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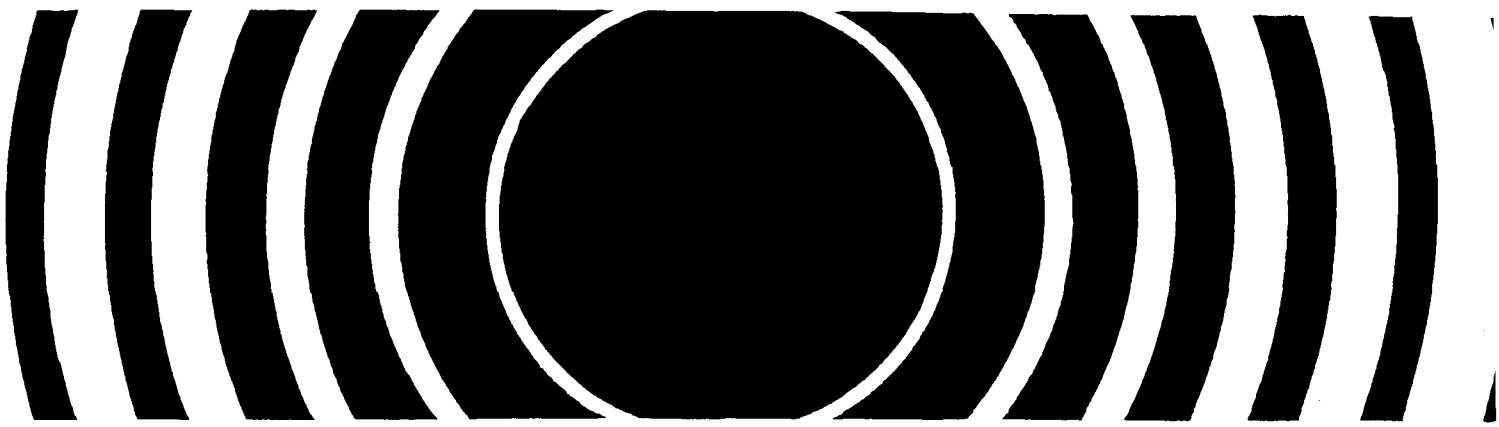
The Eastern Environmental Radiation Facility's Participation in Interlaboratory and Intralaboratory Comparisons of Environmental Sample Analyses



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The Eastern Environmental Radiation Facility's Participation in Interlaboratory and Intralaboratory Comparisons of Environmental Sample Analyses: 1981 - 1986

by

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1989

U. S. Environmental Protection Agency
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PREFACE

The Eastern Environmental Radiation Facility (EERF) helps solve problems defined by the Office of Radiation Programs. The facility provides analytical capability for evaluating and assessing radiation sources through environmental studies and surveillance and analysis. The EERF provides special analytical support for Environmental Protection Agency Regional Offices and other federal government agencies as requested as well as technical assistance to the radiological health programs of state and local health departments.

Readers of this report are encouraged to comment freely. Comments may be directed to the EERF directly or to the Office of Radiation Programs in Washington, DC.

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Director
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1. INTRODUCTION

The Eastern Environmental Radiation Facility (EERF), which is a part of the U.S. Environmental Protection Agency's Office of Radiation Programs (ORP), has compared its results of analyses of radionuclides in environmental and biological samples with those of other agencies since EPA's inception in 1970. In fact, the comparison of results began back in 1964 when the EERF was known as the Southeastern Radiological Health Laboratory and was operated by the U.S. Public Health Service. Such intercomparisons are sponsored by several agencies and the results are routinely published by the quality assurance reference center of the respective sponsoring agency. All samples in these intercomparisons are treated anonymously, identified by a code known only by the originating laboratory and appropriate reference center.

The EERF is committed to making its results of interlaboratory comparison studies a matter of public record. This provides a basis for judging the validity of routinely reported results. The Environmental Measurements Laboratory (EML), formerly the Health and Safety Laboratory (HASL), was first to publish the results of their participation in an intercomparison program (We77). In 1979, and again in 1982, the EERF published all results of intercomparison programs prior to 1981 that were sponsored by the EPA National Quality Assurance Program at the Environmental Monitoring and Systems Laboratory - Las Vegas (EMSL-LV), the World Health Organization (WHO), and the International Atomic Energy Agency (IAEA) (Bl79, Bl82).

This report presents our results for 1981 through 1986 of intercomparison studies sponsored by EMSL-LV, WHO, and the DOE Mound Facility at Miamisburg, Ohio, as well as our intralaboratory analyses results. The latter includes the results for replicate, blind, and spiked sample analyses. We plan to publish similar reports periodically that provide updated performances of our Quality Assurance programs.

2. INTERLABORATORY COMPARISON PROGRAMS

2.1. EMSL-LV Intercomparison Program

The most comprehensive intercomparison program with respect to numbers of samples, sample types, and radionuclides has been conducted with the EMSL-LV Reference Center. Routine sample types and the radionuclides that were included in each are shown in Table 2.1.

Table 2.1 EMSL-LV Intercomparison Reference Samples

Sample Type	Radionuclides Included in Sample
Water	$^{3}H(26)$, $^{51}Cr(17)$, $^{60}Co(23)$, $^{65}Zn(15)$, $^{89}Sr(29)$, $^{90}Sr(25)$, $^{106}Ru(15)$, $^{131}I(17)$, $^{134}Cs(24)$, $^{137}Cs(25)$, $^{226}Ra(38)$, $^{228}Ra(28)$, $^{234,238}U(17)$, $^{239}Pu(12)$, Gross Alpha (32), Gross Beta (30)
Milk	$^{60}Co(1)$, $^{89}Sr(15)$, $^{90}Sr(13)$, $^{131}I(16)$, $^{137}Cs(13)$, $^{140}Ba(8)$, K(9)
Food	$^{60}Co(2)$, $^{89}Sr(12)$, $^{90}Sr(12)$, $^{131}I(12)$, $^{137}Cs(12)$, K(12)
Air Filters	$^{90}Sr(5)$, $^{137}Cs(5)$, Gross Alpha (5), Gross Beta (5)
Soil	$^{210}Pb(1)$, $^{226}Ra(1)$, $^{230}Th(1)$, $^{238}U(1)$

Note:--The number of samples is given in parentheses.

