



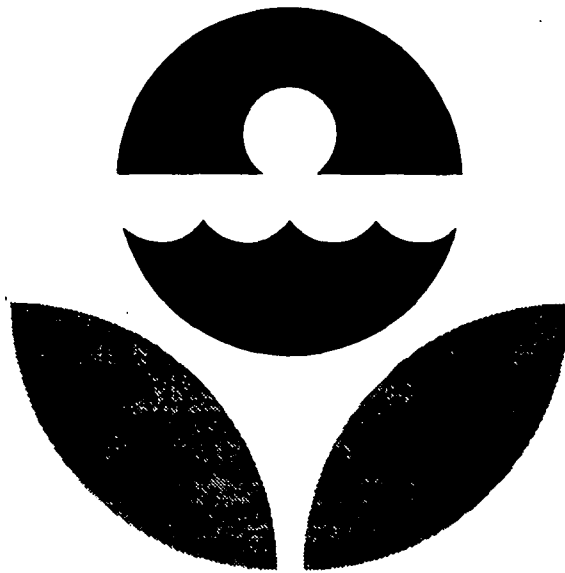
Uranium-Radium in Water Performance Evaluation Study

A Statistical Evaluation of the December 6, 1996 Data

002RSL97.COV

A decorative graphic at the bottom of the page consisting of two sets of parallel black and white chevrons pointing to the right.

Uranium-Radium in Water
Performance Evaluation Study
December 6, 1996



Environmental Protection Agency
National Exposure Research Laboratory
Characterization Research Division
Las Vegas, Nevada



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
NATIONAL EXPOSURE RESEARCH LABORATORY
CHARACTERIZATION RESEARCH DIVISION-LAS VEGAS
P.O. BOX 93478
LAS VEGAS, NEVADA 89193-3478
(702/798-2100)

Dear Participant,

Enclosed are the results of the Analytical Sciences Branch (CRD-LV)
Performance Evaluation Study for *Uranium-Radium in Water*; *December 6, 1996*.

The known value for each analysis was determined by gravimetric methods,
checked by chemical analyses performed by CRD-LV's Radiochemistry Laboratory,
and compared to the participating laboratories' grand average.

The expected precision, determined by the known value, was taken from
"Table 3. Laboratory Precision: One Standard Deviation Values and Control Limits
for Various Analyses", which is based on data accumulated over the years by the
Performance Evaluation Program, and can be found in the Environmental Radioactivity
Performance Evaluation Studies Program and Radioactive Standards Distribution
Program information brochure.

Please take a few minutes to review this report and the analytical data your
laboratory submitted to us. If there are any apparent discrepancies, please notify us
immediately.

We encourage you to make use of the computer-automated data-entry system
that has been in place for some time now. As the number of participants increases,
and it becomes unrealistic for us to receive results by mail or FAX, the computer
system will be our only avenue for accepting data.

If you have any questions or comments, please send a message via the data-entry
system or contact Stephen Pia at 702/798-2102 or Patricia Honsa at 702/798-2141.

Sincerely,

A handwritten signature in black ink, appearing to read "Stephen Pia".

Stephen Pia
Team Leader
RADQA Program

Enclosure

NOTICE

This material has been funded wholly by the U.S. Environmental Protection Agency. It has been subjected to the Agency's review, and has been approved for publication as an EPA document.

The following pages consist of separate sections for each of the nuclides in this study with four parts per section. After the first, each part is separated from the next by a new page or a thick horizontal bar. The first page of each section is a statistical summary for the nuclide and starts with a statement of the known value, the control limits, and the warning limits.

The warning limits are placed at two normalized standard deviations above and below the known value and the control limits are three normalized standard deviations above and below the known value. If you keep control charts, these values will be useful for anticipating problems with the accuracy of your analytical methods.

The coin shaped pie chart at the top of the summary page shows the fate of all the samples sent out in number and percentage terms. The pie chart starts at the top and rotates clockwise. The first sector represents those participants who submitted analytical results within both the warning and control limits. The next sector represents those who are in the warning region but not out of control. The third sector represents those who are out of control, but have passed the outlier test. The fourth sector represents those who have failed the outlier test. The last sector represents those participants who have failed to respond properly. This is the case if no analytical results were returned, or less than three determinations were reported, or if the results were received too late. The reeding on the edge of the coin is spaced at one percent intervals, and the sector shading becomes darker as the data reliability decreases. Sectors with zero width are not shown.

The table in the center shows a number of statistical quantities calculated from the submitted data based on the mean and median values in relation to the known value, both before and after outlier removal. The lower pie chart uses the same construction as the upper chart and shows the distribution of properly submitted data in terms of deviation from the known value divided into sectors representing one, two, three, and greater than three normalized standard deviations.

The second part is an alphabetical listing, in lab-code order, of submitted data and several calculated quantities. An entry that is shaded has been rejected because of one of the reasons listed above or failure of the outlier test. The fifth and sixth columns are a measure of laboratory precision. The Range analysis is a normalized value that you may use to keep precision control charts. The eighth and ninth columns are the differences from the mean of all non-outliers and from the known value, respectively. If this value is between 2.0 and 3.0, your analytical process precision is in the warning zone; if it exceeds 3.0 it is out of control. A tag symbol may appear in the last column. Each page with tags has a symbol definition summary at the bottom. If there is no tag symbol, the data is within the control limits, but it may be in the warning zone.

The third part is a three-column listing of result average, tag symbol, and lab-code in average order excluding those labs not responding properly. In this order, all outliers and out-of-control results appear at the top or bottom of the list.

The last part is two bar chart displays showing frequency distributions of responding participants. The first chart places the known value at the center and a bar at each 0.2 unit of expected precision. The second chart places the mean of the reported measurements at the center and a bar at each 0.2 unit of standard deviation. In both cases, a bar includes those results within 0.1 unit up to the maximum of six. Any results more than six units from the center value are shown cumulatively by a shaded bar one past the sixth unit. If the central tendency of the known value distribution falls away from the center, an error in accuracy is indicated. If the distribution is broad, poor precision is indicated. The mean value distribution is similar but uses the average and standard deviation of reported results as its basis.

The Range Analysis($R + SR$) is calculated from the range, mean range and standard error of the range values. The range is the difference between the maximum and minimum results for the laboratory. The mean range is calculated by multiplying the expected precision by 1.693(for three results). The standard error of the range is calculated by multiplying the mean range by 2.575(for three results), subtracting the mean range from this product, and dividing the result by 3. If the range is greater than the mean range, then the range analysis is calculated by subtracting the mean range from the range, dividing the result by the standard error of the range and adding 1. If the mean range is greater than or equal to the range, then the range analysis is calculated by dividing the range by the mean range.

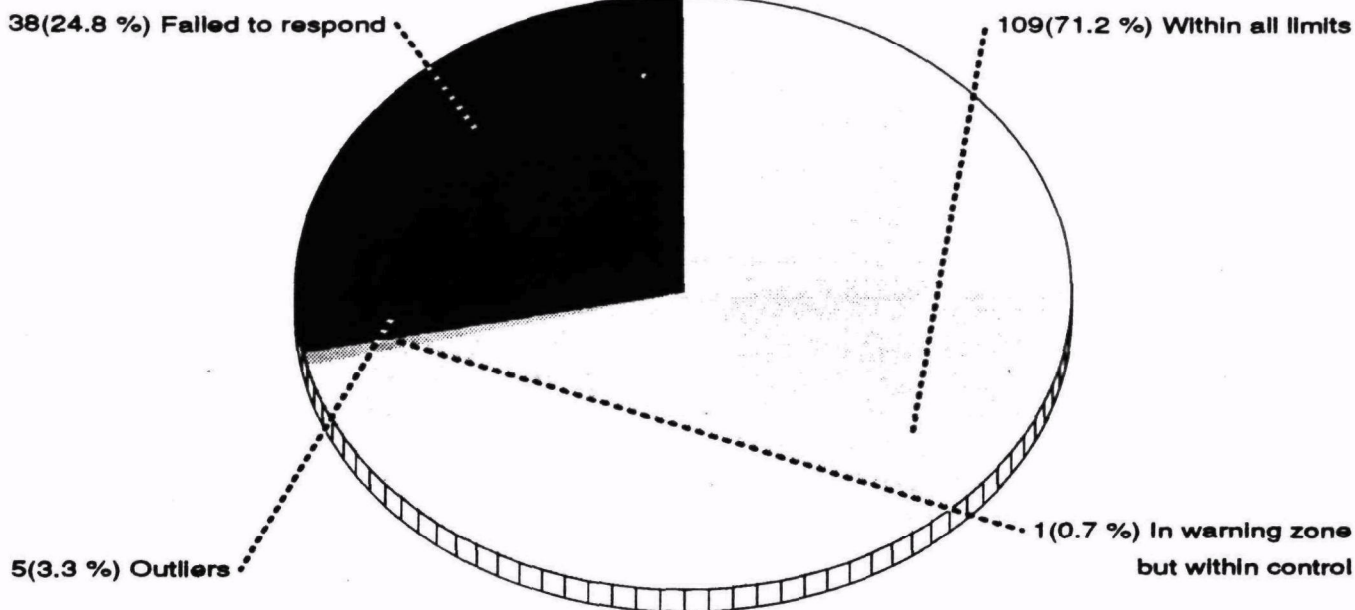
The normalized deviation of the mean from the grand average is calculated from the deviation of the mean from the grand average and the standard error of the mean values. The deviation of the mean from the grand average is calculated by subtracting the grand average from the average of the laboratory's three results. The standard error of the mean is calculated by dividing the expected precision by the square root of 3(the number of results). The normalized deviation of the mean from the grand average is calculated by dividing the deviation of the mean from the grand average by the standard error of the mean.

