Semiannual Monitoring Results of Natural Gas Wells near the Rulison, Colorado, Site
September 2016 Monitoring Event

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

Date Sampled: September 20, 2016

Background

The Rulison, Colorado, Site is in the Piceance Basin of western Colorado, 40 miles northeast of Grand Junction. The site, identified as Lot 11 (Figure 1), was the location of an underground nuclear test conducted by the U.S. Atomic Energy Commission (a predecessor agency to the U.S. Department of Energy [DOE]) in partnership with the Austral Oil Company Inc. and the nuclear engineering firm CER Geonuclear Corporation. The test was called Project Rulison, and it was designed to evaluate the use of a nuclear detonation to enhance gas production in a low-permeability sandstone reservoir. This was the second natural gas reservoir stimulation experiment in the Plowshare Program, which was a program to develop peaceful uses for nuclear energy. The device was detonated in the emplacement well (R-E) at a depth of 8426 feet (ft) below ground surface on September 10, 1969. It had a reported yield of 40 kilotons, and the detonation created a temporary cavity, a collapse chimney, and a fractured zone surrounding the cavity (collectively known as the detonation zone). A sidetrack hole (reentry well) was drilled off the exploration well (R-Ex) into the chimney and tested to evaluate the success of the detonation at improving gas production. In 1976, the participating parties agreed that future gas production would not occur at the site, the wells (R-E and R-Ex) were abandoned, and a deed restriction was established for Lot 11. The deed restriction prohibits penetration or withdrawal of any material below 6000 ft within the boundary of Lot 11 unless authorized by the U.S. government.

Purpose

To ensure public safety, samples are collected from natural gas wells near the Rulison site. The samples are analyzed for radionuclides that may be associated with the detonation. Tritium is the most abundant radionuclide remaining in the detonation zone that can be present in the gas and aqueous phases. Its presence in water vapor (a minor constituent of natural gas) is the primary concern because gas is more mobile than liquid in a gas reservoir. The natural gas wells produce some liquids along with natural gas. The liquids (produced water and hydrocarbon condensate) are brought to the surface with the natural gas and mechanically separated at the wellhead. Produced water is a mixture of water vapor in the natural gas that condenses at the surface, formation water, and remnant water from hydrofracturing well development. Natural gas and produced water samples are collected for analysis. The Colorado Oil and Gas Conservation Commission (COGCC) requires that operators with gas wells within 3 miles of the Rulison site adhere to the *Rulison Sampling and Analysis Plan* developed by the COGCC (COGCC 2017). The DOE Office of Legacy Management (LM), in a separate effort, has implemented the *Rulison Monitoring Plan*, which samples gas wells within 1 mile of the detonation zone (DOE 2010). The *Rulison Monitoring Plan* and analytical results from past monitoring activities are available on the LM website at https://www.lm.doe.gov/Rulison/Documents.aspx. Analytical results obtained from LM's September 20, 2016, monitoring event are summarized in the following sections.

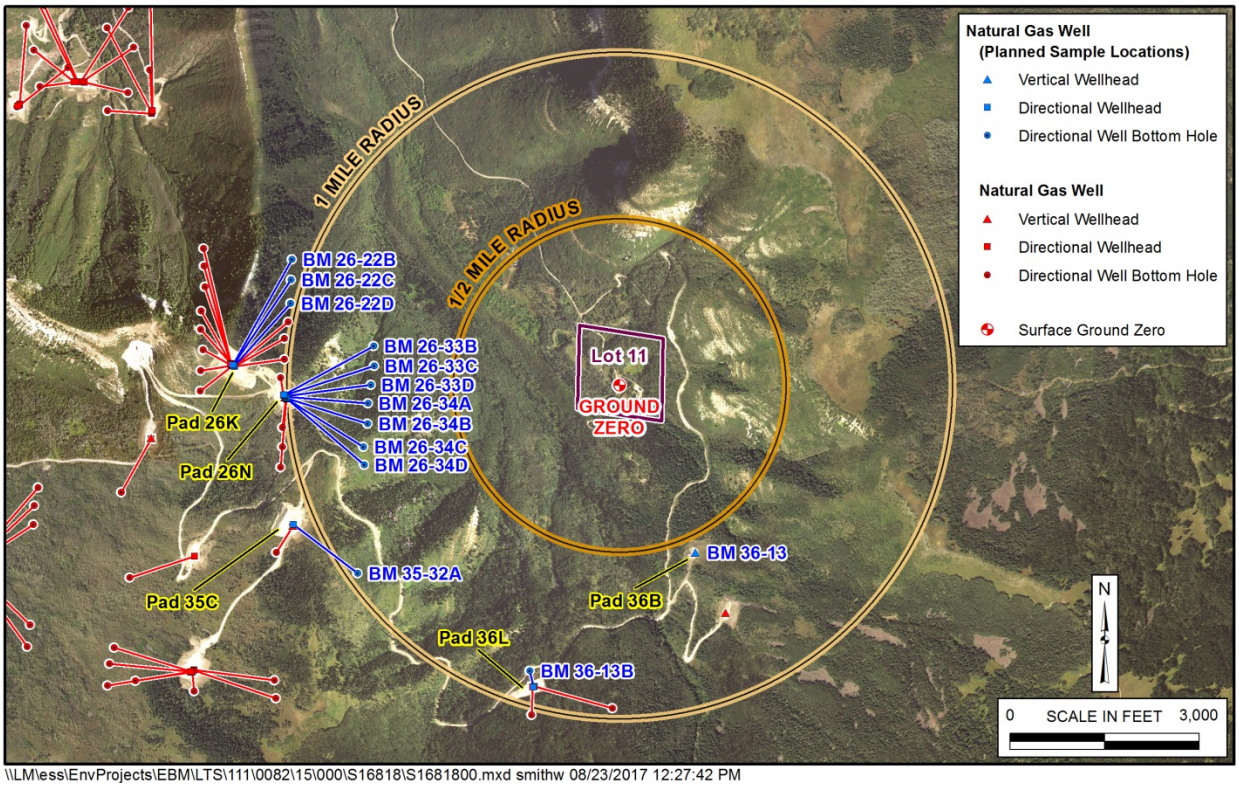

Figure 1. Rulison Site and Well Location Map

Monitoring Protocol

The *Rulison Monitoring Plan* provides guidance on the type of samples collected (natural gas or produced water), laboratory analyses performed, and the frequency of sample collection as a function of distance and direction from the Rulison site. It also establishes screening levels or concentrations that, if exceeded in the sample results, require samples to be reanalyzed or additional sampling to be done. The natural gas and produced water samples are analyzed for tritium, which is the most mobile contaminant remaining in significant quantities in the detonation zone. Produced water samples are also analyzed for gross alpha and beta radiation and gamma-emitting nuclides to obtain background information. Produced water samples are submitted to a commercial laboratory, which provides analytical services in accordance with the *Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (updated annually) to ensure that data are of known, documented quality. These laboratory analytical data are validated according to the "Standard Practice for Validation of Environmental Data" section in the *Environmental Procedures Catalog* (LMS/POL/S04325). Table 1 provides the gas and produced water screening activities (concentrations) for tritium, gross alpha and beta radiation, and gamma-emitting nuclides (specifically cesium-137). It should be noted that background concentrations for gross alpha and beta have not yet been established.