Each analysis was made in triplicate. The results of these analyses with the known concentrations are presented in Appendixes A through E. In the appendixes, the values reported by EERF are compared in two different ways to the known values supplied by the reference center. For the first comparison, the average of the triplicate analyses (column 3) was divided by the known concentration (column 4) resulting in a ratio (R) shown in the fifth column. The value of R is a measure of agreement between the measured and known concentrations. The closer the value of R approaches one, the better the agreement between measured and known concentrations. However, for low concentration measurements, large values of R are often acceptable, since the uncertainties of measurement and known concentration are frequently large at low concentrations. That is, as the concentration decreases the standard deviation (the uncertainty) increases relative to the measured concentration. As the concentrations become smaller and the uncertainties relatively larger, a point is reached at which the size of the combined uncertainties equal or exceed the small absolute difference between measured and known concentrations. When this occurs, the result of the analysis is considered to be satisfactory, even though, for these cases, the value of R often differs considerably from unity.

A second method of comparison is a semi-quantitative statistic known as the coefficient of variation (CV) (Mo51). The coefficient of variation is particularly useful in comparing dispersion of two or more sets of positive variates measured in the same or different units. For a sample

with a true mean (μ), a sample mean($\bar{X}$), and a sample standard deviation (S_X), the coefficient of variation (CV) is usually defined as

$$CV = \frac{S_x}{\mu} \cdot 100 \text{ percent} \qquad 2\text{-}1$$

where

$$S_x = \left[\frac{\sum(X_i-\mu)^2}{n} \right]^{1/2} . \qquad 2\text{-}2$$

When the true mean (μ) is not known, the coefficient of variation is defined as

$$CV = \frac{\hat{S}_x}{\bar{X}} \cdot 100 \text{ percent} \qquad 2\text{-}3$$

where

$$\hat{S}_x = \left[\frac{\sum(X_i-\bar{X})^2}{n-1} \right]^{1/2} . \qquad 2\text{-}4$$

There is normally a wide range of values over which radioactivity intercomparisons are made, therefore, CV is particularly useful for these applications. Equations 2-3 and 2-4 were used to compute the coefficient of variation as a percentage of the mean value, and the results are listed in the sixth column of Appendixes A through E.

A comparison of the EERF results with the reference center supplied concentrations, as indicated by the ratio R, is summarized for the various sample media in Tables 2-2 to 2-5. The radionuclide is identified in the first column with the number of samples analyzed shown in parentheses; analyses that resulted in less-than values or samples containing concentrations below the MDL are not included in these tables. The ranges in the

values of R and the mean value of R are listed in the second and third columns, respectively, followed by the percent of the analyses differing by ± 10 percent, ± 20 percent, and by more than 20 percent of the known reference center value. Agreement within 10 percent is considered very good; those within 20 percent of the known value are considered satisfactory.[a]

Approximately 86 percent of all EMSL-LV cross-check results (416 of 486 analyses) were within 20 percent of the known value. However, 49 (70 percent) of the 70 EMSL-LV cross-check samples for which our results differed from the known value by more than 20 percent are judged satisfactory because of the low sample concentrations, the uncertainty in the measurements and known values, and the small absolute difference between the results. These results have asterisks by them in Appendixes A through E. Thus, over 95 percent of the EMSL-LV cross-check analyses are acceptable by this test. In addition, of 48 samples that contained concentrations below the minimum detectable level (MDL), 43 (90 percent) were correctly identified as containing less than the minimum detectable concentration.

The data listed in Tables 2-2 to 2-4 are presented graphically in Figures 2-1 and 2-2. Although we noted above that over 95 percent of the EMSL-LV cross-check analyses were in agreement, these graphs indicate that the results of these analyses, particularly for radionuclides measured in water, are biased downwards. That is, although a result of an analysis may have been within 20 percent of the concentration supplied by EMSL-LV, it was generally less than the EMSL-LV value. However, a similar bias is not apparent for

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(a) This is an arbitrary judgment first used in 1977 by Welford and Harley (We77) and continued in the two reports that followed (Bl79, Bl82).

Table 2-2

Summary of EMSL-LV Cross-Check Water Sample Analyses[a]

Nuclide	Range in R	Mean Value of R[b]	Percent of Values differing from R = 1.00 by:			Coefficient of Variation (CV), percent	
			<10%	<20%	>20%	Range	Mean
H-3(26)[c]	0.83 - 1.19	0.97 ± 0.07	81	100	0	0.45 - 17	7
Cr-51(9)	0.77 - 2.35	1.12 ± 0.47	78	78	22	3.8 - 149	34
Co-60(21)	0.70 - 1.23	1.01 ± 0.12	52	90	10	2.9 - 32	14
Zn-65(13)	0.58 - 1.09	0.96 ± 0.13	92	92	8	3.5 - 43	14
Sr-89(26)	0.57 - 1.36	0.98 ± 0.17	62	85	15	3.0 - 45	15
Sr-90(25)	0.81 - 1.21	0.99 ± 0.09	80	96	4	2.9 - 32	9
Ru-106(5)	0.81 - 1.32	0.95 ± 0.21	20	80	20	15 - 38	23
I-131(17)	0.71 - 1.08	0.90 ± 0.10	53	76	24	2.1 - 29	12
Cs-134(21)	0.77 - 1.18	1.01 ± 0.12	57	95	5	1.7 - 32	14
Cs-137(23)	0.81 - 1.63	1.09 ± 0.17	57	87	13	5.9 - 64	19
Ra-226(38)	0.82 - 1.22	0.96 ± 0.09	76	97	3	0.0 - 23	9
Ra-228(25)	0.68 - 1.48	0.97 ± 0.20	44	72	28	4.5 - 42	17
U-238/234(17)	0.82 - 1.13	0.95 ± 0.08	71	100	0	0.0 - 18	8
Pu-239(12)	0.77 - 1.01	0.91 ± 0.08	58	92	8	1.5 - 23	10
Gross alpha(32)	0.66 - 1.3	0.96 ± 0.18	34	78	22	1.7 - 34	16
Gross beta(30)	0.70 - 1.26	0.88 ± 0.12	33	70	30	0.0 - 31	15

(a) Individual results are listed in Appendix A.
(b) ± values are the standard deviation of individual analyses.
(c) Number of analyses are given in parentheses. Analyses of samples containing quantities below MDL or measured to be below MDL are not included in the table.