The normalized deviation of the mean from the known value is calculated from the deviation of the mean from the known value and the standard error of the mean values. The deviation of the mean from the known value is calculated by subtracting the known value from the average of the laboratory's three results. The standard error of the mean is calculated by dividing the expected precision by the square root of 3(the number of results). The normalized deviation of the mean from the known value is calculated by dividing the deviation of the mean from the known value by the standard error of the mean.

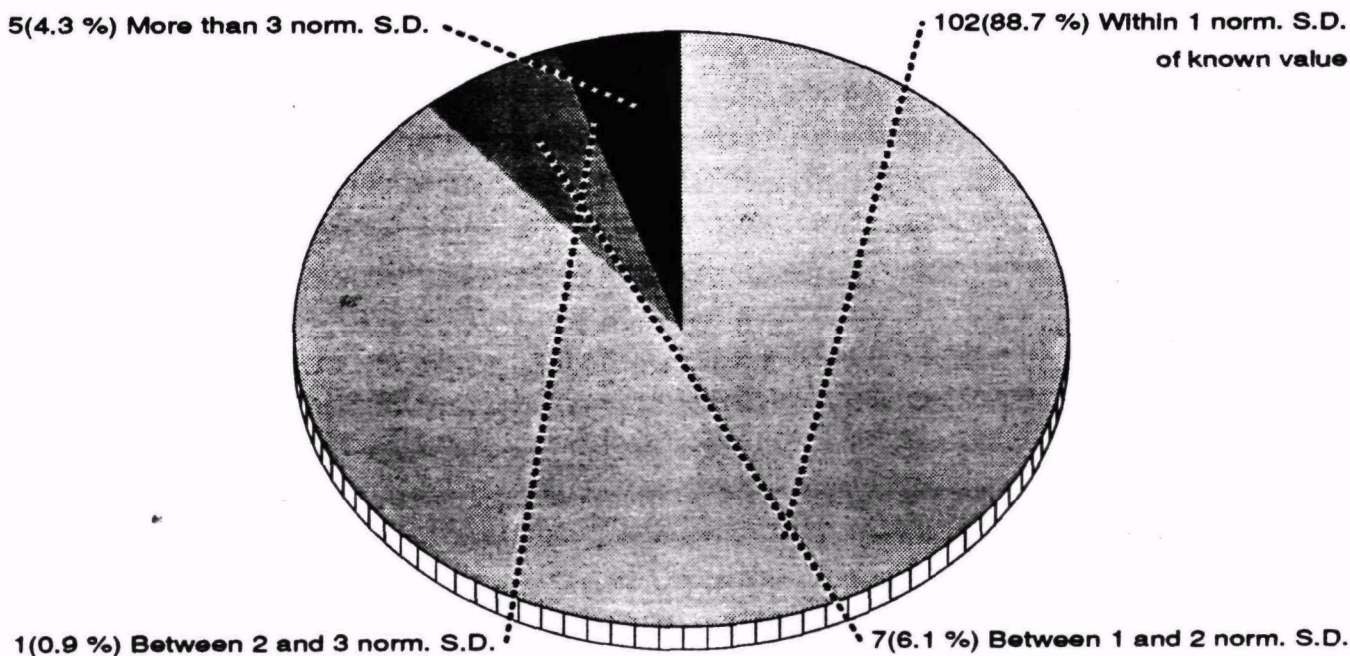
A complete explanation of the statistical calculations involved in the report may be found in the Environmental Radioactivity Performance Evaluation Studies Program information brochure [Draft Revision of EPA-600/4-81-004], available from Patricia Honsa, CRD-LV, 702/798-2141.

Uranium (Natural)**Statistical Summary****153 Participants**

The known value of this nuclide is 5.0 pCi/l with an expected precision of 3.0; the control limits are 0.0 to 10.2; the warning regions are 0.0 to 1.5 and 8.5 to 10.2



Statistic	Respondents	Non-outliers
Mean	5.63	Grand Avg 5.14
Std. Dev.	2.66	0.94
Variance	7.07	0.88
% Coef. of Var.	47.23	18.27
% deviation of mean from known value	12.56	2.74
Norm. dev. of mean from known value	0.24	0.15
Median	5.07	5.00
% deviation of median from known value	1.33	0.00
Norm. dev. of median from known value	0.03	0.00



Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
A	4.9	4.8	4.9	0.06	0.020	4.87	-0.16	-0.08
AE	5.3	5.4	5.4	0.06	0.020	5.37	0.13	0.21
AF	6.0	5.2	6.2	0.53	0.197	5.80	0.38	0.46
AH	4.7	4.4	4.6	0.15	0.059	4.57	-0.33	-0.25
AJ								
AK	5.4	5.1	5.3	0.15	0.059	5.27	0.07	0.15
AL	5.2	4.2	4.5	0.51	0.197	4.63	-0.29	-0.21
AP	6.2	5.0	5.5	0.60	0.236	5.57	0.25	0.33
AR	4.6	4.5	4.5	0.06	0.020	4.53	-0.35	-0.27
AU								
AW	4.4	4.2	5.5	0.70	0.256	4.70	-0.25	-0.17
AZ	4.8	5.1	5.0	0.15	0.059	4.97	-0.10	-0.02
BA	4.5	4.4	4.6	0.10	0.039	4.50	-0.37	-0.29
BC	4.9	4.9	4.8	0.06	0.020	4.87	-0.16	-0.08
BG	5.1	5.2	5.5	0.21	0.079	5.27	0.07	0.15
BG	5.3	5.2	5.4	0.10	0.039	5.30	0.09	0.17
BG	3.8	3.7	3.7	0.06	0.020	3.73	-0.81	-0.73
BH	5.2	5.4	4.7	0.36	0.138	5.10	-0.02	0.06
BK	4.6	4.6	4.5	0.06	0.020	4.57	-0.33	-0.25
BM	5.3	5.4	5.6	0.15	0.059	5.43	0.17	0.25
BN	6.6	5.4	4.5	1.05	0.413	5.50	0.21	0.29
BO	4.2	4.6	5.4	0.61	0.236	4.73	-0.23	-0.15
C	4.0	4.0	4.0	0.00	0.000	4.00	-0.66	-0.58
CA	5.1	5.3	5.3	0.12	0.039	5.23	0.06	0.13
CC	10.0	10.0	11.0	0.58	0.197	10.33	3.00	3.08
CE	5.6	5.2	5.6	0.23	0.079	5.47	0.19	0.27
CG	8.7	9.7	6.0	1.91	0.728	8.13	1.73	1.81
CJ	5.4	5.1	4.9	0.25	0.098	5.13	0.00	0.08
CM								
CS	4.5	4.6	4.6	0.06	0.020	4.57	-0.33	-0.25
CX	5.7	5.8	5.9	0.10	0.039	5.80	0.38	0.46
D	5.0	4.9	5.1	0.10	0.039	5.00	-0.08	0.00
DB	3.9	3.9	4.4	0.29	0.098	4.07	-0.62	-0.54
DE	8.1	8.2	8.3	0.10	0.039	8.20	1.77	1.85
DI	5.1	4.9	4.8	0.15	0.059	4.93	-0.12	-0.04
DO	4.1	4.5	4.8	0.35	0.138	4.47	-0.39	-0.31
DR								
DT	5.5	5.4	4.8	0.38	0.138	5.23	0.06	0.13
DZ	5.5	5.6	6.1	0.32	0.118	5.73	0.34	0.42
E	4.9	4.9	5.0	0.06	0.020	4.93	-0.12	-0.04
EB	4.9	5.1	5.2	0.15	0.059	5.07	-0.04	0.04
EL	4.7	4.6	4.8	0.10	0.039	4.70	-0.25	-0.17
EO								
EP								
ER	10.3	10.1	9.4	0.47	0.177	9.93	2.77	2.85