Table 1. Rulison Area Natural Gas and Produced Water Sample Screening Levels

Analyte	Sample Matrix	Laboratory Detection Limit	Screening Concentration	Action Concentration
Tritium	Natural gas	10 TU[a]	19,293 TU[b]	TBD[d]
	Produced water	400 pCi/L	800 pCi/L	TBD[d]
Gross alpha radiation	Produced water	2 pCi/L	3× background[c]	TBD[d]
Gross beta radiation	Produced water	4 pCi/L	3× background[c]	TBD[d]
Cesium-137 (high-resolution gamma spectrometry)	Produced water	10 pCi/L	20 pCi/L	TBD[d]

Notes:
The screening activities (concentrations) were obtained from the *Rulison Monitoring Plan* (DOE 2010).
[a] A tritium unit (TU) is equal to 3.19 picocuries per liter (pCi/L) in water.
[b] The natural gas screening concentration for tritium assumes a standard temperature (0 °C) and pressure (1 atmosphere).
[c] Background concentrations have not been established for gross alpha and beta radiation.
[d] Action concentrations have not been established for the analytes of interest.

Abbreviations:
pCi/L = picocuries per liter
TBD = to be determined
TU = tritium unit (1 tritium atom in 1×10^{18} hydrogen atoms)

Monitoring Event and Sample Collection

The September 20, 2016, monitoring event included the collection of natural gas and produced water samples from 11 area natural gas wells. Two wells (BM 26-22B and BM 36-13) could not be sampled because the wells were not in production at the time of the monitoring event (Figure 1; Table 2). Samples of the produced water were collected from a tap on the dump line connecting the gas–liquid separators and accumulation tank. Prior to sample collection, the gas–liquid separators that share a dump line were isolated using valves and then purged of produced water and condensate. The samples were contained in 1-gallon plastic containers provided by the laboratory. The produced water samples were submitted to ALS Laboratory Group in Fort Collins, Colorado, for the determination of tritium, gross alpha and beta radiation, and gamma-emitting nuclides.

Samples of the natural gas were collected from a tap on the production line downstream from the gas–liquid separator. Tubing used to connect the tap to the sample bottle was purged prior to sample collection. The natural gas samples were contained in an evacuated 18-liter propane bottle provided by the laboratory. The natural gas samples were submitted to Isotech Laboratories Inc. in Champaign, Illinois, for tritium and carbon-14 analysis. Carbon-14 was included in the natural gas analytical suite to get background levels to use in the future after tritium has decayed to insignificant levels. Carbon-14 is present in the gas phase. It is a longer-lived radionuclide with a half-life of 5700 years. The background data will be useful if gas production in the area continues beyond the next 80 years.

Table 2. Rulison Area Natural Gas Well Sample Locations

Well Name/Number	Well Pad	API No. 05-045-	Sample Type	
			Gas	Liquid
BM 26-33B	26N	15743	Sampled	Sampled
BM 26-33C	26N	15742	Sampled	Sampled
BM 26-33D	26N	15739	Sampled	Sampled
BM 26-34A	26N	15744	Sampled	Sampled
BM 26-34B	26N	15745	Sampled	Sampled
BM 26-34C	26N	15741	Sampled	Sampled
BM 26-22C	26K	16087	Sampled	Sampled
BM 26-22D	26K	16074	Sampled	Sampled
BM 35-32A	35C	10919	Sampled	Sampled
BM 26-22B	26K	16086	Not sampled	Not sampled
BM 26-34D	26N	15748	Sampled	Sampled
BM 36-13B	36L	15469	Sampled	Sampled
BM 36-13	36B	10840	Not sampled	Not sampled

Abbreviation:
API = American Petroleum Institute

Sample Results

Analytical results of produced water and natural gas samples collected on September 20, 2016, are provided in Table 3. Tritium was detected at an activity (concentration) of 15.6 tritium units (TU) in the natural gas sample collected from well BM 26-33C. The sample was reanalyzed by the laboratory, and that result was 17.0 TU. These results are much lower than the screening level (Table 1) established in the *Rulison Monitoring Plan* (DOE 2010) and the *Rulison Sampling and Analysis Plan* prepared by COGCC (COGCC 2017) and do not require any action. Tritium was not detected in the natural gas or produced water samples from any of the other wells. Carbon-14 and cesium-137 were also not detected above their respective laboratory minimum detectable concentrations (MDCs). Concentrations of gross alpha and beta radiation were detected above the MDCs in select samples, but they were consistent with past sample results and within the expected range for background concentrations from naturally occurring radionuclides.

The analytical results were validated in accordance with the "Standard Practice for Validation of Environmental Data" section in the *Environmental Procedures Catalog.* All analyses were completed, and the samples were prepared and analyzed in accordance with accepted procedures based on the specified methods. The laboratory radiochemical MDC reported with these data is an a priori estimate of the detection capability of a given analytical procedure, not an absolute concentration that can or cannot be detected. A copy of the Data Validation Package is provided as Appendix A.

Table 3. Rulison Area 2016 Natural Gas and Produced Water Sample Analytical Results

Well Name/Number	API No. 05-045-	Natural Gas[a]		Produced Water			
		Tritium (TU)[b]	Carbon-14 (pMC)[c]	Tritium (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Cesium-137 (pCi/L)
BM 26-33B	15743	<10	<0.4	<300	58.6	69	<4.4
BM 26-33C	15742	15.6	<0.4	<310	36.6	113	<4.9
		17.0[f]	NA	NA	NA	NA	NA
BM 26-33D	15739	<10	<0.4	<300	<38	79.9	<4.8
BM 26-34A	15744	<10	<0.4	<330	<29	81.6	<6.3
BM 26-34B	15745	<11.4	<0.4	<330	<22	34.1	<4.7
BM 26-34C	15741	<10	<0.4	<350	30.6	<22	<4.6
BM 26-22C	16087	<10	<0.4	<310	33.3	102	<4.2
BM 26-22D	16074	<10	<0.4	<320	<23	88.9	<6.6
BM 35-32A	10919	<10	<0.4	<320	35.2	132	<4.2
BM 26-22B	16086	NS	NS	NS	NS	NS	NS
BM 26-34D[d]	15748	<10	<0.4	<330	36	65.3	<4.7
		NA	NA	<310	<26	50.4	<4.8
BM 36-13B	15469	<10	<0.4	<320	23	86.4	<5.0
BM 36-13	10840	NS	NS	NS	NS	NS	NS
Screening concentrations		19,293	TBD	800	3× background[e]	3× background[e]	20

Notes:
[a] The natural gas samples were initially analyzed by gas chromatography to determine the composition of the natural gas. The samples were then combusted, and the resulting water was collected for tritium and carbon-14 analysis.
[b] A tritium unit (TU), 1 tritium atom in 1×10^{18} hydrogen atoms, is equal to 3.19 picocuries per liter (pCi/L) in water.
[c] Percent modern carbon (pMC) is based on the International Radiocarbon Dating Standard, which is 1950 Before Present (BP).
[d] Indicates that the sample was provided to the laboratory as a field duplicate.
[e] Background activities (concentrations) have not yet been established for gross alpha and beta radiation.
[f] Indicates the sample was reanalyzed by the laboratory.

