



June 24, 2022

Mr. James Smith  
U.S. Nuclear Regulatory Commission  
11555 Rockville Pike  
Rockville, MD 20852-2738

Mr. Paul Davis  
Oklahoma Department of Environmental Quality  
707 North Robinson  
Oklahoma City, OK 73101

Mr. Robert Evans  
U.S. Nuclear Regulatory Commission  
1600 East Lamar Blvd; Suite 400  
Arlington, TX 76011-4511

Re: Docket No. 07000925; License No. SNM-928  
Cimarron Environmental Response Trust  
Uranium Daughters in Groundwater

Dear Sirs:

Solely as Trustee for the Cimarron Environmental Response Trust (CERT), Environmental Properties Management LLC (EPM) submits herein information on the potential presence of certain radionuclides in groundwater at the Cimarron site. This document is a revision of the May 2, 2022, submittal with the same title; it contains corrections in response to comments by the Oklahoma Department of Environmental Quality (DEQ).

In a letter dated August 11, 2021, the U. S. Nuclear Regulatory Commission (NRC) requested information regarding the potential presence of daughter radionuclides in groundwater. On November 23, 2021, EPM provided information on the daughters of U-235 and U-238 that may be present in groundwater.

EPM provided analytical results for groundwater samples collected in October (Attachments 1 and 2) to the NRC and the DEQ in a December 1, 2021, email. EPM further discussed the presence (of lack thereof) of uranium daughters in groundwater at the Cimarron site.

In a letter dated January 19, 2022, the Oklahoma Department of Environmental Quality (DEQ) stated that the information provided by EPM in the December 1, 2021, email did not mention U-234 (as a daughter of uranium) and asked if it is reasonable to state that the U-234 was already present in the feedstock received by the facility.

The intent of this letter is to present a fuller explanation of our understanding regarding daughter radionuclides in site groundwater and to respond to the DEQ's question regarding the source of the U-234 detected in site groundwater.

### U-234 in the Uranium Feedstock

Purified enriched uranium was received by the Cimarron facility as gaseous uranium hexafluoride (UF<sub>6</sub>). The ratio of uranium isotopes in the feedstock varied as the U-235 enrichment varied. Enrichment is expressed in terms of the weight percent (wt. %) of the mass of U-235 relative to the mass of all uranium isotopes. Attachment 3 presents the percentage of the total mass of uranium for all three uranium isotopes as enrichment increases.

As enrichment increases, the total activity per gram of total uranium increases. Attachment 3 shows that the activity per gram of 5% enriched uranium is over 3½ times the activity per gram of natural uranium (0.711 wt. % U-235). Based on the specific activity of each uranium isotope, the activity percentage for each isotope was calculated.

The Cimarron facility received UF<sub>6</sub> with a wide range of enrichment values. In 2017-2018, Enercon Services, Inc. evaluated the enrichment of groundwater in areas where the concentration of uranium exceeds the NRC criterion for groundwater. Enrichment values varied from 1.3% in Burial Area #1 (BA1) to 2.9% in the WAA U>DCGL remediation area.

Looking at the graph in Attachment 3, at 1.3% enrichment, 100 pCi/g of total uranium activity in the feedstock would consist of approximately 60 pCi/g of U-234, 3 pCi/g of U-235, and 37 pCi/g of U-238. At 2.9% enrichment, 100 pCi/g of total uranium activity in the feedstock would consist of approximately 75 pCi/g of U-234, 4 pCi/g of U-235, and 21 pCi/g of U-238. This means that the feedstock received by the Cimarron facility contained U-234 at significantly higher activity concentrations than that of U-238, although the mass concentration of U-238 would have consistently been above 95% of the total uranium mass concentration.

### Daughter Radionuclides in the Feedstock

The facility received chemically purified uranium, which means that when the UF<sub>6</sub> was produced it did not contain any daughter isotopes. Attachment 4 presents the decay chains for U-235 and U-238. These charts provide the half-lives of each radionuclide in the decay chain. After seven half-lives, the activity of a daughter radionuclide would become essentially equal to the activity of the parent. The decay chain for U-235 indicates that only one week would be required for Th-231 to achieve the same activity as U-235, whereas it would take over two hundred thousand years for Pa-231 to achieve that activity.

The decay chain for U-238 indicates that approximately seven months would be required for Th-234 (and then only minutes for Pa-234) to reach equilibrium with U-238, but it would take most of two million years for U-234 to achieve that same activity. With the passage of only five decades, the activity concentration of U-234 generated from the decay of U-238 would be far less than 0.01% of the activity concentration of the U-238. Consequently, the only U-234 that could be present in groundwater (excluding naturally occurring uranium) is the U-234 that was received in the feedstock.

If we assume that the licensed material was still on site for at least seven months after the production of the UF<sub>6</sub>, then the activity concentration of Th-234 and Pa-234 would be the same as the U-238, and the activity concentration of Th-231 would be the same as the U-235.

