environmental
properties management, LLC

May 2, 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.

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.

9400 Ward Parkway • Kansas City, MO 64114
Tel: 405-642-5152 • jlux@envpm.com

U-234 in the Uranium Feedstock

Purified enriched uranium was received by the Cimarron facility as gaseous uranium hexafluoride (UF_6). 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_6 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_6 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 centuries 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 millennia 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 less than 0.01% of the activity concentration of the U-238. Consequently, any U-234 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 six months after the production of the UF_6, 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 even its short-lived daughters are present in the groundwater. When uranium decays by alpha emission, the thorium daughters that are formed are not chemically identical to 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 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 4th 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.

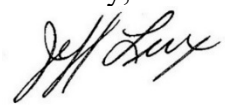
Conclusion

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; if the resin does adsorb some or all of the daughter radionuclides, it is unlikely that they will be present in effluent at detectable concentrations. 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, or write 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

GEL Laboratories LLC
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

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.

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

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:

Laboratory ID	Client ID
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.

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

559068 ☒ ORIGINAL

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

COC # : 2021-059

SHIP TO:
Company Name: GEL Laboratories LLC
Address: 2040 Savage Road
Address: Charleston, SC 29407
Contact Person: Julie Robinson
Phone: 843-769-7393

SHIP FROM:
Environmental Properties Management
100 North Highway 74
Guthrie, OK 73044
Contact Person: Jeff Lux
Phone: 405-642-5152

I ATTEST THAT THE PROPER FIELD SAMPLING PROCEDURES WERE USED DURING THE COLLECTION OF THESE SAMPLES.
SAMPLER SIGNATURE:

SITE: CIMARRON FACILITY

SAMPLE			CONTAINER			SAMPLE TYPE: SOLID		SAMPLE TYPE: WATER			ANALYSIS REQUESTED	
ID	DATE	TIME	NO.	TYPE	SIZE	SOIL	OTHER	"X" IF WATER	PRESERV.	FILTERED .45µ Y/N	Th-234, Th-231, Pa-234 (EPA 901.1)	U-234, U-235, U-238 (HASL 300)
TMW-13	10/13/2021	945	1	P	2 L			X	HNO3	Y	X	
TMW-13	10/13/2021	945	1	P	500 ml			X	HNO3	Y		X
02W02	10/13/2021	1125	1	P	2 L			X	HNO3	Y	X	
02W02	10/13/2021	1125	1	P	500 ml			X	HNO3	Y		X
02W01	10/13/2021	1450	1	P	2 L			X	HNO3	Y	X	
02W01	10/13/2021	1450	1	P	500 ml			X	HNO3	Y		X
TMW-09	10/13/2021	1550	1	P	2 L			X	HNO3	Y	X	
TMW-09	10/13/2021	1550	1	P	500 ml			X	HNO3	Y		X

Potential Hazardous Characteristics
■ Non-Haz ☐ RCRA D001,2&3, or 4 ☐ RCRA Listed ☐ Radioactive ☐ Unknown

Sample Disposal
■ Disposal Lab ☐ Return to Client ☐ Holding pending further instructions

PROJECT NAME: Uranium Daughter Activities Evaluation
PO#: 176069

THIS SAMPLE MEETS ALL APPROPRIATE RADIOLOGICAL REQUIREMENTS: HP INITIAL: BB

NOTES:

RELINQUISHED BY SAMPLER:	DATE:	TIME:	RECEIVED BY:	DATE:	TIME:
	10/14/21	1600		10/15/21	0955
RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:	DATE:	TIME:

Distribution:
Standard GEL EDD & GEL lab report in .pdf format to:
- jlux@envpm.com
- slawrence@burnsmcd.com
- jmaisler@enercon.com
EQuIS EDD to:
- jlux@envpm.com
- dhorne@burnsmcd.com

PAGE 1 OF 1

DOCUMENT CONTROL: QA Review DATE: 10/14/2021

Rev. 1

SR

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: CMRN	SDG/AR/COC/Work Order: SS91063
Received By: BE	Date Received: 10/15/21
Carrier and Tracking Number	Circle Applicable: (FedEx Express) FedEx Ground UPS Field Services Courier Other 2848 9647 6414 2848 9647 3757