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

Ø = Insufficient data

× = Determined to be an outlier

↓ = Below control limit

Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
FE									•
FJ									•
FN	5.3	5.0	5.6	0.30	0.118	5.30	0.09	0.17	
FZ									•
GN	4.0	4.1	3.9	0.10	0.039	4.00	-0.66	-0.58	
GQ	5.8	5.8	5.2	0.35	0.118	5.60	0.27	0.35	
HK	5.4	5.6	5.1	0.25	0.098	5.37	0.13	0.21	
HL	5.5	6.1	5.9	0.31	0.118	5.83	0.40	0.48	
HP	5.5	5.1	5.1	0.23	0.079	5.23	0.06	0.13	
I	6.1	6.2	5.5	0.38	0.138	5.93	0.46	0.54	
ID	14.5	14.6	14.1	0.26	0.098	14.40	5.35	5.43	×
J									•
JE	4.9	4.5	4.8	0.21	0.079	4.73	-0.23	-0.15	
JG									•
JK	5.2	4.7	5.0	0.25	0.098	4.97	-0.10	-0.02	
JN	6.1	4.4	7.2	1.41	0.551	5.90	0.44	0.52	
JP	4.6	4.7	4.4	0.15	0.059	4.57	-0.33	-0.25	
JS	5.3	5.3	5.3	0.00	0.000	5.30	0.09	0.17	
JX									•
JY	5.4	4.7	4.2	0.60	0.236	4.77	-0.21	-0.13	
K	5.6	4.2	5.0	0.70	0.276	4.93	-0.12	-0.04	
KH	4.8	4.8	4.9	0.06	0.020	4.83	-0.18	-0.10	
KL									•
KT	0.8	2.0							Ø
L	5.0	5.0	5.2	0.12	0.039	5.07	-0.04	0.04	
LF	5.1	4.9	4.9	0.12	0.039	4.97	-0.10	-0.02	
LH									•
LT	3.9	3.9	4.4	0.29	0.098	4.07	-0.62	-0.54	
LZ	5.0	5.0	5.0	0.00	0.000	5.00	-0.08	0.00	
M									•
MX	27.9	19.9	20.6	4.43	2.095	22.80	10.20	10.28	×
N									•
NA	8.0	7.0	7.0	0.58	0.197	7.33	1.27	1.35	
NH	4.3	4.2	4.2	0.06	0.020	4.23	-0.52	-0.44	
NJ	5.2	5.4	5.0	0.20	0.079	5.20	0.04	0.12	
NK	4.9	4.7	4.7	0.12	0.039	4.77	-0.21	-0.13	
NO	5.1	5.3	5.5	0.20	0.079	5.30	0.09	0.17	
NT	4.0	4.7	4.3	0.35	0.138	4.33	-0.46	-0.38	
O									•
OB	5.3	5.3	5.0	0.17	0.059	5.20	0.04	0.12	
OF									•
OM									•
OS	5.2	4.6	5.6	0.50	0.197	5.13	0.00	0.08	
OX									•
OY									•

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Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
P	6.7	4.9	5.8	0.90	0.354	5.80	0.38	0.46
PB	4.9	5.2	4.7	0.25	0.098	4.93	-0.12	-0.04
PG	5.6	4.7	4.6	0.55	0.197	4.97	-0.10	-0.02
PQ	5.1	5.1	5.2	0.06	0.020	5.13	0.00	0.08
PV	4.5	4.7	5.1	0.31	0.118	4.77	-0.21	-0.13
PW	3.1	2.8	3.5	0.35	0.138	3.13	-1.16	-1.08
PX	5.4	5.2	5.0	0.20	0.079	5.20	0.04	0.12
Q	4.7	4.1	4.5	0.31	0.118	4.43	-0.41	-0.33
QM	14.6	14.2	14.7	0.26	0.098	14.50	5.41	5.48 x
QQ	5.5	5.0	5.8	0.40	0.158	5.43	0.17	0.25
QU	4.2	5.9	4.9	0.85	0.335	5.00	-0.08	0.00
QX	1.8	2.3	3.3	0.76	0.295	2.47	-1.54	-1.46
QZ	5.0	4.8	4.7	0.15	0.059	4.83	-0.18	-0.10
R								•
RD	4.6	4.7	4.6	0.06	0.020	4.63	-0.29	-0.21
RF	5.2	5.1	4.8	0.21	0.079	5.03	-0.06	0.02
RG	5.0	4.9	5.0	0.06	0.020	4.97	-0.10	-0.02
RK								•
RP	5.2	4.6	4.8	0.31	0.118	4.87	-0.16	-0.08
RR	5.0	4.5	4.9	0.26	0.098	4.80	-0.19	-0.12
RX	22.0	18.4	20.0	1.80	0.709	20.13	8.66	8.74 x
RZ	4.5	4.3	4.7	0.20	0.079	4.50	-0.37	-0.29
S	4.9	4.5	4.6	0.21	0.079	4.67	-0.27	-0.19
SC	5.3	5.9	4.7	0.60	0.236	5.30	0.09	0.17
SD	5.3	5.1	4.8	0.25	0.098	5.07	-0.04	0.04
SF	5.0	4.9	5.0	0.06	0.020	4.97	-0.10	-0.02
SI	4.9	4.8	4.9	0.06	0.020	4.87	-0.16	-0.08
SL	6.3	4.9	5.8	0.71	0.276	5.67	0.31	0.38
SM	7.5	5.7	4.5	1.51	0.591	5.90	0.44	0.52
SO	7.0	7.0	6.5	0.29	0.098	6.83	0.98	1.06
SS	5.2	5.1	5.0	0.10	0.039	5.10	-0.02	0.06
SX	4.7	4.9	4.8	0.10	0.039	4.80	-0.19	-0.12
SZ	4.6	4.6	4.8	0.12	0.039	4.67	-0.27	-0.19
T								•
TD	5.5	5.4	5.5	0.06	0.020	5.47	0.19	0.27
TH								•
TL								•
TN								•
TQ	5.2	5.4	5.3	0.10	0.039	5.30	0.09	0.17
TS								•
U	5.0	5.0	4.9	0.06	0.020	4.97	-0.10	-0.02
UE	4.5	5.0	5.1	0.32	0.118	4.87	-0.16	-0.08
UN								•
UP	3.4	4.2	3.6	0.42	0.158	3.73	-0.81	-0.73
UQ								•

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Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
UZ	4.0	8.8	12.2	4.12	2.170	8.33	1.85	1.92	
VA									•
VH	6.6	6.7	5.8	0.49	0.177	6.37	0.71	0.79	
VI	5.3	5.6	5.3	0.17	0.059	5.40	0.15	0.23	
W	5.5	5.4	5.5	0.06	0.020	5.47	0.19	0.27	
WO									•
WG	5.5	5.2	5.2	0.17	0.059	5.30	0.09	0.17	
WH	5.2	5.2	5.4	0.12	0.039	5.27	0.07	0.15	
WI	4.7	4.6	4.6	0.06	0.020	4.63	-0.29	-0.21	
WJ	4.6	4.4	4.4	0.12	0.039	4.47	-0.39	-0.31	
WO									•
WR	4.5	4.4	4.4	0.06	0.020	4.43	-0.41	-0.33	
WS									•
WV									•
WX									•
X	5.5	5.0	4.8	0.36	0.138	5.10	-0.02	0.06	
XA	5.1	5.4	6.0	0.46	0.177	5.50	0.21	0.29	
XC									•

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
2.47		QX	4.67		SZ	4.97		RG
3.13		PW	4.67		S	4.97		PG
3.73		UP	4.70		EL	4.97		LF
3.73		BG	4.70		AW	4.97		JK
4.00		GN	4.73		BO	4.97		AZ
4.00		C	4.73		JE	5.00		QU
4.07		LT	4.77		PV	5.00		LZ
4.07		DB	4.77		NK	5.00		D
4.23		NH	4.77		JY	5.03		RF
4.33		NT	4.80		SX	5.07		L
4.43		WR	4.80		RR	5.07		EB
4.43		Q	4.83		QZ	5.07		SD
4.47		WJ	4.83		KH	5.10		X
4.47		DO	4.87		UE	5.10		SS
4.50		RZ	4.87		SI	5.10		BH
4.50		BA	4.87		RP	5.13		PQ
4.53		AR	4.87		BC	5.13		OS
4.57		JP	4.87		A	5.13		CJ
4.57		CS	4.93		PB	5.20		PX
4.57		BK	4.93		K	5.20		OB
4.57		AH	4.93		E	5.20		NJ
4.63		WI	4.93		DI	5.23		HP
4.63		RD	4.97		U	5.23		DT
4.63		AL	4.97		SF	5.23		CA