Abbreviations:
API = American Petroleum Institute
NA = not analyzed
NS = not sampled
pCi/L = picocuries per liter
pMC = percent modern carbon
TBD = to be determined
TU = tritium unit (1 tritium atom in 1×10^{18} hydrogen atoms)

Conclusion

The laboratory analytical results obtained from this monitoring event continue to demonstrate that no Rulison detonation-related contaminants have impacted the natural gas wells near the site. This report is available on the LM public website at https://www.lm.doe.gov/rulison/Sites.aspx. Data collected during this and previous monitoring events are available on the GEMS website at http://gems.lm.doe.gov/#site=RUL.

References

DOE (U.S. Department of Energy), 2010. *Rulison Monitoring Plan,* LMS/RUL/S06178, Office of Legacy Management, July.

Environmental Procedures Catalog, LMS/POL/S04325, continually updated, prepared by Navarro Research and Engineering, Inc., for the U.S. Department of Energy Office of Legacy Management.

COGCC (Colorado Oil and Gas Conservation Commission), 2017. *Rulison Sampling and Analysis Plan, Operational and Environmental Monitoring Near Project Rulison, Revision 4,* July.

Appendix A

Data Validation Package

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Data Validation Package

September 2016
Natural Gas and Produced Water Sampling at the Rulison, Colorado, Site

August 2017

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Contents

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Sampling Event Summary

Site: Rulison, Colorado, Site

Sampling Period: September 20, 2016

The U.S. Department of Energy Office of Legacy Management conducted sampling at the Rulison, Colorado, Site on September 20, 2016, in accordance with the 2010 *Rulison Monitoring Plan*. See Attachment 1 for the trip report. 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 16098016 to Isotech Laboratories in Champaign, Illinois, for the determination of carbon-14 and tritium.
- Produced water samples were submitted under requisition 16098015 to ALS Laboratory Group in Fort Collins, Colorado, for the determination of gross alpha/beta, gamma-emitting nuclides, and tritium.

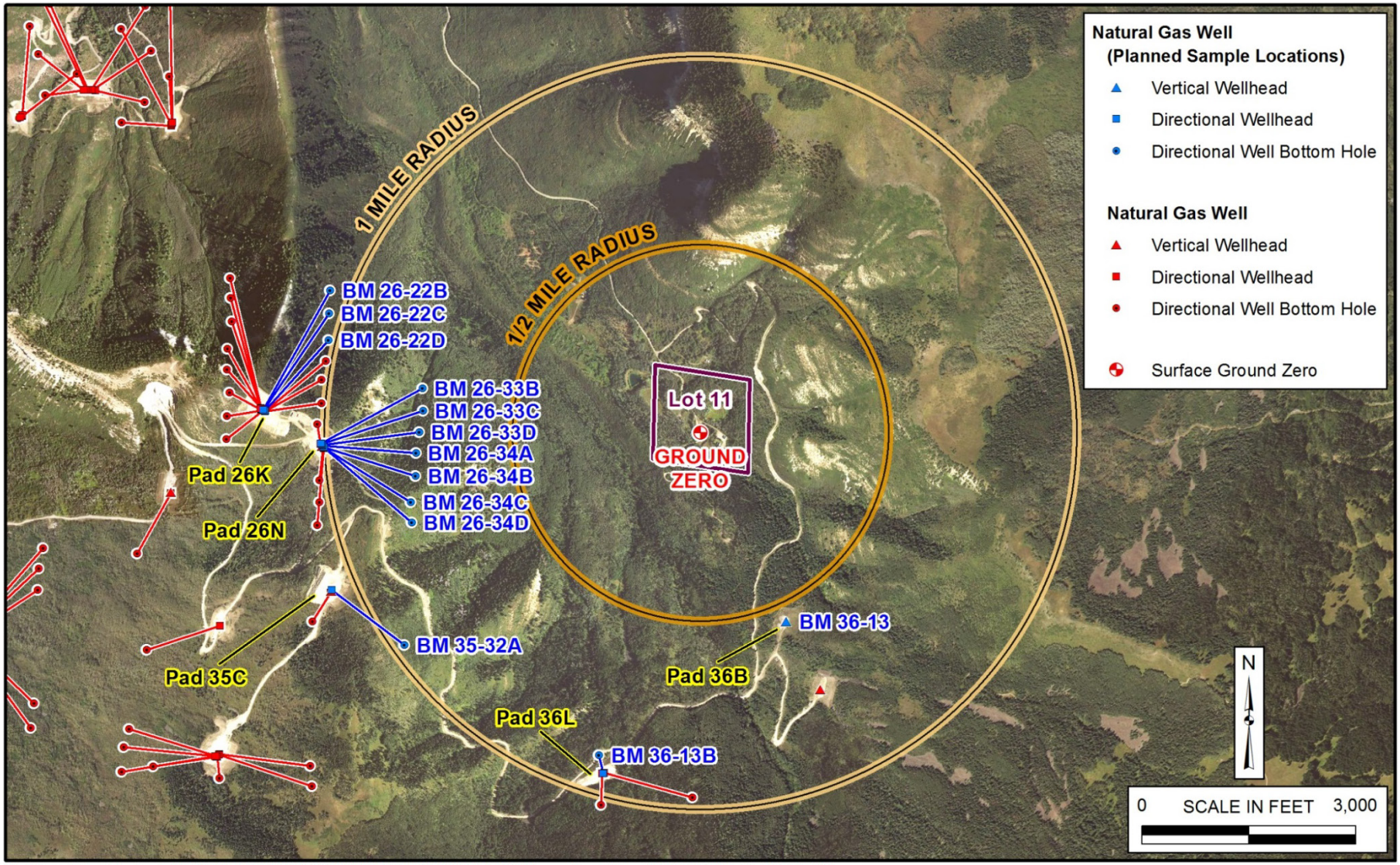
Sampling and analyses were conducted as specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351, continually updated). A duplicate sample of produced water was collected at location BM 26-34D (05-045-15748).

Sample radionuclide results for gamma-emitting nuclides and tritium are compared to the screening levels listed in the Monitoring Plan to determine if any further action is merited. Screening levels have not been determined for gross alpha and gross beta. None of the results for the 11 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 2.

Richard C Findlay 8-22-2017

Rick Findlay, Site Lead
Navarro Research and Engineering, Inc.

Date



Rulison, Colorado, Site, Sample Location Map

Data Assessment Summary

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Water Sampling Field Activities Verification Checklist

Project	Rulison, Colorado	**Date(s) of Water Sampling**	September 20, 2016
Date(s) of Verification	December 7, 2016	**Name of Verifier**	Stephen Donivan

	Response (Yes, No, NA)	Comments
1. Is the SAP the primary document directing field procedures?	Yes	
List any Program Directives or other documents, SOPs, instructions.		Program Directive RUL-2015-01.
2. Were the sampling locations specified in the planning documents sampled?	No	The natural gas wells BM 26-22B and BM 36-13 were not in production at the time of sampling.
3. Were field equipment 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?	NA	
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?	NA	
6. Were wells categorized correctly?	NA	This sampling event did not include groundwater.
7. Were the following conditions met when purging a Category I well:		
Was one pump/tubing volume purged prior to sampling?	NA	This sampling event did not include groundwater.
Did the water level stabilize prior to sampling?	NA	
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 groundwater.