Table 2-3

Summary of EMSL-LV Cross-Check Milk Sample Analyses[a]

Nuclide	Range in R	Mean Value of R[b]	Percent of Values differing from R = 1.00 by:			Coefficient of Variation (CV), percent	
			<10%	<20%	>20%	Range	Mean
K(9)[c]	0.91 - 1.23	1.01 ± 0.10	89	89	11	2.7 - 23	7.4
Co-60(1)	- - -	1.07	100	0	0	- - -	7.2
Sr-89(12)	0.62 - 1.14	0.92 ± 0.14	50	83	17	3.8 - 38	14
Sr-90(12)	0.71 - 1.19	0.98 ± 0.13	75	92	8	3.7 - 30	11
I-131(13)	0.64 - 1.42	1.00 ± 0.18	69	85	15	6.1 - 58	16
Cs-137(13)	0.90 - 1.65	1.11 ± 0.20	62	69	31	6.6 - 66	18
Ba-140(2)	0.96 - 1.03	1.00 ± 0.05	100	0	0	3.2 - 3.5	3.4

(a) Individual results are listed in Appendix B.
(b) ± values are the standard deviation of individual analyses.
(c) Number of analyses are given in parentheses. Analyses of samples containing quantities below MDL or measured to be below MDL are not included in the table.

Table 2-4

Summary of EMSL-LV Cross-Check Food Sample Analyses[a]

Nuclide	Range in R	Mean Value of R[b]	Percent of Values differing from R = 1.00 by:			Coefficient of Variation (CV), percent	
			<10%	<20%	>20%	Range	Mean
K(12)[c]	0.86 - 1.10	0.99 ± 0.06	92	100	0	1.9 - 14	4.9
Co-60(2)	0.99 - 1.33	1.16 ± 0.24	50	50	50	6.3 - 34	20
Sr-89(11)	0.51 - 1.32	0.95 ± 0.23	36	73	27	6.6 - 50	20
Sr-90(12)	0.95 - 1.17	1.05 ± 0.07	75	100	0	1.9 - 18	10
I-131(11)	0.73 - 1.61	1.04 ± 0.22	64	82	18	3.5 - 67	17
Cs-137(12)	0.90 - 1.18	1.05 ± 0.10	67	100	0	6.9 - 20	13

(a) Individual results are listed in Appendix C.
(b) ± values are the standard deviation of individual analyses.
(c) Number of analyses are given in parentheses. Analyses of samples containing quantities below MDL or measured to be below MDL are not included in the table.

Table 2-5

Summary of EMSL-LV Cross-Check Analyses of Miscellaneous Sample Media

Nuclide	Range in R	Mean Value of R[a]	Percent of Values differing from R = 1.00 by:			Coefficient of Variation (CV), percent	
			<10%	<20%	>20%	Range	Mean
		Air Filters[b]					
Gross Alpha(5)[c]	0.76 - 1.04	0.93 ± 0.11	60	80	20	5 - 24	10
Gross Beta(5)	1.03 - 2.01	1.31 ± 0.41	40	60	40	4 - 156	43
Sr-90(5)	0.73 - 1.00	0.85 ± 0.11	40	60	40	8 - 27	17
Cs-137(5)	1.09 - 1.77	1.38 ± 0.25	20	20	80	9 - 77	37
		Soil[d]					
Pb-210(1)	- - -	0.79	0	0	100	- - -	23
Ra-226(1)	- - -	1.12	0	100	0	- - -	12
Th-230(1)	- - -	1.00	100	0	0	- - -	5
U-238(1)	- - -	0.88	0	100	0	- - -	13

(a) ± values are the standard deviation of individual analyses.
(b) Individual results are listed in Appendix D.
(c) Number of analyses are given in parentheses.
(d) Individual results are listed in Appendix E.