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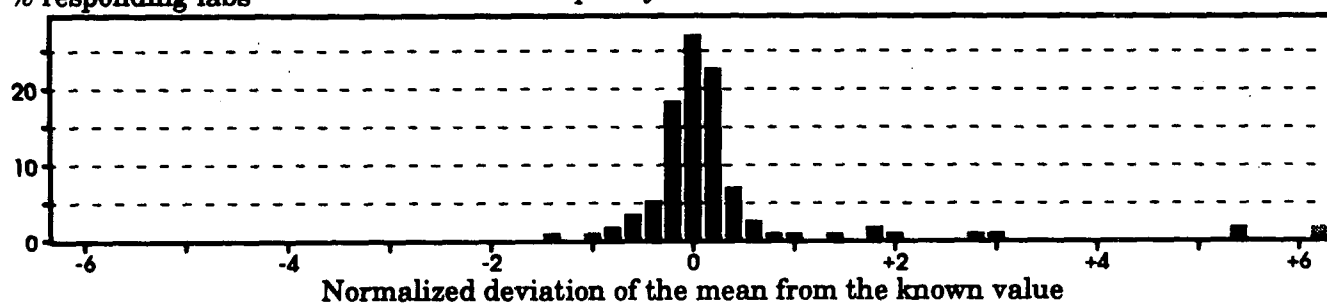
Uranium (Natural)

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
5.27		WH	5.43		BM	5.90		SM
5.27		BG	5.47		W	5.90		JN
5.27		AK	5.47		TD	5.93		I
5.30		WG	5.47		CE	6.37		VH
5.30		TQ	5.50		XA	6.83		SO
5.30		SC	5.50		BN	7.33		NA
5.30		NO	5.57		AP	8.13		CG
5.30		JS	5.60		GQ	8.20		DE
5.30		FN	5.67		SL	8.33		UZ
5.30		BG	5.73		DZ	9.93		ER
5.37		HK	5.80		P	10.33	x	CC
5.37		AE	5.80		CX	14.40	x	ID
5.40		VI	5.80		AF	14.50	x	QM
5.43		QQ	5.83		HL	20.13	x	RX
						22.80	x	MX

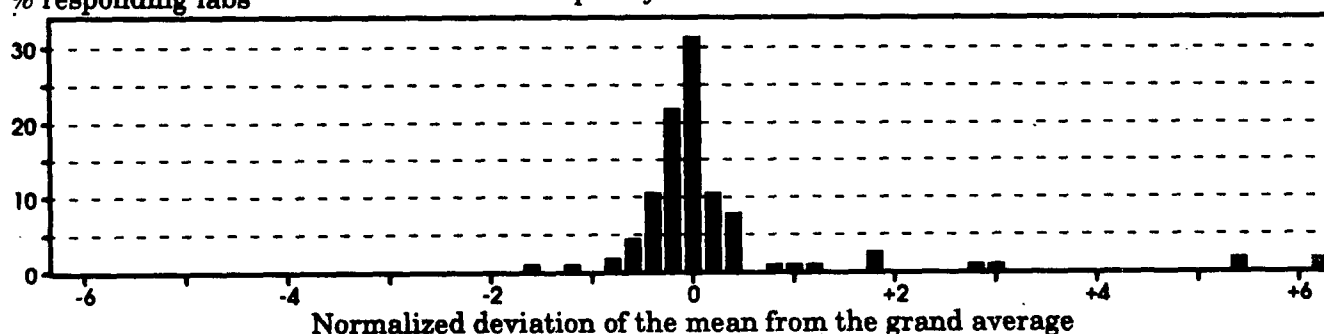
% responding labs

Frequency distribution



% responding labs

Frequency distribution



• = No data submitted

TAG SYMBOLS

↑ = Above control limit

∅ = Insufficient data

x = Determined to be an outlier

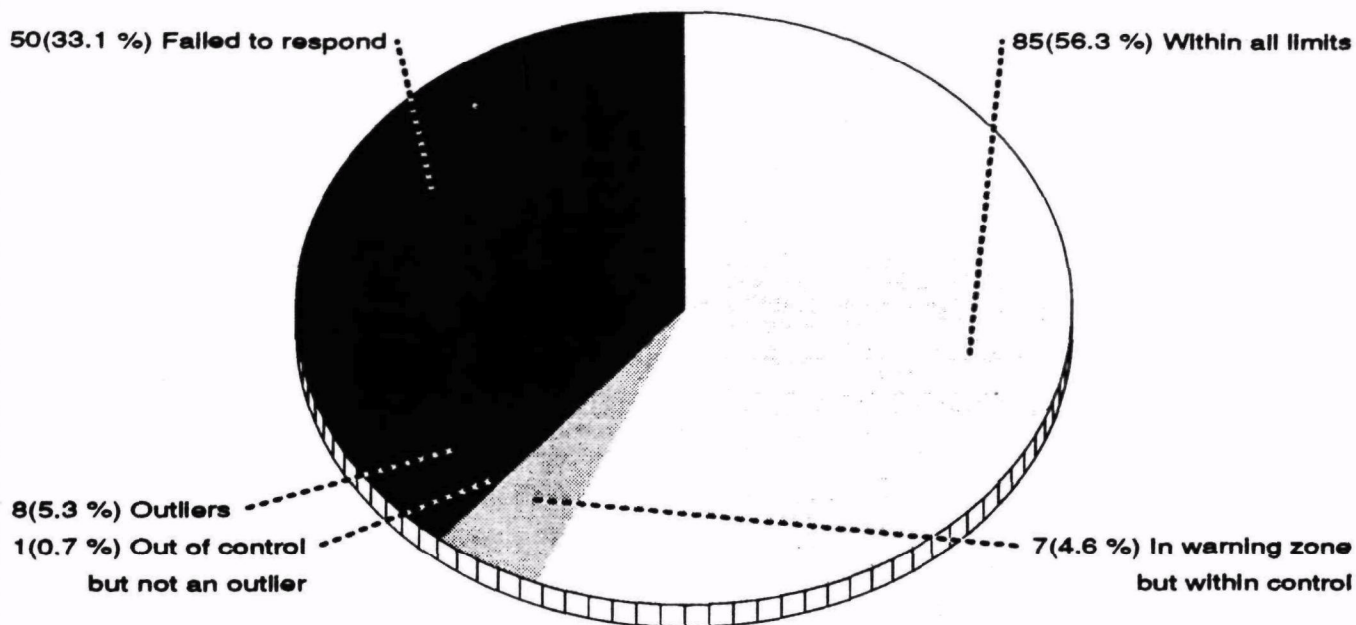
↓ = Below control limit

Radium-226

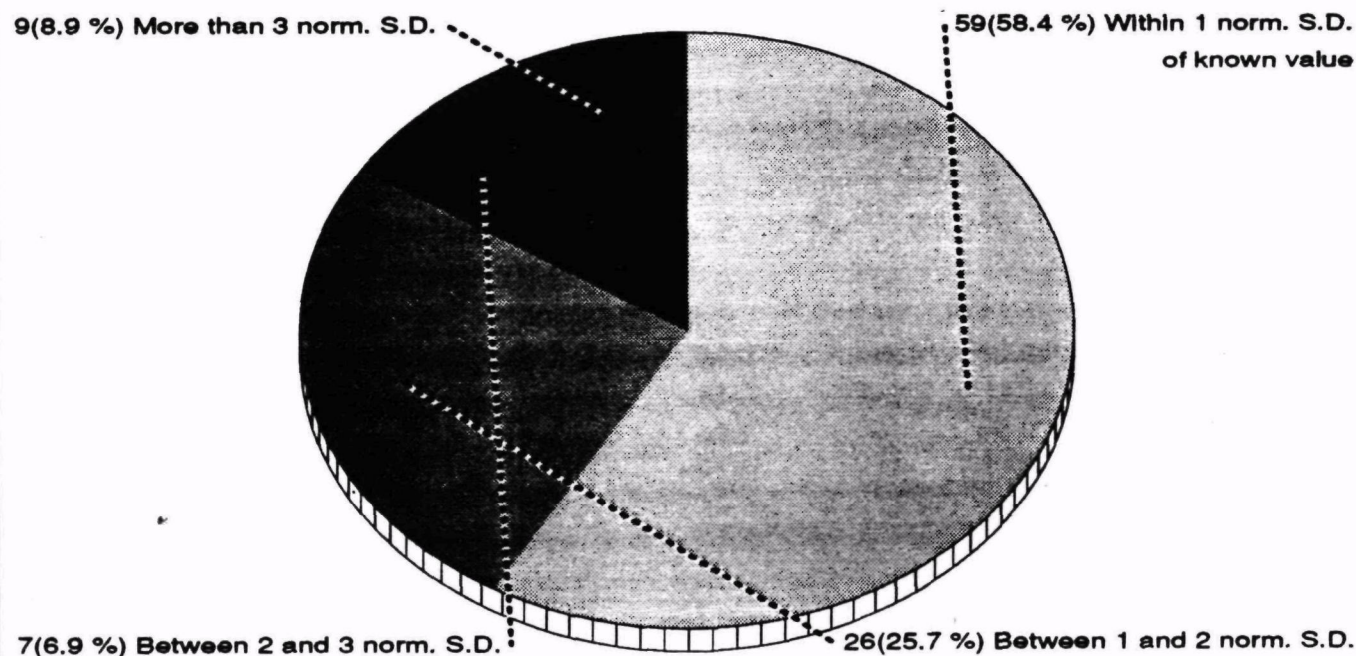
Statistical Summary

151 Participants

The known value of this nuclide is 20.1 pCi/l with an expected precision of 3.0; the control limits are 14.9 to 25.3; the warning regions are 14.9 to 16.6 and 23.6 to 25.3