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?	NA	This sampling event did not include groundwater.
Was one pump/tubing volume removed prior to sampling?		
9. Were duplicates taken at a frequency of one per 20 samples?	Yes	A duplicate sample of produced water was collected at location BM 26-34D (05 045 15748).
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	
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): 16098015
Sample Event: September 20, 2016
Site(s): Rulison, Colorado, Site
Laboratory: ALS Laboratory Group, Fort Collins, Colorado
Work Order No.: 1609372
Analysis: Radiochemistry
Validator: Stephen Donivan
Review Date: November 16, 2016

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
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
1609372-1	BM 26-34D Duplicate	Actinium-228	U	Nuclide identification criteria
1609372-1	BM 26-34D Duplicate	Gross Beta	J	Less than the determination limit
1609372-2	BM 26-22C	Thorium-234	U	Nuclide identification criteria
1609372-2	BM 26-22C	Gross Alpha	J	Less than the determination limit
1609372-4	BM 26-33B	Actinium-228	U	Nuclide identification criteria
1609372-4	BM 26-33B	Gross Alpha	J	Less than the determination limit
1609372-5	BM 26-33C	Actinium-228	U	Nuclide identification criteria
1609372-5	BM 26-33C	Gross Alpha	J	Less than the determination limit
1609372-6	BM 26-33D	Actinium-228	U	Nuclide identification criteria
1609372-7	BM 26-34A	Actinium-228	U	Nuclide identification criteria

Table 2 (continued). Data Qualifier Summary

Sample Number	Location	Analyte	Flag	Reason
1609372-7	BM 26-34A	Tritium	J	Matrix spike recovery
1609372-8	BM 26-34B	Europium-154	U	Nuclide identification criteria
1609372-8	BM 26-34B	Gross Alpha	J	Matrix spike recovery
1609372-8	BM 26-34B	Gross Beta	J	Less than the determination limit
1609372-9	BM 26-34C	Uranium-235	U	Nuclide identification criteria
1609372-9	BM 26-34C	Gross Alpha	J	Less than the determination limit
1609372-10	BM 26-34D	Actinium-228	U	Nuclide identification criteria
1609372-10	BM 26-34D	Yttrium-88	U	Nuclide identification criteria
1609372-10	BM 26-34D	Gross Alpha	J	Less than the determination limit
1609372-11	BM 26-32A	Gross Alpha	J	Less than the determination limit
1609372-12	BM 36-13B	Potassium-40	J	Less than the determination limit

Sample Shipping/Receiving

ALS Laboratory Group in Fort Collins, Colorado, received twelve water samples on September 22, 2016, 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% 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% 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 MDCs for radiochemical analytes met the detection limits requirements with the following exception. 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 verification demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. 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.

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 for gross alpha and tritium did not meet the acceptance criteria. The associated sample gross alpha and tritium results are qualified with a "J" flag as estimated values.

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 November 3, 2016. 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 was 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: 16098015 **Lab Code:** PAR **Validator:** Stephen Donivan **Validation Date:** 11/15/2016

Project: Rulison Site **Analysis Type:** ☐ Metals ☐ General Chem ☑ Rad ☐ Organics

# of Samples: 12 **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	All analyses were completed within the applicable holding times.
☑ Detection Limits	There are 25 detection limit failures.
☐ Field/Trip Blanks	
☑ Field Duplicates	There was 1 duplicate evaluated.

Figure 1. General Validation Worksheet

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 16098015 **Lab Code:** PAR **Date Due:** 10/20/2016

Matrix: Water **Site Code:** RUL01 **Date Completed:** 11/3/2016

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
BM 26-33B	Actinium-228	10/10/2016						0.87
BM 26-33B	Americium-241	10/10/2016						0.04
Blank_Spike	Americium-241	10/12/2016				94.2		
BM 26-33B	Antimony-125	10/10/2016						0.19
BM 26-33B	Cerium-144	10/10/2016						0.46
BM 26-33B	Cesium-134	10/10/2016						0.28
BM 26-33B	Cesium-137	10/10/2016						0.59
Blank_Spike	Cesium-137	10/12/2016				104		
BM 26-33B	Cobalt-60	10/10/2016						1.36
Blank_Spike	Cobalt-60	10/12/2016				98.7		
BM 26-33B	Europium-152	10/10/2016						0.4
BM 26-33B	Europium-154	10/10/2016						1.07
BM 26-33B	Europium-155	10/10/2016						0.17
Blank	GROSS ALPHA	10/20/2016	-0.2180	U				
BM 26-34B	GROSS ALPHA	10/20/2016					52.2	
Blank_Spike	GROSS ALPHA	10/20/2016				92.2		
BM 36-13B	GROSS ALPHA	10/21/2016						1.15
Blank_Spike	GROSS BETA	10/20/2016				98.2		
Blank	GROSS BETA	10/20/2016	-0.4990	U				
BM 26-34B	GROSS BETA	10/20/2016					97.3	
BM 36-13B	GROSS BETA	10/21/2016						0.74
BM 26-34B	H-3	10/12/2016						0.23
Blank	H-3	10/12/2016	98.4	U				
BM 26-34A	H-3	10/12/2016					73.7	
Blank_Spike	H-3	10/12/2016				105		
BM 26-33B	Lead-212	10/10/2016						0.83
BM 26-33B	Potassium-40	10/10/2016						2.42
BM 26-33B	Promethium-144	10/10/2016						0.47
BM 26-33B	Promethium-146	10/10/2016						1.19
BM 26-33B	Ruthenium-106	10/10/2016						0.63
BM 26-33B	Thorium-234	10/10/2016						0.39
BM 26-33B	Uranium-235	10/10/2016						0.07

Figure 2. Radiochemistry Validation Worksheet

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 16098015 **Lab Code:** PAR **Date Due:** 10/20/2016

Matrix: Water **Site Code:** RUL01 **Date Completed:** 11/3/2016

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
BM 26-33B	Yttrium-88	10/10/2016						1.57

Figure 2 (continued). Radiochemistry Validation Worksheet

General Information

Requisition (RIN):	16098016
Sample Event:	September 20, 2016
Site(s):	Rulison, Colorado
Laboratory:	Isotech Laboratories
Work Order No.:	33122
Analysis:	Radiochemistry
Validator:	Stephen Donivan
Review Date:	December 7, 2016

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 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 3.

Table 3. 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 9 natural gas samples on October 5, 2016, 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.

Summary

Eleven 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 collected water by liquid scintillation counting. There were no analytical difficulties noted by the laboratory.

Completeness

The results of the gas chromatography analyses 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 (TU). Carbon-14 was not detected in any of the samples. Tritium was detected in sample BM 26-33C with a result of 15.6 TU. On November 14, the laboratory was requested to reanalyze this sample to confirm the reported result.

The original vial of combusted methane was recounted with a result of 18.9 ± 3.8 TU. Additionally, the remaining sample methane was combusted and counted with a result of 17.0 ± 3.0 TU. Both of these values validate the original reported value of 15.6 ± 3.7 TU.

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-2015-01 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

Equipment blanks are prepared and analyzed to document contamination attributable to the sample collection process. 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 26-34D. 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 this criteria demonstrating acceptable precision.

