LMS/RUL/S15545

2016 Long-Term Hydrologic Monitoring Program Report for Rulison, Colorado, Site

September 2018

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Abbreviations

CDPHE	Colorado Department of Public Health and Environment
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet
GEMS	Geospatial Environmental Mapping System
LM	Office of Legacy Management
LTHMP	Long-Term Hydrologic Monitoring Program
pCi/L	picocuries per liter
SGZ	surface ground zero

1.0 Introduction

This report presents the monitoring data collected by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) at the Rulison, Colorado, Site (Figure 1). The Rulison site was the location of an underground nuclear test in 1969. The test resulted in residual radionuclide contamination at the depth of the detonation, which was approximately 8400 feet (ft) below ground surface. Monitoring includes the collection of samples from shallow groundwater wells, surface water locations, and producing natural gas wells near the site to assess for any potential impacts that may be attributed to the nuclear test. This report summarizes the laboratory analytical results obtained from the 2016 annual sampling of shallow groundwater wells and surface water locations near the site. Analytical results from the sampling of natural gas wells are summarized in a separate report. This annual report and the natural gas well monitoring reports are available on the LM public website at https://www.lm.doe.gov/Rulison/Documents.aspx. Data collected during this and previous monitoring events are available on the Geospatial Environmental Mapping System (GEMS) website at https://gems.lm.doe.gov/#site=RUL.

2.0 Site Location and Background

The Rulison site is in the Piceance Basin of western Colorado and is 40 miles northeast of Grand Junction, Colorado (Figure 1). The U.S. Atomic Energy Commission (a predecessor agency to DOE) conducted the underground nuclear test 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 natural gas production in the low-permeability, gas-bearing sandstone of the Williams Fork Formation. This was the second natural gas stimulation experiment in the Plowshare Program, which was a program to develop peaceful uses for nuclear energy. The nuclear device used at Rulison was detonated in the emplacement hole (R-E) at a depth of approximately 8400 ft on September 10, 1969. The device had a reported yield of 40 kilotons, which produced extremely high temperatures that vaporized a volume of rock, temporarily creating a cavity surrounded by a fractured area extending outward from the detonation point (AEC 1973). Shortly after the detonation, the overlying fractured rock collapsed into the void space, creating a rubble-filled collapse chimney that extends above the detonation point. The former cavity, now the lower part of the collapse chimney, and the surrounding fractured rock are together referred to as the detonation zone. A reentry well (R-En) was drilled as a sidetrack hole off the exploration well (R-Ex) into the collapse chimney and tested to evaluate the success of the detonation at improving gas production in the low-permeability sandstone reservoir. Results of this testing are summarized in the *Modeling of Flow and Transport Induced by Gas Production Wells near the Project Rulison Site, Piceance Basin, Colorado* (DOE 2013).

Site decommissioning and cleanup activities were initiated in July 1972. This included collecting soil and vegetation samples to be analyzed for radiological contaminants, decontaminating equipment, and removing equipment and material not needed for future gas production activities (AEC 1973). The “final” decommissioning and cleanup occurred in 1976 after the participating parties agreed that future gas production would not occur at the site (ERDA 1977). Remaining equipment and material were removed; the mud pits adjacent to the R-En well were backfilled;

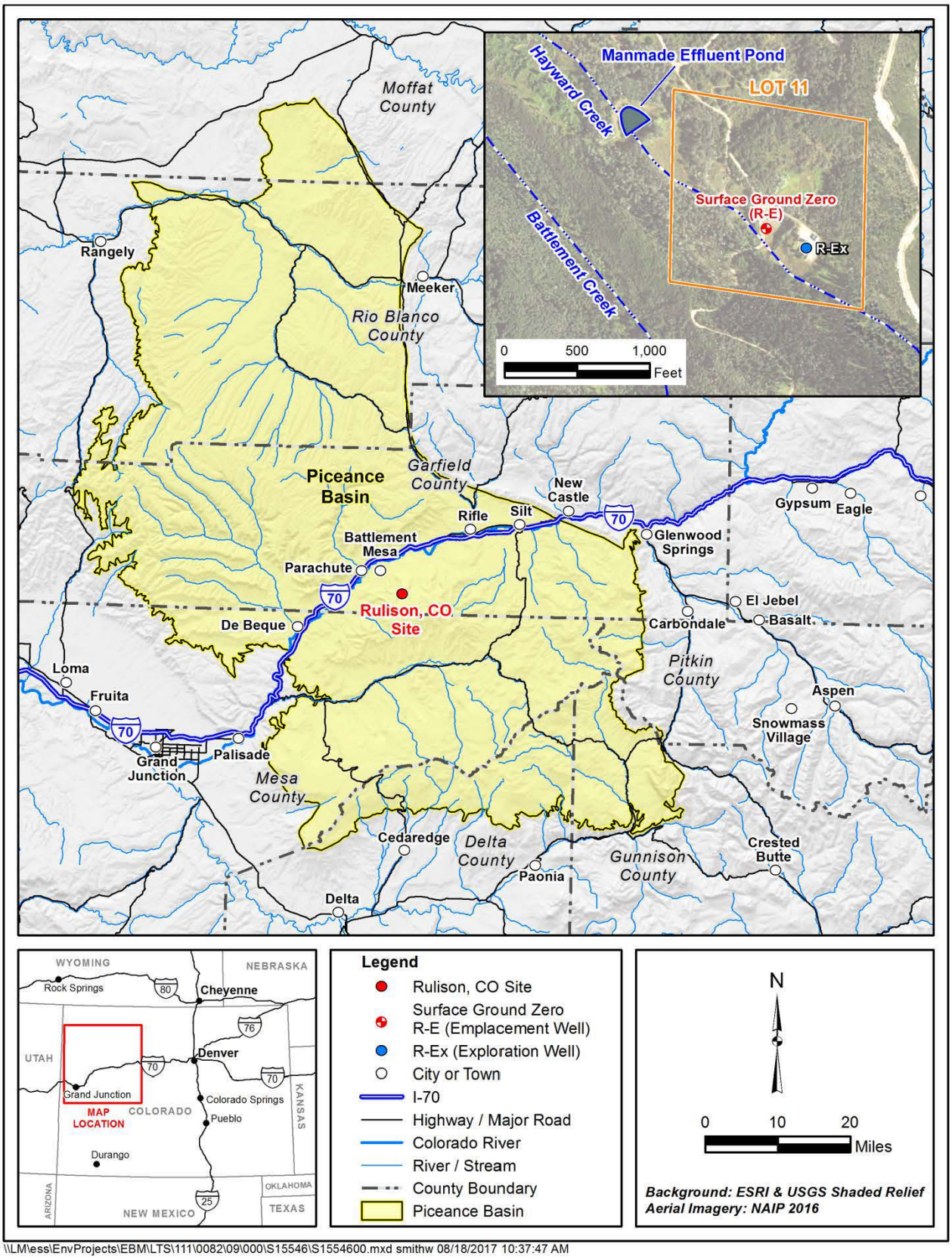

Figure 1. Site Location Map, Rulison Site

tritium-contaminated soils were removed; and the radiological condition of the site was further characterized through extensive surficial soil sampling. At the request of the landowner, the effluent pond used to store drilling fluids during the installation of the R-E emplacement hole was left in place. As part of this cleanup, the R-E and R-En wells were abandoned and a deed restriction was established for the site (ERDA 1977). The deed restriction prohibits the penetration or withdrawal of any material below 6000 ft within Lot 11 (also referred to as the site boundary) unless authorized by the U.S. government.

In 1994 and 1995, soil and sediment samples were collected from the former effluent pond and areas near the former R-E and R-En wells. Samples were analyzed for chemical and radiological contaminants to assess the completeness of past cleanup operations (IT 1996). Corrective action consisted of draining the effluent pond and removing contaminated sediments that exceeded State of Colorado regulatory limits. Shallow groundwater monitoring wells were also installed near the effluent pond and monitored to verify that the remedial actions had been complete. In 1998, DOE provided Colorado regulators with a Surface Closure Report and recommended closure of the site surface with no further action (DOE 1998). The Colorado Department of Public Health and Environment (CDPHE) reviewed the report, agreed with the recommendation, and approved the surface closure activities (CDPHE 1998). The shallow monitoring wells were abandoned in 1999.

2.1 Source of Contamination

Surface and subsurface contamination resulted from the underground nuclear test at Rulison. The surface contamination was excavated and removed in 1996, and CDPHE approved closure of the surface with no further actions in 1998. Subsurface contamination remains in the detonation zone near the R-E emplacement hole, which includes the former cavity, collapse chimney, and fractured rock surrounding the former cavity. The detonation zone is contaminated by residual radioactive isotopes, with the high-melting-point radionuclides trapped in the solidified melt rock (often referred to as melt glass due to its glassy texture) at the bottom of the former cavity. The radionuclides incorporated in the melt rock can only be released to groundwater very slowly through dissolution of the melt rock (e.g., Tompson et al. 1999, Pawloski et al. 2001). Though dissolution of radionuclides from melt rock can represent a long-term source of subsurface contamination, dissolved-phase transport of radionuclides away from the detonation zone is considered insignificant, because the rock surrounding the former cavity and collapse chimney is unsaturated with respect to water. The presence of gas in the surrounding Williams Fork Formation also severely limits liquid movement (if present), making any solidified radionuclides that may have dissolved in the former cavity essentially immobile.

The primary contaminants of concern are expected to be those radionuclides that can exist in the gas phase, because the gas phase is much more mobile than liquids in the gas-producing reservoirs of the Williams Fork Formation. Of the radionuclides that can exist in the gas phase, tritium and krypton-85 are expected to constitute most of the radioactivity (Smith 1971). Samples collected during production testing in 1970 and 1971 indicated that most of the krypton-85 was removed and flared but that tritium remained (DOE 2013). Since tritium is the most abundant radionuclide remaining in the detonation zone that can be present in the gas and aqueous phases, it is the primary radionuclide of concern at the Rulison site.

2.2 Geologic Setting

The Williams Fork Formation of the Mesaverde Group is the primary gas-producing zone within the Piceance Basin. The Piceance Basin is a northwest-southeast-oriented structure about 100 miles long and 40−50 miles wide (Figure 2). The bedding on the western flank of the basin dips gently to the east, and the bedding on the eastern flank of the basin dips steeply to the west, causing the basin to be asymmetrical and deepest along its eastern edge, where more than 20,000 ft of sedimentary rocks were deposited. The Williams Fork Formation is encountered between the depths of approximately 6500 and 9000 ft near the site and is overlain by the Ohio Creek Conglomerate and the Wasatch and Green River formations. The Colorado River divides the Piceance Basin into a northern and southern province. The southern province, which includes the Rulison site, is marked by two significant erosional remnants, Grand Mesa and Battlement Mesa.

The Williams Fork Formation is composed of low-permeability, discontinuous, interbedded fluviodeltaic sandstones and shales. These sandstones vary in clay content; the cleaner sandstones (less clay) in the lower two-thirds of the formation are the main targets for hydrofracturing and natural gas production. Sandstones in the upper one-third of the Williams Fork are not production targets because of their higher water content, which lowers the relative permeability of the gas phase and causes water production to be excessive compared to the amount of gas that can be produced. Despite improvements in hydrofracturing technology, formation properties greatly inhibit fluid migration outside the extent of the hydrofractures. Wells near Rulison are being spaced relatively close (located on 10-acre centers), about 400 ft north/south and about 1320 ft east/west of adjacent wells. The east-west trend of natural fractures in the Williams Fork causes the hydrofracturing and drainage patters to be elongated in that direction (DOE 2013). A more-detailed description of the hydrofracturing and drainage patters at Rulison is provided in the *Modeling of Flow and Transport Induced by Gas Production Wells near the Project Rulison Site, Piceance Basin, Colorado* (DOE 2013).

