32A	Yttrium-88	01/29/2015						1.65

SAMPLE MANAGEMENT SYSTEM
Wet Chemistry Data Validation Worksheet

RIN: 14126699 **Lab Code:** PAR **Date Due:** 02/06/2015
Matrix: Water **Site Code:** RUL01 **Date Completed:** 02/03/2015

Analyte	Date Analyzed	CALIBRATION				Method Blank	LCS %R	MS %R	MSD %R	DUP RPD	Serial Dil. %R
		Int.	R^2	CCV	CCB						
CHLORIDE	01/13/2015	0.000	1.0000	OK	OK	OK	105.00	100.0	95.0	1.00	

General Information

Requisition (RIN): 14126698
Sample Event: January 1, 2015
Site(s): Rulison, Colorado
Laboratory: Isotech Laboratories
Work Order No.: 27809
Analysis: Radiochemistry
Validator: Stephen Donivan
Review Date: April 2, 2015

This validation was performed according to the *Environmental Procedures Catalog*, (LMS/POL/S04325, continually updated) "Standard Practice for Validation of Environmental Data." The procedure was applied at Level 1, Data Deliverables Examination. The data were examined to assess the completeness of the deliverables, identify any reporting errors, and assess the usability of the data based on the results of the field duplicate and the laboratory's evaluation of their data, as described in the narrative provided. The data are acceptable as received. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Natural Gas Analysis	LMG-01	NA	Gas Chromatography
Carbon-14 and Tritium	LMG-03	Combustion	Liquid Scintillation Counting

Data Qualifier Summary

None of the analytical results required qualification.

Sample Shipping/Receiving

Isotech Laboratories received 13 natural gas samples on January 12, 2015, accompanied by a Chain of Custody (COC) form. The COC form was checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. The COC form was complete with no errors or omissions.

Summary

Thirteen natural gas samples were received at Isotech Laboratories and analyzed by gas chromatography to determine the natural gas composition. The samples were then combusted with the resulting water collected for analysis. Carbon-14 and tritium were measured in the water collected by liquid scintillation counting. There were no analytical difficulties noted by the laboratory.

Completeness

The results of the gas chromatography analysis were reported in volume percent showing the average sample composition of 90% methane.

The carbon-14 results were reported in percent modern carbon (pMC). The tritium results were reported in tritium units. Carbon-14 and tritium were not detected in any of the samples.

Sampling Quality Control Assessment

The following information summarizes and assesses quality control for this sampling event.

Sampling Protocol

The produced water samples were collected from a tap on a common line connecting the output of two separators (each servicing a well) and the nearby accumulation tanks. The collected water sample from one separator was isolated from the other separator by valves. Lines from each of the two separators were purged before sample collection.

Natural gas samples were collected as specified in Program Directive RUL-2013-01 in an evacuated 17.8-liter gas cylinder provided by Isotech Laboratories, Inc. Each sampling container was filled to approximately 25 pounds per square inch with natural gas from each well.

Equipment Blank Assessment

An equipment blank was not required.

Field Duplicate Assessment

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. A duplicate sample was collected from location BM 36-13. For non-radiochemical measurements, the relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results less than 5 times the PQL, the range should be no greater than the PQL. For radiochemical measurements, the relative error ratio (the ratio of the absolute difference between the sample and duplicate results and the sum of the 1-sigma uncertainties) is used to evaluate duplicate results and should be less than 3. All duplicate results met these criteria demonstrating acceptable precision.

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 14126699 Lab Code: PAR Project: Rulison Site Validation Date: 04/02/2015

Duplicate: 2657

Sample: BM 36-13

Analyte	Sample				Duplicate				RPD	RER	Units
	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution			
Actinium-228	12.7	U	13.5	1	12.7	U	20.8	1		0	pCi/L
Americium-241	-6.23	U	15.1	1	-15.4	U	55.4	1		0.3	pCi/L
Antimony-125	4.17	U	5.79	1	4.04	U	6.71	1		0	pCi/L
Cerium-144	6.8	U	12.5	1	-12.2	U	20.8	1		1.5	pCi/L
Cesium-134	1.04	U	4.29	1	-0.245	U	2.84	1		0.5	pCi/L
Cesium-137	-1.47	U	2.57	1	-0.593	U	2.76	1		0.5	pCi/L
CHLORIDE	9600			1000	10000			1000	4.08		MG/L
Cobalt-60	1.72	U	3.25	1	0.271	U	2.77	1		0.7	pCi/L
Europium-152	-4.24	U	16.8	1	9.41	U	13.9	1		1.2	pCi/L
Europium-154	-8.58	U	16.6	1	-5.55	U	15.4	1		0.3	pCi/L
Europium-155	-0.559	U	7.15	1	-2.85	U	8.06	1		0.4	pCi/L
GROSS ALPHA	24.1	U	24.4	1	11.7	U	26.2	1		0.7	pCi/L
GROSS BETA	181		40.9	1	180		41	1		0	pCi/L
H-3	-65.8	U	207	1	-133	U	185	1		0.5	pCi/L
Lead-212	0.118	U	7.19	1	0.492	U	8.69	1		0.1	pCi/L
Potassium-40	150		88.6	1	103	U	121	1		0.6	pCi/L
Promethium-144	2.89	U	2.99	1	-2.1	U	2.91	1		2.3	pCi/L
Promethium-146	-0.0925	U	3.03	1	-1.36	U	3.04	1		0.6	pCi/L
Ruthenium-106	-9.12	U	25.4	1	-19.3	U	25.7	1		0.6	pCi/L
Thorium-234	21.3	U	74.5	1	34.9	U	90.6	1		0.2	pCi/L
Uranium-235	-5.71	U	20.9	1	15.7	U	15.6	1		1.6	pCi/L
Yttrium-88	2.26	U	2.79	1	-2.96	U	7.74	1		1.2	pCi/L

Certification

All laboratory analytical quality control criteria were met except as qualified in this report. The data qualifiers listed on the SEEPro database reports are defined on the last page of each report. All data in this package are considered validated and available for use.