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
A)Shipped as a DOT Hazardous?		\	Hazard Class Shipped: UN#: If UN2910, Is the Radioactive Shipment Survey Compliant? Yes___ No___
B) Did the client designate the samples are to be received as radioactive?		\	COC notation or radioactive stickers on containers equal client designation.
C) Did the RSO classify the samples as radioactive?		\	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 (CPM) mR/Hr Classified as: Rad 1 Rad 2 Rad 3
D) Did the client designate samples are hazardous?		\	COC notation or hazard labels on containers equal client designation.
E) Did the RSO identify possible hazards?		\	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?	\			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	\			Circle Applicable: Client contacted and provided COC COC created upon receipt
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*		\		Preservation Method: Wet Ice Ice Packs Dry ice (None) Other: *all temperatures are recorded in Celsius TEMP: 24
4	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: IR2-21 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?	\			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
6	Samples requiring chemical preservation at proper pH?	\			Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			\	If Yes, are Encores or Soil Kits present for solids? Yes___ No___ NA___(If yes, take to VOA Freezer) Do liquid VOA vials contain acid preservation? Yes___ No___ NA___(If unknown, select No) Are liquid VOA vials free of headspace? Yes___ No___ NA___ Sample ID's and containers affected:
8	Samples received within holding time?	\			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	\			ID's and containers affected:
10	Date & time on COC match date & time on bottles?	\			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?	\			Circle Applicable: No container count on COC Other (describe)
12	Are sample containers identifiable as GEL provided by use of GEL labels?	\			
13	COC form is properly signed in relinquished/received sections?	\			Circle Applicable: Not relinquished Other (describe)

Comments (Use Continuation Form if needed):

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

Laboratory Certification

List of current GEL Certifications as of 11 November 2021

State	Certification
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).

GEL Sample ID#	Client Sample Identification
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).

GEL Sample ID#	Client Sample Identification
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

Qualifier	Reason	Analyte	Sample	Client Sample
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

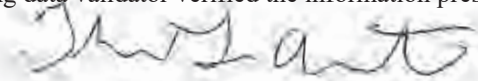
The Qualifiers in this report are defined as follows:

* 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

Report Date: November 11, 2021

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

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.
Rad Alpha Spec Analysis														
Alphaspec U, Liquid "As Received"														
Uranium-233/234		602	+/-21.8	1.84	+/-130	1.00	pCi/L			BV1	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							
Rad Gamma Spec Analysis														
Gammaspec, Gamma, Liquid "As Received"														
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.
Rad Alpha Spec Analysis														
Alphaspec U, Liquid "As Received"														
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							
Rad Gamma Spec Analysis														
Gammaspec, Gamma, Liquid "As Received"														
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
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: 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.
Rad Alpha Spec Analysis														
Alphaspec U, Liquid "As Received"														
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							
Rad Gamma Spec Analysis														
Gammaspec, Gamma, Liquid "As Received"														
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
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: 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.
Rad Alpha Spec Analysis														
Alphaspec U, Liquid "As Received"														
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							
Rad Gamma Spec Analysis														
Gammaspec, Gamma, Liquid "As Received"														
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

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

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						

QC Summary

Workorder: 559068

Parmname	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.

QC Summary

Workorder: **559068**

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.
N1	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 acceptence 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

9400 Ward Parkway • Kansas City, MO 64114
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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

Notes:

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.

TMW-13 Pa-234 DL:U-238 Ratio	02W02 Pa-234 DL:U-238 Ratio	02W01 Pa-234 DL:U-238 Ratio	TMMW-09 Pa-234 DL:U-238 Ratio
0.20	0.16	0.13	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

9400 Ward Parkway • Kansas City, MO 64114
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ATTACHMENT 3
DISTRIBUTION OF URANIUM ISOTOPES IN ENRICHED URANIUM