2.2.1 Site Hydrology

There are three surface water features at the site (Lot 11). They include Battlement Creek, a smaller, spring-fed tributary of Battlement Creek (locally known as Hayward Creek), and a man-made effluent pond (Figure 1). Battlement Creek is a perennial stream that flows through the southwest corner of the site and discharges to the Colorado River. The flow in Battlement Creek is regulated by Battlement Reservoir and is primarily fed by snow melt, shallow groundwater, and springs. The smaller, spring-fed tributary of Battlement Creek flows across the site east of Battlement Creek. The man-made pond covers a surface area of approximately 1 acre and is approximately 1300 ft northwest of the R-E emplacement borehole (also referred to as surface ground zero [SGZ]). The pond was constructed by DOE at the request of the land owner from the drilling effluent pond during the surface restoration. Battlement Creek and its tributaries flow in a generally northwesterly direction toward the Colorado River (USGS 1969).

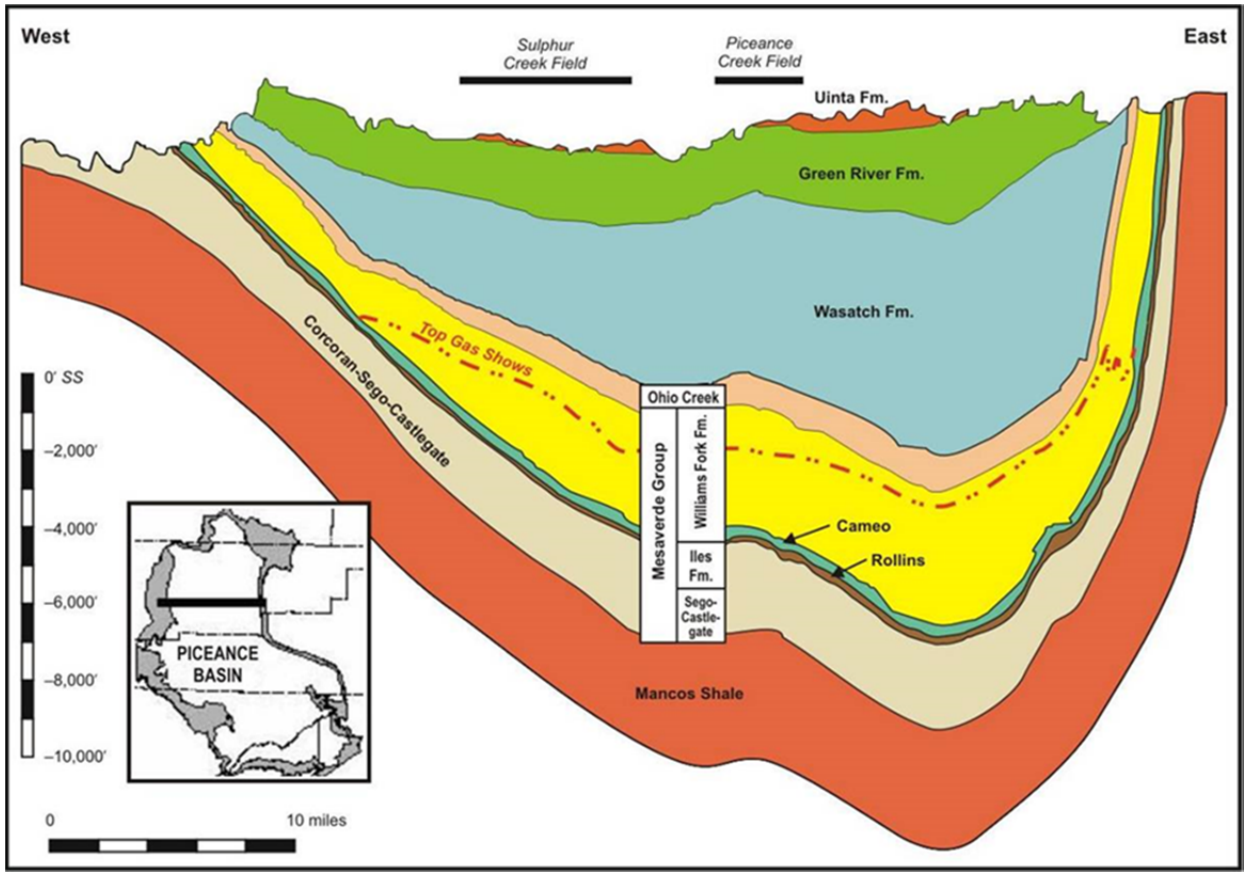

Figure 2. Piceance Basin Cross Section

Groundwater is encountered in the surficial deposits (shallow alluvium <200 ft thick) near the site, with recharge to this aquifer occurring from the infiltration of snowmelt. The wells used by local residents are completed in this shallow alluvial aquifer (<200 ft thick). The next possible groundwater source would be a few sandy zones in the lower part of the underlying Green River Formation (1700 ft thick) capable of yielding minor quantities of water. The Wasatch and Fort Union formations and Ohio Creek Conglomerate extend from a depth of approximately 1700 ft to 6500 ft and are generally not a source of groundwater in the Rulison area. They effectively separate the overlying water-bearing aquifers from the gas-producing zones in the Mesaverde Group.

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. The produced water is high in total dissolved solids and is not a useable water source.

2.3 Previous Monitoring Programs

Shallow groundwater and surface water surrounding the Rulison site has been monitored to ensure public safety under the Long-Term Hydrologic Monitoring Program (LTHMP) since 1972. The U.S. Environmental Protection Agency (EPA) performed the LTHMP sampling from

the program's inception in 1972 through 2007. In 2008, LM assumed responsibility for the sampling and conducted a review of all previous LTHMP data to evaluate the effectiveness of the monitoring program. Analytical results show that nuclear-test-related contamination has not impacted groundwater or surface water at the sample locations. The evaluation considered the depth of the detonation and the potential transport pathways for contaminant migration from the detonation zone. It was concluded that the most likely contaminant transport pathway from the detonation zone to the surface is through a gas production well drilled near enough to the site to allow hydrofractures from the well to interact with nuclear fractures of the detonation. Based on the findings of that evaluation, a new monitoring program was implemented to emphasize the sampling of natural gas production wells near the site. Although gas production wells are the most likely transport path for detonation-related contaminants, LM has continued the sampling of shallow groundwater and surface water at several locations near the site.

3.0 Monitoring Program

The monitoring program for the Rulison site includes the collection of samples from shallow groundwater wells, surface water locations, and producing natural gas wells near the site to assess for any potential impacts that may be attributed to the Rulison nuclear test. Laboratory analytical results from the sampling of natural gas wells are summarized in a separate report. A summary of the shallow groundwater and surface water sampling is provided with the laboratory analytical results in the following sections.

3.1 Groundwater and Surface Water Monitoring

LM has continued the yearly sampling of shallow groundwater wells and surface water locations near the site that was initiated in 1972 as part of the LTHMP. The sampling has continued to assure the public that no radiological contamination associated with the Rulison nuclear test has impacted the sample locations near the site. The annual monitoring event conducted on May 16, 2016, included the collection of samples from 13 locations (Figure 3). The sampled locations are a combination of shallow groundwater wells (<200 ft deep) and surface water locations. Four of the locations (two surface and two shallow groundwater wells) are within the site boundary (Lot 11). The remaining nine locations (three surface and six shallow groundwater wells) are offsite, with these locations ranging from 2 to 6 miles from the former R-E emplacement well that signifies surface ground zero at the site (Figure 3). Samples are collected according to the *Sampling and Analysis Plan for the U. S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351). The Sampling and Analysis Plan can be accessed on the LM public website at https://energy.gov/lm/downloads/sampling-and-analysis-plan-us-department-energy-office-legacy-management-sites.

Samples collected during the annual sampling were analyzed for tritium, because it is the most mobile contaminant remaining in significant quantities in the detonation zone. Some of these samples were analyzed for tritium using the electrolytic enrichment method, which allows the laboratory to provide a minimum detectable concentration that is approximately 2 orders of magnitude lower than the conventional method. Samples were also analyzed for gamma-emitting radionuclides (using high-resolution gamma spectrometry) that may be associated with the nuclear detonation. The samples were submitted to GEL Laboratories in Charleston, South Carolina, and were analyzed using accepted procedures based on specified methods. The laboratory minimum detectable concentration reported with these data is an estimate of the

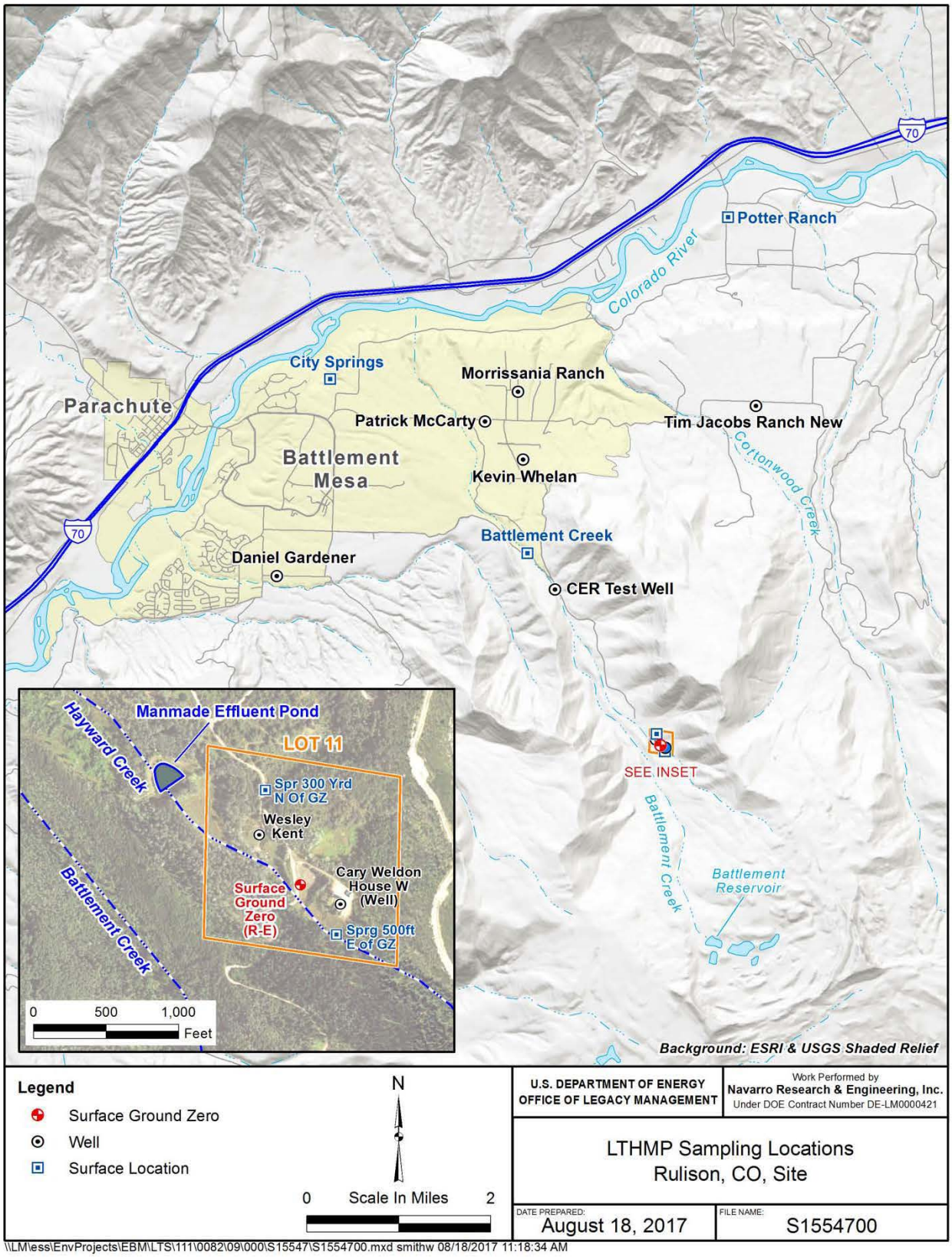

Figure 3. Shallow Groundwater and Surface Sampling Location Map, Rulison Site

predicted detection capability of a given analytical procedure, not an absolute concentration that can or cannot be detected. 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). A summary of the laboratory analytical results is provided in the following section.