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 16098015 **Lab Code:** PAR **Project:** Rulison Site **Validation Date:** 11/15/2016

Duplicate: 2657 **Sample:** BM 26-34D

Analyte	Sample Result	Flag	Error	Dilution	Duplicate Result	Flag	Error	Dilution	RPD	RER	Units
Actinium-228	35.5		15.5	1	40.8		15.6	1		0.5	pCi/L
Americium-241	1.02	U	28.8	1	-4.73	U	29	1		0.3	pCi/L
Antimony-125	-1.27	U	6.9	1	0.0147	U	6.69	1		0.3	pCi/L
Cerium-144	10.4	U	13.7	1	2.83	U	13.6	1		0.8	pCi/L
Cesium-134	-2.37	U	2.86	1	0.131	U	2.14	1		1.4	pCi/L
Cesium-137	-0.06	U	2.77	1	-0.78	U	2.78	1		0.4	pCi/L
Cobalt-60	-0.275	U	3.07	1	0	U	3.09	1		0.1	pCi/L
Europium-152	-5.47	U	15	1	-6.83	U	14.2	1		0.1	pCi/L
Europium-154	8.44	U	15.4	1	-9.25	U	16.2	1		1.6	pCi/L
Europium-155	5.89	U	8.09	1	-0.623	U	7.91	1		1.1	pCi/L
GROSS ALPHA	36		19.4	1	21.7	U	16.8	1		1.1	pCi/L
GROSS BETA	65.3		17.4	1	50.4		15.6	1		1.2	pCi/L
H-3	116	U	201	1	-80.4	U	182	1		1.4	pCi/L
Lead-212	1.46	U	6.74	1	2.1	U	6.95	1		0.1	pCi/L
Potassium-40	21.7	U	104	1	4.55	U	105	1		0.2	pCi/L
Promethium-144	0.727	U	3.06	1	-2.62	U	2.97	1		1.5	pCi/L
Promethium-146	-0.79	U	3.07	1	0.438	U	3.18	1		0.5	pCi/L
Ruthenium-106	-9.23	U	25.9	1	-13.3	U	25.9	1		0.2	pCi/L
Thorium-234	33.2	U	68.3	1	23	U	71.8	1		0.2	pCi/L
Uranium-235	7.89	U	15.8	1	-11.2	U	25.6	1		1.2	pCi/L
Yttrium-88	7.23		3.62	1	2.77	U	2.78	1		1.9	pCi/L

Figure 3. Field Duplicates Validation Worksheet

Certification

All laboratory analytical quality control criteria were met except as qualified in this report. The data qualifiers listed on the environmental 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 8-22-2017

Stephen Donivan — Date

Data Validation Lead: Stephen Donivan 8-22-2017

Stephen Donivan — Date

Attachment 1

Trip Report

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memo

NAVARRO

To: Distribution
From: Rick Findlay, Navarro
Date: October 13, 2016
CC: Art Kleinrath, DOE
Steve Donivan, Navarro
Rex Hodges, Navarro
EDD Delivery
Re: Trip Report - 2nd Semiannual Gas Well Sampling Event

Site: Rulison, Colorado, Site.

Date of Sampling Event: September 20, 2016.

Team Members: Jeff Price, Tony Franzone, and Rick Findlay, Navarro.

Number of Locations Sampled: Samples (produced water and natural gas) were collected from 11 natural gas wells during the sampling event.

Locations Not Sampled/Reason: Two gas wells (BM 26-22B and BM36-13) could not be sampled because the wells were not in production at the time of the sampling event.

Quality Control Sample Cross Reference: The following is the false identification assigned to the quality control sample.

False ID	Ticket Number	True ID	Sample Type	Associated Matrix
2657	OKU 575	BM 26-34D	Duplicate	Produced Water

Requisition Index Number Assigned: Samples were assigned to RINs 16098015 and 16098016. Field data sheets can be found at \\crow\sms\16098015\FieldData.

Sample Shipment: The samples (produced water and natural gas) were shipped via FedEx from Grand Junction, Colorado. The produced water samples were sent to GEL Laboratories in Charleston, South Carolina, on September 21, 2016 and the natural gas samples were shipped to Isotech Laboratories in Champaign, Illinois, on October 3, 2016.

Well Inspection Summary: No issues were identified.

Sampling Method: Samples were collected according to the *Sampling and Analysis Plan (SAP) for the U. S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351, continually updated) and Program Directive RUL-2015-01.

Field Variance: None.

Equipment: All equipment functioned properly.

Stakeholder/Regulatory/DOE: A. Kleinrath (DOE site manager) was onsite to observe the sampling activities. K. Rice with Caerus Oil and Gas provided access to the natural gas wells.

Safety Issues: None.

Access Issues: None.

General Information: Nothing to note.

Immediate Actions Taken: None.

Future Actions Required or Suggested: None.

BM 26-33D Natural Gas Sample

BM 26-33B Produced Water Sample

Attachment 2

Data Presentation

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Produced Water Data

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General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-10919 WELL BM 35-32A

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	13.7	U		#	36	21.8
Americium-241	pCi/L	09/20/2016	N001	-29.3	U		#	110	62.6
Antimony-125	pCi/L	09/20/2016	N001	-2.28	U		#	11	6.27
Cerium-144	pCi/L	09/20/2016	N001	5.37	U		#	26	15.7
Cesium-134	pCi/L	09/20/2016	N001	0.644	U		#	4.5	2.67
Cesium-137	pCi/L	09/20/2016	N001	1.35	U		#	4.2	2.52
Cobalt-60	pCi/L	09/20/2016	N001	-0.851	U		#	5	2.86
Europium-152	pCi/L	09/20/2016	N001	0.853	U		#	24	14
Europium-154	pCi/L	09/20/2016	N001	4.39	U		#	23	13.8
Europium-155	pCi/L	09/20/2016	N001	0.797	U		#	17	10.4
Gross Alpha	pCi/L	09/20/2016	N001	35.2			#	32	21.4
Gross Beta	pCi/L	09/20/2016	N001	132			#	21	25.6
Lead-212	pCi/L	09/20/2016	N001	3.59	U		#	12	7.58
Potassium-40	pCi/L	09/20/2016	N001	-35.8	U		#	130	80.1
Promethium-144	pCi/L	09/20/2016	N001	1.04	U		#	4.8	2.86
Promethium-146	pCi/L	09/20/2016	N001	-1.84	U		#	5.1	3
Ruthenium-106	pCi/L	09/20/2016	N001	-19.5	U		#	44	25.3
Thorium-234	pCi/L	09/20/2016	N001	-47.7	U		#	230	141
Tritium	pCi/L	09/20/2016	N001	73.3	U		#	320	192
Uranium-235	pCi/L	09/20/2016	N001	6.42	U		#	42	18.7
Yttrium-88	pCi/L	09/20/2016	N001	4.81	U		#	5.1	3.24