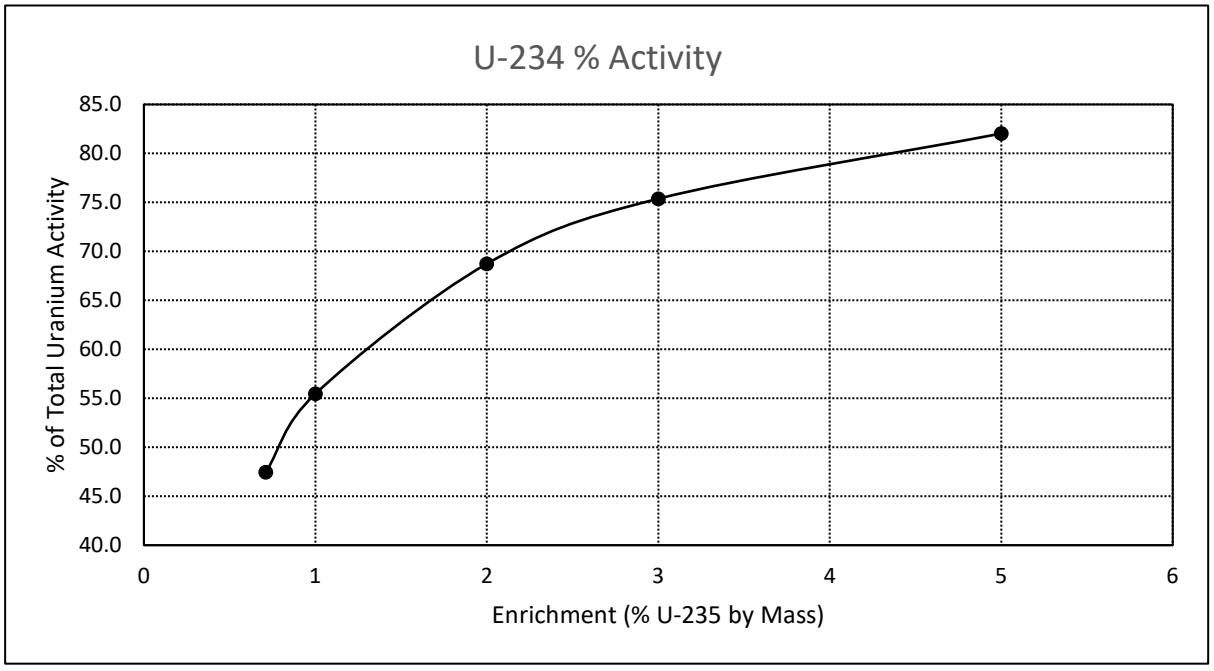
Enrichment (% U-235 by Mass)	Percent Total Mass		
	U-234	U-235	U-238
0.711	0.005	0.711	99.284
1	0.007	1	98.993
2	0.013	2	97.987
3	0.019	3	96.981
5	0.031	5	94.969

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)	Activity (pCi/µg of Total U)			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

Activity (pCi/µg of Total U)		
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