Laboratory Coordinator: Stephen Donivan 5-29-2015
Stephen Donivan Date

Data Validation Lead: Stephen Donivan 5-29-2015
Stephen Donivan Date

Attachment 1

Data Presentation

This page intentionally left blank

Produced Water Data

This page intentionally left blank

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-10840 WELL BM 36-13

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	01/07/2015	N001	0	-	0	12.7	U		#	28	13.5
Actinium-228	pCi/L	01/07/2015	N002	0	-	0	12.7	U		#	34	20.8
Americium-241	pCi/L	01/07/2015	N001	0	-	0	-6.23	U		#	26	15.1
Americium-241	pCi/L	01/07/2015	N002	0	-	0	-15.4	U		#	92	55.4
Antimony-125	pCi/L	01/07/2015	N001	0	-	0	4.17	U		#	11	5.79
Antimony-125	pCi/L	01/07/2015	N002	0	-	0	4.04	U		#	12	6.71
Cerium-144	pCi/L	01/07/2015	N001	0	-	0	6.8	U		#	21	12.5
Cerium-144	pCi/L	01/07/2015	N002	0	-	0	-12.2	U		#	35	20.8
Cesium-134	pCi/L	01/07/2015	N001	0	-	0	1.04	U		#	7.1	4.29
Cesium-134	pCi/L	01/07/2015	N002	0	-	0	-.245	U		#	4.8	2.84
Cesium-137	pCi/L	01/07/2015	N001	0	-	0	-1.47	U		#	4.4	2.57
Cesium-137	pCi/L	01/07/2015	N002	0	-	0	-.593	U		#	4.7	2.76
Chloride	mg/L	01/07/2015	N001	0	-	0	9600			#	200	
Chloride	mg/L	01/07/2015	N002	0	-	0	10000			#	200	
Cobalt-60	pCi/L	01/07/2015	N001	0	-	0	1.72	U		#	5.4	3.25
Cobalt-60	pCi/L	01/07/2015	N002	0	-	0	0.271	U		#	4.8	2.77
Europium-152	pCi/L	01/07/2015	N001	0	-	0	-4.24	U		#	29	16.8
Europium-152	pCi/L	01/07/2015	N002	0	-	0	9.41	U		#	23	13.9

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-10840 WELL BM 36-13

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Europium-154	pCi/L	01/07/2015	N001	0	-	0	-8.58	U		#	29	16.6
Europium-154	pCi/L	01/07/2015	N002	0	-	0	-5.55	U		#	27	15.4
Europium-155	pCi/L	01/07/2015	N001	0	-	0	-559	U		#	12	7.15
Europium-155	pCi/L	01/07/2015	N002	0	-	0	-2.85	U		#	14	8.06
Gross Alpha	pCi/L	01/07/2015	N001	0	-	0	24.1	U		#	39	24.4
Gross Alpha	pCi/L	01/07/2015	N002	0	-	0	11.7	U		#	44	26.2
Gross Beta	pCi/L	01/07/2015	N001	0	-	0	181			#	43	40.9
Gross Beta	pCi/L	01/07/2015	N002	0	-	0	180			#	44	41
Lead-212	pCi/L	01/07/2015	N001	0	-	0	0.118	U		#	12	7.19
Lead-212	pCi/L	01/07/2015	N002	0	-	0	0.492	U		#	14	8.69
Potassium-40	pCi/L	01/07/2015	N001	0	-	0	150		J	#	140	88.6
Potassium-40	pCi/L	01/07/2015	N002	0	-	0	103	U		#	200	121
Promethium-144	pCi/L	01/07/2015	N001	0	-	0	2.89	U		#	4.8	2.99
Promethium-144	pCi/L	01/07/2015	N002	0	-	0	-2.1	U		#	5.1	2.91
Promethium-146	pCi/L	01/07/2015	N001	0	-	0	-0.925	U		#	5.1	3.03
Promethium-146	pCi/L	01/07/2015	N002	0	-	0	-1.36	U		#	5.2	3.04
Ruthenium-106	pCi/L	01/07/2015	N001	0	-	0	-9.12	U		#	43	25.4
Ruthenium-106	pCi/L	01/07/2015	N002	0	-	0	-19.3	U		#	45	25.7

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 04/17/2015
Location: 05-045-10840 WELL BM 36-13

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Thorium-234	pCi/L	01/07/2015	N001	0	-	0	21.3	U	#	120	74.5	
Thorium-234	pCi/L	01/07/2015	N002	0	-	0	34.9	U	#	150	90.6	
Tritium	pCi/L	01/07/2015	N001	0	-	0	-65.8	U	#	350	207	
Tritium	pCi/L	01/07/2015	N002	0	-	0	-133	U	#	320	185	
Uranium-235	pCi/L	01/07/2015	N001	0	-	0	-5.71	U	#	35	20.9	
Uranium-235	pCi/L	01/07/2015	N002	0	-	0	15.7	U	#	25	15.6	
Yttrium-88	pCi/L	01/07/2015	N001	0	-	0	2.26	U	#	4.6	2.79	
Yttrium-88	pCi/L	01/07/2015	N002	0	-	0	-2.96	U	#	13	7.74	

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-10919 WELL BM 35-32A

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	01/07/2015	N001	0	-	0	18		U	#	17	9.67
Americium-241	pCi/L	01/07/2015	N001	0	-	0	-15	U		#	25	14.8
Antimony-125	pCi/L	01/07/2015	N001	0	-	0	-143	U		#	9.7	5.36
Cerium-144	pCi/L	01/07/2015	N001	0	-	0	7.6	U		#	20	11.9
Cesium-134	pCi/L	01/07/2015	N001	0	-	0	-4.46	U		#	4.6	2.66
Cesium-137	pCi/L	01/07/2015	N001	0	-	0	-151	U		#	4.1	2.41
Chloride	mg/L	01/07/2015	N001	0	-	0	8800			#	200	
Cobalt-60	pCi/L	01/07/2015	N001	0	-	0	-1.46	U		#	5	2.84
Europium-152	pCi/L	01/07/2015	N001	0	-	0	0.744	U		#	25	14.6
Europium-154	pCi/L	01/07/2015	N001	0	-	0	17.1	U		#	23	14.2
Europium-155	pCi/L	01/07/2015	N001	0	-	0	-2.98	U		#	10	6.06
Gross Alpha	pCi/L	01/07/2015	N001	0	-	0	18.7	U		#	41	25.1
Gross Beta	pCi/L	01/07/2015	N001	0	-	0	143			#	45	37.1
Lead-212	pCi/L	01/07/2015	N001	0	-	0	1.28	U		#	12	7
Potassium-40	pCi/L	01/07/2015	N001	0	-	0	114	U		#	120	72.6
Promethium-144	pCi/L	01/07/2015	N001	0	-	0	1.16	U		#	3.6	1.73
Promethium-146	pCi/L	01/07/2015	N001	0	-	0	-1.53	U		#	4.7	2.74
Ruthenium-106	pCi/L	01/07/2015	N001	0	-	0	6.06	U		#	54	32.2