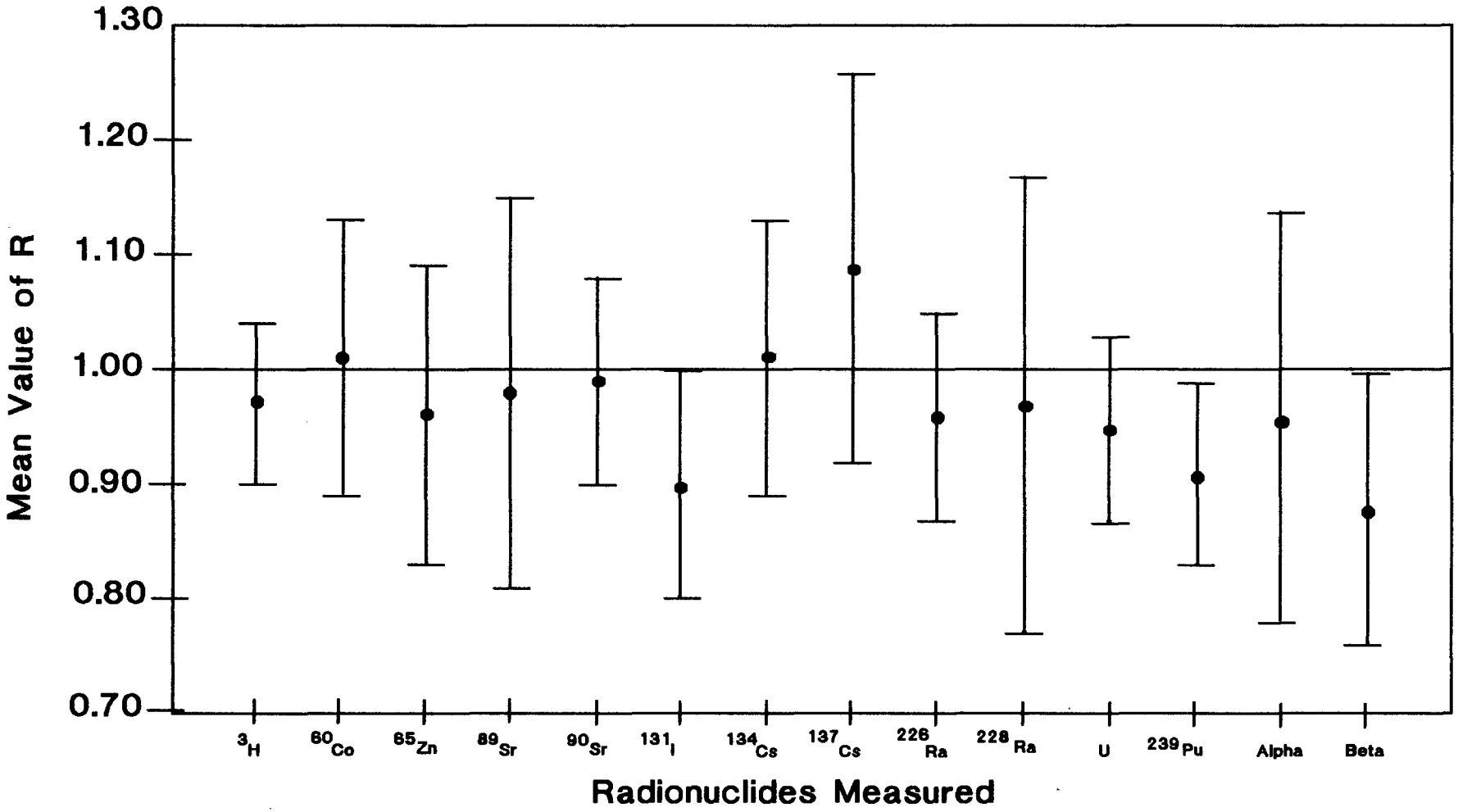

Figure 2-1. The mean value of R, with standard deviation, for each radionuclide measured in EMSL-LV water samples.

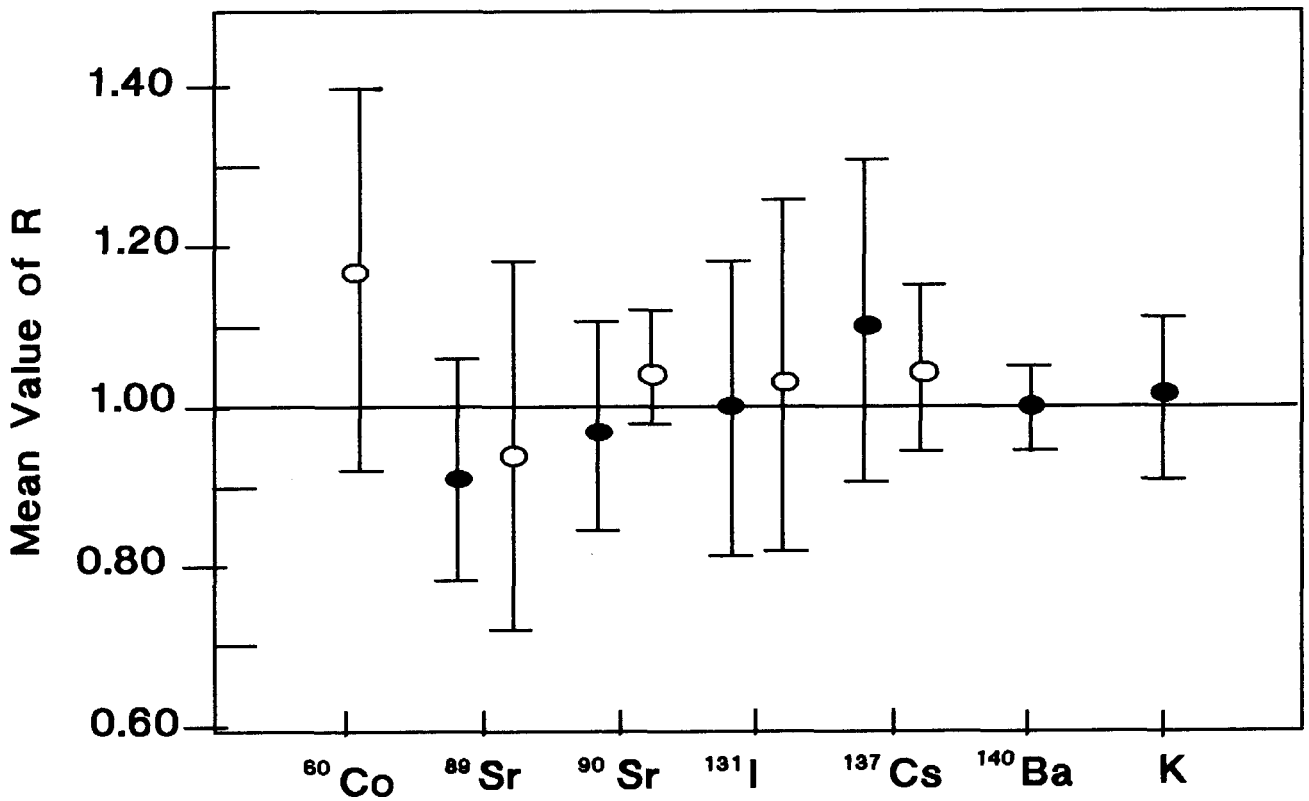

Figure 2-2. The mean value of R, with standard deviation, for radionuclides measured in EMSL-LV Milk (●) and food (○) samples.

radionuclides measured in milk and food samples (Figure 2-2). The graphical results also show a broad distribution in R about the desired value of 1.00 for some radionuclides. This is reflected by a large standard deviation which, for example, appears excessive for ^{89}Sr, ^{137}Cs, and ^{228}Ra measured in water.