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15469 WELL BM 36-13B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	15.3	U		#	19	12
Americium-241	pCi/L	09/20/2016	N001	-2.6	U		#	34	20
Antimony-125	pCi/L	09/20/2016	N001	-4.28	U		#	12	6.53
Cerium-144	pCi/L	09/20/2016	N001	-3.22	U		#	22	13
Cesium-134	pCi/L	09/20/2016	N001	-3.56	U		#	5.5	3.21
Cesium-137	pCi/L	09/20/2016	N001	-1.55	U		#	5	2.87
Cobalt-60	pCi/L	09/20/2016	N001	-1.67	U		#	5.7	3.24
Europium-152	pCi/L	09/20/2016	N001	-16.5	U		#	29	16.4
Europium-154	pCi/L	09/20/2016	N001	-5.34	U		#	29	16.7
Europium-155	pCi/L	09/20/2016	N001	-4	U		#	13	7.69
Gross Alpha	pCi/L	09/20/2016	N001	9.15	U		#	23	13.8
Gross Beta	pCi/L	09/20/2016	N001	86.4			#	21	19.5
Lead-212	pCi/L	09/20/2016	N001	-0.276	U		#	13	7.81
Potassium-40	pCi/L	09/20/2016	N001	182		J	#	130	86.5
Promethium-144	pCi/L	09/20/2016	N001	1.32	U		#	2.9	1.7
Promethium-146	pCi/L	09/20/2016	N001	-1.2	U		#	5.9	3.48
Ruthenium-106	pCi/L	09/20/2016	N001	15.3	U		#	43	26.1
Thorium-234	pCi/L	09/20/2016	N001	-20.9	U		#	150	89.4
Tritium	pCi/L	09/20/2016	N001	-37.1	U		#	320	190
Uranium-235	pCi/L	09/20/2016	N001	17.9	U		#	56	25
Yttrium-88	pCi/L	09/20/2016	N001	4.81	U		#	5.8	3.65

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15739 WELL BM 26-33D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	30		U	#	29	14.8
Americium-241	pCi/L	09/20/2016	N001	-1.06	U		#	43	25.8
Antimony-125	pCi/L	09/20/2016	N001	1.46	U		#	10	6.23
Cerium-144	pCi/L	09/20/2016	N001	3.95	U		#	18	10.7
Cesium-134	pCi/L	09/20/2016	N001	-3.86	U		#	4.6	2.66
Cesium-137	pCi/L	09/20/2016	N001	-1.75	U		#	4.8	2.78
Cobalt-60	pCi/L	09/20/2016	N001	-0.666	U		#	5.7	3.31
Europium-152	pCi/L	09/20/2016	N001	-0.761	U		#	27	15.7
Europium-154	pCi/L	09/20/2016	N001	-9.91	U		#	28	15.9
Europium-155	pCi/L	09/20/2016	N001	-2.16	U		#	21	12.7
Gross Alpha	pCi/L	09/20/2016	N001	13.9	U		#	38	22.8
Gross Beta	pCi/L	09/20/2016	N001	79.9			#	23	19.6
Lead-212	pCi/L	09/20/2016	N001	-2.79	U		#	13	7.84
Potassium-40	pCi/L	09/20/2016	N001	-19.3	U		#	140	81
Promethium-144	pCi/L	09/20/2016	N001	-4.82	U		#	7.1	4.04
Promethium-146	pCi/L	09/20/2016	N001	-0.452	U		#	4.9	2.86
Ruthenium-106	pCi/L	09/20/2016	N001	0.0000134	U		#	42	25
Thorium-234	pCi/L	09/20/2016	N001	-6.99	U		#	130	77.3
Tritium	pCi/L	09/20/2016	N001	20.7	U		#	300	181
Uranium-235	pCi/L	09/20/2016	N001	-5.71	U		#	40	24
Yttrium-88	pCi/L	09/20/2016	N001	1.28	U		#	5.3	3.19

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15741 WELL BM 26-34C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	23.1	U		#	32	20
Americium-241	pCi/L	09/20/2016	N001	1.88	U		#	5.2	3.12
Antimony-125	pCi/L	09/20/2016	N001	0.87	U		#	9.9	5.09
Cerium-144	pCi/L	09/20/2016	N001	-2.12	U		#	16	9.25
Cesium-134	pCi/L	09/20/2016	N001	-2.84	U		#	4.4	2.54
Cesium-137	pCi/L	09/20/2016	N001	-2.65	U		#	4.6	2.59
Cobalt-60	pCi/L	09/20/2016	N001	-0.702	U		#	5	2.87
Europium-152	pCi/L	09/20/2016	N001	1.36	U		#	26	14.9
Europium-154	pCi/L	09/20/2016	N001	-0.77	U		#	26	15.3
Europium-155	pCi/L	09/20/2016	N001	2.13	U		#	7.4	4.47
Gross Alpha	pCi/L	09/20/2016	N001	30.6		J	#	24	16.1
Gross Beta	pCi/L	09/20/2016	N001	20.3	U		#	22	13.8
Lead-212	pCi/L	09/20/2016	N001	1.23	U		#	13	8.01
Potassium-40	pCi/L	09/20/2016	N001	73.6	U		#	110	66.3
Promethium-144	pCi/L	09/20/2016	N001	0.0325	U		#	7.1	4.22
Promethium-146	pCi/L	09/20/2016	N001	-2.81	U		#	4.6	2.64
Ruthenium-106	pCi/L	09/20/2016	N001	-27.7	U		#	42	23.7
Thorium-234	pCi/L	09/20/2016	N001	9.54	U		#	77	46.7
Tritium	pCi/L	09/20/2016	N001	51.8	U		#	350	209
Uranium-235	pCi/L	09/20/2016	N001	17.9		U	#	17	9.59
Yttrium-88	pCi/L	09/20/2016	N001	-3.08	U		#	13	7.98

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15742 WELL BM 26-33C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	21.9		U	#	21	12
Americium-241	pCi/L	09/20/2016	N001	15.8	U		#	26	16
Antimony-125	pCi/L	09/20/2016	N001	2.28	U		#	12	6.63
Cerium-144	pCi/L	09/20/2016	N001	7.58	U		#	22	13.1
Cesium-134	pCi/L	09/20/2016	N001	-3.64	U		#	6.7	3.88
Cesium-137	pCi/L	09/20/2016	N001	0.146	U		#	4.9	2.9
Cobalt-60	pCi/L	09/20/2016	N001	-1.93	U		#	6	3.42
Europium-152	pCi/L	09/20/2016	N001	-3.16	U		#	28	16.4
Europium-154	pCi/L	09/20/2016	N001	-0.391	U		#	27	16
Europium-155	pCi/L	09/20/2016	N001	0.322	U		#	13	7.62
Gross Alpha	pCi/L	09/20/2016	N001	36.6		J	#	33	22
Gross Beta	pCi/L	09/20/2016	N001	113			#	22	23.6
Lead-212	pCi/L	09/20/2016	N001	2.16	U		#	14	8.44
Potassium-40	pCi/L	09/20/2016	N001	91.9	U		#	140	87.8
Promethium-144	pCi/L	09/20/2016	N001	1.36	U		#	5.1	3.08
Promethium-146	pCi/L	09/20/2016	N001	-0.0873	U		#	5.1	3.03
Ruthenium-106	pCi/L	09/20/2016	N001	-17.7	U		#	46	27
Thorium-234	pCi/L	09/20/2016	N001	8.8	U		#	140	83.2
Tritium	pCi/L	09/20/2016	N001	-134	U		#	310	183
Uranium-235	pCi/L	09/20/2016	N001	6.87	U		#	21	12.9
Yttrium-88	pCi/L	09/20/2016	N001	0.687	U		#	9.9	5.94