3.2 Groundwater and Surface Water Analytical Results

Table 1 shows the analytical results for the samples collected on May 16, 2016. The sample results continue to demonstrate that no detonation-related contaminants have impacted any of the sampled locations. Tritium was not detected above the laboratory minimum detectable concentration using the conventional analytical method. The three samples analyzed using the enrichment method detected tritium above the laboratory minimum detectable concentration (Table 1). The detection of tritium using the enrichment method is consistent with historical LTHMP results and with the worldwide tritium distribution in precipitation that resulted from aboveground nuclear tests during the 1950s and early 1960s (Brown 1995). Aboveground tests conducted by the United States and Soviet Union ended with the test ban treaty in 1963. The tritium results obtained using the enrichment method are shown with the plot of tritium in precipitation (Figure 4 and Figure 5) at Ottawa, Canada (Brown 1995). The natural decay rate for tritium (12.3 years) has also been included in the figures for comparison. The similarity of the tritium levels obtained from the enrichment laboratory method to tritium levels in precipitation indicates that the wells and surface locations are supplied by recent infiltration of water from rain or snowmelt. These results are much lower than the EPA drinking water standard for tritium of 20,000 picocuries per liter (pCi/L) (Title 40 *Code of Federal Regulations* Part 141.16). No other radionuclides were detected by high-resolution gamma spectrometry analysis. Specific radionuclides that are included in gamma spectrometry analysis are listed in the data validation package. The data validation package is provided as Appendix A.

4.0 Conclusions

The laboratory analytical results obtained from this monitoring event continue to demonstrate that no Rulison detonation-related contaminants have impacted the shallow groundwater or surface water near the site. This report is available on the LM Public Website at https://www.lm.doe.gov/Rulison/Documents.aspx. Data collected during this and previous monitoring events are available on the GEMS website at http://gems.lm.doe.gov/#site=RUL.

Table 1. Shallow Groundwater and Surface Water Sample Analytical Results for Rulison Site Samples Collected May 16, 2016

Sample Location	Sample Location Type	Tritium by Conventional Method (pCi/L)	Tritium by Enriched Method (pCi/L)	Gamma-Emitting Radionuclides[a] (pCi/L)
Cary Weldon House (private well)	Groundwater	<316	NA	ND
		<321[b]	NA	ND[b]
CER Test Well (private well)		NA	16.5	ND[c]
Daniel Gardner (private well)		<317	NA	ND
Kevin Whelan (private well)		NA	16.8	ND
Morrissania Ranch (private well)		<320	NA	ND
Patrick McCarty (private well)		<328	NA	ND
Tim Jacobs Ranch (private well)		<313	NA	ND
Wesley Kent House (private well)[d]		<324	NA	ND
City Springs (spring)	Surface Water	<319	NA	ND
Spring 300 yd north of SGZ (spring)		<321	NA	ND
Spring 500 ft east of SGZ (spring)		<325	NA	ND[c]
Battlement Creek (creek)		<327	NA	ND[c]
Potter Ranch (spring)		NA	16.0	ND

Notes:
[a] See data validation package for list of radionuclides included in this analysis.
[b] Field duplicate sample.
[c] The sample was filtered because the turbidity requirements were not met per the Sampling and Analysis Plan.
[d] Well water is derived from a gravity-fed line from the spring (500 ft east of SGZ).

Abbreviations:
ft = feet
NA = not analyzed
ND = not detected
SGZ = surface ground zero
yd = yards

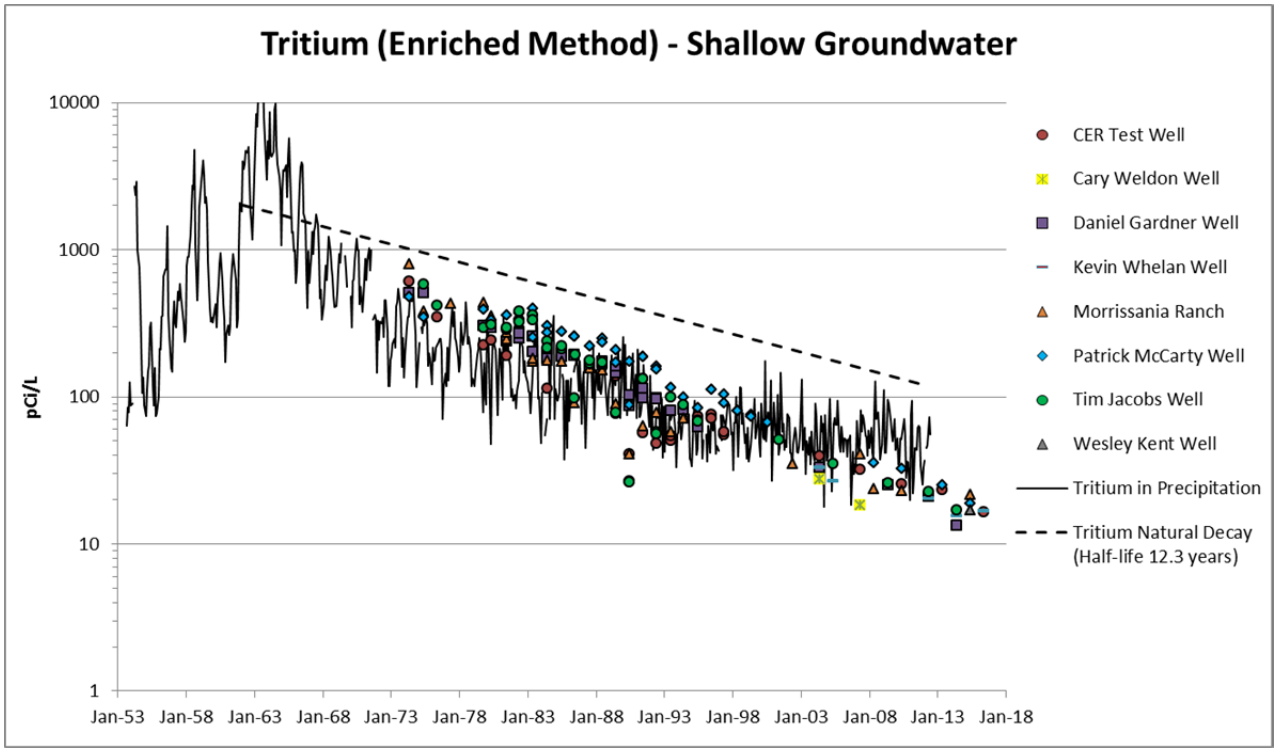

Figure 4. Comparison of Enriched Tritium in Shallow Aquifer Wells in the Vicinity of the Rulison Site with Tritium in Precipitation at Ottawa, Canada (site with longest historical tritium record [Brown 1995])

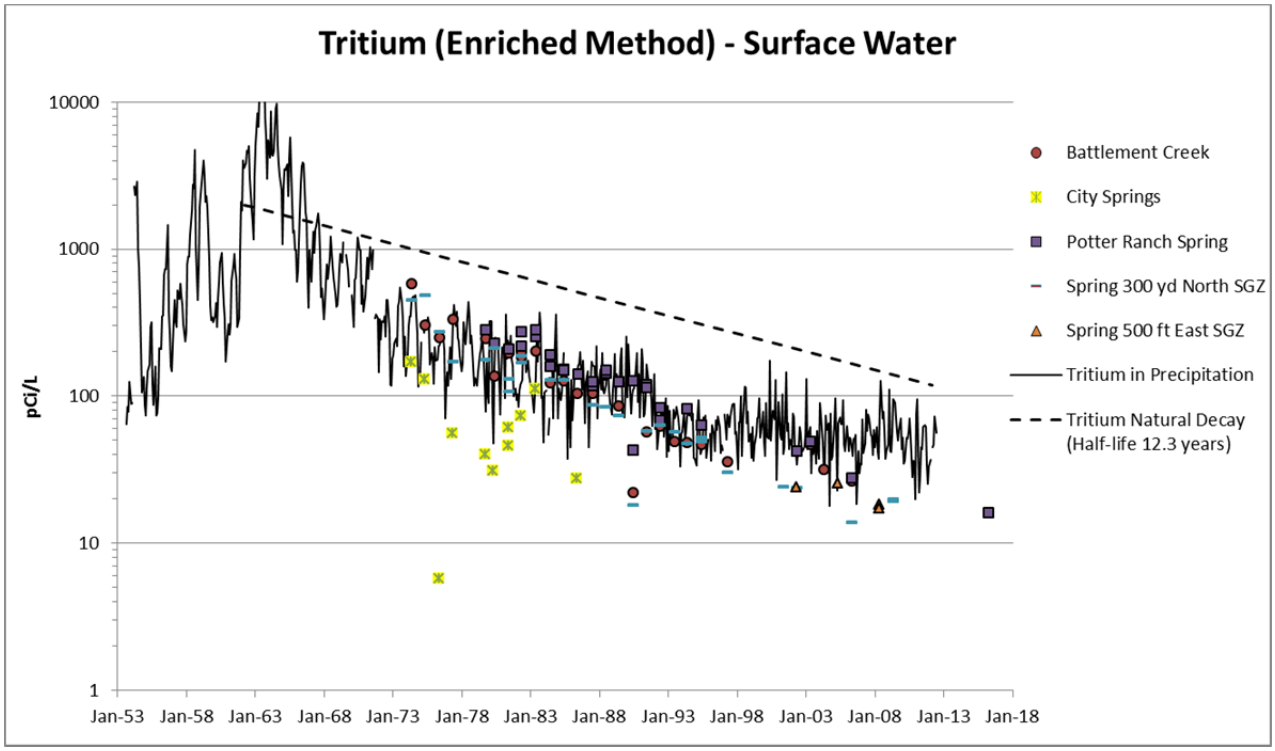

Figure 5. Comparison of Enriched Tritium in Surface Water in the Vicinity of the Rulison Site with Tritium in Precipitation at Ottawa, Canada (site with longest historical tritium record [Brown 1995])

5.0 References

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Appendix A

Data Validation Package

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Data Validation Package

May 2016
Groundwater and Surface Water Sampling at the Rulison, Colorado, Site

February 2017

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Sampling Event Summary

Site: Rulison, Colorado, Site

Sampling Period: May 16, 2016

Annual sampling was conducted at the Rulison, Colorado, site for the Long-Term Hydrologic Monitoring Program on May 16, 2016, to monitor groundwater and surface water for potential radionuclide contamination. Planned monitoring locations are shown in Attachment 1, Sampling and Analysis Work Order.

