

**Monitoring Results  
for Natural Gas Wells  
Near Project Rulison,  
2nd Quarter, Fiscal Year 2015**

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

**Date Sampled:** March 31, 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 and finally collected on January 7, 2015. Following the January sampling event, the operator of the wells initiated a cleaning of the well return lines of organic buildup. This process requires a mechanical well bore “scrubbing” and a chemical cleaning. On Pad 26N, 6 of the 7 wells produced some production water but all samples collected contained significant amounts of hydrocarbons which required decanting before analysis. Analytical results of production water samples collected in March 2015 were all below the screening levels specified in the *Rulison Monitoring Plan*.

The March sampling effort consisted of sampling production water from 13 natural gas wells near the site. Two wells Battlement Mesa (BM) 26-34D and BM 13B produced no production water for sampling. After decanting the hydrocarbons from the samples collected, 3 wells

(BM 26-34A, 34C, and BM 26-22B) did not have enough water volume to conduct any scheduled analysis. At four locations (BM 26-33B, 33D, 22C, BM 35 32A, and the duplicate sample from BM 26-22C) enough sample volume was produced after decanting for only a tritium analysis. Most of the wells had lower line pressure and temperatures than normal. 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    | No           | Yes <sup>1</sup> | 48     | 199     |
| 2         | 26N | BM 26-33C | 15742         | WL   | NGSA    | No           | Yes <sup>1</sup> | 46.8   | 205     |
| 3         | 26N | BM 26-33D | 15739         | WL   | NGSA    | No           | Yes <sup>1</sup> | 49.3   | 190     |
| 4         | 26N | BM 26-34A | 15744         | WL   | NGSA    | No           | Yes <sup>1</sup> | 47     | 198.3   |
| 5         | 26N | BM 26-34B | 15745         | WL   | NGSA    | No           | Yes <sup>1</sup> | 46     | 183     |
| 6         | 26N | BM 26-34C | 15741         | WL   | NGSA    | No           | Yes <sup>1</sup> | 88.1   | 205     |
| 7         | 26N | BM 26-34D | 15748         | WL   | NGSA    | No           | No               | 51     | 207     |
| 8         | 26K | BM 26-22B | 16086         | WL   | NGSA    | No           | Yes <sup>1</sup> | 71.6   | 155     |
| 9         | 26K | BM 26-22C | 16087         | WL   | NGSA    | No           | Yes <sup>1</sup> | 77     | 212     |
| Duplicate | 26K | BM 26-22C | 10840         | WL   | NGSV    | No           | Yes <sup>2</sup> | 77     | 212     |
| 10        | 26K | BM 26-22D | 16074         | WL   | NGSA    | No           | Yes <sup>1</sup> | 85     | 204     |
| 11        | 35C | BM 35-32A | 10919         | WL   | NGSA    | No           | Yes <sup>1</sup> | 69.7   | 205     |
| 12        | 36L | BM 36-13B | 15469         | WL   | NGSV    | No           | No               | 49     | 212     |
| 13        | 36B | BM 36-13  | 10840         | WL   | NGSV    | No           | Yes <sup>1</sup> | 57     | 246     |

<sup>1</sup> Volume amount of 400 to 1900 mL of production water were collected with significant amount of hydrocarbon in the sample

<sup>2</sup> Duplicate volume of 250 mL, (only enough for tritium analysis)

**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.

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                  | $5.183 \times 10^{-6}$ pCi/cc <sup>-1</sup> TU <sup>-1</sup>                |
| <sup>14</sup> Carbon | pMC             | 2 pMC                   | 5 pMC                | $6.54 \times 10^{-5}$ pCi/cc and $16.4 \times 10^{-5}$ pCi/cc, respectively |

### Abbreviations:

|                                       |                                                                 |
|---------------------------------------|-----------------------------------------------------------------|
| pCi/cc                                | picocuries per cubic centimeter                                 |
| pCi/cc <sup>-1</sup> TU <sup>-1</sup> | 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**

At two natural gas well locations (BM-26-34D and BM 13) the wells produced no production water for sampling. At four well locations (BM 26 33C 34B, 22D, and BM 35-32A) the production water collected contained higher than normal amounts of hydrocarbons in the sample. Each sample was decanted to remove the hydrocarbon prior to laboratory analysis. The amount of production water remaining in each sample after decanting allows for only tritium analysis to be conducted. Only four wells (BM 26-33C, BM 26 34B, BM 26-22D, and BM-13) produced enough sample volume to allow for conducting all laboratory analysis. Results of the production-water analysis show no exceedance of any screening level for Rulison related contaminants.

Production water analytical results are tabulated for each 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   | 0/12 <sup>1</sup>                    | 0                           | 0         | 0  | 0                              | 9         | 3  | 0                     | 0         | 0  |

**Notes:**

<sup>1</sup>12 samples collected includes BM 26-22C duplicate which after decanting, approximately 250 mL remained for tritium analysis.

As scheduled, no natural gas samples were collected from during this sampling event. At wells BM 26-34D and BM 13B, no production water was produced during sampling operations. At three wells (BM 26-34A, 34C, and BM 26-22B), after decanting the hydrocarbons insufficient sample volume remained for any analysis. Following the decanting of hydrocarbons from the production-water samples, the water volumes remaining for BM 26-33B, 33D, 22C, and BM 35 32A, were adequate for only analysis of tritium. Wells BM 26-33C, 34B, 22D, and BM-13 produced enough sample volume for all scheduled analysis.

*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   | 4                              | 2                   | 2         | 0  | 1                  | 3         | 0  |

**Notes:**

No production water collected, or insufficient amounts of production water, remained following the decanting of hydrocarbons for wells BM 26-34D and BM 13B (no production water collected), BM 26 33B, 33D, 22C, and BM 35 32A ( volume for tritium only).