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15743 WELL BM 26-33B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	16.6		U	#	16	7.97
Americium-241	pCi/L	09/20/2016	N001	-0.901	U		#	160	96.2
Antimony-125	pCi/L	09/20/2016	N001	4.56	U		#	11	5.55
Cerium-144	pCi/L	09/20/2016	N001	-1.53	U		#	25	14.8
Cesium-134	pCi/L	09/20/2016	N001	0.998	U		#	3.5	1.66
Cesium-137	pCi/L	09/20/2016	N001	-0.564	U		#	4.4	2.57
Cobalt-60	pCi/L	09/20/2016	N001	0.633	U		#	4.5	2.64
Europium-152	pCi/L	09/20/2016	N001	2.71	U		#	21	12.2
Europium-154	pCi/L	09/20/2016	N001	3.73	U		#	23	13.6
Europium-155	pCi/L	09/20/2016	N001	1.24	U		#	17	10.3
Gross Alpha	pCi/L	09/20/2016	N001	58.6		J	#	31	23.5
Gross Beta	pCi/L	09/20/2016	N001	69			#	23	18.4
Lead-212	pCi/L	09/20/2016	N001	3.6	U		#	14	8.31
Potassium-40	pCi/L	09/20/2016	N001	-111	U		#	150	87.7
Promethium-144	pCi/L	09/20/2016	N001	0.778	U		#	4.7	2.79
Promethium-146	pCi/L	09/20/2016	N001	2.58	U		#	4.4	2.68
Ruthenium-106	pCi/L	09/20/2016	N001	-4.35	U		#	38	22.4
Thorium-234	pCi/L	09/20/2016	N001	-11.2	U		#	230	141
Tritium	pCi/L	09/20/2016	N001	-64.9	U		#	300	178
Uranium-235	pCi/L	09/20/2016	N001	13.1	U		#	32	19.3
Yttrium-88	pCi/L	09/20/2016	N001	1.49	U		#	3	1.83

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15744 WELL BM 26-34A

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	28.9		U	#	23	11.4
Americium-241	pCi/L	09/20/2016	N001	16.1	U		#	33	20.2
Antimony-125	pCi/L	09/20/2016	N001	5.84	U		#	13	7.82
Cerium-144	pCi/L	09/20/2016	N001	3.51	U		#	27	16
Cesium-134	pCi/L	09/20/2016	N001	4.45	U		#	9.6	5.96
Cesium-137	pCi/L	09/20/2016	N001	-2.79	U		#	6.3	3.62
Cobalt-60	pCi/L	09/20/2016	N001	-4.1	U		#	9	5.1
Europium-152	pCi/L	09/20/2016	N001	-12.4	U		#	43	24.8
Europium-154	pCi/L	09/20/2016	N001	16.3	U		#	40	23.9
Europium-155	pCi/L	09/20/2016	N001	-0.29	U		#	13	7.76
Gross Alpha	pCi/L	09/20/2016	N001	-0.159	U		#	29	16.6
Gross Beta	pCi/L	09/20/2016	N001	81.6			#	22	19.3
Lead-212	pCi/L	09/20/2016	N001	3.33	U		#	12	7.32
Potassium-40	pCi/L	09/20/2016	N001	101	U		#	190	116
Promethium-144	pCi/L	09/20/2016	N001	0.789	U		#	14	8.57
Promethium-146	pCi/L	09/20/2016	N001	-0.61	U		#	7	4.12
Ruthenium-106	pCi/L	09/20/2016	N001	-10.7	U		#	61	35.7
Thorium-234	pCi/L	09/20/2016	N001	47.1	U		#	150	93.8
Tritium	pCi/L	09/20/2016	N001	-2.73	U	J	#	330	198
Uranium-235	pCi/L	09/20/2016	N001	17.2	U		#	26	15.7
Yttrium-88	pCi/L	09/20/2016	N001	-1.58	U		#	14	8.59

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	16.7	U		#	38	23.4
Americium-241	pCi/L	09/20/2016	N001	11.9	U		#	26	15.7
Antimony-125	pCi/L	09/20/2016	N001	7.98	U		#	11	6.62
Cerium-144	pCi/L	09/20/2016	N001	-1.17	U		#	22	13.2
Cesium-134	pCi/L	09/20/2016	N001	-1.65	U		#	4.9	2.87
Cesium-137	pCi/L	09/20/2016	N001	1.02	U		#	4.7	2.83
Cobalt-60	pCi/L	09/20/2016	N001	-2.34	U		#	6	3.45
Europium-152	pCi/L	09/20/2016	N001	-13.4	U		#	29	16.5
Europium-154	pCi/L	09/20/2016	N001	25.2		U	#	24	15.8
Europium-155	pCi/L	09/20/2016	N001	-1.95	U		#	13	7.52
Gross Alpha	pCi/L	09/20/2016	N001	12.9	U	J	#	22	13.4
Gross Beta	pCi/L	09/20/2016	N001	34.1		J	#	22	14.9
Lead-212	pCi/L	09/20/2016	N001	0.146	U		#	14	8.12
Potassium-40	pCi/L	09/20/2016	N001	17.7	U		#	140	86.4
Promethium-144	pCi/L	09/20/2016	N001	3.36	U		#	4.9	3.04
Promethium-146	pCi/L	09/20/2016	N001	-0.67	U		#	5.2	3.04
Ruthenium-106	pCi/L	09/20/2016	N001	-19.1	U		#	47	27.6
Thorium-234	pCi/L	09/20/2016	N001	-6.11	U		#	140	83.4
Tritium	pCi/L	09/20/2016	N001	18.6	U		#	330	196
Uranium-235	pCi/L	09/20/2016	N001	10.9	U		#	21	12.8
Yttrium-88	pCi/L	09/20/2016	N001	0.435	U		#	9.9	5.94

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15748 WELL BM 26-34D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	35.5		U	#	32	15.5
Actinium-228	pCi/L	09/20/2016	N002	40.8		U	#	30	15.6
Americium-241	pCi/L	09/20/2016	N001	1.02	U		#	48	28.8
Americium-241	pCi/L	09/20/2016	N002	-4.73	U		#	49	29
Antimony-125	pCi/L	09/20/2016	N001	-1.27	U		#	12	6.9
Antimony-125	pCi/L	09/20/2016	N002	0.0147	U		#	12	6.69
Cerium-144	pCi/L	09/20/2016	N001	10.4	U		#	22	13.7
Cerium-144	pCi/L	09/20/2016	N002	2.83	U		#	23	13.6
Cesium-134	pCi/L	09/20/2016	N001	-2.37	U		#	4.9	2.86
Cesium-134	pCi/L	09/20/2016	N002	0.131	U		#	5.1	2.14
Cesium-137	pCi/L	09/20/2016	N001	-0.06	U		#	4.7	2.77
Cesium-137	pCi/L	09/20/2016	N002	-0.78	U		#	4.8	2.78
Cobalt-60	pCi/L	09/20/2016	N001	-0.275	U		#	5.3	3.07
Cobalt-60	pCi/L	09/20/2016	N002	0	U		#	5.3	3.09
Europium-152	pCi/L	09/20/2016	N001	-5.47	U		#	26	15
Europium-152	pCi/L	09/20/2016	N002	-6.83	U		#	25	14.2
Europium-154	pCi/L	09/20/2016	N001	8.44	U		#	26	15.4
Europium-154	pCi/L	09/20/2016	N002	-9.25	U		#	28	16.2
Europium-155	pCi/L	09/20/2016	N001	5.89	U		#	13	8.09
Europium-155	pCi/L	09/20/2016	N002	-0.623	U		#	13	7.91
Gross Alpha	pCi/L	09/20/2016	N001	36		J	#	29	19.4