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, http://energy.gov/lm/downloads/sampling-and-analysis-plan-us-department-energy-office-legacy-management-sites). A duplicate sample was collected from location "Cary Weldon House W." Samples were analyzed by GEL Laboratories in Charleston, South Carolina. Samples were analyzed for gamma-emitting radionuclides by high-resolution gamma spectrometry and for tritium using the conventional and enrichment methods. Water levels were measured at all sampled wells. See Attachment 2, Trip Report for additional details.

The electrolytic enrichment method for tritium analysis yielded positive results for the samples analyzed ranging from 16.0 to 16.8 picocuries per liter (pCi/L). These results are consistent with background levels for tritium and are well below the U.S. Environmental Protection Agency (EPA) drinking-water standard for tritium of 20,000 pCi/L. All high-resolution gamma spectrometry results were below detectable concentrations. An assessment of anomalous data is included in Attachment 4. The results from this sampling event indicate that groundwater and surface water supplies in the area have not been impacted by detonation-related contaminants.

Richard C Findlay

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

5-15-2017

Date

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Data Assessment Summary

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Water Sampling Field Activities Verification Checklist

Project	Rulison, Colorado, Site	**Date(s) of Water Sampling**	May 16, 2016
Date(s) of Verification	January 24, 2017	**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.		Work Order letter dated April 14, 2016.
2. Were the sampling locations specified in the planning documents sampled?	Yes	
3. Were field equipment calibrations conducted as specified in the above-named documents?	Yes	Calibrations were performed on May 12, 2016.
4. Was an operational check of the field equipment conducted daily?	Yes	
Did the operational checks meet criteria?	Yes	
5. Were the number and types (alkalinity, temperature, specific conductance, pH, turbidity, DO, ORP) of field measurements taken as specified?	Yes	
6. Were wells categorized correctly?	Yes	
7. Were the following conditions met when purging a Category I well:		
Was one pump/tubing volume purged prior to sampling?	NA	There were no Category I wells.
Did the water level stabilize prior to sampling?		
Did pH, specific conductance, and turbidity measurements meet criteria prior to sampling?		
Was the flow rate less than 500 mL/min?		

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?	Yes	
Was one pump/tubing volume removed prior to sampling?	Yes	
9. Were duplicates taken at a frequency of one per 20 samples?	Yes	A duplicate sample was collected at location Cary Weldon House W.
10. Were equipment blanks taken at a frequency of one per 20 samples that were collected with non-dedicated equipment?	NA	Dedicated equipment was used for all sample collection and 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?	Yes	

Laboratory Performance Assessment

General Information

Task ID:	RUL01.1-16050001
Sample Event:	May 16, 2016
Site(s):	Rulison, Colorado, Site
Laboratory:	GEL Laboratories, Charleston, South Carolina
Work Order No.:	397660
Analysis:	Radiochemistry
Validator:	Stephen Donivan
Review Date:	January 24, 2017

This validation was performed according to "Standard Practice for Validation of Environmental Data" found in Appendix A of the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351, continually updated, http://energy.gov/lm/downloads/sampling-and-analysis-plan-us-department-energy-office-legacy-management-sites). The procedure was applied at Level 3, Data Validation.

This validation includes the evaluation of data quality indicators (DQIs) associated with the data. DQIs are the quantitative and qualitative descriptors that are used to interpret the degree of acceptability or utility of data. Indicators of data quality include the analysis of laboratory control samples to assess accuracy; duplicates and replicates to assess precision; and interference check samples to assess bias (see Figures 1 and 2, Data Validation Worksheets). The DQIs comparability, completeness, and sensitivity are also evaluated in the sections to follow.

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	EPA 901.1	EPA 901.1
Tritium, Enrichment Method	LMR-17	DOE HASL 300	DOE HASL 300
Tritium	LSC-A-001	EPA 906.0m	EPA 906.0m

Data Qualifier Summary

None of the analytical results required qualification.

Sample Shipping/Receiving

GEL Laboratories in Charleston, South Carolina, received 14 water samples on May 18, 2016, accompanied by a Chain of Custody form. The Chain of Custody was checked to confirm that all the samples were listed with a sample collection date and time, and that signatures and dates

were present indicating sample relinquishment and receipt. The Chain of Custody had no errors or omissions.

Preservation and Holding Times

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

Detection and Quantitation Limits

Radiochemical 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 demonstrate compliance with contractual requirements.

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. 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.

Radiochemical Analysis

Tritium
Instrument quench calibration curves were generated on July 1, 2016. The daily instrument checks performed on July 25 and August 9, 2016 met the acceptance criteria.

Gamma Spectrometry
The gamma spectrometry efficiency calibrations were performed within a year prior to sample analysis. All daily calibration and background check results met the acceptance criteria.

Method Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. All method blank results associated with the samples were below the DLC for all analytes.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate samples were analyzed for tritium as a measure of method performance in the sample matrix. All spike results were within the acceptance range.

Laboratory Replicate Analysis

Laboratory replicate analyses are used to determine laboratory precision for each sample matrix. The relative error ratio for radiochemical replicate results (calculated using the one-sigma total propagated uncertainty) was less than three, indicating acceptable precision.

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.

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 August 26, 2016. The EDD was examined to verify that the file was complete and in compliance with requirements. The contents of the file were compared 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.

General Data Validation Report

Task Code: RUL01.1-16050001 **Lab Code:** GEN **Validator:** Stephen Donivan **Validation Date:** 01-24-2017

Project: Rulison Site Monitoring **# Samples:** 14

Analysis Type: [ ] General Chemistry [ ] Metals [ ] Organics [X] Radiochemistry

Chain of Custody

Present: OK Signed: OK Dated: OK

Sample

Integrity: OK Preservation OK Temperature: OK

Check	Summary
Holding Times:	All analyses were completed within the applicable holding times.
Detection Limits:	There were 17 detection limits above the contract required limits.
Field Duplicates:	There was 1 duplicate evaluated.

Figure 1. General Validation Worksheet

Radiochemistry Data Validation Worksheet

24-Jan-2017

Project: Rulison Site Monitoring **Task Code:** RUL01.1-16050001 **Lab Code:** GEN

Sample ID	Analyte	Analysis Date	QC Type	Result Type	Result	Flag	TPU	Spike Recovery	Spike Dup Recovery	Lower Limit	Upper Limit	RPD	RPD Limit	RER	Comments
	Actinium-228	08-12-2016	LCS	TRG	241	U	755								
	Actinium-228	08-12-2016	MB	TRG	1.15	U	24.2								
	Actinium-228	08-12-2016	R	TRG	-1.71	U	15.2					0			
	Americium-241	08-12-2016	LCS	SC	1.15E+05		9500	105		75	125				
	Americium-241	08-12-2016	MB	TRG	1.27	U	4.66								
	Americium-241	08-12-2016	R	TRG	-21.7	U	34.6					0			
	Antimony-125	08-12-2016	LCS	TRG	-326	U	453								
	Antimony-125	08-12-2016	MB	TRG	0.181	U	9.81								
	Antimony-125	08-12-2016	R	TRG	0.00	UI	28.7					0			
	Cerium-144	08-12-2016	LCS	TRG	-240	U	813								
	Cerium-144	08-12-2016	MB	TRG	20.2	U	18.4								
	Cerium-144	08-12-2016	R	TRG	1.84	U	28.0					0			
	Cesium-134	08-12-2016	LCS	TRG	-76	U	179								
	Cesium-134	08-12-2016	MB	TRG	-1.87	U	4.44								
	Cesium-134	08-12-2016	R	TRG	3.59	U	4.06					0			
	Cesium-137	08-12-2016	LCS	SC	44600		3730	104		75	125				
	Cesium-137	08-12-2016	MB	TRG	-1.23	U	3.82								
	Cesium-137	08-12-2016	R	TRG	2.51	U	3.40					0			
	Cobalt-60	08-12-2016	LCS	SC	43300		3950	101		75	125				
	Cobalt-60	08-12-2016	MB	TRG	1.40	U	4.52								
	Cobalt-60	08-12-2016	R	TRG	0.0934	U	5.11					0			

QC Types: LCS: Laboratory Control Sample LCSD: Laboratory Control Sample Duplicate MB: Method Blank MS: Matrix Spike MSD: Matrix Spike Duplicate R: Replicate

Result Types: IS: Internal Standard SC: Spike Analyte TRG: Target analyte

QC Checks: RPD: Relative Percent Difference RER: Relative Error Ratio TPU: Total Propagated Uncertainty

Figure 2. Radiochemistry Validation Worksheet

Radiochemistry Data Validation Worksheet

24-Jan-2017

Project: Rulison Site Monitoring **Task Code:** RUL01.1-16050001 **Lab Code:** GEN

Sample ID	Analyte	Analysis Date	QC Type	Result Type	Result	Flag	TPU	Spike Recovery	Spike Dup Recovery	Lower Limit	Upper Limit	RPD	RPD Limit	RER	Comments
	Europium-152	08-12-2016	LCS	TRG	-473	U	458								
	Europium-152	08-12-2016	MB	TRG	-1.05	U	10.1								
	Europium-152	08-12-2016	R	TRG	-1.54	U	11.8					0			
	Europium-154	08-12-2016	LCS	TRG	150	U	265								
	Europium-154	08-12-2016	MB	TRG	-4.36	U	12.5								
	Europium-154	08-12-2016	R	TRG	-4.13	U	11.7					0			
	Europium-155	08-12-2016	LCS	TRG	-123	U	416								
	Europium-155	08-12-2016	MB	TRG	3.72	U	7.27								
	Europium-155	08-12-2016	R	TRG	-1.71	U	12.8					0			
	Lead-212	08-12-2016	LCS	TRG	-55.5	U	222								
	Lead-212	08-12-2016	MB	TRG	6.04	U	8.87								
	Lead-212	08-12-2016	R	TRG	2.16	U	14.1					0			
	Potassium-40	08-12-2016	LCS	TRG	-485	U	683								
	Potassium-40	08-12-2016	MB	TRG	26.9	U	58.2								
	Potassium-40	08-12-2016	R	TRG	15.6	U	59.3					0			
	Promethium-144	08-12-2016	LCS	TRG	5.68	U	125								
	Promethium-144	08-12-2016	MB	TRG	2.63	U	4.43								
	Promethium-144	08-12-2016	R	TRG	-0.934	U	4.64					0			
	Promethium-146	08-12-2016	LCS	TRG	-67	U	218								
	Promethium-146	08-12-2016	MB	TRG	-0.779	U	5.26								
	Promethium-146	08-12-2016	R	TRG	-0.912	U	4.21					0			
	Ruthenium-106	08-12-2016	LCS	TRG	-21.8	U	1280								
	Ruthenium-106	08-12-2016	MB	TRG	-19.6	U	40.2								

QC Types: LCS: Laboratory Control Sample LCSD: Laboratory Control Sample Duplicate MB: Method Blank MS: Matrix Spike MSD: Matrix Spike Duplicate R: Replicate

Result Types: IS: Internal Standard SC: Spike Analyte TRG: Target analyte

QC Checks: RPD: Relative Percent Difference RER: Relative Error Ratio TPU: Total Propagated Uncertainty