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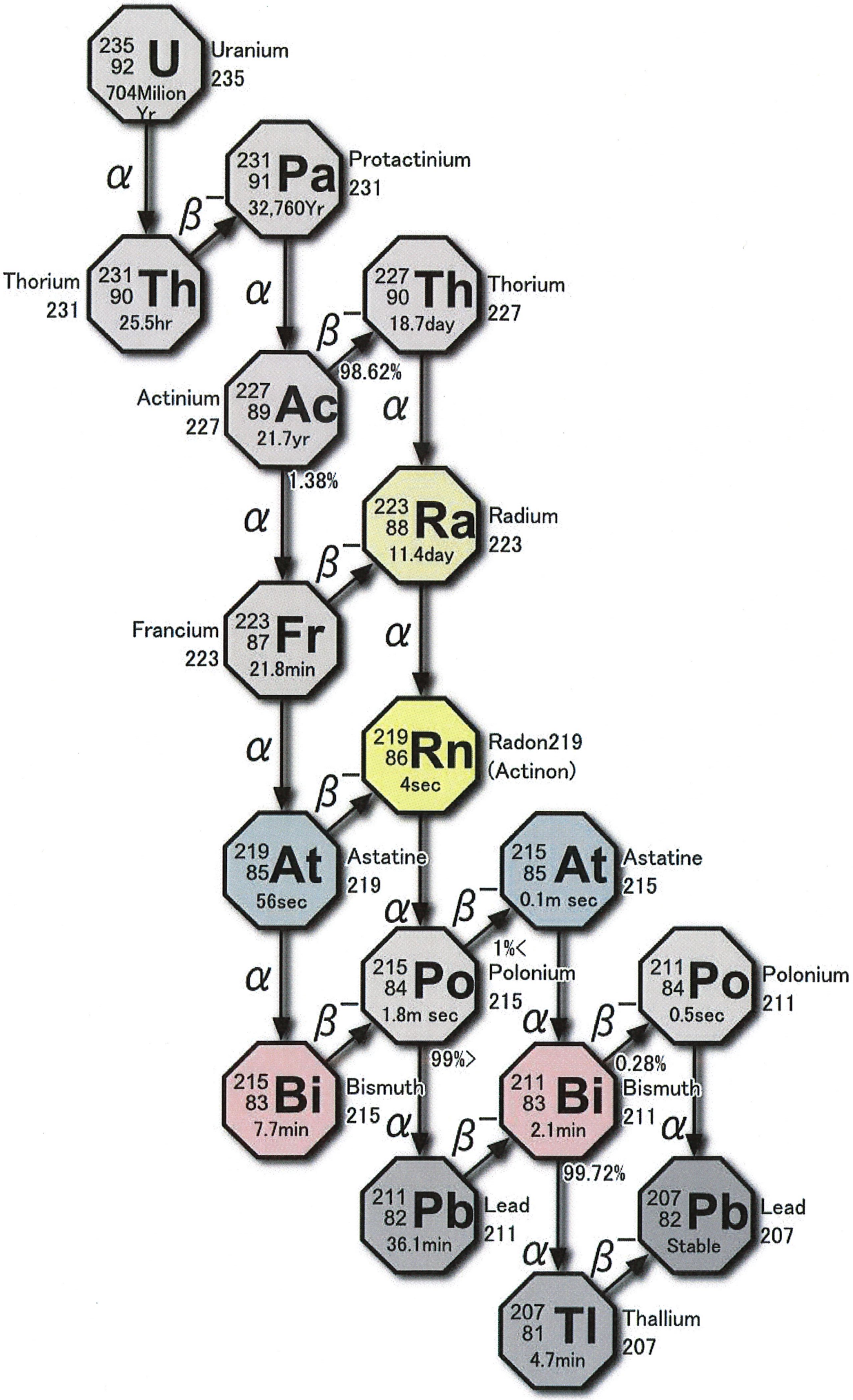
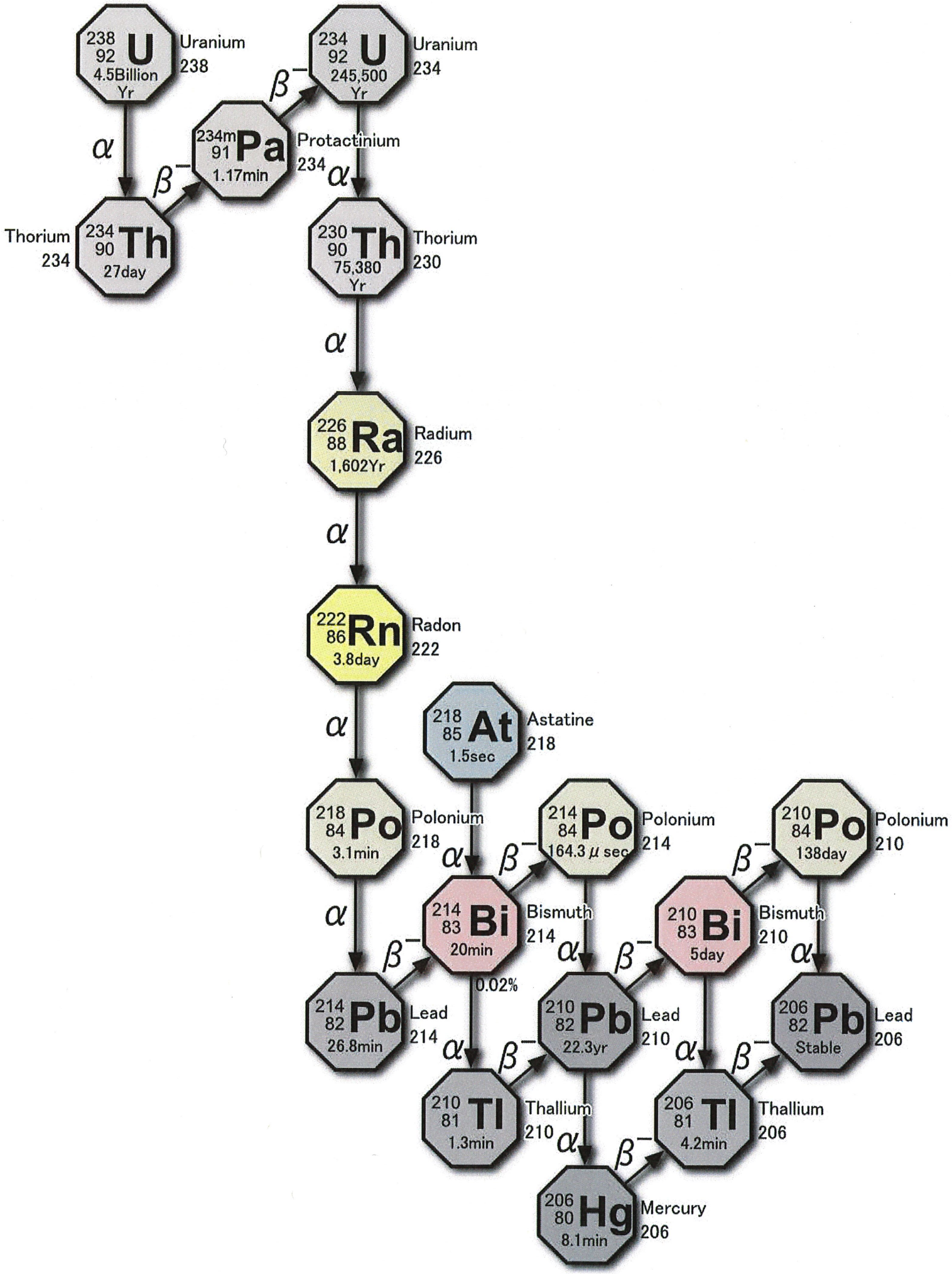