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   | 4                              | 0                    | 3         | 1  |

**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, or 26-22B.

## **Data Review and Validation Report**

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# Data Validation Package

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**March 2015  
Produced Water Sampling at the  
Rulison, Colorado, Site**

**October 2015**

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](mailto: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](mailto:reports@adonis.osti.gov)

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## **Attachment 1—Data Presentation**

Produced Water Quality Data  
Equipment Blank Data

## **Attachment 2—Trip Report**

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# Sampling Event Summary

**Site:** Rulison, Colorado, Site

**Sampling Period:** March 31, 2015

The U.S. Department of Energy Office of Legacy Management conducted sampling at the Rulison, Colorado, Site on March 31, 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. 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:

- Produced-water samples were submitted under requisition 15036889 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 05-045-16087.

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 nine 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.

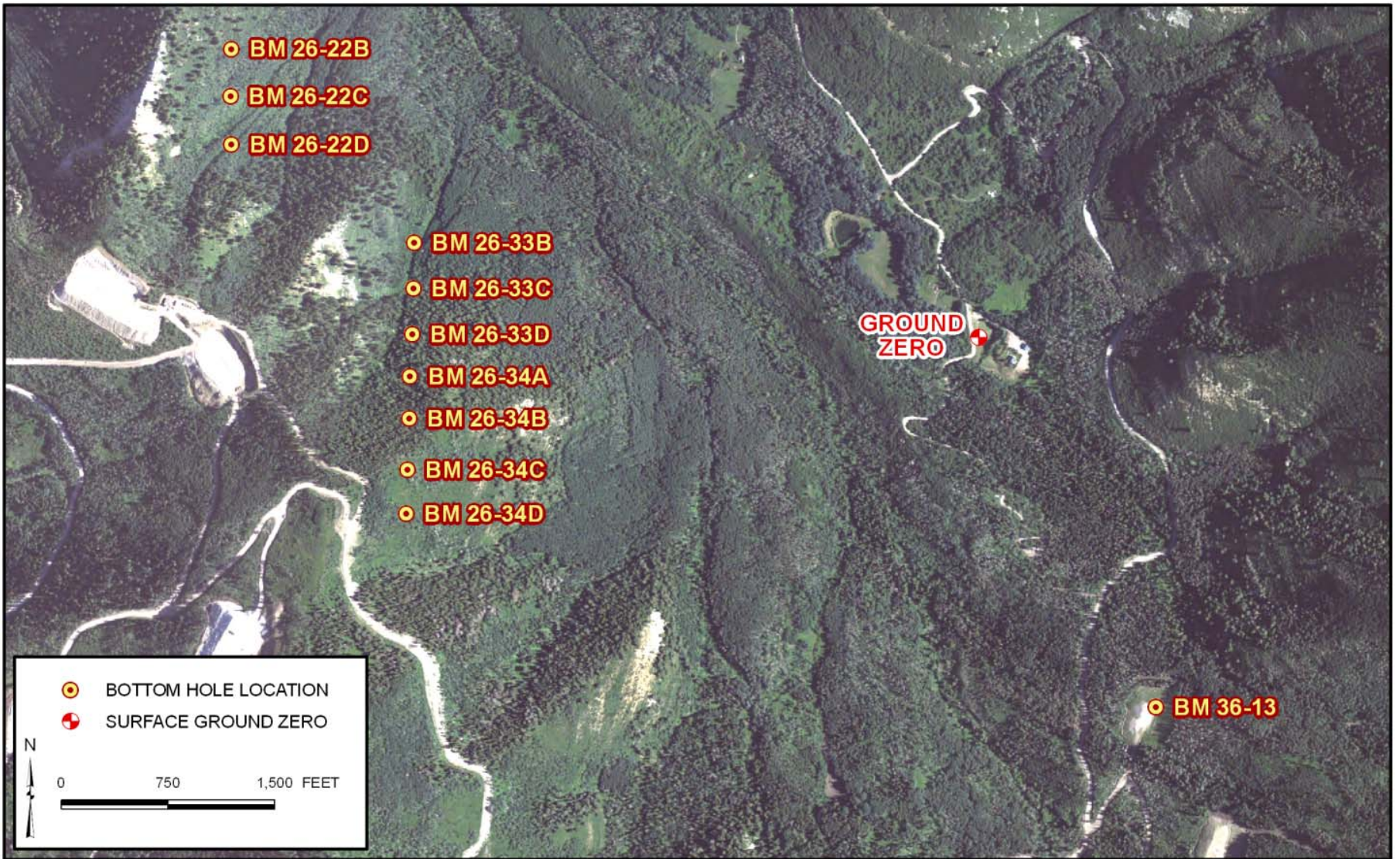


Rick Hutton, Site Lead  
Navarro Research and Engineering, Inc.

10-6-2015

Date





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*Rulison, Colorado, Site, Sample Location Map*

# Data Assessment Summary

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### Water Sampling Field Activities Verification Checklist

|                                |                           |                                  |                        |
|--------------------------------|---------------------------|----------------------------------|------------------------|
| <b>Project</b>                 | <u>Rulison, Colorado</u>  | <b>Date(s) of Water Sampling</b> | <u>March 31, 2015</u>  |
| <b>Date(s) of Verification</b> | <u>September 28, 2015</u> | <b>Name of Verifier</b>          | <u>Stephen Donovan</u> |

|                                                                                                                                                                                                                                                                                                                          | <b>Response<br/>(Yes, No, NA)</b> | <b>Comments</b>                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|--------------------------------------------------------------------------------|
| 1. Is the SAP the primary document directing field procedures?<br>List any Program Directives or other documents, SOPs, instructions.                                                                                                                                                                                    | <u>Yes</u>                        |                                                                                |
|                                                                                                                                                                                                                                                                                                                          | <u>NA</u>                         |                                                                                |
| 2. Were the sampling locations specified in the planning documents sampled?                                                                                                                                                                                                                                              | <u>No</u>                         | <u>Limited volume of produced water was available from seven of the wells.</u> |
| 3. Were calibrations conducted as specified in the above-named documents?                                                                                                                                                                                                                                                | <u>NA</u>                         | <u>Field measurements were not required.</u>                                   |
| 4. Was an operational check of the field equipment conducted daily?<br>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?                                                                                                                                                                                                                                                                                     | <u>NA</u>                         | <u>This sampling event did not include groundwater.</u>                        |
| 7. Were the following conditions met when purging a Category I well:<br>Was one pump/tubing volume purged prior to sampling?<br>Did the water level stabilize prior to sampling?<br>Did pH, specific conductance, and turbidity measurements meet criteria prior to sampling?<br>Was the flow rate less than 500 mL/min? | <u>NA</u>                         | <u>This sampling event did not include groundwater.</u>                        |