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 04/17/2015
Location: 05-045-10919 WELL BM 35-32A

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Thorium-234	pCi/L	01/07/2015	N001	0	-	0	-30.9	U		#	140	83.9
Tritium	pCi/L	01/07/2015	N001	0	-	0	-184	U		#	340	198
Uranium-235	pCi/L	01/07/2015	N001	0	-	0	8.43	U		#	12	7.29
Yttrium-88	pCi/L	01/07/2015	N001	0	-	0	4.16	U		#	4.7	2.99

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-15469 WELL BM 36-13B

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	01/07/2015	N001	0	-	0	19.2	U		#	36	21.9
Americium-241	pCi/L	01/07/2015	N001	0	-	0	-2.51	U		#	4.3	2.5
Antimony-125	pCi/L	01/07/2015	N001	0	-	0	4.56	U		#	8.6	4.9
Cerium-144	pCi/L	01/07/2015	N001	0	-	0	-2.83	U		#	14	8.26
Cesium-134	pCi/L	01/07/2015	N001	0	-	0	-2.55	U		#	3.8	2.2
Cesium-137	pCi/L	01/07/2015	N001	0	-	0	-2.08	U		#	3.9	2.2
Chloride	mg/L	01/07/2015	N001	0	-	0	9500			#	200	
Cobalt-60	pCi/L	01/07/2015	N001	0	-	0	1.02	U		#	3.9	2.33
Europium-152	pCi/L	01/07/2015	N001	0	-	0	4.1	U		#	20	11.8
Europium-154	pCi/L	01/07/2015	N001	0	-	0	-5.99	U		#	21	12.3
Europium-155	pCi/L	01/07/2015	N001	0	-	0	0.515	U		#	5.7	3.41
Gross Alpha	pCi/L	01/07/2015	N001	0	-	0	57.6		J	#	45	30.6
Gross Beta	pCi/L	01/07/2015	N001	0	-	0	170			#	43	39.5
Lead-212	pCi/L	01/07/2015	N001	0	-	0	4.03	U		#	9.3	5.64
Potassium-40	pCi/L	01/07/2015	N001	0	-	0	77.6	U		#	110	67.1
Promethium-144	pCi/L	01/07/2015	N001	0	-	0	0.497	U		#	4	2.37
Promethium-146	pCi/L	01/07/2015	N001	0	-	0	-2.02	U		#	4.3	2.52
Ruthenium-106	pCi/L	01/07/2015	N001	0	-	0	-11	U		#	34	19.5

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 04/17/2015
Location: 05-045-15469 WELL BM 36-13B

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Thorium-234	pCi/L	01/07/2015	N001	0	-	0	1.32	U		#	70	42.1
Tritium	pCi/L	01/07/2015	N001	0	-	0	-64.5	U		#	330	192
Uranium-235	pCi/L	01/07/2015	N001	0	-	0	8.32	U		#	14	8.21
Yttrium-88	pCi/L	01/07/2015	N001	0	-	0	1.64	U		#	4.3	2.59

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	01/07/2015	N001	0	-	0	14.5	U		#	22	13.7
Americium-241	pCi/L	01/07/2015	N001	0	-	0	17	U		#	28	17.1
Antimony-125	pCi/L	01/07/2015	N001	0	-	0	-1.14	U		#	13	7.67
Cerium-144	pCi/L	01/07/2015	N001	0	-	0	-4.48	U		#	25	14.8
Cesium-134	pCi/L	01/07/2015	N001	0	-	0	4.18	U		#	5.2	3.15
Cesium-137	pCi/L	01/07/2015	N001	0	-	0	-0.77	U		#	5.5	3.22
Chloride	mg/L	01/07/2015	N001	0	-	0	6500			#	100	
Cobalt-60	pCi/L	01/07/2015	N001	0	-	0	-1.6	U		#	7.7	4.41
Europium-152	pCi/L	01/07/2015	N001	0	-	0	-7.22	U		#	36	20.8
Europium-154	pCi/L	01/07/2015	N001	0	-	0	8.41	U		#	33	19.8
Europium-155	pCi/L	01/07/2015	N001	0	-	0	0.389	U		#	12	7.4
Gross Alpha	pCi/L	01/07/2015	N001	0	-	0	-8.25	U		#	29	16.6
Gross Beta	pCi/L	01/07/2015	N001	0	-	0	46.1		J	#	23	16.2
Lead-212	pCi/L	01/07/2015	N001	0	-	0	6.63	U		#	13	7.86
Potassium-40	pCi/L	01/07/2015	N001	0	-	0	36.3	U		#	170	105
Promethium-144	pCi/L	01/07/2015	N001	0	-	0	2.21	U		#	6.1	3.69
Promethium-146	pCi/L	01/07/2015	N001	0	-	0	4.04	U		#	5.6	3.45
Ruthenium-106	pCi/L	01/07/2015	N001	0	-	0	-0.748	U		#	54	31.9

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 04/17/2015
Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Thorium-234	pCi/L	01/07/2015	N001	0	-	0	-62.1	U		#	170	102
Tritium	pCi/L	01/07/2015	N001	0	-	0	-112	U		#	350	202
Uranium-235	pCi/L	01/07/2015	N001	0	-	0	20.7	U		#	23	14.6
Yttrium-88	pCi/L	01/07/2015	N001	0	-	0	3.01	U		#	6.9	4.18