With a half-life of over 75,000 years, Th-230 would not achieve equilibrium with its parent U-234 for several hundred thousand years; hence, similar to the above description of U-234, the activity concentration of Th-230 generated from the decay of U-234 would be less than 0.01% of the activity concentration of U-234.

#### Daughter Radionuclides in Groundwater

It is important to understand that the presence of uranium in groundwater does not mean that its short-lived daughters are present in the groundwater. When uranium decays by alpha emission, the thorium daughters that are formed are chemically different from their uranium parent. Their presence in groundwater would be a function of the solubility of the thorium compound that is created. If the distribution coefficient ( $K_d$ ) for the thorium compound that forms when uranium undergoes decay is significantly higher than that of the uranium compound, the thorium will sorb onto soil particles and no longer remain in solution.

The activity concentration of uranium in groundwater in the WAA U>DCGL remediation area has rarely exceeded 200 pCi/L total uranium since 2010. At 2.9% enrichment, 200 pCi/L total uranium would yield approximately 150 pCi/L U-234, 8 pCi/L U-235, and 42 pCi/L U-238. If the thorium and protactinium daughters were in equilibrium (in the groundwater) with the parent uranium isotopes, you would expect to have 8 pCi/L Th-231 and 42 pCi/L Th-234 and Pa-234 in the groundwater. With detection limits of 100 pCi/L for Th-231 and Pa-231, and 400 pCi/L for Th-234, none of these daughter isotopes could be detected.

Burial Area #1 is the only remediation area in which uranium activity concentrations are high enough that daughter radionuclides may be detected. Four monitor wells that were to be sampled during the 4<sup>th</sup> quarter 2021 redox sampling event routinely yield over 700 pCi/L total uranium; two routinely yield over 1,600 pCi/L total uranium. At 1.3% enrichment, 1,600 pCi/L total uranium would yield approximately 960 pCi/L U-234, 48 pCi/L U-235, and 592 pCi/L U-238. If (in the groundwater) the thorium and protactinium daughters were in equilibrium with the parent uranium isotopes, you would expect to have 48 pCi/L Th-231, 592 pCi/L Th-234, and 592 pCi/L Pa-234 in the groundwater. Th-231 would not be detectable at 48 pCi/L, but both Th-234 and Pa-234 would be.

The half-life of Pa-234 is less than 2 minutes, and the groundwater samples were analyzed for thorium and protactinium twelve days after the sample was collected. If any groundwater sample contained over 100 pCi/L Th-234, the concentration of Pa-234 would have been above its detection limit. Attachments 1 and 2 show that none of the daughter radionuclides were detected in any of the groundwater samples, so no sample could have contained over 100 pCi/L Th-234.



## Conclusion

None of the uranium daughters were detected in any of the groundwater samples submitted for isotopic analysis. The data demonstrates that the short-lived daughters of uranium can at most be present in groundwater at the Cimarron site at a small fraction of the concentration of the uranium parent radionuclides.

The uranium in recovered groundwater will be captured by ion exchange resin, and it is anticipated that the ion exchange resin will continue to adsorb uranium for several months between change-outs. The daughter radionuclides may be present in the ion exchange resin; even if the resin does not capture any of the daughter radionuclides, they will not be detectable in the effluent.

Please call me at (405) 642-5152, email me at [jlux@envpm.com](mailto:jlux@envpm.com), or respond by written correspondence should you have questions or desire clarification.

Sincerely,



Jeff Lux, P.E.  
Project Manager

cc: Michael Broderick, Oklahoma Department of Environmental Quality  
NRC Public Document Room



ATTACHMENT 1  
GEL LABORATORY REPORT  
NOVEMBER 11, 2021



a member of **The GEL Group** INC

PO Box 30712 Charleston, SC 29417  
2040 Savage Road Charleston, SC 29407  
P 843.556.8171  
F 843.766.1178

[gel.com](http://gel.com)

November 11, 2021

Mr. Jeff Lux  
Environmental Properties Management, LLC  
615 N. Hudson  
Suite 200  
Oklahoma City, Oklahoma 73102

Re: Uranium Daughter Activities Evaluation  
Work Order: 559068

Dear Mr. Lux:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the following analytical results for the sample(s) we received on October 15, 2021. This original data report has been prepared and reviewed in accordance with GEL's standard operating procedures.

Test results for NELAP or ISO 17025 accredited tests are verified to meet the requirements of those standards, with any exceptions noted. The results reported relate only to the items tested and to the sample as received by the laboratory. These results may not be reproduced except as full reports without approval by the laboratory. Copies of GEL's accreditations and certifications can be found on our website at [www.gel.com](http://www.gel.com).

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4289.