### Water Sampling Field Activities Verification Checklist (continued)

|                                                                                                                                                                           | Response<br>(Yes, No, NA) | Comments                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|------------------------------------------------------------|
| 8. Were the following conditions met when purging a Category II well:<br>Was the flow rate less than 500 mL/min?<br>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 05-045-16087. |
| 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): 15036889  
Sample Event: March 31, 2015  
Site(s): Rulison Site  
Laboratory: ALS Laboratory Group, Fort Collins, Colorado  
Work Order No.: 1504097  
Analysis: Radiochemistry and Wet Chemistry  
Validator: Stephen Donovan  
Review Date: June 4, 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 |
|--------------------|----------------|--------------|-------------------|
| 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                            |
|---------------|-----------|--------------|------|-----------------------------------|
| 1504097-4     | BM 26-22D | Gross Alpha  | J    | Less than the determination limit |
| 1504097-6     | BM 26-33C | Gross Beta   | J    | Less than the determination limit |
| 1504097-8     | BM 26-34B | Actinium-228 | U    | Nuclide identification criteria   |
| 1504097-8     | BM 26-34B | Gross Alpha  | J    | Less than the determination limit |
| 1504097-8     | BM 26-34B | Gross Beta   | J    | Less than the determination limit |

### Sample Shipping/Receiving

ALS Laboratory Group in Fort Collins, Colorado, received 10 water samples on April 3, 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; signatures and dates were present to indicate 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 it 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 1-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, but 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 exceptions. The required detection limits were not met for several 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.

## 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 1-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 May 1, 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: 15036889    Lab Code: PAR    Validator: Stephen Donovan    Validation Date: 06/04/2015  
Project: Rulison Site    Analysis Type:    Metals    General Chem    Rad    Organics  
# of Samples: 10    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 8 detection limit failures.

There was 1 trip/equipment blank evaluated.

There was 1 duplicate evaluated.

**SAMPLE MANAGEMENT SYSTEM**

RIN: 15036889      Lab Code: PAR

**Non-Compliance Report: Detection Limits**

Project: Rulison Site

Validation Date: 06/04/2015

| Ticket  | Location  | Lab Sample ID | Method Code | Lab Method | Analyte Name | Result | Qualifier | Reported Detection Limit | Required Detection Limit | Units |
|---------|-----------|---------------|-------------|------------|--------------|--------|-----------|--------------------------|--------------------------|-------|
| NEU 504 | BM 26-22D | 1504097-4     | GPC-A-001   | 724R11     | GROSS ALPHA  | 101    |           | 86                       | 2                        | pCi/L |
| NEU 504 | BM 26-22D | 1504097-4     | GPC-A-001   | 724R11     | GROSS BETA   | 269    |           | 52                       | 4                        | pCi/L |
| NEU 511 | BM 26-33C | 1504097-6     | GPC-A-001   | 724R11     | GROSS BETA   | 117    |           | 52                       | 4                        | pCi/L |
| NEU 511 | BM 26-33C | 1504097-6     | GPC-A-001   | 724R11     | GROSS ALPHA  | 28.8   | U         | 57                       | 2                        | pCi/L |
| NEU 501 | BM 26-34B | 1504097-8     | GPC-A-001   | 724R11     | GROSS BETA   | 125    |           | 49                       | 4                        | pCi/L |
| NEU 501 | BM 26-34B | 1504097-8     | GPC-A-001   | 724R11     | GROSS ALPHA  | 63.9   |           | 46                       | 2                        | pCi/L |
| NEU 506 | BM 36-13  | 1504097-10    | GPC-A-001   | 724R11     | GROSS ALPHA  | 41     | U         | 57                       | 2                        | pCi/L |
| NEU 506 | BM 36-13  | 1504097-10    | GPC-A-001   | 724R11     | GROSS BETA   | 171    |           | 47                       | 4                        | pCi/L |

**SAMPLE MANAGEMENT SYSTEM**  
**Radiochemistry Data Validation Worksheet**

**RIN:** 15036889                      **Lab Code:** PAR                      **Date Due:** 04/30/2015  
**Matrix:** Water                      **Site Code:** RUL01                      **Date Completed:** 05/01/2015