235 92 U 704Milion Yr
Uranium 235
α
231 91 Pa 32,760Yr
Protactinium 231
β−
Thorium 231
231 90 Th 25.5hr
α
227 90 Th 18.7day
Thorium 227
β−
98.62%
Actinium 227
227 89 Ac 21.7yr
α
1.38%
α
223 88 Ra 11.4day
Radium 223
β−
Francium 223
223 87 Fr 21.8min
α
α
219 86 Rn 4sec
Radon219 (Actinon)
β−
219 85 At 56sec
Astatine 219
α
215 85 At 0.1m sec
Astatine 215
β−
α
1%<
215 84 Po 1.8m sec
Polonium 215
β−
211 84 Po 0.5sec
Polonium 211
α
β−
99%>
0.28%
215 83 Bi 7.7min
Bismuth 215
α
211 83 Bi 2.1min
Bismuth 211
α
β−
99.72%
211 82 Pb 36.1min
Lead 211
207 82 Pb Stable
Lead 207
α
β−
207 81 Tl 4.7min
Thallium 207


238 92 U 4.5Billion Yr
Uranium 238
α
234 92 U 245,500 Yr
Uranium 234
β−
234m 91 Pa 1.17min
Protactinium 234
β−
α
Thorium 234
234 90 Th 27day
230 90 Th 75,380 Yr
Thorium 230
α
226 88 Ra 1,602Yr
Radium 226
α
222 86 Rn 3.8day
Radon 222
α
218 85 At 1.5sec
Astatine 218
218 84 Po 3.1min
Polonium 218
α
214 84 Po 164.3 μ sec
Polonium 214
β−
210 84 Po 138day
Polonium 210
β−
α
214 83 Bi 20min
Bismuth 214
β−
α
210 83 Bi 5day
Bismuth 210
β−
α
0.02%
214 82 Pb 26.8min
Lead 214
α
210 82 Pb 22.3yr
Lead 210
β−
α
206 82 Pb Stable
Lead 206
β−
210 81 Tl 1.3min
Thallium 210
α
206 81 Tl 4.2min
Thallium 206
β−
206 80 Hg 8.1min
Mercury 206