Statistic	Respondents	Non-outliers
Mean	18.84	Grand Avg 19.25
Std. Dev.	3.68	1.80
Variance	13.51	3.23
% Coef. of Var.	19.51	9.33
% deviation of mean from known value	-6.28	-4.21
Norm. dev. of mean from known value	-0.34	-0.47
Median	19.17	19.33
% deviation of median from known value	-4.64	-3.81
Norm. dev. of median from known value	-0.25	-0.43



10 / 20 CRD-LV Performance Evaluation: Uranium-Radium in Water, 6-Dec-1996

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
A	19.4	19.9	19.8	0.26	0.098	19.70	0.26	-0.23
AE	18.3	17.9	17.5	0.40	0.158	17.90	-0.78	-1.27
AF	18.4	18.7	18.8	0.21	0.079	18.63	-0.36	-0.85
AH	15.1	19.4	18.4	2.25	0.847	17.63	-0.94	-1.42
AJ								
AK	21.5	19.2	18.8	1.46	0.532	19.83	0.33	-0.15
AL	20.1	18.2	19.9	1.04	0.374	19.40	0.08	-0.40
AP	20.2	20.6	20.7	0.26	0.098	20.50	0.72	0.23
AR								
AU	2.6	4.4	4.3	1.01	0.354	3.77	-8.94	-9.43
AW	17.9	18.1	18.7	0.42	0.158	18.23	-0.59	-1.08
AZ	20.9	18.0	16.9	2.07	0.788	18.60	-0.38	-0.87
BA	16.5	18.2	14.8	1.70	0.669	16.50	-1.59	-2.08
BC	18.8	20.4	19.1	0.85	0.315	19.43	0.10	-0.38
BG								
BH	16.4	17.6	16.1	0.79	0.295	16.70	-1.47	-1.96
BK	19.5	20.1	19.7	0.31	0.118	19.77	0.30	-0.19
BM	18.2	18.2	18.1	0.06	0.020	18.17	-0.63	-1.12
BN	18.1	20.1	19.8	1.08	0.394	19.33	0.05	-0.44
BO	21.1	21.2	20.0	0.67	0.236	20.77	0.87	0.38
C	19.1	18.3	18.2	0.49	0.177	18.53	-0.42	-0.90
CA	20.2	20.2	20.2	0.00	0.000	20.20	0.55	0.06
CC	21.0	19.0	20.0	1.00	0.394	20.00	0.43	-0.06
CE	19.9	20.2	18.7	0.79	0.295	19.60	0.20	-0.29
CG	18.2	17.3	20.3	1.54	0.591	18.60	-0.38	-0.87
CJ	20.0	21.0	20.0	0.58	0.197	20.33	0.62	0.13
CM								
CS	21.2	21.9	23.1	0.96	0.374	22.07	1.62	1.14
CX								
D								
DB	18.3	18.9	19.4	0.55	0.217	18.87	-0.22	-0.71
DE	20.2	20.3	20.4	0.10	0.039	20.30	0.60	0.12
DI								
DO								
DR								
DT	19.4	19.1	19.0	0.21	0.079	19.17	-0.05	-0.54
DZ	21.8	22.0	20.5	0.81	0.295	21.43	1.26	0.77
E	17.4	20.3	18.5	1.46	0.571	18.73	-0.30	-0.79
EB	19.5	20.2	21.0	0.75	0.295	20.23	0.57	0.08
EL	17.8	22.1	16.0	3.13	1.383	18.63	-0.36	-0.85
EO	20.3	20.0	16.8	1.94	0.689	19.03	-0.13	-0.62
EP	17.1	17.6	17.6	0.29	0.098	17.43	-1.05	-1.54
ER	23.9	27.9	29.8	3.01	1.308	27.20	4.59	4.10
FE								
FJ								

• = No data submitted

TAG SYMBOLS

Ø = Insufficient data

× = Determined to be an outlier

↑ = Above control limit

↓ = Below control limit

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
FN	15.3	15.5	15.4	0.10	0.039	15.40	-2.22	-2.71
FZ								•
GN	18.5	18.1	18.5	0.23	0.079	18.37	-0.51	-1.00
GQ	17.6	18.2	18.1	0.32	0.118	17.97	-0.74	-1.23
HK	19.5	19.5	19.2	0.17	0.059	19.40	0.08	-0.40
HL	20.7	17.9	16.5	2.14	0.827	18.37	-0.51	-1.00
HP	18.8	19.7	18.6	0.59	0.217	19.03	-0.13	-0.62
I	17.1	17.6	16.0	0.82	0.315	16.90	-1.36	-1.85
ID	18.8	16.9	17.5	0.97	0.374	17.73	-0.88	-1.37
J								•
JE	21.7	18.8	21.4	1.59	0.571	20.63	0.80	0.31
JG								•
JK								•
JN								•
JP								•
JS	23.0	21.0	24.0	1.53	0.591	22.67	1.97	1.48
JX	20.0	21.9	20.7	0.96	0.374	20.87	0.93	0.44
JY	19.1	21.0	22.1	1.52	0.591	20.73	0.85	0.37
K	22.3	17.2	16.3	3.24	1.345	18.60	-0.38	-0.87
KH	19.5	18.5	18.5	0.58	0.197	18.83	-0.24	-0.73
KL	23.5	22.8	22.1	0.70	0.276	22.80	2.05	1.56
KT								•
L	17.7	19.0	19.7	1.01	0.394	18.80	-0.26	-0.75
LF								•
LH								•
LT	21.7	21.7	17.5	2.42	0.827	20.30	0.60	0.12
LZ	19.8	20.2	20.0	0.20	0.079	20.00	0.43	-0.06
M	17.5	20.2	19.3	1.37	0.532	19.00	-0.15	-0.64
MX	6.8	7.2	6.6	0.83	0.315	6.53	-7.34	-7.83
N								•
NA								•
NH								•
NJ	20.7	19.9	23.6	1.95	0.728	21.40	1.24	0.75
NK								•
NO	9.8	10.0	12.0	1.22	0.433	10.60	-5.00	-5.48
NT	19.8	19.9	19.8	0.06	0.020	19.83	0.33	-0.15
O	15.6	15.3	15.9	0.30	0.118	15.60	-2.11	-2.60
OB	19.9	19.4	21.9	1.32	0.492	20.40	0.66	0.17
OF	21.9	17.6	13.0	4.45	2.433	17.50	-1.01	-1.50
OM								•
OS								•
OX								•
OY								•
P	15.9	21.1	15.5	3.12	1.195	17.50	-1.01	-1.50
PB	20.4	19.9	20.4	0.29	0.098	20.23	0.57	0.08