Sincerely,

Grace Bodiford for  
Julie Robinson  
Project Manager

Purchase Order: 176069  
Chain of Custody: 2021-059  
Enclosures



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# Case Narrative

**CASE NARRATIVE  
for  
Burns & McDonnell  
Uranium Daughter Activities Evaluation  
SDG:559068**

**November 11, 2021**

**Laboratory Identification:**

GEL Laboratories LLC  
2040 Savage Road  
Charleston, South Carolina 29407  
(843) 556-8171

**Summary**

**Sample receipt** The samples arrived at GEL Laboratories LLC, Charleston, South Carolina on October 15, 2021 for analysis. The samples were delivered with proper chain of custody documentation and signatures. All sample containers arrived without any visible signs of tampering or breakage. There are no additional comments concerning sample receipt.

**Items of Note** There are no additional items of note concerning this SDG.

**Sample Identification** The laboratory received the following samples:

<u>Laboratory ID</u>	<u>Client ID</u>
559068001	TMW-13
559068002	02W02
559068003	02W01
559068004	TMW-09

**Case Narrative**

Sample analyses were conducted using methodology as outlined in GEL Laboratories, LLC (GEL) Standard Operating Procedures. Any technical or administrative problems during analysis, data review, and reduction are contained in the analytical case narratives in the enclosed data package.

**Data Package**

The enclosed data package contains the following sections: Case Narrative, Chain of Custody, Cooler Receipt Checklist, Data Package Qualifier Definitions and data from the following fractions: Radiochemistry.

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This data package, to the best of my knowledge, is in compliance with technical and administrative requirements.

*Grace Bodiford*

Grace Bodiford for  
Julie Robinson  
Project Manager



# **Chain of Custody and Supporting Documentation**

PAGE 1 OF 1

DATE: 10/14/2021

JR



Laboratories LLC

**SAMPLE RECEIPT & REVIEW FORM**

Client: <u>CMRN</u>		SDG/AR/COC/Work Order: <u>559063</u>	
Received By: <u>BE</u>		Date Received: <u>10/15/21</u>	
Carrier and Tracking Number		Circle Applicable: <input checked="" type="radio"/> FedEx Express <input type="radio"/> FedEx Ground <input type="radio"/> UPS <input type="radio"/> Field Services <input type="radio"/> Courier <input type="radio"/> Other	
		<u>2848 9647 6414</u> <u>2848 9647 3757</u>	
Suspected Hazard Information	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.	
A) Shipped as a DOT Hazardous?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Hazard Class Shipped: _____ UN#: _____ If UN2910, Is the Radioactive Shipment Survey Compliant? Yes <input type="checkbox"/> No <input type="checkbox"/>	
B) Did the client designate the samples are to be received as radioactive?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	COC notation or radioactive stickers on containers equal client designation.	
C) Did the RSO classify the samples as radioactive?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): <u>00</u> CPM, mR/Hr Classified as: Rad 1    Rad 2    Rad 3	
D) Did the client designate samples are hazardous?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	COC notation or hazard labels on containers equal client designation.	
E) Did the RSO identify possible hazards?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	If D or E is yes, select Hazards below. PCB's    Flammable    Foreign Soil    RCRA    Asbestos    Beryllium    Other: _____	

Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1 Shipping containers received intact and sealed?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Circle Applicable: Seals broken    Damaged container    Leaking container    Other (describe)
2 Chain of custody documents included with shipment?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Circle Applicable: Client contacted and provided COC    COC created upon receipt
3 Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Preservation Method: Wet Ice    Ice Packs    Dry ice <input checked="" type="radio"/> None    Other: _____ *all temperatures are recorded in Celsius                      TEMP: <u>24</u>
4 Daily check performed and passed on IR temperature gun?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Temperature Device Serial #: <u>IR2-21</u> Secondary Temperature Device Serial # (If Applicable): _____
5 Sample containers intact and sealed?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Circle Applicable: Seals broken    Damaged container    Leaking container    Other (describe)
6 Samples requiring chemical preservation at proper pH?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Sample ID's and Containers Affected: _____ If Preservation added, Lot#: _____
7 Do any samples require Volatile Analysis?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	If Yes, are Encores or Soil Kits present for solids? Yes <input type="checkbox"/> No <input type="checkbox"/> NA <input type="checkbox"/> (If yes, take to VOA Freezer)
				Do liquid VOA vials contain acid preservation? Yes <input type="checkbox"/> No <input type="checkbox"/> NA <input type="checkbox"/> (If unknown, select No)
				Are liquid VOA vials free of headspace? Yes <input type="checkbox"/> No <input type="checkbox"/> NA <input type="checkbox"/>
8 Samples received within holding time?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Sample ID's and containers affected: _____
9 Sample ID's on COC match ID's on bottles?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	ID's and containers affected: _____
10 Date & time on COC match date & time on bottles?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Circle Applicable: No dates on containers    No times on containers    COC missing info    Other (describe)
11 Number of containers received match number indicated on COC?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Circle Applicable: No container count on COC    Other (describe)
12 Are sample containers identifiable as GEL provided by use of GEL labels?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
13 COC form is properly signed in relinquished/received sections?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Circle Applicable: Not relinquished    Other (describe)

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials NRL Date 10/18/21 Page 1 of 1