| Sample      | Analyte        | Date Analyzed | Result   | Flag | Tracer %R | LCS %R | MS %R | Duplicate RER |
|-------------|----------------|---------------|----------|------|-----------|--------|-------|---------------|
| 2694        | Actinium-228   | 04/18/2015    |          |      |           |        |       | 1.71          |
| 2694        | Americium-241  | 04/18/2015    |          |      |           |        |       | 0.61          |
| Blank_Spike | Americium-241  | 04/18/2015    |          |      |           | 98.50  |       |               |
| 2694        | Antimony-125   | 04/18/2015    |          |      |           |        |       | 0.93          |
| 2694        | Cerium-144     | 04/18/2015    |          |      |           |        |       | 0.89          |
| 2694        | Cesium-134     | 04/18/2015    |          |      |           |        |       | 1.72          |
| 2694        | Cesium-137     | 04/18/2015    |          |      |           |        |       | 1.12          |
| Blank_Spike | Cesium-137     | 04/18/2015    |          |      |           | 104.00 |       |               |
| 2694        | Cobalt-60      | 04/18/2015    |          |      |           |        |       | 0.81          |
| Blank_Spike | Cobalt-60      | 04/18/2015    |          |      |           | 97.70  |       |               |
| 2694        | Europium-152   | 04/18/2015    |          |      |           |        |       | 0.40          |
| 2694        | Europium-154   | 04/18/2015    |          |      |           |        |       | 0.37          |
| 2694        | Europium-155   | 04/18/2015    |          |      |           |        |       | 0.75          |
| BM 26-34B   | GROSS ALPHA    | 04/16/2015    |          |      |           |        |       | 0.60          |
| Blank       | GROSS ALPHA    | 04/18/2015    | -0.1600  | U    |           |        |       |               |
| BM 26-22D   | GROSS ALPHA    | 04/18/2015    |          |      |           |        | 121.0 |               |
| Blank_Spike | GROSS ALPHA    | 04/18/2015    |          |      |           | 89.00  |       |               |
| BM 26-34B   | GROSS BETA     | 04/16/2015    |          |      |           |        |       | 2.35          |
| Blank_Spike | GROSS BETA     | 04/18/2015    |          |      |           | 94.80  |       |               |
| BM 26-22D   | GROSS BETA     | 04/18/2015    |          |      |           |        | 100.0 |               |
| Blank       | GROSS BETA     | 04/18/2015    | -1.1200  | U    |           |        |       |               |
| 2694        | H-3            | 04/23/2015    |          |      |           |        |       | 0.52          |
| BM 26-33C   | H-3            | 04/23/2015    |          |      |           |        | 104.0 |               |
| Blank_Spike | H-3            | 04/24/2015    |          |      |           | 110.00 |       |               |
| Blank       | H-3            | 04/24/2015    | 257.0000 | U    |           |        |       |               |
| 2694        | Lead-212       | 04/18/2015    |          |      |           |        |       | 0.99          |
| 2694        | Potassium-40   | 04/18/2015    |          |      |           |        |       | 1.68          |
| 2694        | Promethium-144 | 04/18/2015    |          |      |           |        |       | 0.60          |
| 2694        | Promethium-146 | 04/18/2015    |          |      |           |        |       | 0.12          |
| 2694        | Ruthenium-106  | 04/18/2015    |          |      |           |        |       | 0.33          |
| 2694        | Thorium-234    | 04/18/2015    |          |      |           |        |       | 0.48          |
| 2694        | Uranium-235    | 04/18/2015    |          |      |           |        |       | 0             |



**SAMPLE MANAGEMENT SYSTEM**  
**Radiochemistry Data Validation Worksheet**

**RIN:** 15036889                      **Lab Code:** PAR                      **Date Due:** 04/30/2015  
**Matrix:** Water                      **Site Code:** RUL01                      **Date Completed:** 05/01/2015

| Sample | Analyte    | Date Analyzed | Result | Flag | Tracer %R | LCS %R | MS %R | Duplicate RER |
|--------|------------|---------------|--------|------|-----------|--------|-------|---------------|
| 2694   | Yttrium-88 | 04/18/2015    |        |      |           |        |       | 0.09          |

## 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.

### Equipment Blank

Equipment blanks are prepared and analyzed to document contamination attributable to the sample collection process. One equipment blank was submitted with these samples. There were no analytes detected in this blank.

### Field Duplicate Analysis

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 05-045-16087. 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 thereby demonstrating acceptable precision.

**SAMPLE MANAGEMENT SYSTEM**  
**Validation Report: Field Duplicates**

RIN: 15036889    Lab Code: PAR    Project: Rulison Site    Validation Date: 06/04/2015

Duplicate: 2657

Sample: BM 26-22C

| Analyte | Sample |      |       |          | Duplicate |      |       |          | RPD | RER   | Units |
|---------|--------|------|-------|----------|-----------|------|-------|----------|-----|-------|-------|
|         | Result | Flag | Error | Dilution | Result    | Flag | Error | Dilution |     |       |       |
| H-3     | 150    | U    | 226   | 1        | 222       | U    | 233   | 1        | 0.4 | 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: Steph Donovan 10-6-2015  
Stephen Donovan Date

Data Validation Lead: Steph Donovan 10-6-2015  
Stephen Donovan Date

# **Attachment 1**

## **Data Presentation**

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## **Produced Water Quality Data**

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

**REPORT DATE: 09/28/2015**

**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 | 03/31/2015  | N001      | 0                    | - | 0 | 9.58   | U          |      | #  | 40              | 24.4        |
| Americium-241  | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -8.62  | U          |      | #  | 27              | 16          |
| Antimony-125   | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 2.75   | U          |      | #  | 11              | 6.15        |
| Cerium-144     | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -8.8   | U          |      | #  | 22              | 12.7        |
| Cesium-134     | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -2.96  | U          |      | #  | 5               | 2.91        |
| Cesium-137     | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -4.29  | U          |      | #  | 4.6             | 2.67        |
| Cobalt-60      | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -1.98  | U          |      | #  | 5.7             | 3.25        |
| Europium-152   | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 3.82   | U          |      | #  | 26              | 15.4        |
| Europium-154   | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 3.77   | U          |      | #  | 26              | 15.5        |
| Europium-155   | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 2.27   | U          |      | #  | 11              | 6.42        |
| Gross Alpha    | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 41     | U          |      | #  | 57              | 35.8        |
| Gross Beta     | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 171    |            |      | #  | 47              | 41.1        |
| Lead-212       | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 3.55   | U          |      | #  | 12              | 7.33        |
| Potassium-40   | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 132    | U          |      | #  | 140             | 86.5        |
| Promethium-144 | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 2.28   | U          |      | #  | 4.7             | 2.88        |
| Promethium-146 | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 1.68   | U          |      | #  | 4.8             | 2.92        |
| Ruthenium-106  | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -23.8  | U          |      | #  | 46              | 26.7        |
| Thorium-234    | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -55.8  | U          |      | #  | 140             | 80.9        |