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-15748 WELL BM 26-34D

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	01/07/2015	N001	0	-	0	12.9	U		#	18	9.81
Americium-241	pCi/L	01/07/2015	N001	0	-	0	-12	U		#	140	81.7
Antimony-125	pCi/L	01/07/2015	N001	0	-	0	1.86	U		#	10	5.75
Cerium-144	pCi/L	01/07/2015	N001	0	-	0	-.547	U		#	24	14.4
Cesium-134	pCi/L	01/07/2015	N001	0	-	0	-1.42	U		#	4.1	2.39
Cesium-137	pCi/L	01/07/2015	N001	0	-	0	-.722	U		#	3.8	2.21
Chloride	mg/L	01/07/2015	N001	0	-	0	13000			#	200	
Cobalt-60	pCi/L	01/07/2015	N001	0	-	0	-.255	U		#	3.8	2.2
Europium-152	pCi/L	01/07/2015	N001	0	-	0	3.29	U		#	19	11
Europium-154	pCi/L	01/07/2015	N001	0	-	0	-5.03	U		#	22	12.5
Europium-155	pCi/L	01/07/2015	N001	0	-	0	9.98	U		#	16	9.69
Gross Alpha	pCi/L	01/07/2015	N001	0	-	0	33.5	U		#	48	30.4
Gross Beta	pCi/L	01/07/2015	N001	0	-	0	120		J	#	45	34.6
Lead-212	pCi/L	01/07/2015	N001	0	-	0	1.01	U		#	11	6.46
Potassium-40	pCi/L	01/07/2015	N001	0	-	0	75	U		#	130	77.9
Promethium-144	pCi/L	01/07/2015	N001	0	-	0	1.22	U		#	3.9	2.36
Promethium-146	pCi/L	01/07/2015	N001	0	-	0	1.13	U		#	4.5	2.68
Ruthenium-106	pCi/L	01/07/2015	N001	0	-	0	-8.54	U		#	36	21.1

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 04/17/2015
Location: 05-045-15748 WELL BM 26-34D

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Thorium-234	pCi/L	01/07/2015	N001	0	-	0	14	U		#	210	128
Tritium	pCi/L	01/07/2015	N001	0	-	0	-161	U		#	340	200
Uranium-235	pCi/L	01/07/2015	N001	0	-	0	3.39	U		#	40	24.4
Yttrium-88	pCi/L	01/07/2015	N001	0	-	0	-.103	U		#	8.6	5.11

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-16074 WELL BM 26-22D

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	01/07/2015	N001	0	-	0	45.7		U	#	30	18.9
Americium-241	pCi/L	01/07/2015	N001	0	-	0	-5.5	U		#	37	22.1
Antimony-125	pCi/L	01/07/2015	N001	0	-	0	3.49	U		#	11	6.09
Cerium-144	pCi/L	01/07/2015	N001	0	-	0	5.11	U		#	22	13
Cesium-134	pCi/L	01/07/2015	N001	0	-	0	-2.61	U		#	4.5	2.61
Cesium-137	pCi/L	01/07/2015	N001	0	-	0	-0.99	U		#	4.7	2.72
Chloride	mg/L	01/07/2015	N001	0	-	0	13000			#	200	
Cobalt-60	pCi/L	01/07/2015	N001	0	-	0	-1.2	U		#	5.6	3.17
Europium-152	pCi/L	01/07/2015	N001	0	-	0	-8.73	U		#	26	14.8
Europium-154	pCi/L	01/07/2015	N001	0	-	0	-8.86	U		#	26	15
Europium-155	pCi/L	01/07/2015	N001	0	-	0	1.79	U		#	13	7.9
Gross Alpha	pCi/L	01/07/2015	N001	0	-	0	58		J	#	47	31.8
Gross Beta	pCi/L	01/07/2015	N001	0	-	0	211			#	45	45.5
Lead-212	pCi/L	01/07/2015	N001	0	-	0	-3.43	U		#	14	8.37
Potassium-40	pCi/L	01/07/2015	N001	0	-	0	158		J	#	120	78.9
Promethium-144	pCi/L	01/07/2015	N001	0	-	0	2.57	U		#	4.7	2.88
Promethium-146	pCi/L	01/07/2015	N001	0	-	0	-1.86	U		#	5.7	3.32
Ruthenium-106	pCi/L	01/07/2015	N001	0	-	0	-6.59	U		#	45	26.6

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 04/17/2015
Location: 05-045-16074 WELL BM 26-22D

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Thorium-234	pCi/L	01/07/2015	N001	0	-	0	6.32	U		#	140	87.2
Tritium	pCi/L	01/07/2015	N001	0	-	0	58	U		#	330	200
Uranium-235	pCi/L	01/07/2015	N001	0	-	0	0.58	U		#	44	26.6
Yttrium-88	pCi/L	01/07/2015	N001	0	-	0	2.14	U		#	5.2	3.15

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-16087 WELL BM 26-22C

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	01/07/2015	N001	0	-	0	14.2	U		#	32	19.2
Americium-241	pCi/L	01/07/2015	N001	0	-	0	28.8	U		#	110	63.9
Antimony-125	pCi/L	01/07/2015	N001	0	-	0	-2.9	U		#	10	5.85
Cerium-144	pCi/L	01/07/2015	N001	0	-	0	12.3	U		#	26	15.6
Cesium-134	pCi/L	01/07/2015	N001	0	-	0	-2.98	U		#	4.6	2.65
Cesium-137	pCi/L	01/07/2015	N001	0	-	0	-65	U		#	4.5	2.63
Chloride	mg/L	01/07/2015	N001	0	-	0	9900			#	200	
Cobalt-60	pCi/L	01/07/2015	N001	0	-	0	0.484	U		#	4.4	2.58
Europium-152	pCi/L	01/07/2015	N001	0	-	0	6.26	U		#	22	13
Europium-154	pCi/L	01/07/2015	N001	0	-	0	-9.06	U		#	24	13.6
Europium-155	pCi/L	01/07/2015	N001	0	-	0	2.25	U		#	17	10
Gross Alpha	pCi/L	01/07/2015	N001	0	-	0	45.6		J	#	42	27.6
Gross Beta	pCi/L	01/07/2015	N001	0	-	0	167			#	43	38.9
Lead-212	pCi/L	01/07/2015	N001	0	-	0	1.87	U		#	16	9.49
Potassium-40	pCi/L	01/07/2015	N001	0	-	0	115	U		#	130	78.4
Promethium-144	pCi/L	01/07/2015	N001	0	-	0	1.04	U		#	4.6	2.74
Promethium-146	pCi/L	01/07/2015	N001	0	-	0	0.184	U		#	4.8	2.86
Ruthenium-106	pCi/L	01/07/2015	N001	0	-	0	7	U		#	41	24.3

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 04/17/2015

Location: 05-045-16087 WELL BM 26-22C

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Thorium-234	pCi/L	01/07/2015	N001	0	-	0	4.16	U		#	230	137
Tritium	pCi/L	01/07/2015	N001	0	-	0	61.1	U		#	330	198
Uranium-235	pCi/L	01/07/2015	N001	0	-	0	7.11	U		#	58	35.2
Yttrium-88	pCi/L	01/07/2015	N001	0	-	0	-3.16	U		#	12	6.9

SAMPLE ID CODES: 000X = Filtered sample (0.45 µm). N00X = Unfiltered sample. X = replicate number.