# **Laboratory Certification**

**List of current GEL Certifications as of 11 November 2021**

<b>State</b>	<b>Certification</b>
Alabama	42200
Alaska	17-018
Alaska Drinking Water	SC00012
Arkansas	88-0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH-0169
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330-15-00283, P330-15-00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho	SC00012
Illinois NELAP	200029
Indiana	C-SC-01
Kansas NELAP	E-10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana Drinking Water	LA024
Louisiana NELAP	03046 (AI33904)
Maine	2019020
Maryland	270
Massachusetts	M-SC012
Massachusetts PFAS Approv	Letter
Michigan	9976
Mississippi	SC00012
Nebraska	NE-OS-26-13
Nevada	SC000122021-1
New Hampshire NELAP	2054
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R-158
Oklahoma	2019-165
Pennsylvania NELAP	68-00485
Puerto Rico	SC00012
S. Carolina Radiochem	10120002
Sanitation Districts of L	9255651
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235-21-19
Utah NELAP	SC000122021-36
Vermont	VT87156
Virginia NELAP	460202
Washington	C780

# **Radiological Analysis**

# Case Narrative

**Radiochemistry  
Technical Case Narrative  
Burns & McDonnell  
SDG #: 559068**

**Product:** Alphaspec U, Liquid

**Analytical Method:** DOE EML HASL-300, U-02-RC Modified

**Analytical Procedure:** GL-RAD-A-011 REV# 28

**Analytical Batch:** 2191040

The following samples were analyzed using the above methods and analytical procedure(s).

<b><u>GEL Sample ID#</u></b>	<b><u>Client Sample Identification</u></b>
559068001	TMW-13
559068002	02W02
559068003	02W01
559068004	TMW-09
1204943045	Method Blank (MB)
1204943046	559068001(TMW-13) Sample Duplicate (DUP)
1204943047	Laboratory Control Sample (LCS)

The samples in this SDG were analyzed on an "as received" basis.

**Data Summary:**

There are no exceptions, anomalies or deviations from the specified methods. All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable.

**Product:** Gammaspec, Gamma, Liquid

**Analytical Method:** EPA 901.1

**Analytical Procedure:** GL-RAD-A-013 REV# 27

**Analytical Batch:** 2186917

The following samples were analyzed using the above methods and analytical procedure(s).

<b><u>GEL Sample ID#</u></b>	<b><u>Client Sample Identification</u></b>
559068001	TMW-13
559068002	02W02
559068003	02W01
559068004	TMW-09
1204934355	Method Blank (MB)
1204934356	559068001(TMW-13) Sample Duplicate (DUP)
1204934357	Laboratory Control Sample (LCS)

The samples in this SDG were analyzed on an "as received" basis.



**Data Summary:**

There are no exceptions, anomalies or deviations from the specified methods. All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable.

**Qualifier Information**

<b>Qualifier</b>	<b>Reason</b>	<b>Analyte</b>	<b>Sample</b>	<b>Client Sample</b>
UI	Results are considered a false positive due to high peak-width.	Thorium-234	559068004	TMW-09
UI	Results are considered a false positive due to interference.	Thorium-231	559068001	TMW-13

**Certification Statement**

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

## GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

### Qualifier Definition Report for

CMRN001 Burns & McDonnell

Client SDG: 559068 GEL Work Order: 559068

#### The Qualifiers in this report are defined as follows:

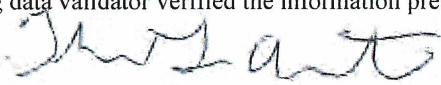
- \* A quality control analyte recovery is outside of specified acceptance criteria
- \*\* Analyte is a Tracer compound
- U Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
- UI Gamma Spectroscopy--Uncertain identification

#### Review/Validation

GEL requires all analytical data to be verified by a qualified data reviewer. In addition, all CLP-like deliverables receive a third level review of the fractional data package.

The following data validator verified the information presented in this data report:

Signature:



Name: Theresa Austin

Date: 11 NOV 2021

Title: Group Leader

# **Sample Data Summary**

# GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

## Certificate of Analysis

Company : Environmental Properties  
Address : Management, LLC  
615 N. Hudson  
Suite 200  
Oklahoma City, Oklahoma 73102  
Contact: Mr. Jeff Lux  
Project: Uranium Daughter Activities Evaluation

Report Date: November 11, 2021

Client Sample ID: TMW-13  
Sample ID: 559068001  
Matrix: Water  
Collect Date: 13-OCT-21  
Receive Date: 15-OCT-21  
Collector: Client  
Project: CMRN00620  
Client ID: CMRN001