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 09/28/2015**  
**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 |                 |             |
| Tritium     | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 92.9   | U          |      | #  | 380             | 225         |
| Uranium-235 | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 11.9   | U          |      | #  | 20              | 12.3        |
| Yttrium-88  | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | -779   | U          |      | #  | 9.2             | 5.44        |

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 09/28/2015**  
**Location: 05-045-10919 WELL BM 35-32A**

| Parameter | Units | Sample Date | Sample ID | Depth Range (Ft BLS) | Result | Qualifiers Lab | Data | QA | Detection Limit | Uncertainty |
|-----------|-------|-------------|-----------|----------------------|--------|----------------|------|----|-----------------|-------------|
| Tritium   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 198    | U              |      | #  | 380             | 232         |

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

**REPORT DATE: 09/28/2015**

**Location: 05-045-15739 WELL BM 26-33D**

| Parameter | Units | Sample Date | Sample ID | Depth Range (Ft BLS) |   |   | Result | Lab | Qualifiers Data | QA | Detection Limit | Uncertainty |
|-----------|-------|-------------|-----------|----------------------|---|---|--------|-----|-----------------|----|-----------------|-------------|
| Tritium   | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 41     | U   |                 | #  | 360             | 215         |

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

**REPORT DATE: 09/28/2015**

**Location: 05-045-15742 WELL BM 26-33C**

| Parameter      | Units | Sample Date | Sample ID | Depth Range (Ft BLS) | Result | Qualifiers |      |    | Detection Limit | Uncertainty |
|----------------|-------|-------------|-----------|----------------------|--------|------------|------|----|-----------------|-------------|
|                |       |             |           |                      |        | Lab        | Data | QA |                 |             |
| Actinium-228   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 27.9   | U          |      | #  | 30              | 14.1        |
| Americium-241  | pCi/L | 03/31/2015  | N001      | 0 - 0                | 3.73   | U          |      | #  | 25              | 14.7        |
| Antimony-125   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 0.401  | U          |      | #  | 12              | 6.42        |
| Cerium-144     | pCi/L | 03/31/2015  | N001      | 0 - 0                | 1.06   | U          |      | #  | 20              | 11.8        |
| Cesium-134     | pCi/L | 03/31/2015  | N001      | 0 - 0                | -1.14  | U          |      | #  | 4.7             | 2.74        |
| Cesium-137     | pCi/L | 03/31/2015  | N001      | 0 - 0                | -.301  | U          |      | #  | 4.7             | 2.74        |
| Cobalt-60      | pCi/L | 03/31/2015  | N001      | 0 - 0                | -.9    | U          |      | #  | 4.8             | 2.75        |
| Europium-152   | pCi/L | 03/31/2015  | N001      | 0 - 0                | -7.14  | U          |      | #  | 24              | 13.4        |
| Europium-154   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 0.398  | U          |      | #  | 25              | 14.8        |
| Europium-155   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 8.49   | U          |      | #  | 11              | 6.89        |
| Gross Alpha    | pCi/L | 03/31/2015  | N001      | 0 - 0                | 28.8   | U          |      | #  | 57              | 34.8        |
| Gross Beta     | pCi/L | 03/31/2015  | N001      | 0 - 0                | 117    |            | J    | #  | 52              | 37.7        |
| Lead-212       | pCi/L | 03/31/2015  | N001      | 0 - 0                | 0.471  | U          |      | #  | 11              | 6.73        |
| Potassium-40   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 73.6   | U          |      | #  | 130             | 79.5        |
| Promethium-144 | pCi/L | 03/31/2015  | N001      | 0 - 0                | -.0557 | U          |      | #  | 4.9             | 2.91        |
| Promethium-146 | pCi/L | 03/31/2015  | N001      | 0 - 0                | -.587  | U          |      | #  | 5.4             | 3.18        |
| Ruthenium-106  | pCi/L | 03/31/2015  | N001      | 0 - 0                | -23.1  | U          |      | #  | 44              | 25.1        |
| Thorium-234    | pCi/L | 03/31/2015  | N001      | 0 - 0                | -22.4  | U          |      | #  | 130             | 77.2        |

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 09/28/2015**  
**Location: 05-045-15742 WELL BM 26-33C**

| Parameter   | Units | Sample Date | Sample ID | Depth Range (Ft BLS) |   |   | Result | Qualifiers |      |    | Detection Limit | Uncertainty |
|-------------|-------|-------------|-----------|----------------------|---|---|--------|------------|------|----|-----------------|-------------|
|             |       |             |           |                      |   |   |        | Lab        | Data | QA |                 |             |
| Tritium     | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 92.3   | U          |      | #  | 380             | 226         |
| Uranium-235 | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 11.8   | U          |      | #  | 19              | 10.9        |
| Yttrium-88  | pCi/L | 03/31/2015  | N001      | 0                    | - | 0 | 2.98   | U          |      | #  | 5.3             | 3.26        |

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 09/28/2015**  
**Location: 05-045-15743 WELL BM 26-33B**

| Parameter | Units | Sample Date | Sample ID | Depth Range (Ft BLS) | Result | Lab | Qualifiers Data | QA | Detection Limit | Uncertainty |
|-----------|-------|-------------|-----------|----------------------|--------|-----|-----------------|----|-----------------|-------------|
| Tritium   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 39.1   | U   |                 | #  | 360             | 214         |