LAB QUALIFIERS:

- * Replicate analysis not within control limits.
- > Result above upper detection limit.
- A TIC is a suspected aldol-condensation product.
- B Inorganic: Result is between the IDL and CRDL. Organic: Analyte also found in method blank.
- C Pesticide result confirmed by GC-MS.
- D Analyte determined in diluted sample.
- E Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
- H Holding time expired, value suspect.
- I Increased detection limit due to required dilution.
- J Estimated
- N Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compound (TIC).
- P > 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
- U Analytical result below detection limit.
- W Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
- X,Y,Z Laboratory defined qualifier, see case narrative.

DATA QUALIFIERS:

- F Low flow sampling method used.
- L Less than 3 bore volumes purged prior to sampling.
- U Parameter analyzed for but was not detected.
- G Possible grout contamination, pH > 9.
- Q Qualitative result due to sampling technique.
- X Location is undefined.
- J Estimated value.
- R Unusable result.

QA QUALIFIER:

- # Validated according to quality assurance guidelines.

This page intentionally left blank

Natural Gas Data

This page intentionally left blank

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-10840 WELL, Natural Gas Well - Angle, BM 36-13

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N003	MNU 699	8683	- 8683	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N003	MNU 699	8683	- 8683	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-10919 WELL, Natural Gas Well - Angle, BM 35-32A

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N002	MNU 698	9236	- 9236	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N002	MNU 698	9236	- 9236	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15469 WELL, Natural Gas Well - Angle, BM 36-13B

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N002	MNU 700	8901	- 8901	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N002	MNU 700	8901	- 8901	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15739 WELL, Natural Gas Well - Angle, BM 26-33D

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N001	MNU 690	8963.5 - 8963.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N001	MNU 690	8963.5 - 8963.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15741 WELL, Natural Gas Well - Angle, BM 26-34C

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N001	MNU 693	8963.5	- 8963.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N001	MNU 693	8963.5	- 8963.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15742 WELL, Natural Gas Well - Angle, BM 26-33C

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N001	MNU 689	8963.5	- 8963.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N001	MNU 689	8963.5	- 8963.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15743 WELL, Natural Gas Well - Angle, BM 26-33B

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N001	MNU 688	8963.5	- 8963.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N001	MNU 688	8963.5	- 8963.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15744 WELL, Natural Gas Well - Angle, BM 26-34A

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N001	MNU 691	8963.5	- 8963.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N001	MNU 691	8963.5	- 8963.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15745 WELL, Natural Gas Well - Angle, BM 26-34B

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N002	MNU 692	8963.5	- 8963.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N002	MNU 692	8963.5	- 8963.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-15748 WELL, Natural Gas Well - Angle, BM 26-34D

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N002	MNU 694	8963.5	- 8963.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N002	MNU 694	8963.5	- 8963.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-16074 WELL, Natural Gas Well - Angle, BM 26-22D

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N002	MNU 697	8983.5 - 8983.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N002	MNU 697	8983.5 - 8983.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-16086 WELL, Natural Gas Well - Angle, BM 26-22B

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	01/07/2015	N001	MNU 695	8983.5	- 8983.5	NATURAL GAS	0.2	U		#	0.2	
Tritium	pCi/L	01/07/2015	N001	MNU 695	8983.5	- 8983.5	NATURAL GAS	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site

REPORT DATE: 06/01/2015

Location: 05-045-16087 WELL, Natural Gas Well - Angle, BM 26-22C

Parameter	Units	Sample		Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Qualifiers		Detection Limit	Uncertainty
		Date	ID		Lab	Data QA						
Carbon-14	pMC	01/07/2015	N002	MNU 696	8983.5	- 8983.5	NATURAL GAS	0.2	U	#	0.2	
Tritium	pCi/L	01/07/2015	N002	MNU 696	8983.5	- 8983.5	NATURAL GAS	0.0514	U	#	0.0514	

SAMPLE ID CODES: 000X = Filtered sample (0.45 µm). N00X = Unfiltered sample. X = replicate number.

LAB QUALIFIERS:

- * Replicate analysis not within control limits.
- > Result above upper detection limit.
- A TIC is a suspected aldol-condensation product.
- B Inorganic: Result is between the IDL and CRDL. Organic: Analyte also found in method blank.
- C Pesticide result confirmed by GC-MS.
- D Analyte determined in diluted sample.
- E Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
- H Holding time expired, value suspect.
- I Increased detection limit due to required dilution.
- J Estimated
- N Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compound (TIC).
- P > 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
- U Analytical result below detection limit.
- W Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
- X,Y,Z Laboratory defined qualifier, see case narrative.

DATA QUALIFIERS:

- F Low flow sampling method used.
- L Less than 3 bore volumes purged prior to sampling.
- U Parameter analyzed for but was not detected.
- G Possible grout contamination, pH > 9.
- Q Qualitative result due to sampling technique.
- X Location is undefined.
- J Estimated value.
- R Unusable result.

QA QUALIFIER:

- # Validated according to quality assurance guidelines.

This page intentionally left blank

Attachment 2

Trip Report

This page intentionally left blank

**Trip Report
Natural Gas Wells near Project Rulison
First Quarter 2015**

**U.S. Department of Energy Office of Legacy Management
Grand Junction, Colorado**

Date Sampled

January 7, 2015

Background

Project Rulison was the second Plowshare Program test to investigate using a nuclear detonation to stimulate natural gas recovery from deep, low-permeability formations. On September 10, 1969, a 40-kiloton-yield nuclear device was detonated 8,426 feet (1.6 miles) below ground surface in the Williams Fork Formation, at what is now the Rulison, Colorado, Site. A series of production tests followed the detonation, and the site was subsequently shut down, the emplacement well (R-E) and reentry well (R-Ex) were plugged, and the surface soils were remediated.