Figure 2. Radiochemistry Validation Worksheet (continued)

Radiochemistry Data Validation Worksheet

24-Jan-2017

Project: Rulison Site Monitoring **Task Code:** RUL01.1-16050001 **Lab Code:** GEN

Sample ID	Analyte	Analysis Date	QC Type	Result Type	Result	Flag	TPU	Spike Recovery	Spike Dup Recovery	Lower Limit	Upper Limit	RPD	RPD Limit	RER	Comments
	Ruthenium-106	08-12-2016	R	TRG	0.405	U	31.9					0			
	Thorium-234	08-12-2016	LCS	TRG	-5370	U	5690								
	Thorium-234	08-12-2016	MB	TRG	-21.6	U	73.9								
	Thorium-234	08-12-2016	R	TRG	-121	U	337					0			
	Tritium	07-26-2016	LCS	SC	72.8		21.2	88.7		75	125				
	Tritium	07-26-2016	MB	TRG	-0.112	U	1.54								
	Tritium	08-09-2016	LCS	SC	2220		508	96.1		75	125				
	Tritium	08-09-2016	MB	TRG	27.0	U	188								
	Tritium	08-09-2016	MS	SC	2390		546	102		75	125				
	Tritium	08-09-2016	R	TRG	63.9	U	189					0			
	Uranium-235	08-12-2016	LCS	TRG	223	U	717								
	Uranium-235	08-12-2016	MB	TRG	-26.1	U	23.4								
	Uranium-235	08-12-2016	R	TRG	7.68	U	27.7					0			
	Uranium-238	08-12-2016	LCS	TRG	-5370	U	5690								
	Uranium-238	08-12-2016	MB	TRG	-21.6	U	73.9								
	Uranium-238	08-12-2016	R	TRG	-121	U	337					0			
	Yttrium-88	08-12-2016	LCS	TRG	-18.1	U	77.4								
	Yttrium-88	08-12-2016	MB	TRG	1.52	U	4.04								
	Yttrium-88	08-12-2016	R	TRG	-3.96	U	7.10					0			

QC Types: LCS: Laboratory Control Sample LCSD: Laboratory Control Sample Duplicate MB: Method Blank MS: Matrix Spike MSD: Matrix Spike Duplicate R: Replicate

Result Types: IS: Internal Standard SC: Spike Analyte TRG: Target analyte

QC Checks: RPD: Relative Percent Difference RER: Relative Error Ratio TPU: Total Propagated Uncertainty

Figure 2. Radiochemistry Validation Worksheet (continued)

Sampling Quality Control Assessment

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

Sampling Protocol

Location CER Test Well was sampled using a dedicated bladder pump as a Category II well. Data from this well are qualified with the "FQ" flags in the database, which indicate the well was Category II, purged and sampled using the low-flow sampling method. All other sample locations were domestic wells or surface water locations.

Equipment Blank

Equipment blanks are prepared and analyzed to document contamination attributable to the sample collection process. Dedicated equipment was used for all sample collection and an equipment blank was not required.

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 Cary Weldon House W. 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 (Figure 3).

Validation Report: Field Duplicates

24-Jan-2017

Project: Rulison Site Monitoring **Task Code:** RUL01.1-16050001 Lab Code: GEN

	Duplicate: RUL01.1-16050001-013				Sample: RUL01.1-16050001-004 Cary Weldon House W						
Analyte	**Result**	**Qualifiers**	**Uncert.**	**Dilution**	**Result**	**Qualifiers**	**Uncert.**	**Dilution**	**RPD**	**RER**	**Units**
Actinium-228	13.4	U	31.5	1	11.7	U	28.1	1		0.1	pCi/L
Americium-241	-1.26	U	9.36	1	-9.35	U	23.3	1		0.6	pCi/L
Antimony-125	-5.95	U	10.5	1	0.599	U	9.41	1		-0.9	pCi/L
Cerium-144	-16	U	22.5	1	12.4	U	26.0	1		-1.6	pCi/L
Cesium-134	0.587	U	3.66	1	2.35	U	4.19	1		-0.6	pCi/L
Cesium-137	-0.734	U	4.14	1	-0.757	U	3.39	1		0.0	pCi/L
Cobalt-60	2.41	U	3.51	1	-0.581	U	3.39	1		1.2	pCi/L
Europium-152	-8.5	U	10.9	1	-6.32	U	10.0	1		-0.3	pCi/L
Europium-154	4.60	U	12.7	1	2.75	U	9.91	1		0.2	pCi/L
Europium-155	5.96	U	10.8	1	-3.29	U	11.7	1		1.1	pCi/L
Lead-212	-0.139	U	7.34	1	6.14	U	10.8	1		-0.9	pCi/L
Potassium-40	-44.7	U	54.1	1	22.3	U	70.2	1		-1.5	pCi/L
Promethium-144	-0.0534	U	3.54	1	0.0742	U	3.75	1		0.0	pCi/L
Promethium-146	0.604	U	4.22	1	-0.998	U	4.49	1		0.5	pCi/L
Ruthenium-106	-34	U	37.4	1	3.39	U	38.4	1		-1.4	pCi/L
Thorium-234	-25.3	U	113	1	-133	U	262	1		0.7	pCi/L
Tritium	-20.5	U	181	1	-3.26	U	179	1		-0.1	pCi/L
Uranium-235	0.414	U	26.7	1	6.28	U	24.6	1		-0.3	pCi/L
Uranium-238	-25.3	U	113	1	-133	U	262	1		0.7	pCi/L
Yttrium-88	6.55	U	7.13	1	-2.35	U	5.79	1		1.9	pCi/L

QC Checks: RPD: Relative Percent Difference RER: Relative Error Ratio

Figure 3. Field Duplicates

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 — Stephen Donivan — 2-22-2017 — Date

Data Validation Lead: Stephen Donivan — Stephen Donivan — 2.22.2017 — Date

Attachment 1

Sampling and Analysis Work Order

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April 14, 2016

Task Assignment 104
Control Number 16-0505

U.S. Department of Energy
Office of Legacy Management
ATTN: Art Kleinrath
Site Manager
2597 Legacy Way
Grand Junction, CO 81503

SUBJECT: Contract No. DE-LM0000421, Navarro Research & Engineering, Inc. (Navarro)
Task Assignment 104 LTS&M-Nevada Off Sites and Monticello Site
May 2016 Environmental Sampling at the Rulison, Colorado, Site

REFERENCE: Task Assignment 104, 1-104-1-04-619, Rulison, Colorado, Site

Dear Mr. Kleinrath:

The purpose of this letter is to inform you of the upcoming sampling event at the Rulison, Colorado, site. Enclosed are the map and tables specifying sample locations and analytes for monitoring at the site. Water quality data will be collected at this site as part of the routine environmental sampling currently scheduled to begin the week of May 16, 2016.

The following lists show the locations scheduled for sampling during this event.

MONITORING WELLS

Off-Site

CER Test Well	Daniel Gardener	Kevin Whelan	Morrissania Ranch
Patrick McCarty	Tim Jacobs Ranch New		

On-Site

Cary Weldon House W	Wesley Kent House W

Municipal Water Supply

City Springs

SURFACE WATER

On-Site

Spr 300 Yrd N of GZ	Sprg 500ft E of GZ

Off-Site

Battlement Creek	Potter Ranch

All samples will be collected as directed in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites*. Notification for access to locations on private property will be conducted prior to the beginning of fieldwork.

Please contact me at (970) 248-6477 or Rick Findlay at (970) 248-6419 if you have any questions.

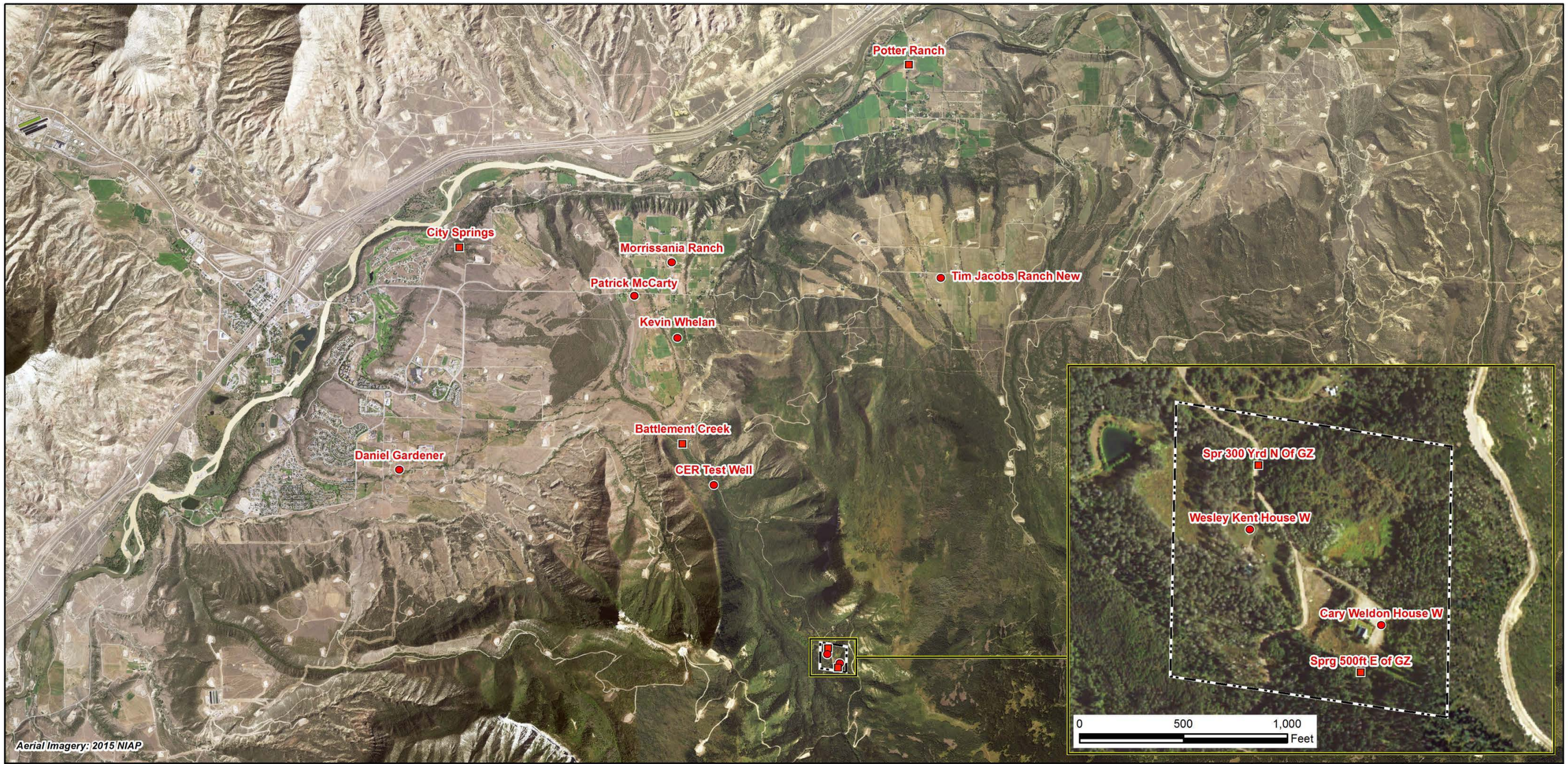
Sincerely,

Richard D. Hutton
LMS Site Lead

RDH/lcg/bkb

Enclosures (3)

cc: (electronic)
Christina Pennal, DOE
Bev Cook, Navarro
Steve Donivan, Navarro
Lauren Goodknight, Navarro
Rick Hutton, Navarro
Kenneth Karp, Navarro
Sam Marutzky, Navarro
Diana Osborne, Navarro
EDD Delivery
rc-grand.junction
File: RUL 400.02



LEGEND

- WELL TO BE SAMPLED
- SURFACE LOCATION TO BE SAMPLED
- SITE BOUNDARY

N

0 1 2 Miles

U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421

Planned Sample Locations
Rulison, CO, Site
May 2016

DATE PREPARED: April 6, 2016

FILE NAME: S1406500-11x17

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Rulison, Colorado, Site, Planned Sample Locations Map

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Sampling Frequencies for Locations at Rulison, Colorado

Location ID	Quarterly	Semiannually	Annually	Biennially	Not Sampled	Notes
Monitoring Wells						
Off-Site						
CER Test Well			X			
Daniel Gardener			X			
Kevin Whelan			X			
Morrissania Ranch			X			
Patrick McCarty			X			
Tim Jacobs Ranch New			X			
On-Site						
Cary Weldon House W			X			
Wesley Kent House W			X			
Municipal Water Supply						
City Springs			X			
Surface Locations						
On-Site						
Spr 300 Yrd N Of GZ			X			
Sprg 500ft E of GZ			X			
Off-Site						
Battlement Creek			X			
Potter Ranch			X			

Sampling conducted in May

Be sure to pick different locations from last year for enriched tritium.