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

Ø = Insufficient data

× = Determined to be an outlier

↓ = Below control limit

12 / 20 CRD-LV Performance Evaluation: Uranium-Radium in Water, 6-Dec-1996

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
PG	17.8	17.8	17.5	0.17	0.059	17.70	-0.90	-1.39	
PQ									•
PV	11.6	11.3	11.7	0.21	0.079	11.53	-4.46	-4.95	×
PW	19.8	21.0	18.4	1.30	0.512	19.73	0.28	-0.21	
PX	21.0	20.6	21.0	0.23	0.079	20.87	0.93	0.44	
Q	25.1	21.9	24.5	1.70	0.630	23.83	2.64	2.16	
QM	19.4	19.9	19.7	0.25	0.098	19.67	0.24	-0.25	
QQ	17.2	20.2	17.3	1.70	0.591	18.23	-0.59	-1.08	
QU	18.0	17.4	17.4	0.35	0.118	17.60	-0.95	-1.44	
QX	19.7	22.0	20.7	1.15	0.453	20.80	0.89	0.40	
QZ	19.0	18.4	18.0	0.50	0.197	18.47	-0.45	-0.94	
R	16.4	13.8	14.4	1.36	0.512	14.87	-2.53	-3.02	↓
RD	22.3	22.2	22.1	0.10	0.039	22.20	1.70	1.21	
RF	18.9	19.3	20.0	0.56	0.217	19.40	0.08	-0.40	
RG									•
RK									•
RP									•
RR									•
RX	9.6	9.2	9.9	0.35	0.138	9.57	-5.59	-6.08	×
RZ	20.6	20.1	19.6	0.50	0.197	20.10	0.49	0.00	
S	20.7	21.1	21.1	0.23	0.079	20.97	0.99	0.50	
SC	19.9	18.6	15.7	2.15	0.827	18.07	-0.69	-1.17	
SD	15.7	15.5	15.1	0.31	0.118	15.43	-2.21	-2.69	
SF	19.1	18.3	17.9	0.61	0.236	18.43	-0.47	-0.96	
SI	14.9	15.4	14.5	0.45	0.177	14.93	-2.49	-2.98	
SL									•
SM	20.3	21.2	18.8	1.21	0.473	20.10	0.49	0.00	
SO									•
SS	17.8	15.9	20.4	2.26	0.886	18.03	-0.70	-1.19	
SX									•
SZ	20.9	20.6	20.5	0.21	0.079	20.67	0.82	0.33	
T									•
TD	22.1	22.4	19.6	1.54	0.551	21.37	1.22	0.73	
TH									•
TL									•
TN	18.1	16.1	14.3	1.90	0.748	16.17	-1.78	-2.27	
TQ	16.6	19.6	19.4	1.68	0.591	18.53	-0.42	-0.90	
TS									•
U	18.9	19.7	18.6	0.57	0.217	19.07	-0.11	-0.60	
UE	16.9	18.8	17.6	0.96	0.374	17.77	-0.86	-1.35	
UN									•
UP	22.3	23.8	22.8	0.76	0.295	22.97	2.14	1.66	
UQ	19.1	20.4	19.6	0.66	0.256	19.70	0.26	-0.23	
UZ									•
VA	23.8	21.3	25.2	1.98	0.768	23.43	2.41	1.92	

• = No data submitted

Ø = Insufficient data

TAG SYMBOLS

× = Determined to be an outlier

↑ = Above control limit

↓ = Below control limit

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
VH	18.4	22.2	23.8	2.77	1.120	21.47	1.28	0.79	
VI	18.3	19.9	20.0	0.95	0.335	19.40	0.08	-0.40	
W	37.0	35.0	33.0	2.00	0.788	35.00	9.09	8.60	×
WC	9.7	5.7	8.1	2.01	0.788	7.83	-6.59	-7.08	×
WG									•
WH	19.2	20.2	20.2	0.58	0.197	19.87	0.35	-0.13	
WI									•
WJ	18.8	19.5	19.6	0.44	0.158	19.30	0.03	-0.46	
WO									•
WR									•
WS									•
WV									•
WX									•
X	17.0	16.6	19.5	1.57	0.571	17.70	-0.90	-1.39	
XA	20.3	23.4	18.2	2.62	1.045	20.63	0.80	0.31	
XC									•

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
3.77	×	AU	18.03		SS	19.33		BN
6.53	×	MX	18.07		SC	19.40		VI
7.83	×	WC	18.17		BM	19.40		RF
9.57	×	RX	18.23		QQ	19.40		HK
10.60	×	NO	18.23		AW	19.40		AL
11.53	×	PV	18.37		HL	19.43		BC
14.87	↓	R	18.37		GN	19.60		CE
14.93		SI	18.43		SF	19.67		QM
15.40		FN	18.47		QZ	19.70		A
15.43		SD	18.53		TQ	19.70		UQ
15.60		O	18.53		C	19.73		PW
16.17		TN	18.60		K	19.77		BK
16.50		BA	18.60		CG	19.83		NT
16.70		BH	18.60		AZ	19.83		AK
16.90		I	18.63		EL	19.87		WH
17.43		EP	18.63		AF	20.00		LZ
17.50		P	18.73		E	20.00		CC
17.50		OF	18.80		L	20.10		SM
17.60		QU	18.83		KH	20.10		RZ
17.63		AH	18.87		DB	20.20		CA
17.70		PG	19.00		M	20.23		PB
17.70		X	19.03		EO	20.23		EB
17.73		ID	19.03		HP	20.30		LT
17.77		UE	19.07		U	20.30		DE
17.90		AE	19.17		DT	20.33		CJ
17.97		GQ	19.30		WJ	20.40		OB

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

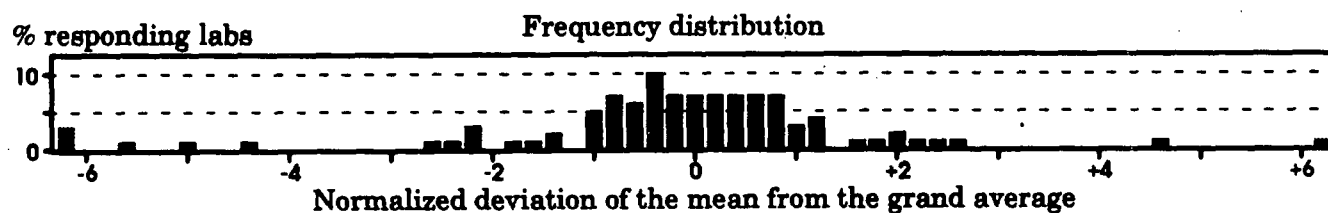
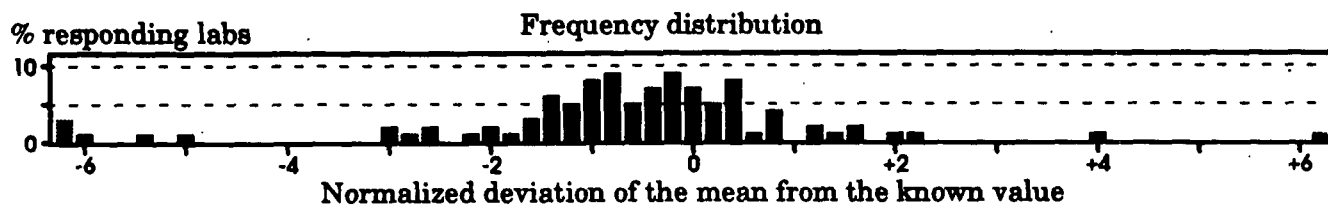
∅ = Insufficient data

× = Determined to be an outlier

↓ = Below control limit

Radium-226**Data sorted by Laboratory Average**

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
20.50		AP	20.87		PX	22.20		RD
20.63		XA	20.87		JX	22.67		JS
20.63		JE	20.97		S	22.80		KL
20.67		SZ	21.37		TD	22.97		UP
20.73		JY	21.40		NJ	23.43		VA
20.77		BO	21.43		DZ	23.83		Q
20.80		QX	21.47		VH	27.20	x	ER
			22.07		CS	35.00	x	W