Similarly, using the coefficient of variation as a measure of consistency with the EMSL-LV cross-check samples (see values in the sixth column of Appendixes A-E), 46 percent had coefficients of variation within 10 percent of the known value; 82 percent were within 20 percent; and less than 2 percent had coefficients of variation greater than 50 percent. These coefficients show a slight improvement in accuracy over the results reported for 1979 and 1980 (B182). A more detailed examination of those samples having high coefficients of variation showed that serious analytical difficulty was not indicated in most cases. For example, the ^{89}Sr water cross-check of April 1986 (see Appendix A) contained 7 pCi/L but was measured to contain 4 pCi/L, resulting in a coefficient of variation of 45 percent. Since the error in the known value of this sample is about 6 pCi/L at the 95 percent confidence level, the measured value of 4 pCi/L is not significantly different from the known value of 7 pCi/L. Thus, when using the coefficient of variation to determine whether a specific analytical problem exists, one must consider the magnitude of the associated analytical errors.

The mean coefficients of variation for each nuclide analyzed in the EMSL-LV water, milk, food, and air-filter samples are listed in the last

column of Tables 2-2 to 2-5. This provides a quick method for comparing the relative accuracy of the analytical procedures for different radionuclides. For example, the mean coefficient of variation of the ^{3}H in water analyses, 7 percent, indicates a relatively accurate procedure compared to that for ^{51}Cr, for which the mean coefficient of variation was 34 percent, indicating a relatively inaccurate procedure. However, this comparison does not consider the concentrations involved and the associated analytical errors.

The mean coefficient of variation for ^{226}Ra of 9 percent compares favorably with the 12 percent value previously determined by Williams (Wi81). Also, the mean coefficients of variation of 16 percent and 15 percent for gross alpha and beta measurements, respectively, compare favorably with the 20 - 40 percent range reported by Jarvis (Ja76). Considering water as the sample medium, ^{3}H, ^{90}Sr, and ^{226}Ra were analyzed most accurately while ^{51}Cr was analyzed with the least success, due primarily to its very low intensity gamma-ray (9 percent). The results also indicate that ^{131}I and ^{239}Pu analyses may be biased somewhat low. It seems apparent that air filters are the most difficult medium to satisfactorily analyze.

Table 2-6 lists the minimum detectable concentrations for the radionuclides commonly measured by the procedures used at the EERF (Li82). These concentrations correspond roughly to one-half the detection limit as defined by Currie (Cu68), in that they are a priori concentrations that should lead to detection at a confidence level of

α = 0.05 and β = 0.05. Although results presented in this report are not sufficient to corroborate the tabulated minimum detectable concentrations, general consistency with those values is demonstrated. Of the 48 analyses of EMSL-LV cross-check samples that EERF reported as being below their respective detection limits, 43 contained less than minimum detectable concentrations. Of the 5 analyses misidentified by EERF, all were the result of reporting less-than-values for samples containing measurable quantities of the radionuclide; two cases each for ^{106}Ru and ^{51}Cr in water and one sample of ^{131}I in milk.

Table 2-6

The Minimum Detectable Concentrations for Routine Cross-Check Sample Analyses

Water Samples (pCi/L)		
^{3}H - 300	^{90}Sr - 1	^{228}Ra -1
^{51}Cr - 30	^{106}Ru - 30	^{239}Pu -0.015
^{60}Co - 10	^{134}Cs - 10	Gross alpha -2
^{65}Zn - 20	^{137}Cs - 10	Gross beta -1
^{89}Sr - 5	^{226}Ra - 0.1	

Milk (pCi/L) and Food (pCi/kg) Samples	
^{89}Sr - 5	^{137}Cs - 10
^{90}Sr - 1	^{140}Ba - 10
^{131}I - 10	

Soil Samples (pCi/g)	
^{60}Co - 0.010	^{137}Cs - 0.010
^{106}Ru - 0.030	^{239}Pu - 0.015
^{134}Cs - 0.010	

2.2 WHO and Mound Facility Intercomparison Programs

In addition to participating in the EMSL-LV intercomparison program, the EERF also participated in similar programs conducted by the World Health Organization (WHO) and the Mound Facility (Department of Energy), Miamisburg, Ohio, although on a much more limited basis. The individual intercomparison results for each sample provided by these two organizations are listed in Appendixes F and G. The two programs consisted of 16 samples on which a total of 71 specific radionuclide analyses were done.

A summary of the WHO International Reference Center Intercomparison sample analyses is given in Table 2-7. The total diet sample (No. G660) has been omitted from the summary because the presence of such very low concentrations of radionuclides resulted in large analytical uncertainties. Agreement between our results and the concentrations supplied by the WHO was similar to or better than that attained in the EMSL-LV program. Sixty percent of the analyses agreed within 10 percent of the reference center value, while 98 percent of the analyses agreed within 20 percent. Only one of 48 analyses differed by more than 20 percent of the known concentration, and it was judged acceptable because of the small concentration present (Sr-90 in WHO fish sample, No. H264 -- see Appendix F). Thus, overall agreement is quite good.

Using the coefficient of variation as a measure of consistency with the WHO cross-check samples (see values in the fifth column of Appendix F), 49 percent were within 10 percent of the known value,

96 percent were within 20 percent, and only 2 analyses had coefficients of variation greater than 20 percent. The mean coefficient of variation for the 48 positive analyses of WHO samples is 10 percent, again showing very good agreement.

The results of the collaborative study of drinking water analyses with the Mound Facility, listed in Appendix G, show good analytical agreement between the two laboratories. The study included 10 analyses of four radionuclides: Co-60, Ru-106, Cs-134, and Cs-137. The values of R ranged from 0.93 - 1.12 with a mean of 1.01 ± 0.06, while the coefficient of variation ranged from 2.5 percent to 16 percent with a mean of only 6.2 percent. Thus, very good agreement for radionuclide measurements in water was realized between the Mound and EPA analytical laboratories.