Constituent Sampling Breakdown

Site	Rulison				
Analyte	Groundwater	Surface Water	Required Detection Limit (mg/L)	Analytical Method	Line Item Code
Approx. No. Samples/yr	9	4			
Field Measurements					
Alkalinity					
Dissolved Oxygen					
Redox Potential					
pH	X	X			
Specific Conductance	X	X			
Turbidity	X				
Temperature	X	X			
Laboratory Measurements					
Aluminum					
Ammonia as N (NH3-N)					
Calcium					
Chloride					
Chromium					
Gamma Spec	X	X	10 pCi/L	Gamma Spectrometry	GAM-A-001
Gross Alpha					
Gross Beta					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Nickel-63					
Nitrate + Nitrite as N (NO3+NO2)-N					
Potassium					
Radium-226					
Radium-228					
Selenium					
Silica					
Sodium					
Strontium					
Sulfate					
Sulfide					
Total Dissolved Solids					
Total Organic Carbon					
Tritium	X	X	400 pCi/L	Liquid Scintillation	LSC-A-001
Tritium, enriched	25% of the samples	25% of the samples	10 pCi/L	Liquid Scintillation	LMR-15
Uranium					
Vanadium					
Zinc					
Total No. of Analytes	3	3			

Note: All private well samples are to be unfiltered. The total number of analytes does not include field parameters.

Attachment 2

Trip Report

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memo

Navarro Research and Engineering

To: Rick Hutton

From: Samantha Tigar

CC: Art Kleinrath, DOE
Steve Donivan, Navarro
Rick Findlay, Navarro
Rex Hodges, Navarro
EDD Delivery

Date: 5/25/2016

Re: Sampling Trip Report

Site: Rulison, CO

Date of Sampling Event: May 16, 2016

Team Members: Dan Sellers and Samantha Tigar

Number of Locations Sampled: Samples were collected from all 13 of the locations identified on the sampling notification letter.

Locations Not Sampled/Reason: All scheduled locations were sampled.

Location Specific Information:

Location IDs	Comments
Sprg 500ft E of GZ, CER Test Well, Battlement Creek	Turbidity was not met. Samples for gamma spectrometry were filtered. Samples for tritium were not filtered.
CER Test Well, Kevin Whelan, Potter Ranch	Enriched tritium samples were collected at these locations.

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

False ID	Sample ID	True ID	Sample Type	Associated Matrix
2487	RUL01.1-16050001-013	Cary Weldon House W	Duplicate	Groundwater

Task Code Assigned: Samples were assigned to task code RUL01.1-16050001. Field data sheets can be found in \\crow\SMS\RUL01.1-16050001\FieldData.

Sample Shipment: Samples were shipped overnight via FedEx from Grand Junction, CO, to GEL Laboratories in Charleston, SC, on May 17, 2016.

Water Level Measurements: Water levels were measured in all sampled wells.

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). Earthsoft EDGE, version 6.4 software edition, was used to collect field data for this event.

Field Variance: None. Samples were collected according to the SAP.

Equipment: All equipment functioned properly.

Stakeholder/Regulatory/DOE: Nothing to note.

Institutional Controls:

Fences, Gates, and Locks: All property owner gates were left as found.
Signs: No issues were observed.
Trespassing/Site Disturbances: None observed.
Disposal Cell/Drainage Structure Integrity: N/A

Safety Issues: None

Access Issues: None

General Information:

Location IDs	Comments
City Springs	New contact for access is James Taylor. He requested to be called a few days prior to sampling and again the day of sampling as a reminder.
Morrissania Ranch	New sample point is the outside spigot on the east side of the new shop.
Wesley Kent House W	New sample point is the spigot along the driveway, near the shed.

Immediate Actions Taken: None

Future Actions Required or Suggested: None

Attachment 3

Data Presentation

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Groundwater Quality Data

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Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Cary Weldon House W CO-00246-000593

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	D	T	13.4	31.5	25.1	U		Y
Actinium-228	pCi/L	05/16/2016	F	T	11.7	28.1	32.1	U		Y
Americium-241	pCi/L	05/16/2016	D	T	-1.26	9.36	16.2	U		Y
Americium-241	pCi/L	05/16/2016	F	T	-9.35	23.3	39.7	U		Y
Antimony-125	pCi/L	05/16/2016	D	T	-5.95	10.5	16.9	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	0.599	9.41	16.9	U		Y
Cerium-144	pCi/L	05/16/2016	D	T	-16	22.5	34.7	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	12.4	26.0	44.8	U		Y
Cesium-134	pCi/L	05/16/2016	D	T	0.587	3.66	6.81	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	2.35	4.19	7.47	U		Y
Cesium-137	pCi/L	05/16/2016	D	T	-0.734	4.14	6.48	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	-0.757	3.39	6.17	U		Y
Cobalt-60	pCi/L	05/16/2016	D	T	2.41	3.51	6.91	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	-0.581	3.39	6.41	U		Y
Europium-152	pCi/L	05/16/2016	D	T	-8.5	10.9	15.5	U		Y
Europium-152	pCi/L	05/16/2016	F	T	-6.32	10.0	16.4	U		Y
Europium-154	pCi/L	05/16/2016	D	T	4.60	12.7	15.8	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Cary Weldon House W CO-00246-000593

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Europium-154	pCi/L	05/16/2016	F	T	2.75	9.91	19.7	U		Y
Europium-155	pCi/L	05/16/2016	D	T	5.96	10.8	16.7	U		Y
Europium-155	pCi/L	05/16/2016	F	T	-3.29	11.7	19.8	U		Y
Lead-212	pCi/L	05/16/2016	D	T	-0.139	7.34	11.3	U		Y
Lead-212	pCi/L	05/16/2016	F	T	6.14	10.8	13.3	U		Y
pH	s.u.	05/16/2016	F	N	7.20					Y
Potassium-40	pCi/L	05/16/2016	D	T	-44.7	54.1	83.7	U		Y
Potassium-40	pCi/L	05/16/2016	F	T	22.3	70.2	66.9	U		Y
Promethium-144	pCi/L	05/16/2016	D	T	-0.0534	3.54	6.47	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	0.0742	3.75	6.97	U		Y
Promethium-146	pCi/L	05/16/2016	D	T	0.604	4.22	7.48	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	-0.998	4.49	7.80	U		Y
Ruthenium-106	pCi/L	05/16/2016	D	T	-34	37.4	57.1	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	3.39	38.4	71.6	U		Y
Specific Conductance	uS/cm	05/16/2016	F	N	638					Y
Temperature	C	05/16/2016	F	N	6.87					Y
Thorium-234	pCi/L	05/16/2016	D	T	-25.3	113	183	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Cary Weldon House W CO-00246-000593

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Thorium-234	pCi/L	05/16/2016	F	T	-133	262	407	U		Y
Tritium	pCi/L	05/16/2016	D	N	-20.5	181	321	U		Y
Tritium	pCi/L	05/16/2016	F	N	-3.26	179	316	U		Y
Turbidity	NTU	05/16/2016	F	N	1.40					Y
Uranium-235	pCi/L	05/16/2016	D	T	0.414	26.7	31.3	U		Y
Uranium-235	pCi/L	05/16/2016	F	T	6.28	24.6	34.7	U		Y
Uranium-238	pCi/L	05/16/2016	D	T	-25.3	113	183	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	-133	262	407	U		Y
Yttrium-88	pCi/L	05/16/2016	D	T	6.55	7.13	14.2	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	-2.35	5.79	10.3	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: CER Test Well CO-00246-000463

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	D	-12.4	19.2	30.4	U	FQ	Y
Americium-241	pCi/L	05/16/2016	F	D	-39.2	20.2	10.7	U	FQ	Y
Antimony-125	pCi/L	05/16/2016	F	D	-1.76	11.3	20.3	U	FQ	Y
Cerium-144	pCi/L	05/16/2016	F	D	-16.1	30.2	43.3	U	FQ	Y
Cesium-134	pCi/L	05/16/2016	F	D	-2.52	5.85	9.08	U	FQ	Y
Cesium-137	pCi/L	05/16/2016	F	D	-4.27	5.08	7.60	U	FQ	Y
Cobalt-60	pCi/L	05/16/2016	F	D	-1.37	4.38	7.85	U	FQ	Y
Europium-152	pCi/L	05/16/2016	F	D	-3.52	11.2	19.7	U	FQ	Y
Europium-154	pCi/L	05/16/2016	F	D	-5.31	12.9	22.5	U	FQ	Y
Europium-155	pCi/L	05/16/2016	F	D	-0.487	12.0	19.8	U	FQ	Y
Lead-212	pCi/L	05/16/2016	F	D	2.23	11.3	14.6	U	FQ	Y
pH	s.u.	05/16/2016	F	N	8.01				FQ	Y
Potassium-40	pCi/L	05/16/2016	F	D	41.3	70.3	131	U	FQ	Y
Promethium-144	pCi/L	05/16/2016	F	D	2.60	6.31	10.0	U	FQ	Y
Promethium-146	pCi/L	05/16/2016	F	D	-3.67	6.26	9.08	U	FQ	Y
Ruthenium-106	pCi/L	05/16/2016	F	D	19.6	46.7	86.1	U	FQ	Y
Specific Conductance	uS/cm	05/16/2016	F	N	391				FQ	Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: CER Test Well CO-00246-000463

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Temperature	C	05/16/2016	F	N	9.41				FQ	Y
Thorium-234	pCi/L	05/16/2016	F	D	-43.6	98.3	176	U	FQ	Y
Tritium	pCi/L	05/16/2016	F	N	16.5	4.96	2.98		FQ	Y
Turbidity	NTU	05/16/2016	F	N	29.8				FQ	Y
Uranium-235	pCi/L	05/16/2016	F	D	-9.85	26.1	43.7	U	FQ	Y
Uranium-238	pCi/L	05/16/2016	F	D	-43.6	98.3	176	U	FQ	Y
Yttrium-88	pCi/L	05/16/2016	F	D	-4.04	8.50	15.0	U	FQ	Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Daniel Gardener CO-00246-000025