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

**REPORT DATE: 09/28/2015**

**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 | 03/31/2015  | N001      | 0 - 0                | 25.9   |            | U    | #  | 22              | 11.2        |
| Americium-241  | pCi/L | 03/31/2015  | N001      | 0 - 0                | 7.59   | U          |      | #  | 30              | 18.2        |
| Antimony-125   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 3.99   | U          |      | #  | 14              | 8.31        |
| Cerium-144     | pCi/L | 03/31/2015  | N001      | 0 - 0                | 10.5   | U          |      | #  | 25              | 15.2        |
| Cesium-134     | pCi/L | 03/31/2015  | N001      | 0 - 0                | -5.56  | U          |      | #  | 9.5             | 5.5         |
| Cesium-137     | pCi/L | 03/31/2015  | N001      | 0 - 0                | -.354  | U          |      | #  | 5.7             | 3.36        |
| Cobalt-60      | pCi/L | 03/31/2015  | N001      | 0 - 0                | 0.77   | U          |      | #  | 7.6             | 4.49        |
| Europium-152   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 8.98   | U          |      | #  | 34              | 20.2        |
| Europium-154   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 8.32   | U          |      | #  | 36              | 21.2        |
| Europium-155   | pCi/L | 03/31/2015  | N001      | 0 - 0                | -3.63  | U          |      | #  | 26              | 15.7        |
| Gross Alpha    | pCi/L | 03/31/2015  | N001      | 0 - 0                | 63.9   |            | J    | #  | 46              | 32.2        |
| Gross Beta     | pCi/L | 03/31/2015  | N001      | 0 - 0                | 125    |            | J    | #  | 49              | 37.2        |
| Lead-212       | pCi/L | 03/31/2015  | N001      | 0 - 0                | 2.14   | U          |      | #  | 14              | 8.74        |
| Potassium-40   | pCi/L | 03/31/2015  | N001      | 0 - 0                | 31     | U          |      | #  | 180             | 107         |
| Promethium-144 | pCi/L | 03/31/2015  | N001      | 0 - 0                | -3.12  | U          |      | #  | 13              | 7.92        |
| Promethium-146 | pCi/L | 03/31/2015  | N001      | 0 - 0                | -1.09  | U          |      | #  | 6.3             | 3.68        |
| Ruthenium-106  | pCi/L | 03/31/2015  | N001      | 0 - 0                | -16.2  | U          |      | #  | 56              | 32.3        |
| Thorium-234    | pCi/L | 03/31/2015  | N001      | 0 - 0                | 34.5   | U          |      | #  | 160             | 96.3        |



**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 09/28/2015**  
**Location: 05-045-15745 WELL BM 26-34B**

| Parameter   | Units | Sample<br>Date | Sample<br>ID | Depth Range<br>(Ft BLS) |      |    | Result | Qualifiers |   |     | Detection<br>Limit | Uncertainty |
|-------------|-------|----------------|--------------|-------------------------|------|----|--------|------------|---|-----|--------------------|-------------|
|             |       |                |              | Lab                     | Data | QA |        |            |   |     |                    |             |
| Tritium     | pCi/L | 03/31/2015     | N001         | 0                       | -    | 0  | 141    | U          | # | 370 | 224                |             |
| Uranium-235 | pCi/L | 03/31/2015     | N001         | 0                       | -    | 0  | 13.4   | U          | # | 25  | 13.3               |             |
| Yttrium-88  | pCi/L | 03/31/2015     | N001         | 0                       | -    | 0  | 4.16   | U          | # | 6.9 | 4.26               |             |

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 09/28/2015**  
**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 |                 |             |
| Gross Alpha | pCi/L | 03/31/2015  | N001      | 0 - 0                | 101    |            | J    | #  | 66              | 46.8        |
| Gross Beta  | pCi/L | 03/31/2015  | N001      | 0 - 0                | 269    |            |      | #  | 52              | 55.3        |
| Tritium     | pCi/L | 03/31/2015  | N001      | 0 - 0                | 85.2   | U          |      | #  | 380             | 226         |

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

**REPORT DATE: 09/28/2015**

**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 |                 |             |
| Tritium   | pCi/L | 03/31/2015 | N001 | 0           | - | 0 | 150    | U          |      | #  | 370             | 226         |
| Tritium   | pCi/L | 03/31/2015 | N002 | 0           | - | 0 | 222    | U          |      | #  | 380             | 233         |

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.

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## **Equipment Blank Data**

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**BLANKS REPORT**

LAB: PARAGON/ALS LABORATORY GROUP (Fort Collins, CO)

RIN: 15036889

Report Date: 09/28/2015

| Parameter      | Site Code | Location ID | Sample Date | Sample ID | Units | Result | Qualifiers Lab | Data | Detection Limit | Uncertainty | Sample Type |
|----------------|-----------|-------------|-------------|-----------|-------|--------|----------------|------|-----------------|-------------|-------------|
| Actinium-228   | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 8.47   | U              |      | 23              | 10.6        | TB          |
| Americium-241  | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 1.79   | U              |      | 3.5             | 2.17        | TB          |
| Antimony-125   | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 0.0534 | U              |      | 9.4             | 4.82        | TB          |
| Cerium-144     | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 8.08   | U              |      | 13              | 8.18        | TB          |
| Cesium-134     | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | -878   | U              |      | 3.8             | 2.22        | TB          |
| Cesium-137     | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | -1.43  | U              |      | 3.7             | 2.12        | TB          |
| Cobalt-60      | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 0.345  | U              |      | 4.2             | 2.46        | TB          |
| Europium-152   | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 5.14   | U              |      | 20              | 11.7        | TB          |
| Europium-154   | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 8.42   | U              |      | 21              | 12.6        | TB          |
| Europium-155   | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 2.55   | U              |      | 3.6             | 2.24        | TB          |
| Gross Alpha    | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 0.314  | U              |      | 1.2             | 0.663       | TB          |
| Gross Beta     | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 1.32   | U              |      | 2.1             | 1.33        | TB          |
| Lead-212       | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 1.79   | U              |      | 10              | 6.26        | TB          |
| Potassium-40   | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | -57.5  | U              |      | 110             | 62.8        | TB          |
| Promethium-144 | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 0.491  | U              |      | 4.2             | 2.47        | TB          |
| Promethium-146 | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 0.535  | U              |      | 3.8             | 2.29        | TB          |
| Ruthenium-106  | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | -6.06  | U              |      | 33              | 19.4        | TB          |
| Thorium-234    | RUL01     | 0999        | 03/31/2015  | N001      | pCi/L | 13.3   | U              |      | 67              | 40.3        | TB          |