Table 2-7

Summary of WHO International Reference Center Intercomparison Sample Analyses[a]

Sample Type	Total No. Analyses[b]	Range in R	Mean Value of R[c]	Percent of Values differing from R = 1.00 by:			Mean Coeff. of Variation, percent
				<10%	<20%	>20%	
Milk	9	0.83 - 1.15	1.04 ± 0.11	44	100	0	11
Water	8	0.87 - 1.11	0.98 ± 0.06	75	100	0	11
Soil/ Sediment	9	0.85 - 1.05	0.93 ± 0.06	78	100	0	9
Fish	13	0.79 - 1.15	0.96 ± 0.12	54	92	8	10
Aquatic Plants	9	0.83 - 1.20	1.04 ± 0.14	56	100	0	13

(a) Analyses of total diet are omitted from the summary due to the very low concentrations (see Appendix F).
(b) Radionuclides included in these analyses are H-3, K-40, Mn-54, Co-58, Co-60, Sr-90, Ru-103, Ru-106, Cs-134, Cs-137, Ra-226, U-235, U-234/238, and stable Ca, Sr, and K.
(c) ± values are the standard deviation of individual analyses.

3. INTRALABORATORY COMPARISON PROGRAMS

3.1 Blind Analyses

A routine program of submitting water samples of known concentration to the EERF analytical laboratory was instituted by the EERF quality assurance officer in 1980. Milk and soil samples containing known concentrations have been included in this program since 1981, but on a much less frequent basis. These samples were submitted "blind" to the analytical staff with a request to perform specific analyses. The results of the "blind" water, milk, and soil sample analyses are reported in Appendixes H, I, and J and summarized in Tables 3-1 through 3-3. The known value given in the third column of Appendixes H, I, and J is either the concentration determined from previous repetitive analyses or the concentration made by "spiking" the sample with an aliquot of a standard solution.

A total of 416 "blind" water sample analyses were performed for 21 radioisotopes and gross alpha and beta measurements. Of these analyses, 51 percent of the results were within 10 percent and 75 percent of the results were within 20 percent of the known concentration. Of the 106 analyses that differed from the known concentration by more than 20 percent, 62 were judged acceptable because of low sample concentration, the uncertainty in the measurement and known values, and the small absolute difference (indicated by asterisks in the appendixes). Thus, of the total of 416 "blind" water sample analyses, 372 (89 percent) were considered to have an acceptable accuracy.

The blind water sample analyses are presented graphically in Figure 3-1. Evidence of a negative bias in these results is not as clear as was observed with the EMSL-LV water analyses (see Figure 2-1). These results are more evenly distributed about R = 1.00. The very large standard deviation associated with the Ra-226 analyses, R = 1.2 $\pm$ 0.5, is somewhat surprising considering the recognized accuracy and reliability of this method, and suggests there may be a problem associated with this analysis.

There is some indication that the accuracy of some analyses has improved with time. For example, most inaccurate Sr-89 and Ra-226 analyses occurred in 1981. The improvements may be the result of procedural modifications or improved techniques. The results indicate continued difficulties associated with the Po-210 analyses. The results of the Rn-222 in water, although small in number, reflect very good precision but may be biased somewhat high.

A total of 19 "blind" milk sample analyses were performed for five radionuclides (see Appendix I). The results, summarized in Table 3.2, indicate that milk is a more difficult medium to analyze than water. Of the 19 samples analyzed, 42 percent of the results were within 10 percent and 74 percent of the results were within 20 percent of the known concentration. In general, too few analyses of milk were performed to judge definitively the reliability of these measurements.

Table 3-1

Summary of Intralaboratory Blind Water Sample Analyses[a]

Radionuclide	Range in Values of R	Mean Value of R[b]	Percent of Values Differing from R = 1.00 by: < 10%	< 20%	> 20%
H-3 (23) [c]	0.78 - 1.28	1.00 ± 0.11	83	87	13
K-40 (2)	0.90 - 1.07	0.98 ± 0.12	100	100	0
Co-60 (2)	1.09 - 1.12	1.10 ± 0.02	50	100	0
Zn-65 (1)	- - -	1.18	0	100	0
Sr-89 (23)	0.81 - 1.40	1.08 ± 0.15	57	78	22
Sr-90 (27)	0.59 - 1.30	1.00 ± 0.17	48	81	19
I-131 (23)	0.63 - 1.20	0.92 ± 0.13	39	91	9
Cs-137 (4)	0.93 - 1.29	1.12 ± 0.16	50	75	25
Pb-210 (19)	0.78 - 1.35	1.10 ± 0.17	42	58	42
Po-210 (20)	0.23 - 1.43	0.92 ± 0.32	35	70	30
Rn-222 (5)	1.05 - 1.14	1.08 ± 0.03	80	100	0
Ra-226 (30)	0.39 - 2.75	1.23 ± 0.48	53	70	30
Ra-228 (18)	0.72 - 1.32	1.03 ± 0.17	56	72	28
Th-228 (1)	- - -	0.92	100	100	0
Th-230 (22)	0.63 - 1.38	1.09 ± 0.20	27	45	55
Th-232 (7)	0.90 - 1.28	1.09 ± 0.14	57	71	29
U-234 (32)	0.73 - 1.21	0.96 ± 0.11	59	88	12
U-235 (31)	0.23 - 1.86	0.81 ± 0.29	32	45	55
U-238 (32)	0.43 - 1.21	0.90 ± 0.15	56	84	16
Pu-238 (15)	0.76 - 1.35	0.97 ± 0.14	73	87	13
Pu-239 (30)	0.43 - 1.32	0.97 ± 0.20	43	73	27
Gross Alpha (22)	0.31 - 1.36	0.92 ± 0.21	45	77	23
Gross Beta (27)	0.61 - 1.34	0.98 ± 0.18	56	74	26

(a) Individual results are listed in Appendix H.
(b) ± values are the standard deviation of individual analyses.
(c) Number of analyses are given in parentheses.