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	11.0	20.5	19.3	U		Y
Americium-241	pCi/L	05/16/2016	F	T	11.5	13.5	21.1	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	3.33	10.9	19.5	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	-4.27	25.7	43.2	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	1.72	5.22	8.90	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	-1.01	3.77	6.68	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	0.0966	3.24	6.31	U		Y
Europium-152	pCi/L	05/16/2016	F	T	0.835	10.6	18.8	U		Y
Europium-154	pCi/L	05/16/2016	F	T	-2.82	11.9	21.5	U		Y
Europium-155	pCi/L	05/16/2016	F	T	6.61	11.3	19.4	U		Y
Lead-212	pCi/L	05/16/2016	F	T	-5.66	9.08	13.5	U		Y
pH	s.u.	05/16/2016	F	N	7.79					Y
Potassium-40	pCi/L	05/16/2016	F	T	12.9	49.3	65.8	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	-1.46	6.10	8.23	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	-1.36	5.09	8.62	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	-17.5	37.0	63.3	U		Y
Specific Conductance	uS/cm	05/16/2016	F	N	720					Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Daniel Gardener CO-00246-000025

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Temperature	C	05/16/2016	F	N	11.59					Y
Thorium-234	pCi/L	05/16/2016	F	T	125	176	189	U		Y
Tritium	pCi/L	05/16/2016	F	N	283	202	317	U		Y
Turbidity	NTU	05/16/2016	F	N	4.36					Y
Uranium-235	pCi/L	05/16/2016	F	T	-18.6	28.3	39.9	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	125	176	189	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	0.854	6.51	13.2	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Kevin Whelan CO-00246-000592

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	3.03	21.2	35.4	U		Y
Americium-241	pCi/L	05/16/2016	F	T	-26.5	40.3	55.6	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	6.77	12.4	22.5	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	4.57	29.3	51.1	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	0.193	5.03	8.12	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	1.64	4.66	8.24	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	3.25	4.81	9.58	U		Y
Europium-152	pCi/L	05/16/2016	F	T	-14.7	14.1	18.8	U		Y
Europium-154	pCi/L	05/16/2016	F	T	2.14	12.6	24.6	U		Y
Europium-155	pCi/L	05/16/2016	F	T	8.19	14.5	23.4	U		Y
Lead-212	pCi/L	05/16/2016	F	T	-0.331	9.34	14.0	U		Y
pH	s.u.	05/16/2016	F	N	7.84					Y
Potassium-40	pCi/L	05/16/2016	F	T	14.2	64.3	118	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	0.935	5.07	9.41	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	-0.642	5.16	9.18	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	43.4	47.0	86.0	U		Y
Specific Conductance	uS/cm	05/16/2016	F	N	816					Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Kevin Whelan CO-00246-000592

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Temperature	C	05/16/2016	F	N	12.73					Y
Thorium-234	pCi/L	05/16/2016	F	T	203	558	451	U		Y
Tritium	pCi/L	05/16/2016	F	N	16.8	5.05	3.04			Y
Turbidity	NTU	05/16/2016	F	N	1.61					Y
Uranium-235	pCi/L	05/16/2016	F	T	15.1	27.2	40.5	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	203	558	451	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	-1.51	7.73	14.7	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Morrissania Ranch CO-00427-000017

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	-9.16	23.0	34.4	U		Y
Americium-241	pCi/L	05/16/2016	F	T	11.4	26.8	42.0	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	5.97	11.9	21.8	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	-1.08	31.2	52.2	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	2.64	5.49	9.23	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	-2.42	5.05	6.76	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	-4.05	5.53	8.63	U		Y
Europium-152	pCi/L	05/16/2016	F	T	9.60	13.3	20.5	U		Y
Europium-154	pCi/L	05/16/2016	F	T	6.58	16.6	26.1	U		Y
Europium-155	pCi/L	05/16/2016	F	T	-2.06	14.6	24.5	U		Y
Lead-212	pCi/L	05/16/2016	F	T	-3.38	10.2	14.6	U		Y
pH	s.u.	05/16/2016	F	N	8.01					Y
Potassium-40	pCi/L	05/16/2016	F	T	-46.3	71.6	126	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	0.0186	5.57	8.97	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	-2.19	5.31	9.22	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	-24.7	49.4	82.8	U		Y
Specific Conductance	uS/cm	05/16/2016	F	N	461					Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Morrissania Ranch CO-00427-000017

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Temperature	C	05/16/2016	F	N	13.35					Y
Thorium-234	pCi/L	05/16/2016	F	T	160	349	335	U		Y
Tritium	pCi/L	05/16/2016	F	N	92.5	187	320	U		Y
Turbidity	NTU	05/16/2016	F	N	5.07					Y
Uranium-235	pCi/L	05/16/2016	F	T	2.77	32.9	47.1	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	160	349	335	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	7.18	7.82	15.3	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Patrick McCarty CO-00427-000009

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	28.5	28.0	29.1	U		Y
Americium-241	pCi/L	05/16/2016	F	T	4.71	17.5	27.8	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	0.107	9.34	16.7	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	-7.85	24.5	40.8	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	-2.32	4.01	6.81	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	0.390	3.49	6.25	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	-1.4	4.14	6.52	U		Y
Europium-152	pCi/L	05/16/2016	F	T	-11.6	11.7	15.7	U		Y
Europium-154	pCi/L	05/16/2016	F	T	1.88	9.41	17.9	U		Y
Europium-155	pCi/L	05/16/2016	F	T	7.51	11.6	19.8	U		Y
Lead-212	pCi/L	05/16/2016	F	T	-3.45	7.53	12.2	U		Y
pH	s.u.	05/16/2016	F	N	7.93					Y
Potassium-40	pCi/L	05/16/2016	F	T	17.2	60.2	47.0	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	2.23	4.75	7.51	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	0.287	4.27	7.66	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	29.7	31.3	64.4	U		Y
Specific Conductance	uS/cm	05/16/2016	F	N	612					Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Patrick McCarty CO-00427-000009

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Temperature	C	05/16/2016	F	N	12.10					Y
Thorium-234	pCi/L	05/16/2016	F	T	63.1	237	241	U		Y
Tritium	pCi/L	05/16/2016	F	N	64.3	190	328	U		Y
Turbidity	NTU	05/16/2016	F	N	1.47					Y
Uranium-235	pCi/L	05/16/2016	F	T	32.6	38.5	35.3	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	63.1	237	241	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	-1.79	5.60	10.4	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Tim Jacobs Ranch New CO-00427-000146

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	-8.27	17.4	28.7	U		Y
Americium-241	pCi/L	05/16/2016	F	T	-3.85	12.9	21.6	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	8.77	10.6	19.1	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	14.4	23.4	42.5	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	5.65	6.90	7.87	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	-1.75	5.42	7.52	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	0.851	3.59	7.30	U		Y
Europium-152	pCi/L	05/16/2016	F	T	1.52	10.1	18.2	U		Y
Europium-154	pCi/L	05/16/2016	F	T	4.34	10.2	21.0	U		Y
Europium-155	pCi/L	05/16/2016	F	T	-1.69	12.7	20.2	U		Y
Lead-212	pCi/L	05/16/2016	F	T	-3.11	7.50	12.4	U		Y
pH	s.u.	05/16/2016	F	N	7.98					Y
Potassium-40	pCi/L	05/16/2016	F	T	13.6	54.1	84.7	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	-1.46	4.26	7.51	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	0.886	4.16	7.61	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	-6.29	38.3	69.9	U		Y
Specific Conductance	uS/cm	05/16/2016	F	N	359					Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Tim Jacobs Ranch New CO-00427-000146

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Temperature	C	05/16/2016	F	N	9.80					Y
Thorium-234	pCi/L	05/16/2016	F	T	13.2	149	248	U		Y
Tritium	pCi/L	05/16/2016	F	N	164	189	313	U		Y
Turbidity	NTU	05/16/2016	F	N	1.27					Y
Uranium-235	pCi/L	05/16/2016	F	T	-21.3	26.2	38.8	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	13.2	149	248	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	0.283	8.02	15.7	U		Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Wesley Kent House W

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	9.05	14.0	26.8	U		Y
Americium-241	pCi/L	05/16/2016	F	T	-2.14	21.9	33.6	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	-0.495	9.32	16.9	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	9.06	21.0	38.0	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	3.94	4.13	7.84	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	0.658	3.58	6.53	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	-1.56	2.93	5.16	U		Y
Europium-152	pCi/L	05/16/2016	F	T	-4.2	9.50	16.0	U		Y
Europium-154	pCi/L	05/16/2016	F	T	1.07	8.56	16.7	U		Y
Europium-155	pCi/L	05/16/2016	F	T	5.62	10.3	18.7	U		Y
Lead-212	pCi/L	05/16/2016	F	T	4.89	9.08	11.3	U		Y
pH	s.u.	05/16/2016	F	N	6.82					Y
Potassium-40	pCi/L	05/16/2016	F	T	8.51	50.8	100	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	-0.0647	4.23	7.48	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	2.37	4.22	7.81	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	-36.5	46.9	60.1	U		Y
Specific Conductance	uS/cm	05/16/2016	F	N	607					Y

Groundwater Quality Data by Location For Site RUL01, Rulison Site

Location: Wesley Kent House W

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Temperature	C	05/16/2016	F	N	7.34					Y
Thorium-234	pCi/L	05/16/2016	F	T	30.0	238	253	U		Y
Tritium	pCi/L	05/16/2016	F	N	133	193	324	U		Y
Turbidity	NTU	05/16/2016	F	N	2.18					Y
Uranium-235	pCi/L	05/16/2016	F	T	0.0228	30.1	35.2	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	30.0	238	253	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	3.10	7.20	14.6	U		Y

SAMPLE TYPE: D = Duplicate E = Equipment Blank F = Field Sample FB = Field Blank TB = Trip Blank

FRACTION: D = Dissolved N = NA T = Total

MDC / MDL: MDC = Radiochemical minimum detectable concentration MDL = Non-radiochemical minimum detection limit

LAB QUALIFIERS (details can be found in laboratory report):
* = One or more quality control criteria failed (e.g., laboratory control sample, surrogate spike, or calibration verification recovery).
B = Blank contamination. The reported result is associated with a contaminated blank.
D = Result is from the analysis of a diluted sample.
H = Holding time was exceeded.
J = The reported result is an estimated value (e.g., matrix interference was observed or the analyte was detected at a concentration outside the quantitation range).
U = Analytical result is below the MDC or MDL.
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 not detected.
G = Possible grout contamination, pH > 9
Q = Qualitative result due to sampling technique.
X = Location is undefined.
J = Estimated value
R = Rejected, unusable result

QA QUALIFIER: Yes = Validated, acceptable as qualified.