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| Parameter   | Site Code | Location ID | Sample     |      | Units | Result | Qualifiers |      | Detection Limit | Uncertainty | Sample Type |
|-------------|-----------|-------------|------------|------|-------|--------|------------|------|-----------------|-------------|-------------|
|             |           |             | Date       | ID   |       |        | Lab        | Data |                 |             |             |
| Tritium     | RUL01     | 0999        | 03/31/2015 | N001 | pCi/L | 42.9   | U          |      | 380             | 224         | TB          |
| Uranium-235 | RUL01     | 0999        | 03/31/2015 | N001 | pCi/L | 11.1   | U          |      | 14              | 7.46        | TB          |
| Yttrium-88  | RUL01     | 0999        | 03/31/2015 | N001 | pCi/L | 3.59   | U          |      | 4.2             | 2.68        | TB          |

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.

## SAMPLE TYPES:

- E Equipment Blank.



# **Attachment 2 Trip Report**

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

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

**Date Sampled**

March 31, 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**

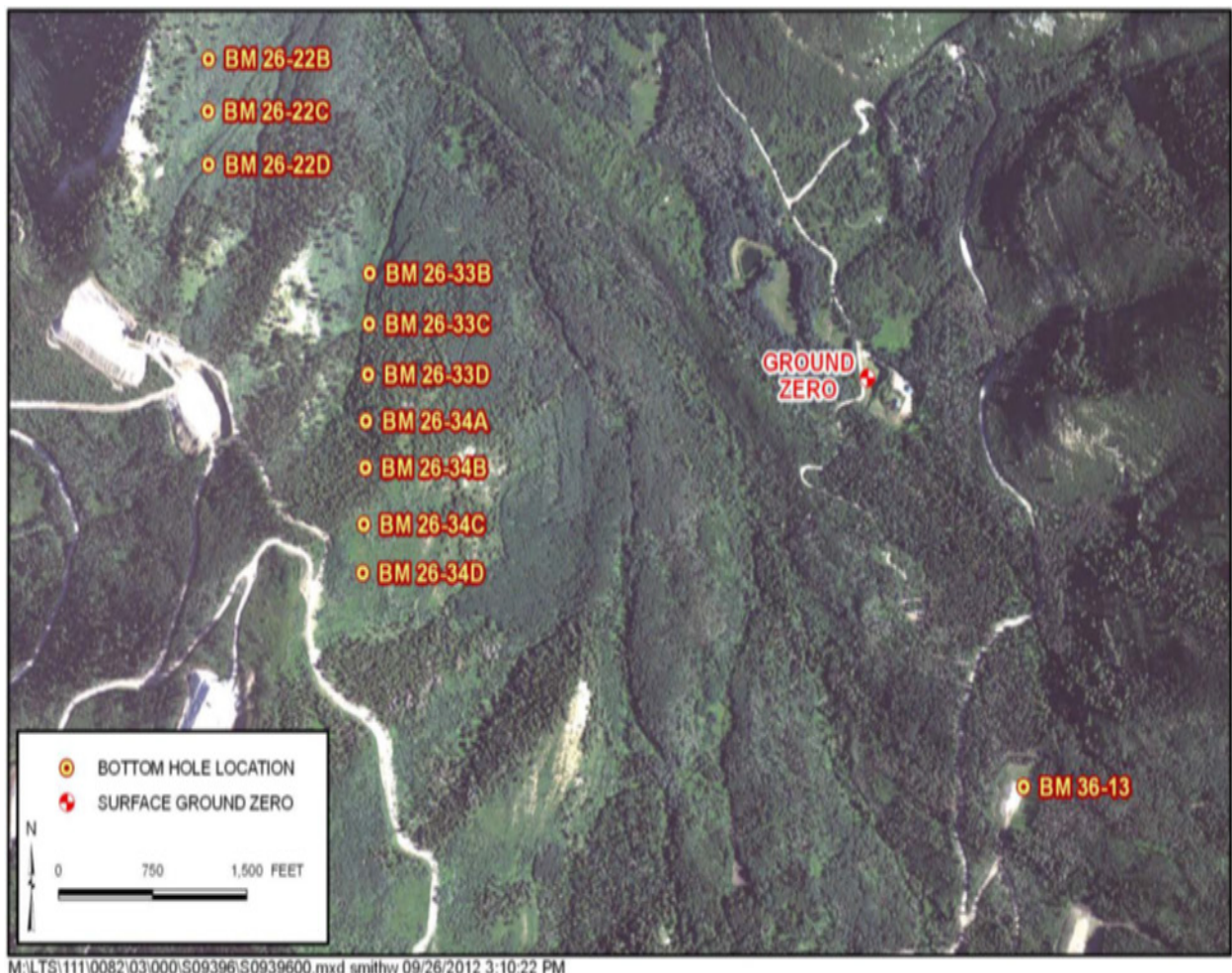
As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM is monitoring natural gas wells near the Rulison site for radionuclides associated with the detonation. The very low permeability of the Williams Fork Formation limits 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**

Following the January 7<sup>th</sup> sampling event, wells on the 26N pad were reworked by the operator to increase production. The operator's reworking process involves mechanically and chemically cleaning out the downhole production piping of organic buildup. On Pad 26N, 6 of the 7 wells produced some production water; but, all samples collected contained significant amounts of hydrocarbons which required decanting before analysis. Two wells, Battlement Mesa (BM) 26-34D and BM 13B, produced no production water for sampling. After decanting the hydrocarbons

from the samples collected, three wells (BM 26-34A, 34C, and BM 26-22B) did not have enough water volume to conduct any scheduled analysis. Following the decanting of hydrocarbons from the production water samples, the water volumes remaining for BM 26-33B, 33D, 22C and BM 35 32A, were adequate only for analysis of tritium. Wells BM 26-33C, 34B, 22D, and BM-13 produced enough sample volume for all scheduled analyses. The well operator was unaware of any operational processes that would cause the lower temperature and pressure to occur.