• = No data submitted

Ø = Insufficient data

TAG SYMBOLS

x = Determined to be an outlier

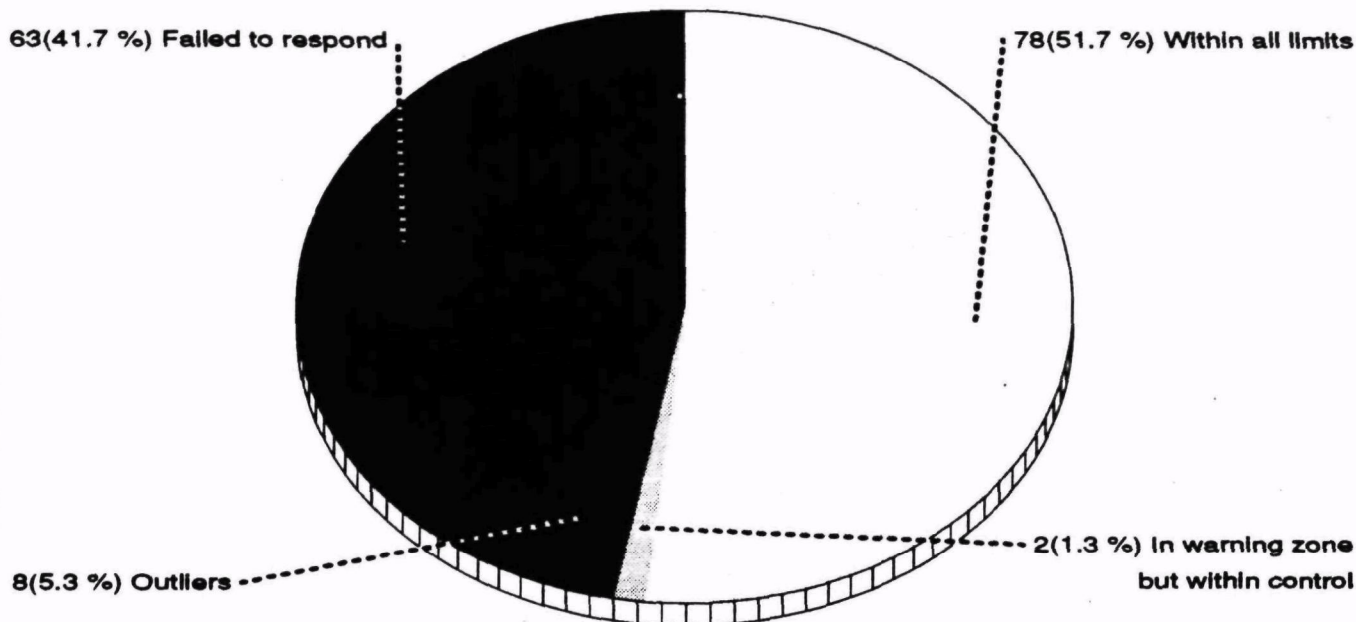
↑ = Above control limit

↓ = Below control limit

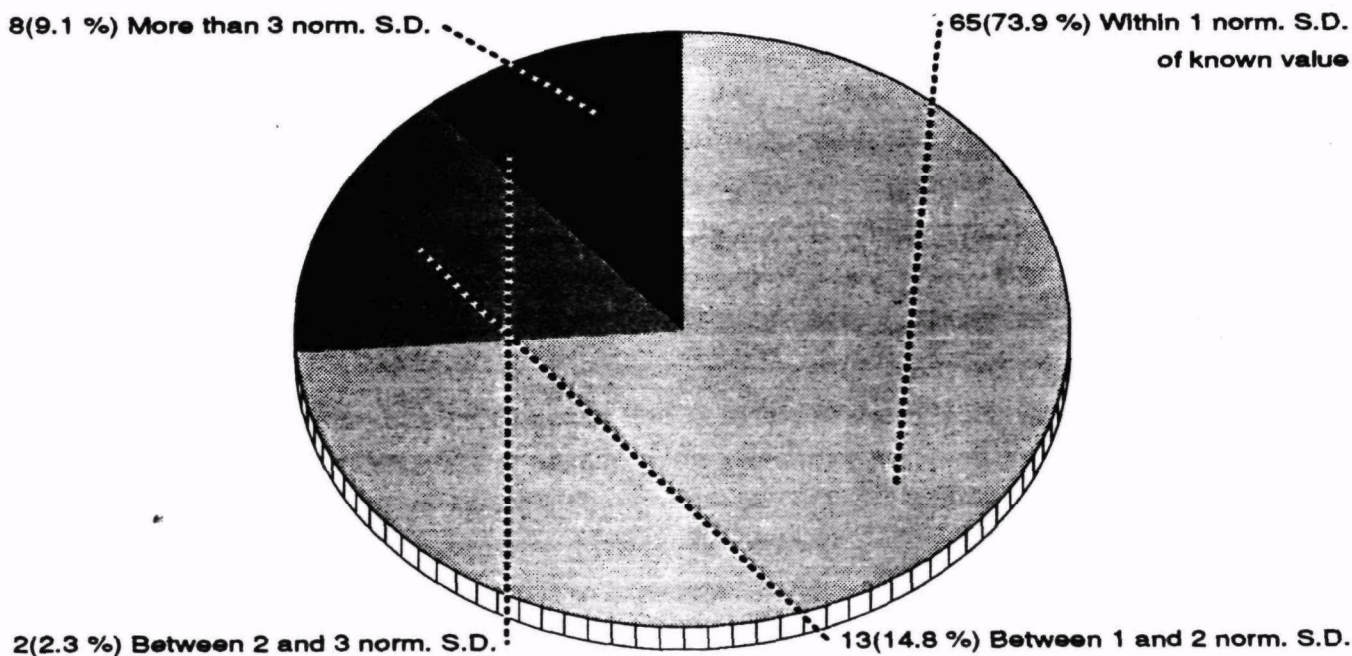
Radium-228**Statistical Summary**

151 Participants

The known value of this nuclide is 10.2 pCi/l with an expected precision of 2.6; the control limits are 5.7 to 14.7; the warning regions are 5.7 to 7.2 and 13.2 to 14.7



Statistic	Respondents	Non-outliers
Mean	10.21	Grand Avg 10.10
Std. Dev.	2.56	1.18
Variance	6.54	1.39
% Coef. of Var.	25.06	11.69
% deviation of mean from known value	0.07	-0.95
Norm. dev. of mean from known value	0.00	-0.08
Median	10.33	10.33
% deviation of median from known value	1.31	1.31
Norm. dev. of median from known value	0.05	0.11



16 / 20 CRD-LV Performance Evaluation: Uranium-Radium in Water, 6-Dec-1996

Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
A	10.4	11.1	12.7	1.18	0.523	11.40	0.86	0.80
AE	8.2	7.0	8.4	0.76	0.318	7.87	-1.49	-1.55
AF	11.2	11.7	11.3	0.26	0.114	11.40	0.86	0.80
AH	7.3	8.8	8.8	0.87	0.341	8.30	-1.20	-1.27
AJ								
AK	11.1	12.0	12.4	0.67	0.295	11.83	1.15	1.09
AL	11.2	10.9	10.3	0.46	0.204	10.80	0.46	0.40
AP	3.9	4.6	4.2	0.35	0.159	4.23	-3.91	-3.97
AR								
AU	2.3	3.2	3.7	0.71	0.318	3.07	-4.69	-4.75
AW	10.8	11.5	12.0	0.60	0.273	11.43	0.89	0.82
AZ	10.5	8.2	7.3	1.65	0.727	8.67	-0.96	-1.02
BA	11.2	12.7	12.4	0.79	0.341	12.10	1.33	1.27
BC	9.3	9.5	9.4	0.10	0.045	9.40	-0.47	-0.53
BG								
BH	6.0	7.7	7.8	1.01	0.409	7.17	-1.96	-2.02
BK	9.3	9.4	9.0	0.21	0.091	9.23	-0.58	-0.64
BM	10.1	10.5	10.6	0.26	0.114	10.40	0.20	0.13
BN								
BO	12.9	12.2	10.8	1.07	0.477	11.97	1.24	1.18
C	10.5	10.2	10.4	0.15	0.068	10.37	0.18	0.11
CA	8.6	10.2	9.8	0.83	0.363	9.53	-0.38	-0.44
CC	10.0	10.0	11.0	0.58	0.227	10.33	0.15	0.09
CE	9.6	9.9	10.5	0.46	0.204	10.00	-0.07	-0.13
CG	9.3	9.2	11.1	1.07	0.432	9.87	-0.16	-0.22
CJ	10.0	11.0	10.0	0.58	0.227	10.33	0.15	0.09
CM								
CS	10.6	12.0	10.1	0.98	0.432	10.90	0.53	0.47
CX								
D								
DB	10.9	10.4	10.5	0.26	0.114	10.60	0.33	0.27
DE	11.3	11.5	11.9	0.31	0.136	11.57	0.97	0.91
DI								
DO								
DR								
DT	17.2	17.8	17.7	0.26	0.114	17.40	4.86	4.80
DZ	10.2	8.6	9.4	0.80	0.363	9.40	-0.47	-0.53
E								
EB	8.7	9.1	10.3	0.83	0.363	9.37	-0.49	-0.56
EL	10.5	9.9	11.1	0.60	0.273	10.50	0.26	0.20
EO	10.6	10.4	8.3	1.27	0.523	9.77	-0.22	-0.29
EP	8.8	9.0	8.7	0.15	0.068	8.83	-0.85	-0.91
ER								
FE								
FJ								