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Surface Water Quality Data

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Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Battlement Creek CO-00246-000459

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	D	1.56	15.9	26.1	U		Y
Americium-241	pCi/L	05/16/2016	F	D	-4.81	19.2	30.4	U		Y
Antimony-125	pCi/L	05/16/2016	F	D	-0.756	9.47	16.7	U		Y
Cerium-144	pCi/L	05/16/2016	F	D	16.5	26.0	44.5	U		Y
Cesium-134	pCi/L	05/16/2016	F	D	0.205	4.20	6.76	U		Y
Cesium-137	pCi/L	05/16/2016	F	D	0.273	3.32	6.19	U		Y
Cobalt-60	pCi/L	05/16/2016	F	D	-1.51	3.92	6.89	U		Y
Europium-152	pCi/L	05/16/2016	F	D	-0.999	10.6	18.1	U		Y
Europium-154	pCi/L	05/16/2016	F	D	3.07	10.1	19.8	U		Y
Europium-155	pCi/L	05/16/2016	F	D	5.76	11.1	19.4	U		Y
Lead-212	pCi/L	05/16/2016	F	D	6.35	8.04	12.6	U		Y
pH	s.u.	05/16/2016	F	N	8.37					Y
Potassium-40	pCi/L	05/16/2016	F	D	39.9	63.8	74.8	U		Y
Promethium-144	pCi/L	05/16/2016	F	D	2.21	3.86	7.18	U		Y
Promethium-146	pCi/L	05/16/2016	F	D	-2.61	4.53	7.32	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	D	-20.4	35.1	59.0	U		Y
SC	uS/cm	05/16/2016	F	N	171					Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Battlement Creek CO-00246-000459

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
TEMP	C	05/16/2016	F	N	7.77					Y
Thorium-234	pCi/L	05/16/2016	F	D	-57.7	180	287	U		Y
Tritium	pCi/L	05/16/2016	F	N	53.2	188	327	U		Y
TURB	NTU	05/16/2016	F	N	36.7					Y
Uranium-235	pCi/L	05/16/2016	F	D	-24.5	29.1	35.3	U		Y
Uranium-238	pCi/L	05/16/2016	F	D	-57.7	180	287	U		Y
Yttrium-88	pCi/L	05/16/2016	F	D	-2.94	6.79	12.1	U		Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: City Springs CO-00246-000058

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	0.00	18.8	2.26	U		Y
Americium-241	pCi/L	05/16/2016	F	T	0.183	15.0	24.5	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	-0.287	9.86	17.6	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	18.3	25.2	39.4	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	1.14	3.75	7.15	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	0.00	6.84	4.40	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	1.70	3.04	6.27	U		Y
Europium-152	pCi/L	05/16/2016	F	T	-2.34	9.83	17.3	U		Y
Europium-154	pCi/L	05/16/2016	F	T	5.40	8.18	17.0	U		Y
Europium-155	pCi/L	05/16/2016	F	T	16.2	16.0	18.9	U		Y
Lead-212	pCi/L	05/16/2016	F	T	3.38	8.57	11.0	U		Y
pH	s.u.	05/16/2016	F	N	6.98					Y
Potassium-40	pCi/L	05/16/2016	F	T	15.2	43.6	59.6	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	0.0715	4.26	7.83	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	0.306	4.24	7.63	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	-0.303	34.5	64.3	U		Y
SC	uS/cm	05/16/2016	F	N	511					Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: City Springs CO-00246-000058

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
TEMP	C	05/16/2016	F	N	13.50					Y
Thorium-234	pCi/L	05/16/2016	F	T	-118	173	245	U		Y
Tritium	pCi/L	05/16/2016	F	N	140	190	319	U		Y
TURB	NTU	05/16/2016	F	N	1.60					Y
Uranium-235	pCi/L	05/16/2016	F	T	-10.3	25.1	34.7	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	-118	173	245	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	0.0526	6.48	12.5	U		Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Potter Ranch CO-00427-000591

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	7.93	20.7	36.5	U		Y
Americium-241	pCi/L	05/16/2016	F	T	-24.4	29.4	47.1	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	12.8	12.6	21.6	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	-21.7	31.4	51.0	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	1.81	4.73	9.05	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	0.143	4.29	7.99	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	-5.28	6.10	8.83	U		Y
Europium-152	pCi/L	05/16/2016	F	T	4.54	11.8	21.0	U		Y
Europium-154	pCi/L	05/16/2016	F	T	-4.96	13.5	23.3	U		Y
Europium-155	pCi/L	05/16/2016	F	T	5.94	16.8	27.6	U		Y
Lead-212	pCi/L	05/16/2016	F	T	6.69	11.7	15.1	U		Y
pH	s.u.	05/16/2016	F	N	7.75					Y
Potassium-40	pCi/L	05/16/2016	F	T	1.81	73.0	82.2	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	-1.86	4.84	8.47	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	-0.35	5.36	9.35	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	-28.6	43.1	71.3	U		Y
SC	uS/cm	05/16/2016	F	N	505					Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Potter Ranch CO-00427-000591

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
TEMP	C	05/16/2016	F	N	12.91					Y
Thorium-234	pCi/L	05/16/2016	F	T	-144	303	458	U		Y
Tritium	pCi/L	05/16/2016	F	N	16.0	4.91	3.61			Y
TURB	NTU	05/16/2016	F	N	0.95					Y
Uranium-235	pCi/L	05/16/2016	F	T	-19.2	31.1	46.7	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	-144	303	458	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	3.42	9.05	18.5	U		Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Spr 300 Yrd N Of GZ CO-00246-000088

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	T	7.08	22.0	33.2	U		Y
Americium-241	pCi/L	05/16/2016	F	T	10.2	35.3	54.6	U		Y
Antimony-125	pCi/L	05/16/2016	F	T	6.91	11.8	21.2	U		Y
Cerium-144	pCi/L	05/16/2016	F	T	-18.6	30.7	46.8	U		Y
Cesium-134	pCi/L	05/16/2016	F	T	0.0437	4.81	8.61	U		Y
Cesium-137	pCi/L	05/16/2016	F	T	1.73	4.62	7.46	U		Y
Cobalt-60	pCi/L	05/16/2016	F	T	0.0837	4.20	7.93	U		Y
Europium-152	pCi/L	05/16/2016	F	T	-3.48	10.6	18.4	U		Y
Europium-154	pCi/L	05/16/2016	F	T	2.07	12.4	23.6	U		Y
Europium-155	pCi/L	05/16/2016	F	T	6.26	14.3	24.8	U		Y
Lead-212	pCi/L	05/16/2016	F	T	9.02	11.5	14.2	U		Y
pH	s.u.	05/16/2016	F	N	7.61					Y
Potassium-40	pCi/L	05/16/2016	F	T	14.5	55.4	93.0	U		Y
Promethium-144	pCi/L	05/16/2016	F	T	3.17	4.89	8.82	U		Y
Promethium-146	pCi/L	05/16/2016	F	T	-1.73	4.89	8.42	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	T	-20	43.6	73.0	U		Y
SC	uS/cm	05/16/2016	F	N	663					Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Spr 300 Yrd N Of GZ CO-00246-000088

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
TEMP	C	05/16/2016	F	N	6.65					Y
Thorium-234	pCi/L	05/16/2016	F	T	96.8	370	517	U		Y
Tritium	pCi/L	05/16/2016	F	N	45.9	185	321	U		Y
TURB	NTU	05/16/2016	F	N	4.17					Y
Uranium-235	pCi/L	05/16/2016	F	T	10.6	36.5	28.5	U		Y
Uranium-238	pCi/L	05/16/2016	F	T	96.8	370	517	U		Y
Yttrium-88	pCi/L	05/16/2016	F	T	8.62	10.0	19.4	U		Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Sprg 500ft E of GZ CO-00246-000012

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
Actinium-228	pCi/L	05/16/2016	F	D	7.39	16.2	30.2	U		Y
Americium-241	pCi/L	05/16/2016	F	D	-4.41	22.1	31.1	U		Y
Antimony-125	pCi/L	05/16/2016	F	D	5.21	9.11	16.6	U		Y
Cerium-144	pCi/L	05/16/2016	F	D	16.4	25.0	42.7	U		Y
Cesium-134	pCi/L	05/16/2016	F	D	1.25	3.59	6.94	U		Y
Cesium-137	pCi/L	05/16/2016	F	D	-0.183	3.60	5.83	U		Y
Cobalt-60	pCi/L	05/16/2016	F	D	-0.996	4.02	6.30	U		Y
Europium-152	pCi/L	05/16/2016	F	D	4.00	10.7	18.0	U		Y
Europium-154	pCi/L	05/16/2016	F	D	-14.8	13.5	13.3	U		Y
Europium-155	pCi/L	05/16/2016	F	D	20.5	14.3	20.9	U		Y
Lead-212	pCi/L	05/16/2016	F	D	0.00726	9.05	12.6	U		Y
pH	s.u.	05/16/2016	F	N	7.90					Y
Potassium-40	pCi/L	05/16/2016	F	D	-18.8	50.6	80.4	U		Y
Promethium-144	pCi/L	05/16/2016	F	D	-0.0372	4.11	7.55	U		Y
Promethium-146	pCi/L	05/16/2016	F	D	1.11	3.90	7.14	U		Y
Ruthenium-106	pCi/L	05/16/2016	F	D	15.4	34.3	65.3	U		Y
SC	uS/cm	05/16/2016	F	N	255					Y

Surface Water Quality Data by Location For Site RUL01, Rulison Site

Location: Sprg 500ft E of GZ CO-00246-000012

Report Date: 01/25/2017

Parameter	Units	Sample Date	Sample Type	Fraction	Result	Uncertainty	MDC/MDL	Lab	Data	QA
TEMP	C	05/16/2016	F	N	5.18					Y
Thorium-234	pCi/L	05/16/2016	F	D	41.6	189	231	U		Y
Tritium	pCi/L	05/16/2016	F	N	-1.66	184	325	U		Y
TURB	NTU	05/16/2016	F	N	19.8					Y
Uranium-235	pCi/L	05/16/2016	F	D	-8.09	26.0	35.6	U		Y
Uranium-238	pCi/L	05/16/2016	F	D	41.6	189	231	U		Y
Yttrium-88	pCi/L	05/16/2016	F	D	1.35	6.65	13.4	U		Y

SAMPLE TYPE: D = Duplicate E = Equipment Blank F = Field Sample FB = Field Blank TB = Trip Blank

FRACTION: D = Dissolved N = NA T = Total

MDC / MDL: MDC = Radiochemical minimum detectable concentration MDL = Non-radiochemical minimum detection limit

LAB QUALIFIERS (details can be found in laboratory report):
* = One or more quality control criteria failed (e.g., laboratory control sample, surrogate spike, or calibration verification recovery).
B = Blank contamination. The reported result is associated with a contaminated blank.
D = Result is from the analysis of a diluted sample.
H = Holding time was exceeded.
J = The reported result is an estimated value (e.g., matrix interference was observed or the analyte was detected at a concentration outside the quantitation range).
U = Analytical result is below the MDC or MDL.
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 not detected.
G = Possible grout contamination, pH > 9
Q = Qualitative result due to sampling technique.
X = Location is undefined.
J = Estimated value
R = Rejected, unusable result

QA QUALIFIER: Yes = Validated, acceptable as qualified.

Attachment 4

Assessment of Anomalous Data

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Potential Outliers Report

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Potential Outliers Report

Potential outliers are results that lie outside the historical range, possibly due to transcription errors, data calculation errors, or measurement system problems. However, outliers can also represent true values outside the historical range. Potential outliers are identified by generating the Data Validation Outliers Report from data in the environmental database. The new data are compared to historical values and data that fall outside the historical data range are listed on the report along with the historical minimum and maximum values. The potential outliers are further reviewed and may be subject to statistical evaluation using the ProUCL application developed by the EPA (https://www.epa.gov/land-research/proucl-software). The review also includes an evaluation of any notable trends in the data that may indicate the outliers represent true extreme values. There were no potential outliers identified, and the data for this event are acceptable as qualified.

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