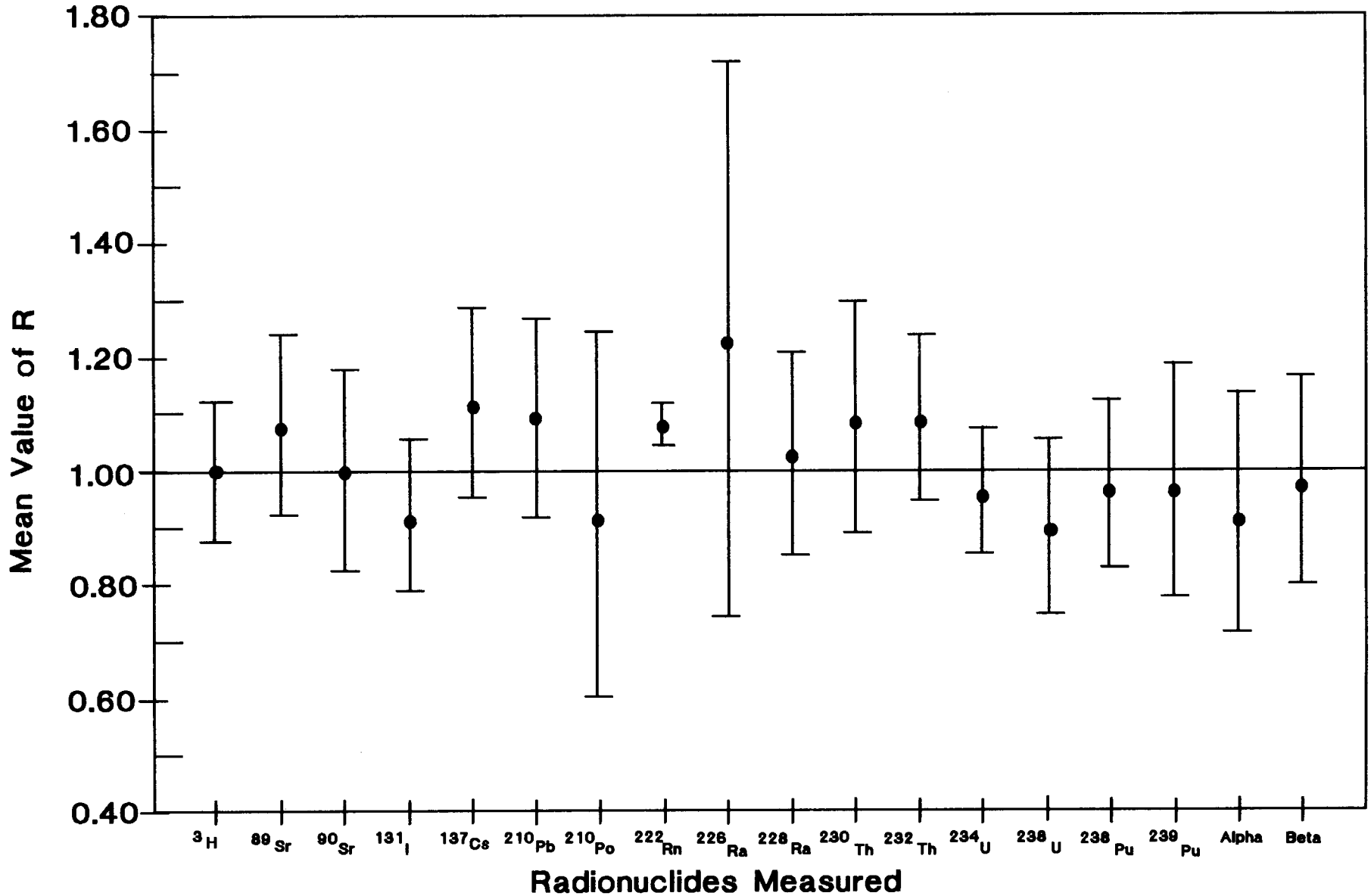

Figure 3-1. The mean value of R, with standard deviation, for each radionuclide measured in the intralaboratory cross-check water samples.

A summary of the results of analyzing 62 "blind" soil samples for ten radionuclides is given in Table 3-3. Individual results of these analyses are listed in Appendix J. Of the 62 analyses, 56 percent were within 10 percent and 87 percent were within 20 percent of the known concentration. Also, of the eight results that differed from the known concentration by more than 20 percent, five were judged acceptable (see Appendix J). Thus, 95 percent of the soil analyses yielded satisfactory results. Although this is quite good, as soil is often considered the more difficult medium to analyze, the results suggest a rather strong negative bias, which will be investigated by laboratory personnel.

The graphical representation of the blind milk and soil sample analyses in Figure 3-2 shows general agreement, although it provides further evidence, as recognized earlier in Figure 2-1, of a negative bias in some analytical results.

These intracomparison results generally show analyses to have an acceptable accuracy and precision, but the degree of accuracy and precision achieved on the EMSL-LV samples was not experienced with the "blind" sample analyses. That is, for most of the "blind" samples, the mean value of R differs more from unity and has a significantly greater standard deviation than for the EMSL-LV samples. This may be due to a greater uncertainty associated with the known value and possibly a general tendency to exercise less care when analyzing what is believed to be a routine sample.