• = No data submitted

Ø = Insufficient data

TAG SYMBOLS

× = Determined to be an outlier

↑ = Above control limit

↓ = Below control limit

Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
FN	8.1	8.0	8.1	0.06	0.023	8.07	-1.36	-1.42
FZ								
GN	9.0	9.1	9.0	0.06	0.023	9.03	-0.71	-0.78
GQ	7.9	8.2	8.6	0.35	0.159	8.23	-1.25	-1.31
HK	9.6	9.7	9.9	0.15	0.068	9.73	-0.25	-0.31
HL	10.3	8.9	8.5	0.95	0.409	9.23	-0.58	-0.64
HP	8.7	9.3	8.1	0.60	0.273	8.70	-0.93	-1.00
I	13.8	12.3	6.8	3.69	2.124	10.97	0.58	0.51
ID	15.9	15.2	15.9	0.06	0.023	15.27	8.44	8.38
JE								
JE								
JG								
JK								
JN								
JP								
JS	11.0	11.0	11.0	0.00	0.000	11.00	0.60	0.53
JX	12.6	10.6	10.0	1.36	0.591	11.07	0.64	0.58
JY	10.9	11.0	10.9	0.06	0.023	10.93	0.55	0.49
K	11.9	10.5	10.6	0.78	0.318	11.00	0.60	0.53
KH	11.1	10.6	10.8	0.25	0.114	10.83	0.49	0.42
KL	12.2	14.2	12.8	1.03	0.454	13.07	1.97	1.91
KT								
L	10.6	10.4	10.4	0.12	0.045	10.47	0.24	0.18
LF								
LH								
LT	9.2	8.7	13.3	2.52	1.086	10.40	0.20	0.13
LZ								
M	11.2	11.8	11.5	0.30	0.136	11.50	0.93	0.87
MX	10.8	11.7	11.0	0.47	0.204	11.17	0.71	0.64
N								
NA								
NH								
NJ	11.1	11.1	10.8	0.17	0.068	11.00	0.60	0.53
NK								
NO	9.0	10.0	11.0	1.00	0.454	10.00	-0.07	-0.13
NT	9.8	9.6	9.3	0.25	0.114	9.57	-0.36	-0.42
O	11.2	7.6	7.9	2.00	0.818	8.90	-0.80	-0.87
OB								
OF	4.8	7.8	14.3	4.86	3.206	8.97	-0.76	-0.82
OM								
OS								
OX								
OY								
P	9.4	8.5	9.2	0.47	0.204	9.03	-0.71	-0.78
PB	10.1	10.9	10.6	0.40	0.182	10.53	0.29	0.22

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

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18 / 20 CRD-LV Performance Evaluation: Uranium-Radium in Water, 6-Dec-1996

Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
PG									
PQ									
PV	10.9	10.7	11.4	0.36	0.159	11.00	0.60	0.53	
PW	10.9	10.3	10.9	0.35	0.136	10.70	0.40	0.33	
PX									
Q	11.1	10.9	9.4	0.93	0.386	10.47	0.24	0.18	
QM									
QQ									
QU	22.5	22.0	21.5	0.50	0.227	22.00	7.93	7.86	
QX	3.5	3.8	3.4	0.10	0.045	3.50	-4.40	-4.46	x
QZ	10.0	9.6	10.0	0.23	0.091	9.87	-0.16	-0.22	
R									
RD	10.6	10.3	9.7	0.46	0.204	10.20	0.06	0.00	
RF	11.5	10.5	10.9	0.50	0.227	10.97	0.58	0.51	
RG									
RK									
RP									
RR									
RX	9.4	9.0	10.0	0.50	0.227	9.47	-0.42	-0.49	
RZ	9.6	10.5	11.1	0.75	0.341	10.40	0.20	0.13	
S	8.2	8.5	9.2	0.51	0.227	8.63	-0.98	-1.04	
SC	9.9	10.7	9.8	0.49	0.204	10.13	0.02	-0.04	
SD	9.5	10.0	10.6	0.55	0.250	10.03	-0.05	-0.11	
SF	10.0	12.0	9.0	1.53	0.682	10.33	0.15	0.09	
SI	8.9	8.4	8.7	0.25	0.114	8.67	-0.96	-1.02	
SL									
SM	8.4	8.9	6.1	1.49	0.636	7.80	-1.53	-1.60	
SO									
SS	10.2	8.7	10.0	0.81	0.341	9.63	-0.31	-0.38	
SX									
SZ	11.9	11.2	11.7	0.36	0.159	11.60	1.00	0.93	
T									
TD	11.3	9.3	11.2	1.13	0.454	10.60	0.33	0.27	
TH									
TL									
TN	9.0	10.2	9.7	0.60	0.273	9.63	-0.31	-0.38	
TQ	9.8	9.1	11.0	0.96	0.432	9.97	-0.09	-0.16	
TS									
U	10.7	11.5	11.2	0.40	0.182	11.13	0.69	0.62	
UE	9.3	9.0	9.6	0.30	0.136	9.30	-0.54	-0.60	
UN									
UP	11.2	10.9	10.8	0.21	0.091	10.97	0.58	0.51	
UQ	12.8	11.3	12.4	0.78	0.341	12.17	1.37	1.31	
UZ									
VA	4.9	5.6	4.8	0.44	0.182	5.10	-3.33	-3.40	x

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Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
VH	9.1	11.9	11.4	1.49	0.636	10.80	0.46	0.40	
VI	10.7	10.6	10.6	0.06	0.023	10.63	0.35	0.29	
W									•
WC	19.1	19.6	19.4	0.25	0.114	19.87	6.17	6.11	×
WG									•
WH	10.4	9.3	9.4	0.61	0.250	9.70	-0.27	-0.33	
WI									•
WJ	10.6	10.0	9.3	0.65	0.295	9.97	-0.09	-0.16	
WO									•
WE									•
WS									•
WV									•
WX									•
X	6.5	7.6	6.2	0.74	0.318	6.77	-2.22	-2.29	
XA									•
XC									•

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
3.07	×	AU	9.47		RX	10.50		EL
3.50	×	QX	9.53		CA	10.53		PB
4.23	×	AP	9.57		NT	10.60		DB
5.10	×	VA	9.63		TN	10.60		TD
6.77		X	9.63		SS	10.63		VI
7.17		BH	9.70		WH	10.70		PW
7.80		SM	9.73		HK	10.80		VH
7.87		AE	9.77		EO	10.80		AL
8.07		FN	9.87		QZ	10.83		KH
8.23		GQ	9.87		CG	10.90		CS
8.30		AH	9.97		WJ	10.93		JY
8.63		S	9.97		TQ	10.97		UP
8.67		SI	10.00		NO	10.97		RF
8.67		AZ	10.00		CE	10.97		I
8.70		HP	10.03		SD	11.00		PV
8.83		EP	10.13		SC	11.00		NJ
8.90		O	10.20		RD	11.00		K
8.97		OF	10.33		SF	11.00		JS
9.03		P	10.33		CJ	11.07		JX
9.03		GN	10.33		CC	11.13		U
9.23		HL	10.37		C	11.17		MX
9.23		BK	10.40		RZ	11.40		AF
9.30		UE	10.40		LT	11.40		A
9.37		EB	10.40		BM	11.43		AW
9.40		DZ	10.47		Q	11.50		M
9.40		BC	10.47		L	11.57		DE

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

Ø = Insufficient data

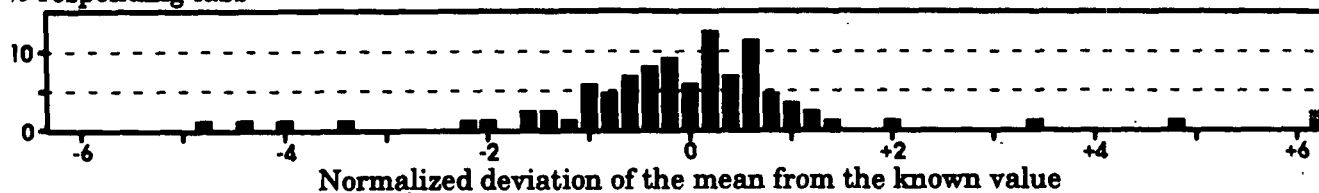
× = Determined to be an outlier

↓ = Below control limit

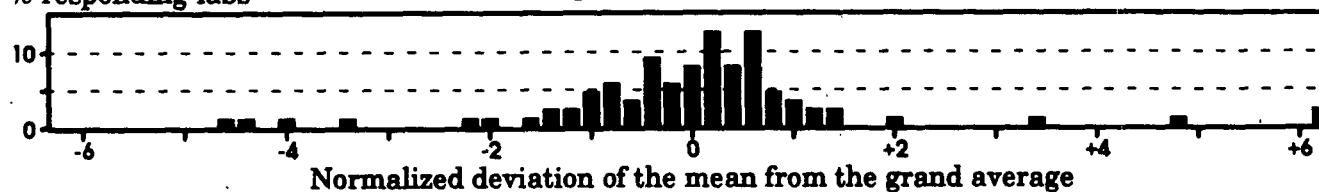
Radium-228**Data sorted by Laboratory Average**

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
11.60		SZ	12.10		BA	15.27	×	ID
11.83		AK	12.17		UQ	17.40	×	DT
11.97		BO	13.07		KL	19.37	×	WC
						22.00	×	QU

% responding labs

Frequency distribution

% responding labs

Frequency distribution

• ≡ No data submitted

TAG SYMBOLS

↑ ≡ Above control limit

∅ ≡ Insufficient data

× ≡ Determined to be an outlier

↓ ≡ Below control limit