Parameter	Qualifier	Result	Uncertainty	MDC	TPU	RL	Units	PF	DF	Analyst	Date	Time	Batch	Mtd.
<b>Rad Alpha Spec Analysis</b>														
<i>Alphaspec U, Liquid "As Received"</i>														
Uranium-233/234		602	+/-21.8	1.84	+/-130	1.00	pCi/L			BVI	11/10/21	1131	2191040	1
Uranium-235/236		38.4	+/-6.14	1.21	+/-10.2	1.00	pCi/L							
Uranium-238		364	+/-16.9	1.51	+/-79.3	1.00	pCi/L							
<b>Rad Gamma Spec Analysis</b>														
<i>Gammasec, Gamma, Liquid "As Received"</i>														
Protactinium-234	U	24.4	+/-30.3	71.2	+/-42.6		pCi/L			MXR1	10/25/21	0845	2186917	2
Thorium-231	UI	0.000	+/-108	107	+/-110		pCi/L							
Thorium-234	U	80.3	+/-311	585	+/-314		pCi/L							

### The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, U-02-RC Modified
2	EPA 901.1

Surrogate/Tracer Recovery	Test	Batch ID	Recovery%	Acceptable Limits
Uranium-232 Tracer	Alphaspec U, Liquid "As Received"	2191040	30.1	(15%-125%)

### Notes:

The MDC is a sample specific MDC.  
TPU and Counting Uncertainty are calculated at the 95% confidence level (1.96-sigma).

### Column headers are defined as follows:

DF: Dilution Factor  
DL: Detection Limit  
Lc/LC: Critical Level  
MDA: Minimum Detectable Activity  
MDC: Minimum Detectable Concentration  
Mtd.: Method  
PF: Prep Factor  
RL: Reporting Limit  
TPU: Total Propagated Uncertainty

# GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

## Certificate of Analysis

Company : Environmental Properties  
Address : Management, LLC  
615 N. Hudson  
Suite 200  
Oklahoma City, Oklahoma 73102

Report Date: November 11, 2021

Contact: Mr. Jeff Lux  
Project: Uranium Daughter Activities Evaluation

Client Sample ID: 02W02  
Sample ID: 559068002  
Matrix: Water  
Collect Date: 13-OCT-21  
Receive Date: 15-OCT-21  
Collector: Client

Project: CMRN00620  
Client ID: CMRN001

Parameter	Qualifier	Result	Uncertainty	MDC	TPU	RL	Units	PF	DF	Analyst	Date	Time	Batch	Mtd.
<b>Rad Alpha Spec Analysis</b>														
<i>Alphaspec U, Liquid "As Received"</i>														
Uranium-233/234		418	+/-17.5	2.12	+/-88.9	1.00	pCi/L			BV1	11/10/21	1131	2191040	1
Uranium-235/236		38.2	+/-5.91	1.13	+/-9.93	1.00	pCi/L							
Uranium-238		309	+/-15.1	1.71	+/-66.1	1.00	pCi/L							
<b>Rad Gamma Spec Analysis</b>														
<i>Gammasespec, Gamma, Liquid "As Received"</i>														
Protactinium-234	U	-14.5	+/-26.3	49.0	+/-31.8		pCi/L			MXR1	10/25/21	0845	2186917	2
Thorium-231	U	2.05	+/-77.5	128	+/-77.5		pCi/L							
Thorium-234	U	-247	+/-321	577	+/-344		pCi/L							

### The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, U-02-RC Modified
2	EPA 901.1

Surrogate/Tracer Recovery	Test	Batch ID	Recovery%	Acceptable Limits
Uranium-232 Tracer	Alphaspec U, Liquid "As Received"	2191040	30.7	(15%-125%)

### Notes:

The MDC is a sample specific MDC.  
TPU and Counting Uncertainty are calculated at the 95% confidence level (1.96-sigma).

### Column headers are defined as follows:

DF: Dilution Factor	Mtd.: Method
DL: Detection Limit	PF: Prep Factor
Lc/LC: Critical Level	RL: Reporting Limit
MDA: Minimum Detectable Activity	TPU: Total Propagated Uncertainty
MDC: Minimum Detectable Concentration	



# GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

## Certificate of Analysis

Company : Environmental Properties  
Address : Management, LLC  
615 N. Hudson  
Suite 200  
Oklahoma City, Oklahoma 73102

Report Date: November 11, 2021

Contact: Mr. Jeff Lux  
Project: Uranium Daughter Activities Evaluation

Client Sample ID: 02W01  
Sample ID: 559068003  
Matrix: Water  
Collect Date: 13-OCT-21  
Receive Date: 15-OCT-21  
Collector: Client

Project: CMRN00620  
Client ID: CMRN001

Parameter	Qualifier	Result	Uncertainty	MDC	TPU	RL	Units	PF	DF	Analyst	Date	Time	Batch	Mtd.
<b>Rad Alpha Spec Analysis</b>														
<i>Alphaspec U, Liquid "As Received"</i>														
Uranium-233/234		1040	+/-35.3	3.22	+/-281	1.00	pCi/L			BV1	11/10/21	1356	2191040	1
Uranium-235/236		74.2	+/-10.5	1.15	+/-22.4	1.00	pCi/L							
Uranium-238		604	+/-26.9	2.05	+/-164	1.00	pCi/L							
<b>Rad Gamma Spec Analysis</b>														
<i>Gammasepec, Gamma, Liquid "As Received"</i>														
Protactinium-234	U	3.89	+/-38.5	79.2	+/-38.8		pCi/L			MXR1	10/25/21	0846	2186917	2
Thorium-231	U	77.6	+/-145	109	+/-145		pCi/L							
Thorium-234	U	-222	+/-322	559	+/-342		pCi/L							