Purpose

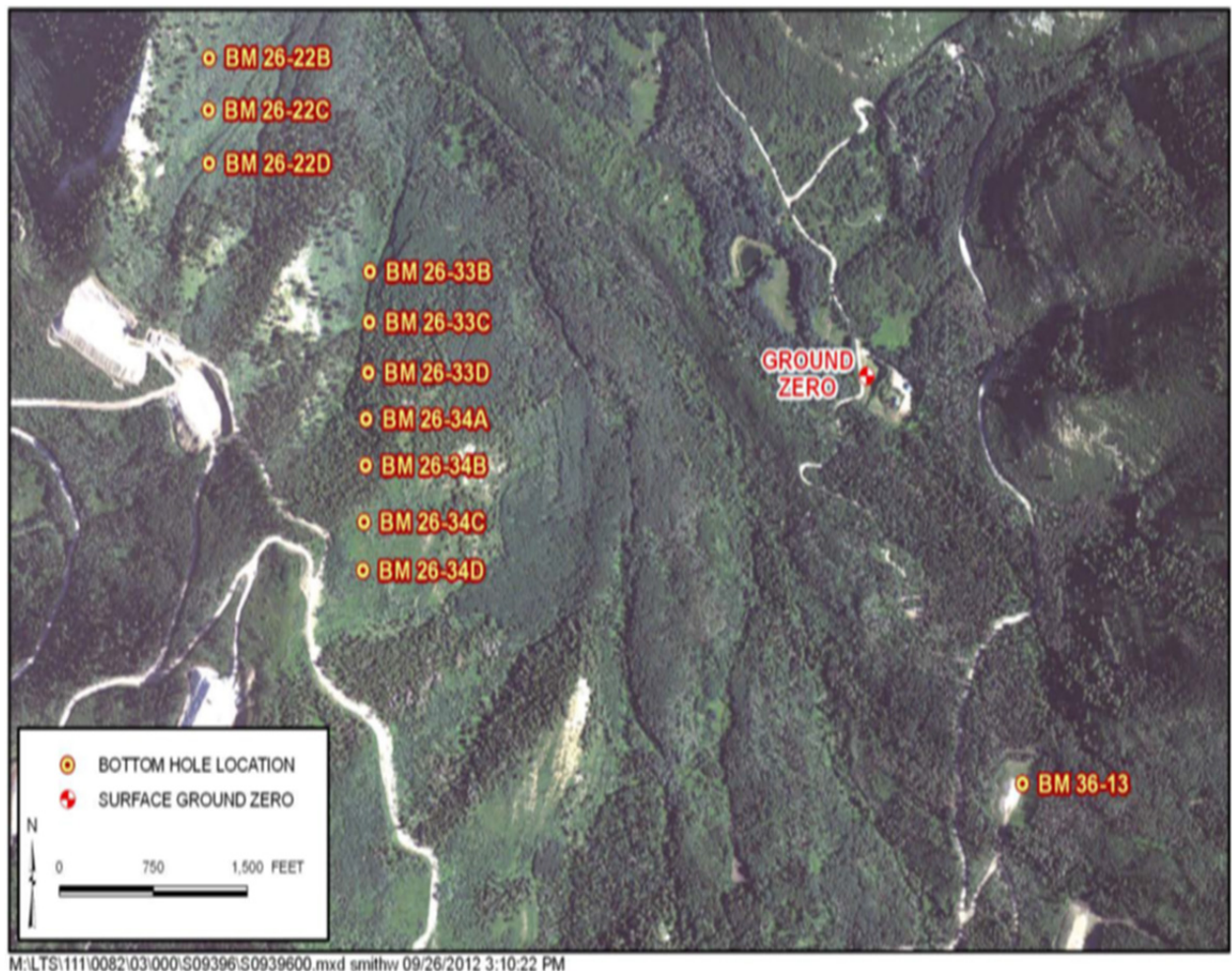
As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM is monitoring natural gas wells near the Rulison site for radionuclides associated with the detonation. The very low permeability of the Williams Fork Formation limits contaminant migration in the subsurface and institutional controls limit subsurface access near the detonation zone. The Colorado Oil and Gas Conservation Commission notifies DOE of any drilling permit activity within 3 miles of the site. The State and DOE review drilling permits and gas well development practices within this boundary to ensure that drilling activities maintain a safe distance from the detonation zone. The DOE *Rulison Monitoring Plan* (LMS/RUL/S06178) provides guidance for sample collection frequency based on distance from the Rulison detonation point, the types of analyses, and the reporting thresholds. The purpose of this trip was to collect natural gas and production water from producing natural gas wells in the Battlement Mesa (BM) field. The sampled wells collect natural gas from the formation horizon where the Project Rulison detonation occurred. The well locations are within 1.5 miles of the detonation location (surface ground zero on Figure 1).

Summary of Results

During the first quarter of 2015, several attempts were made to collect production water and natural gas samples. Due to operational issues at the well heads and bad weather conditions causing safety concerns, the sampling planned for October through December 2014 timeframe was delayed and occurred on January 7, 2015. Operational issues continued during this sampling January 7th sampling event with most of the wells on Pad 26N, not producing production water for unknown reasons. All planned natural gas samples were collected. The operator that owns the wells brought a bailer to collect water samples but obstructions in the water return lines limited

the potential to bail production water for sampling. The following wells were sampled: seven producing gas wells on Pad 26N, three gas wells on Pad 26K, one well on Pad 35C, one well on Pad 36L, and one well on Pad 36B.

For the 10 wells sampled on Pads 26N and 26K, the bottom-hole locations are between 0.76 mile and 1.1 miles from the Project Rulison vertical emplacement well 25-95 (R-E). Wells on Pads 35C and 36L are approximately 0.95 mile from the detonation point. The well on Pad 36B is approximately 0.55 mile southeast of well 25-95 (R-E). Surface projections of the bottom-hole well locations and Project Rulison surface ground zero, at well 25-95 (R-E) (i.e., the detonation point), are shown in Figure 1.



Notes:

All wells sampled have been previously sampled by DOE.
 The first two numerals in the well name designate the section number of the bottom-well location in the BM field.
 The Project Rulison emplacement well, 25-95 (R-E) (i.e., ground zero), is located in Lot 11, Section 25.

Figure 1. Wells Sampled and Well 25-95 (R-E)

Table 1 lists the wells by sample-collection sequence. Before sample collection occurs at each well, each well’s pressure and temperature (see Table 2) were read and recorded from surface transducers in the wells. Latitude and longitude values (not shown in Table 2) were compiled from survey plats included with the applications for permits to drill and from Colorado Oil and Gas Conservation Commission scout cards.