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-15748 WELL BM 26-34D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Gross Alpha	pCi/L	09/20/2016	N002	21.7	U		#	26	16.8
Gross Beta	pCi/L	09/20/2016	N001	65.3			#	21	17.4
Gross Beta	pCi/L	09/20/2016	N002	50.4		J	#	21	15.6
Lead-212	pCi/L	09/20/2016	N001	1.46	U		#	11	6.74
Lead-212	pCi/L	09/20/2016	N002	2.1	U		#	12	6.95
Potassium-40	pCi/L	09/20/2016	N001	21.7	U		#	170	104
Potassium-40	pCi/L	09/20/2016	N002	4.55	U		#	170	105
Promethium-144	pCi/L	09/20/2016	N001	0.727	U		#	5.1	3.06
Promethium-144	pCi/L	09/20/2016	N002	-2.62	U		#	5.2	2.97
Promethium-146	pCi/L	09/20/2016	N001	-0.79	U		#	5.2	3.07
Promethium-146	pCi/L	09/20/2016	N002	0.438	U		#	5.3	3.18
Ruthenium-106	pCi/L	09/20/2016	N001	-9.23	U		#	44	25.9
Ruthenium-106	pCi/L	09/20/2016	N002	-13.3	U		#	45	25.9
Thorium-234	pCi/L	09/20/2016	N001	33.2	U		#	110	68.3
Thorium-234	pCi/L	09/20/2016	N002	23	U		#	120	71.8
Tritium	pCi/L	09/20/2016	N001	116	U		#	330	201
Tritium	pCi/L	09/20/2016	N002	-80.4	U		#	310	182
Uranium-235	pCi/L	09/20/2016	N001	7.89	U		#	33	15.8
Uranium-235	pCi/L	09/20/2016	N002	-11.2	U		#	43	25.6
Yttrium-88	pCi/L	09/20/2016	N001	7.23		U	#	5.4	3.62
Yttrium-88	pCi/L	09/20/2016	N002	2.77	U		#	4.5	2.78

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-16074 WELL BM 26-22D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	27.7	U		#	32	13.1
Americium-241	pCi/L	09/20/2016	N001	24.7	U		#	34	21
Antimony-125	pCi/L	09/20/2016	N001	7.12	U		#	14	7.79
Cerium-144	pCi/L	09/20/2016	N001	3.41	U		#	27	16
Cesium-134	pCi/L	09/20/2016	N001	1.51	U		#	9.8	5.95
Cesium-137	pCi/L	09/20/2016	N001	3.08	U		#	6.6	4.03
Cobalt-60	pCi/L	09/20/2016	N001	-2.73	U		#	9.3	5.33
Europium-152	pCi/L	09/20/2016	N001	-8.28	U		#	42	24.1
Europium-154	pCi/L	09/20/2016	N001	-4.07	U		#	41	23.7
Europium-155	pCi/L	09/20/2016	N001	6.47	U		#	13	7.84
Gross Alpha	pCi/L	09/20/2016	N001	15.6	U		#	23	14.5
Gross Beta	pCi/L	09/20/2016	N001	88.9			#	21	20.1
Lead-212	pCi/L	09/20/2016	N001	2.67	U		#	12	7.06
Potassium-40	pCi/L	09/20/2016	N001	102	U		#	190	114
Promethium-144	pCi/L	09/20/2016	N001	1.92	U		#	6.8	4.09
Promethium-146	pCi/L	09/20/2016	N001	-3.45	U		#	7.2	4.17
Ruthenium-106	pCi/L	09/20/2016	N001	-39.3	U		#	62	35.4
Thorium-234	pCi/L	09/20/2016	N001	18.1	U		#	150	91.5
Tritium	pCi/L	09/20/2016	N001	2.83	U		#	320	188
Uranium-235	pCi/L	09/20/2016	N001	3.57	U		#	44	26.7
Yttrium-88	pCi/L	09/20/2016	N001	-3.76	U		#	14	8.44

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/7/2016
Location: 05-045-16087 WELL BM 26-22C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	09/20/2016	N001	21.8	U		#	35	17.6
Americium-241	pCi/L	09/20/2016	N001	-11.9	U		#	110	63.1
Antimony-125	pCi/L	09/20/2016	N001	4.28	U		#	11	6.18
Cerium-144	pCi/L	09/20/2016	N001	6.74	U		#	27	16.2
Cesium-134	pCi/L	09/20/2016	N001	-1.59	U		#	4.7	2.74
Cesium-137	pCi/L	09/20/2016	N001	2.13	U		#	4.2	2.58
Cobalt-60	pCi/L	09/20/2016	N001	3.09	U		#	4.6	2.88
Europium-152	pCi/L	09/20/2016	N001	-0.398	U		#	22	12.8
Europium-154	pCi/L	09/20/2016	N001	7.63	U		#	24	14.4
Europium-155	pCi/L	09/20/2016	N001	3.41	U		#	17	10.4
Gross Alpha	pCi/L	09/20/2016	N001	33.3		J	#	32	21.3
Gross Beta	pCi/L	09/20/2016	N001	102			#	21	21.5
Lead-212	pCi/L	09/20/2016	N001	6.08	U		#	12	7.6
Potassium-40	pCi/L	09/20/2016	N001	31.4	U		#	140	81.5
Promethium-144	pCi/L	09/20/2016	N001	1.34	U		#	4.8	2.88
Promethium-146	pCi/L	09/20/2016	N001	-3.72	U		#	5.2	3.03
Ruthenium-106	pCi/L	09/20/2016	N001	-9.45	U		#	43	25
Thorium-234	pCi/L	09/20/2016	N001	95.1		U	#	95	59.5
Tritium	pCi/L	09/20/2016	N001	20.3	U		#	310	182
Uranium-235	pCi/L	09/20/2016	N001	-2.57	U		#	43	25.7
Yttrium-88	pCi/L	09/20/2016	N001	2.97	U		#	5.2	3.2

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

QA QUALIFIER:

#	Validated according to quality assurance guidelines.

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Natural Gas Data

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Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 588	9236	-	9236	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 588	9236	-	9236	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 590	8901	-	8901	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 590	8901	-	8901	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 581	8963.5	-	8963.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 581	8963.5	-	8963.5	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 584	8963.5	-	8963.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 584	8963.5	-	8963.5	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 580	8963.5	-	8963.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 580	8963.5	-	8963.5	NATURAL GAS	15.6*			#	10	0.037

*The sample was re-analzed with a result of 17 TU, confirming the reported result.

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 579	8963.5	-	8963.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 579	8963.5	-	8963.5	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 582	8963.5	-	8963.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 582	8963.5	-	8963.5	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 583	8963.5	-	8963.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 583	8963.5	-	8963.5	NATURAL GAS	11.4	U		#	11.4	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 585	8963.5	-	8963.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 585	8963.5	-	8963.5	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
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	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 587	8983.5	-	8983.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 587	8983.5	-	8983.5	NATURAL GAS	10	U		#	10	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/19/2016
Location: 05-045-16087 WELL, Natural Gas Well - Angle, BM 26-22C

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)			Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	09/20/2016	0001	OKU 592	8983.5	-	8983.5	NATURAL GAS	0.4	U		#	0.4	
Tritium	TU	09/20/2016	0001	OKU 592	8983.5	-	8983.5	NATURAL GAS	10	U		#	10	

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

QA QUALIFIER:

#	Validated according to quality assurance guidelines.

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