### **The following Analytical Methods were performed**

Method	Description
1	DOE EML HASL-300, U-02-RC Modified
2	EPA 901.1

Surrogate/Tracer Recovery	Test	Batch ID	Recovery%	Acceptable Limits
Uranium-232 Tracer	Alphaspec U, Liquid "As Received"	2191040	18.4	(15%-125%)

### **Notes:**

The MDC is a sample specific MDC.  
TPU and Counting Uncertainty are calculated at the 95% confidence level (1.96-sigma).

### Column headers are defined as follows:

DF: Dilution Factor	Mtd.: Method
DL: Detection Limit	PF: Prep Factor
Lc/LC: Critical Level	RL: Reporting Limit
MDA: Minimum Detectable Activity	TPU: Total Propagated Uncertainty
MDC: Minimum Detectable Concentration	

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## Certificate of Analysis

Company : Environmental Properties  
Address : Management, LLC  
615 N. Hudson  
Suite 200  
Oklahoma City, Oklahoma 73102  
Contact: Mr. Jeff Lux  
Project: Uranium Daughter Activities Evaluation

Report Date: November 11, 2021

Client Sample ID: TMW-09  
Sample ID: 559068004  
Matrix: Water  
Collect Date: 13-OCT-21  
Receive Date: 15-OCT-21  
Collector: Client

Project: CMRN00620  
Client ID: CMRN001

Parameter	Qualifier	Result	Uncertainty	MDC	TPU	RL	Units	PF	DF	Analyst	Date	Time	Batch	Mtd.
<b>Rad Alpha Spec Analysis</b>														
<i>Alphaspec U, Liquid "As Received"</i>														
Uranium-233/234		950	+/-29.3	1.97	+/-216	1.00	pCi/L			BV1	11/10/21	1356	2191040	1
Uranium-235/236		58.0	+/-8.08	1.61	+/-15.4	1.00	pCi/L							
Uranium-238		660	+/-24.4	1.74	+/-151	1.00	pCi/L							
<b>Rad Gamma Spec Analysis</b>														
<i>Gammasec, Gamma, Liquid "As Received"</i>														
Protactinium-234	U	-13.4	+/-47.6	84.7	+/-50.4		pCi/L			MXR1	10/25/21	0854	2186917	2
Thorium-231	U	-8.39	+/-95.9	165	+/-95.9		pCi/L							
Thorium-234	UI	0.000	+/-815	530	+/-843		pCi/L							

### The following Analytical Methods were performed

Method	Description
1	DOE EML HASL-300, U-02-RC Modified
2	EPA 901.1

Surrogate/Tracer Recovery	Test	Batch ID	Recovery%	Acceptable Limits
Uranium-232 Tracer	Alphaspec U, Liquid "As Received"	2191040	26.7	(15%-125%)

### Notes:

The MDC is a sample specific MDC.

TPU and Counting Uncertainty are calculated at the 95% confidence level (1.96-sigma).

### Column headers are defined as follows:

DF: Dilution Factor

DL: Detection Limit

Lc/LC: Critical Level

MDA: Minimum Detectable Activity

MDC: Minimum Detectable Concentration

Mtd.: Method

PF: Prep Factor

RL: Reporting Limit

TPU: Total Propagated Uncertainty

# **Quality Control Summary**

# GEL LABORATORIES LLC

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## QC Summary

Client : Environmental Properties Management, LLC  
615 N. Hudson  
Suite 200  
Oklahoma City, Oklahoma