All planned wellheads were available for sampling, and wellhead pressures and temperatures were lower than normal. A total of seven 1-gallon production-water samples were collected for total analysis. At six locations—26-33B, 26-33C, 26-33D, 26-34A, 26-34C, and 26-22B—no production water was collected. A duplicate sample was collected from BM 36-13 and is noted in Table 2. All other well functions were performing normally, so no impact to the analytical data is expected.

Table 2. Samples Collected

Sample Collection Sequence	Pad	Well Name	Location			Sample Phase		Well	
			API # 05-045-	Type	Subtype	Gas	Liquid	T (°F)	P (psi)
1	26N	BM 26-33B	15739	WL	NGSA	Yes	No	84	264
2	26N	BM 26-33C	15742	WL	NGSA	Yes	No	85	260
3	26N	BM 26-33D	15743	WL	NGSA	Yes	No	84.9	261
4	26N	BM 26-34A	15744	WL	NGSA	Yes	No	83.9	263
5	26N	BM 26-34B	15745	WL	NGSA	Yes	Yes	80.1	258
6	26N	BM 26-34C	15741	WL	NGSA	Yes	No	88.8	256
7	26N	BM 26-34D	15748	WL	NGSA	Yes	Yes ^a	81	259
8	26K	BM 26-22B	16086	WL	NGSA	Yes	No	91.5	239
9	26K	BM 26-22C	16087	WL	NGSA	Yes	Yes	89.1	234
10	26K	BM 26-22D	16074	WL	NGSA	Yes	Yes	83.1	240
11	35C	BM 35-32A	10919	WL	NGSV	Yes	Yes	65.3	270
12	36L	BM 36-13B	15469	WL	NGSV	Yes	Yes	67.7	223
13	36B	BM 36-13	10840	WL	NGSV	Yes	Yes	76.7	279
Duplicate	36B	BM 36-13	10840	WL	NGSV	No	Yes	76.7	279

^a BM 26-34D included approximately 400ML of production water.

Abbreviations:

API American Petroleum Institute
 NGSA natural gas well–angle
 NGSV natural gas well–vertical
 P (psi) pressure in pounds per square inch
 T (°F) temperature in degrees Fahrenheit
 WL well

The produced-water samples were collected from a tap on a common line connecting the output of two separators (each servicing a well) and the nearby accumulation tanks. With the wells on Pad 26N continuing to have operational issues, a well head service company installed a bailer to try to collect production water. The collected water sample from one separator was isolated from the other separator by valves. Lines from each of the two separators were purged before sample collection.

Water condensation is variable and often not desired for the planned analytes. Collected sample volumes (Table 3) varied due to the water vapor concentration in the gas, temperature, age of the well, the cycle times of the well plunger, and transfer to the accumulation tank. Analysis priorities are tritium, gross alpha/beta, technetium-99, and high-resolution gamma spectrometry.

If condensate was collected with a sample, which happens for most samples, the condensate naturally separated from water after a short time in the sample bottle. The condensate was decanted in the field and returned to the operator. Table 3 lists the estimated sample volumes (including the condensate).

Table 3. Collected Water Sample Volumes (Before Decanting)

Sample Ticket	Well Name	Planned Analytes	Sample Volume (L)
1	BM 26-33B	NA	No Sample
2	BM 26-33C	NA	No Sample
3	BM 26-33D	NA	No Sample
4	BM 26-34A	NA	No Sample
5	BM 26-34B	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 2.5 L
6	BM 26-34C	NA	No Sample
7	BM 26-34D	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 2.5 L400ML
8	BM 26-22B	NA	No Sample
9	BM 26-22C	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 2.5 L
10	BM 26-22D	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 1.75 L
11	BM 35-32A	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 2.5 L
12	BM 36-13B	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 2.5 L
13	BM 36-13	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 2.5 L
Duplicate	BM 36-13	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈ 2.5 L

Notes:

Water sample information is listed in the order of collection.

Wells BM 26-33B, BM 26-33C, BM 26-33D, BM 26-34A, BM 26-34C, and BM 26-22B did not produce water for laboratory analyses.

Abbreviations:

Cl⁻ chloride
 Gamma spec high-resolution gamma spectrometry analysis
 Gross α/β gross alpha and beta analyses
³H tritium
 L liter
 NA not applicable
⁹⁹Tc technetium-99

Equipment

Each produced-water sample was collected in a new, 1-gallon plastic bottle. After decanting, each water sample was poured into white, high-density polyethylene bottles of appropriate volumes for analysis.

Isotech Analysis Report

This page intentionally left blank

Lab #:	482742	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 695				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6040
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-22B				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.10				
Carbon Dioxide -----	2.47				
Methane -----	91.40	-32.62		< 0.2	< 10.0
Ethane -----	4.11				
Ethylene -----	nd				
Propane -----	0.989				
Propylene -----	nd				
Iso-butane -----	0.220				
N-butane -----	0.206				
Iso-pentane -----	0.108				
N-pentane -----	0.0728				
Hexanes + -----	0.324				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1062

Specific gravity, calculated: 0.625

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482743	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 696				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6022
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-22C				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	0.012				
Nitrogen -----	0.10				
Carbon Dioxide -----	3.29				
Methane -----	90.17	-32.77		< 0.2	< 10.0
Ethane -----	4.40				
Ethylene -----	nd				
Propane -----	1.17				
Propylene -----	nd				
Iso-butane -----	0.245				
N-butane -----	0.236				
Iso-pentane -----	0.0989				
N-pentane -----	0.0704				
Hexanes + -----	0.203				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1055

Specific gravity, calculated: 0.634

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #: 482744 Job #: 27809 IS-61901 Co. Job#: _____
 Sample Name: Ticket #MNU 697 Co. Lab#: _____
 Company: S.M. Stoller Cylinder: 6032
 API/Well: _____
 Container: Isotech LP Tank
 Field/Site Name: Rulison Site
 Location: BM 26-22D
 Formation/Depth: _____
 Sampling Point: _____
 Date Sampled: 1/07/2015 Date Received: 1/12/2015 Date Reported: 2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.076				
Carbon Dioxide -----	3.49				
Methane -----	89.25	-34.68		< 0.2	< 10.0
Ethane -----	4.64				
Ethylene -----	nd				
Propane -----	1.50				
Propylene -----	nd				
Iso-butane -----	0.301				
N-butane -----	0.290				
Iso-pentane -----	0.0972				
N-pentane -----	0.0621				
Hexanes + -----	0.289				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1065