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 1) were read and recorded from surface transducers in the wells. Latitude and longitude values (not shown in Table 1) were compiled from survey plats included with the applications for permits to drill and from Colorado Oil and Gas Conservation Commission scout cards.

All wellheads planned for sampling were available, and wellhead pressures and temperatures were lower than normal. Two wells, BM 26-34D and BM 13B, produced no production water for sampling. At some locations, production-water collection volumes were lower than normal and ranged from 400 to 1900 ml. All other well functions were performing normally, so no impact to the analytical data is expected.

*Table 1. Samples Collected*

| Sample Collection Sequence | Pad | Well Name | Location         |      |         | Sample Phase |                  | Well       |            |
|----------------------------|-----|-----------|------------------|------|---------|--------------|------------------|------------|------------|
|                            |     |           | API #<br>05-045- | Type | Subtype | Gas          | Liquid           | T<br>(° F) | P<br>(psi) |
| 1                          | 26N | BM 26-33B | 15739            | WL   | NGSA    | No           | Yes <sup>a</sup> | 48         | 199        |
| 2                          | 26N | BM 26-33C | 15742            | WL   | NGSA    | No           | Yes <sup>a</sup> | 46.8       | 205        |
| 3                          | 26N | BM 26-33D | 15743            | WL   | NGSA    | No           | Yes <sup>a</sup> | 49.3       | 190        |
| 4                          | 26N | BM 26-34A | 15744            | WL   | NGSA    | No           | Yes <sup>a</sup> | 47         | 198.3      |
| 5                          | 26N | BM 26-34B | 15745            | WL   | NGSA    | No           | Yes <sup>a</sup> | 46         | 183        |
| 6                          | 26N | BM 26-34C | 15741            | WL   | NGSA    | No           | Yes <sup>a</sup> | 88.1       | 205        |
| 7                          | 26N | BM 26-34D | 15748            | WL   | NGSA    | No           | No               | 51         | 207        |
| 8                          | 26K | BM 26-22B | 16086            | WL   | NGSA    | No           | Yes <sup>a</sup> | 71.6       | 155        |
| 9                          | 26K | BM 26-22C | 16087            | WL   | NGSA    | No           | Yes <sup>a</sup> | 77         | 212        |
| Duplicate                  | 26K | BM 26-22C | 16087            | WL   | NGSA    | No           | Yes <sup>a</sup> | 77         | 212        |
| 10                         | 26K | BM 26-22D | 16074            | WL   | NGSA    | No           | Yes <sup>a</sup> | 85         | 204        |
| 11                         | 35C | BM 35-32A | 10919            | WL   | NGSV    | No           | Yes <sup>a</sup> | 69.7       | 205        |
| 12                         | 36L | BM 36-13B | 15469            | WL   | NGSV    | No           | No               | 49         | 212        |
| 13                         | 36B | BM 36-13  | 10840            | WL   | NGSV    | No           | Yes <sup>a</sup> | 57         | 246        |

<sup>a</sup> Sample volumes ranged from 400ml to 1900 ml 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. Following the first quarter sampling that was conducted on January 7<sup>th</sup>, the operator of the wells reworked the wells to increase production. While the wells on Pad 26 N were reworked between sampling events, 6 of the 7 wells produced a smaller volume of production water than normally collected and contained higher than normal amounts of hydrocarbons. 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 2) 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, 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 2 lists the estimated sample volumes (including the condensate).

*Table 2. Collected Water Sample Volumes (Before Decanting)*

| Sample Ticket | Well Name | Planned Analytes                      | Sample Volume (L) |
|---------------|-----------|---------------------------------------|-------------------|
| 1             | BM 26-33B | <sup>3</sup> H, Gross α/β, Gamma spec | ≈1900ML           |
| 2             | BM 26-33C | <sup>3</sup> H, Gross α/β, Gamma spec | ≈1400ML           |
| 3             | BM 26-33D | <sup>3</sup> H, Gross α/β, Gamma spec | ≈1400ML           |
| 4             | BM 26-34A | <sup>3</sup> H, Gross α/β, Gamma spec | ≈900ML            |
| 5             | BM 26-34B | <sup>3</sup> H, Gross α/β, Gamma spec | ≈1900ML           |
| 6             | BM 26-34C | <sup>3</sup> H, Gross α/β, Gamma spec | ≈900ML            |
| 7             | BM 26-34D | NA                                    | No Sample         |
| 8             | BM 26-22B | <sup>3</sup> H, Gross α/β, Gamma spec | ≈900ML            |
| 9             | BM 26-22C | <sup>3</sup> H, Gross α/β, Gamma spec | ≈ 900ML           |
| 10            | BM 26-22D | <sup>3</sup> H, Gross α/β, Gamma spec | ≈ 900ML           |
| 11            | BM 35-32A | <sup>3</sup> H, Gross α/β, Gamma spec | ≈ 400ML           |
| 12            | BM 36-13B | NA                                    | No Sample         |
| 13            | BM 36-13  | <sup>3</sup> H, Gross α/β, Gamma spec | ≈ 1900            |

**Notes:**

Water sample information is listed in the order of collection.  
 Wells BM 26-34D, BM 36-13B did not produce water for laboratory analyses.

**Abbreviations:**

Gamma spec      high-resolution gamma spectrometry analysis  
 Gross α/β        gross alpha and beta analyses  
<sup>3</sup>H                    tritium  
 L                     liter  
 NA                   not applicable

**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.