Contact: Mr. Jeff Lux

Workorder: 559068

Report Date: November 11, 2021  
Page 1 of 3

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
Rad Alpha Spec											
Batch	2191040										
QC1204943046 559068001 DUP											
Uranium-233/234		602		553	pCi/L	8.45		(0%-20%)	BV1	11/10/21	13:56
	Uncert:	+/-21.8		+/-20.2							
	TPU:	+/-130		+/-120							
Uranium-235/236		38.4		32.7	pCi/L	16.2		(0%-20%)			
	Uncert:	+/-6.14		+/-5.48							
	TPU:	+/-10.2		+/-8.88							
Uranium-238		364		339	pCi/L	7.03		(0%-20%)			
	Uncert:	+/-16.9		+/-15.8							
	TPU:	+/-79.3		+/-74.3							
QC1204943047 LCS											
Uranium-233/234				26.0	pCi/L				BV1	11/10/21	13:56
	Uncert:			+/-2.57							
	TPU:			+/-4.32							
Uranium-235/236				1.39	pCi/L						
	Uncert:			+/-0.692							
	TPU:			+/-0.716							
Uranium-238	27.1			28.4	pCi/L		105	(75%-125%)			
	Uncert:			+/-2.67							
	TPU:			+/-4.63							
QC1204943045 MB											
Uranium-233/234			U	-0.0464	pCi/L				BV1	11/10/21	13:56
	Uncert:			+/-0.258							
	TPU:			+/-0.258							
Uranium-235/236			U	0.0245	pCi/L						
	Uncert:			+/-0.256							
	TPU:			+/-0.256							
Uranium-238			U	0.252	pCi/L						
	Uncert:			+/-0.351							
	TPU:			+/-0.353							
Rad Gamma Spec											
Batch	2186917										
QC1204934356 559068001 DUP											
Protactinium-234	U	24.4	U	-41.4	pCi/L	0			N/A MXR1	10/25/21	11:07
	Uncert:	+/-30.3		+/-45.0							
	TPU:	+/-42.6		+/-68.1							
Thorium-231	UI	0.000	U	43.4	pCi/L	0			N/A		
	Uncert:	+/-108		+/-106							
	TPU:	+/-110		+/-106							
Thorium-234	U	80.3	U	241	pCi/L	0			N/A		
	Uncert:	+/-311		+/-430							
	TPU:			+/-434							

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## QC Summary

Workorder: 559068

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Parname	NOM	Sample Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gamma Spec									
Batch 2186917									
+/-314									
QC1204934357 LCS									
Americium-241	1.09E+05		1.18E+05	pCi/L		109	(75%-125%)	MXR1	10/25/2109:15
	Uncert:		+/-2070						
	TPU:		+/-11100						
Cesium-137	37800		39900	pCi/L		105	(75%-125%)		
	Uncert:		+/-676						
	TPU:		+/-3450						
Cobalt-60	21400		22700	pCi/L		106	(75%-125%)		
	Uncert:		+/-614						
	TPU:		+/-2140						
Protactinium-234		U	70.5	pCi/L					
	Uncert:		+/-1200						
	TPU:		+/-1210						
Thorium-231		U	93.4	pCi/L					
	Uncert:		+/-990						
	TPU:		+/-991						
Thorium-234		U	-1060	pCi/L					
	Uncert:		+/-2650						
	TPU:		+/-2700						
QC1204934355 MB									
Protactinium-234		U	3.80	pCi/L				MXR1	10/25/2108:46
	Uncert:		+/-41.5						
	TPU:		+/-41.7						
Thorium-231		U	19.8	pCi/L					
	Uncert:		+/-45.4						
	TPU:		+/-46.3						
Thorium-234		U	-185	pCi/L					
	Uncert:		+/-219						
	TPU:		+/-238						

### Notes:

TPU and Counting Uncertainty are calculated at the 95% confidence level (1.96-sigma).

The Qualifiers in this report are defined as follows:

- \*\* Analyte is a Tracer compound
- < Result is less than value reported
- > Result is greater than value reported
- BD Results are either below the MDC or tracer recovery is low
- FA Failed analysis.
- H Analytical holding time was exceeded
- J See case narrative for an explanation
- J Value is estimated
- K Analyte present. Reported value may be biased high. Actual value is expected to be lower.
- L Analyte present. Reported value may be biased low. Actual value is expected to be higher.



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### QC Summary

Workorder: 559068

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Parmname	NOM	Sample Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
M	M if above MDC and less than LLD									
M	REMP Result > MDC/CL and < RDL									
N/A	RPD or %Recovery limits do not apply.									
NI	See case narrative									
ND	Analyte concentration is not detected above the detection limit									
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier									
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.									
R	Sample results are rejected									
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.									
UI	Gamma Spectroscopy--Uncertain identification									
UJ	Gamma Spectroscopy--Uncertain identification									
UL	Not considered detected. The associated number is the reported concentration, which may be inaccurate due to a low bias.									
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier									
Y	Other specific qualifiers were required to properly define the results. Consult case narrative.									
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.									
h	Preparation or preservation holding time was exceeded									

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.

\*\* Indicates analyte is a surrogate/tracer compound.

^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.

For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

ATTACHMENT 2  
TABULATED DATA SUMMARY

**Cimarron Environmental Response Trust**  
**Evaluation of Uranium Daughters in Groundwater**

Activity (pCi/L)	Monitor Well															
	TMW-13				02W02				02W01				TMW-09			
	Result	Uncertainty	Qual	DL	Result	Uncertainty	Qual	DL	Result	Uncertainty	Qual	DL	Result	Uncertainty	Qual	DL
U-238	364	16.9		1.51	309	15.1		1.71	604	26.9		2.05	660	24.4		1.74
Th-234	80.3	311	U	585	-247	321	U	577	-222	322	U	559	0	815	UI	530
Pa-234	24.4	30.3	U	71.2	-14.5	26.3	U	49	3.89	38.5	U	79.2	-13.4	47.6	U	84.7
U-235	38.4	6.14		1.21	38.2	5.91		1.13	74.2	10.5		1.15	58	8.08		1.61
Th-231	0	108	UI	107	2.05	77.5	U	128	77.6	145	U	109	-13.4	47.6	U	84.7
U-234	602	21.8		1.84	418	17.5		2.12	1040	35.3		3.22	950	29.3		1.97

The detection limit for Th-234 is too high relative to the U-238 activities to tell us anything - but Th-234 was never detected.