Specific gravity, calculated: 0.644

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482745	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 688				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6067
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-33B				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	0.082				
Nitrogen -----	0.35				
Carbon Dioxide -----	1.81				
Methane -----	90.74	-34.96		< 0.2	< 10.0
Ethane -----	4.71				
Ethylene -----	nd				
Propane -----	1.30				
Propylene -----	nd				
Iso-butane -----	0.278				
N-butane -----	0.287				
Iso-pentane -----	0.113				
N-pentane -----	0.0829				
Hexanes + -----	0.249				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1075

Specific gravity, calculated: 0.627

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482746	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 689				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6059
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-33C				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.068				
Carbon Dioxide -----	2.87				
Methane -----	89.94	-34.05		< 0.2	< 10.0
Ethane -----	4.80				
Ethylene -----	nd				
Propane -----	1.31				
Propylene -----	nd				
Iso-butane -----	0.294				
N-butane -----	0.280				
Iso-pentane -----	0.116				
N-pentane -----	0.0833				
Hexanes + -----	0.241				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1069

Specific gravity, calculated: 0.636

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482747	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 690				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6044
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-33D				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.076				
Carbon Dioxide -----	4.03				
Methane -----	88.59	-33.26		< 0.2	< 10.0
Ethane -----	5.01				
Ethylene -----	nd				
Propane -----	1.28				
Propylene -----	nd				
Iso-butane -----	0.296				
N-butane -----	0.253				
Iso-pentane -----	0.109				
N-pentane -----	0.0774				
Hexanes + -----	0.277				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1059

Specific gravity, calculated: 0.648

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482748	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 691				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6079
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-34A				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.069				
Carbon Dioxide -----	2.24				
Methane -----	89.94	-37.02		< 0.2	< 10.0
Ethane -----	5.05				
Ethylene -----	nd				
Propane -----	1.55				
Propylene -----	nd				
Iso-butane -----	0.313				
N-butane -----	0.319				
Iso-pentane -----	0.134				
N-pentane -----	0.107				
Hexanes + -----	0.281				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1085

Specific gravity, calculated: 0.636

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482749	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 692				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6098
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-34B				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.059				
Carbon Dioxide -----	4.87				
Methane -----	87.81	-33.65		< 0.2	< 10.0
Ethane -----	5.23				
Ethylene -----	nd				
Propane -----	1.10				
Propylene -----	nd				
Iso-butane -----	0.287				
N-butane -----	0.196				
Iso-pentane -----	0.106				
N-pentane -----	0.0830				
Hexanes + -----	0.259				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1047

Specific gravity, calculated: 0.654

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #: 482750 Job #: 27809 IS-61901 Co. Job#: Co. Lab#: Cylinder: 6078
 Sample Name: Ticket #MNU 693
 Company: S.M. Stoller
 API/Well:
 Container: Isotech LP Tank
 Field/Site Name: Rulison Site
 Location: BM 26-34C
 Formation/Depth:
 Sampling Point:
 Date Sampled: 1/07/2015 Date Received: 1/12/2015 Date Reported: 2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.068				
Carbon Dioxide -----	3.05				
Methane -----	90.00	-34.01		< 0.2	< 10.0
Ethane -----	4.65				
Ethylene -----	nd				
Propane -----	1.25				
Propylene -----	nd				
Iso-butane -----	0.268				
N-butane -----	0.262				
Iso-pentane -----	0.110				
N-pentane -----	0.0806				
Hexanes + -----	0.259				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1065

Specific gravity, calculated: 0.636

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482751	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 694				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6103
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-34D				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.072				
Carbon Dioxide -----	3.28				
Methane -----	89.59	-34.70		< 0.2	< 10.0
Ethane -----	4.85				
Ethylene -----	nd				
Propane -----	1.29				
Propylene -----	nd				
Iso-butane -----	0.274				
N-butane -----	0.246				
Iso-pentane -----	0.0946				
N-pentane -----	0.0677				
Hexanes + -----	0.239				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1063

Specific gravity, calculated: 0.638

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482752	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 698				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6100
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 35-32A				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.065				
Carbon Dioxide -----	3.79				
Methane -----	89.53	-32.49		< 0.2	< 10.0
Ethane -----	4.71				
Ethylene -----	nd				
Propane -----	1.14				
Propylene -----	nd				
Iso-butane -----	0.226				
N-butane -----	0.208				
Iso-pentane -----	0.0808				
N-pentane -----	0.0561				
Hexanes + -----	0.193				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1050

Specific gravity, calculated: 0.638

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #:	482753	Job #:	27809	IS-61901	Co. Job#:
Sample Name:	Ticket #MNU 699				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6110
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 36-13				
Formation/Depth:					
Sampling Point:					
Date Sampled:	1/07/2015	Date Received:	1/12/2015	Date Reported:	2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.14				
Carbon Dioxide -----	1.24				
Methane -----	91.77	-35.11		< 0.2	< 10.0
Ethane -----	4.72				
Ethylene -----	nd				
Propane -----	1.28				
Propylene -----	nd				
Iso-butane -----	0.249				
N-butane -----	0.256				
Iso-pentane -----	0.0981				
N-pentane -----	0.0715				
Hexanes + -----	0.176				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1079
 Specific gravity, calculated: 0.617

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

Lab #: 482754 Job #: 27809 IS-61901 Co. Job#: _____
 Sample Name: Ticket #MNU 700 Co. Lab#: _____
 Company: S.M. Stoller Cylinder: 6035
 API/Well: _____
 Container: Isotech LP Tank
 Field/Site Name: Rulison Site
 Location: BM 36-13B
 Formation/Depth: _____
 Sampling Point: _____
 Date Sampled: 1/07/2015 Date Received: 1/12/2015 Date Reported: 2/12/2015

Component	Chemical mol. %	$\delta^{13}\text{C}$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide -----	nd				
Helium -----	nd				
Hydrogen -----	nd				
Argon -----	nd				
Oxygen -----	nd				
Nitrogen -----	0.064				
Carbon Dioxide -----	3.86				
Methane -----	87.99	-33.40		< 0.2	< 10.0
Ethane -----	5.77				
Ethylene -----	nd				
Propane -----	1.33				
Propylene -----	nd				
Iso-butane -----	0.283				
N-butane -----	0.242				
Iso-pentane -----	0.101				
N-pentane -----	0.0712				
Hexanes + -----	0.289				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1067
 Specific gravity, calculated: 0.650

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

This page intentionally left blank