Pa-234 was never detected, but the detection limit (that was never reached) was a small fraction of the U-238 activity - listed below.

Notes:

TMW-13 Pa-234 DL:U-238 Ratio  
0.20

02W02 Pa-234 DL:U-238 Ratio  
0.16

02W01 Pa-234 DL:U-238 Ratio  
0.13

TMMW-09 Pa-234 DL:U-238 Ratio  
0.13

The detection limit for Th-231 is too high relative to the U-234 activities to tell us anything - but Th-231 was never detected.

ATTACHMENT 3  
DISTRIBUTION OF URANIUM ISOTOPES  
IN ENRICHED URANIUM

# ATTACHMENT 3

## DISTRIBUTION OF URANIUM ISOTOPES IN ENRICHED URANIUM

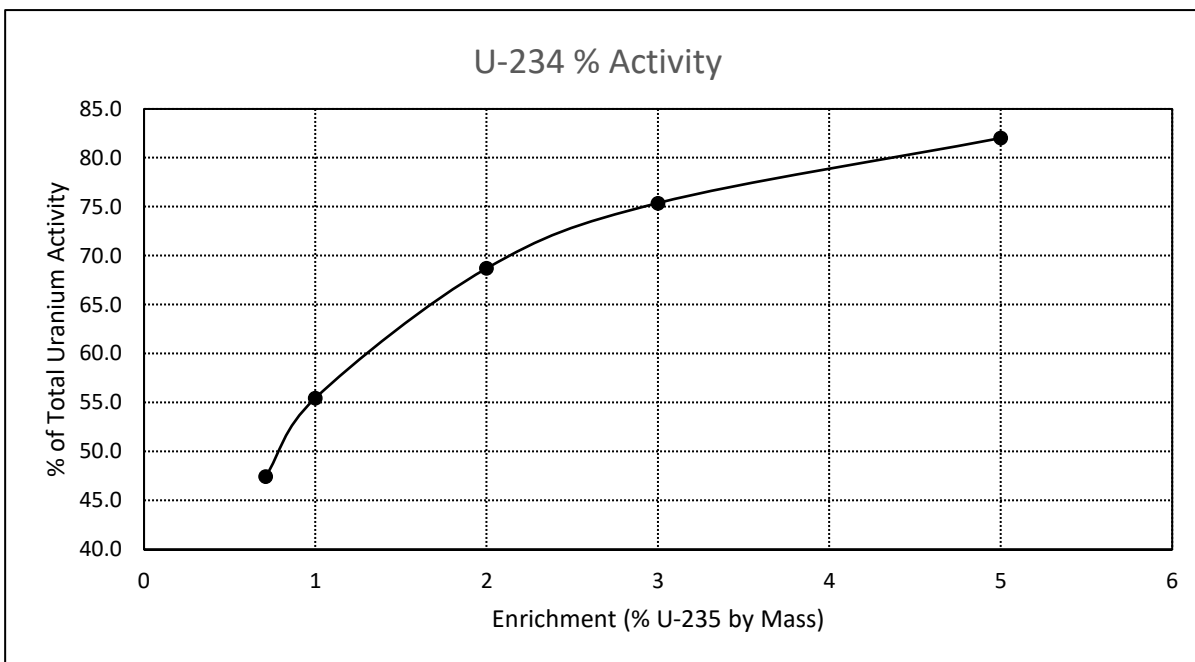
Enrichment (% U-235 by Mass)	Percent Total Mass		
	U-234	U-235	U-238
0.711	0.005	0.711	99.284
1	0.007	1	98.993
2	0.013	2	97.987
3	0.019	3	96.981
5	0.031	5	94.969

Specific Activity (pCi/μg)	
U-234	6.19E+03
U-235	2.14E+00
U-238	3.30E-01

Above Data from Determination of Conservative U-235 Enrichment Levels for Groundwater at Cimarron Site Utilizing ICP-MS Data Collected December 2016 Through 2nd Quarter 2017, Revision 0. Enercon Services, Inc. August 2017.

Enrichment (% U-235 by Mass)	Isotopic Activity (pCi) per μg of Total Uranium			Total U (pCi/μg)
	U-234	U-235	U-238	
0.711	31.0	1.5	32.8	65.2
1	43.3	2.1	32.7	78.1
2	80.5	4.3	32.3	117.1
3	117.6	6.4	32.0	156.0
5	191.9	10.7	31.3	233.9

Isotopic Percentage of Total Activity		
U-234	U-235	U-238
47.4	2.3	50.2
55.5	2.7	41.8
68.7	3.7	27.6
75.4	4.1	20.5
82.0	4.6	13.4





ATTACHMENT 4  
DECAY CHARTS FOR U-238 AND U-235