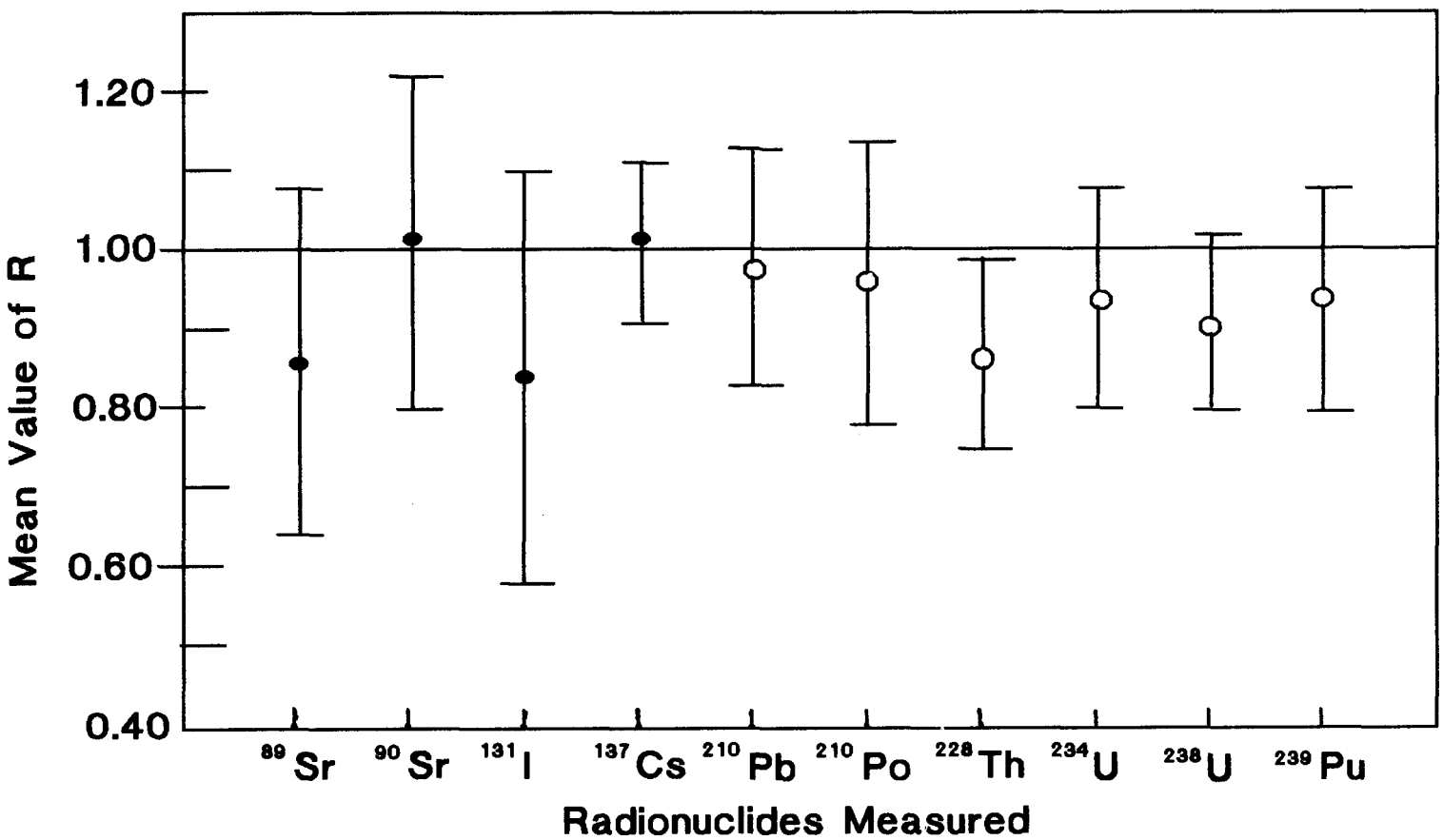

Figure 3-2. The mean value of R, with standard deviation, for radionuclides measured in intralaboratory milk (●) and soil (O) samples.

Table 3-2

Summary of Intralaboratory Blind Milk Sample Analyses[a]

Radio-nuclide	Range in Values of R	Mean Value of R[b]	Percent of Values Differing from R = 1.00 by: < 10%	< 20%	> 20%
Co-60 (1) [c]	- - -	1.00	100	100	0
Sr-89 (3)	0.67 - 1.11	0.86 ± 0.22	0	67	33
Sr-90 (4)	0.71 - 1.18	1.01 ± 0.21	50	75	25
I-131 (8)	0.49 - 1.18	0.84 ± 0.26	38	63	37
Cs-137 (3)	0.89 - 1.08	1.01 ± 0.10	67	100	0

(a) Individual results are listed in Appendix I.
(b) ± values are the standard deviation of individual analyses.
(c) Number of analyses are given in parentheses.

Table 3-3

Summary of Intralaboratory Blind Soil Sample Analyses[a]

Radio-nuclide	Range in Values of R	Mean Value of R[b]	Percent of Values Differing from R = 1.00 by: < 10%	< 20%	> 20%
K-40 (1) [c]	- - -	0.97	100	100	0
Cs-137 (1)	- - -	1.12	0	100	0
Pb-210 (11)	0.56 - 1.18	0.98 ± 0.15	82	91	9
Po-210 (11)	0.65 - 1.15	0.96 ± 0.18	45	82	18
Th-228 (6)	0.74 - 1.06	0.87 ± 0.12	33	67	33
Th-230 (6)	0.84 - 0.99	0.89 ± 0.06	33	100	0
Th-232 (5)	0.83 - 0.96	0.90 ± 0.05	60	100	0
U-234 (7)	0.68 - 1.08	0.94 ± 0.14	71	86	14
U-238 (7)	0.72 - 1.07	0.91 ± 0.11	57	86	14
Pu-239 (7)	0.80 - 1.24	0.94 ± 0.14	57	86	14

(a) Individual results are listed in Appendix J.
(b) ± values are the standard deviation of individual analyses.
(c) Number of analyses are given in parentheses.

3.2 Replicate Analyses

Replicate analyses are performed on every tenth sample analyzed at the EERF and on each interlaboratory cross-check sample. Usually, there were two or three replicate analyses on each cross-check sample, but some samples were analyzed as many as six times. To analyze the precision of these analyses, we calculated the mean range ($\overline{R}$) between duplicate analyses from the standard deviation of the analyses. The mean range (Ro64; Ka77) is defined by the equation

$$\overline{R} = d_2\sigma, \qquad 3\text{-}1$$

where d_2 is a function of the number of replicates involved (see Table 3-4) and σ is the standard deviation (see Table 3-5). The control limits are computed as follows:

$$\overline{R} + 3\,\sigma_R = D_4\overline{R} = D_4 d_2\sigma \qquad 3\text{-}2$$

where σ_R is the standard deviation of the range and D_4 is a function of the number of replicates involved (see Table 3-4). Therefore,

$$\sigma_R = \overline{R}(D_4-1)/3. \qquad 3\text{-}3$$

The range limits were computed for each type analysis by the procedure described above. The observed ranges between replicates were classified as $\leq(\overline{R} + \sigma_R)$, $\leq(\overline{R} + 2\sigma_R)$, $\leq(\overline{R} + 3\sigma_R)$, and $>(\overline{R} + 3\sigma_R)$. The number of replicate analyses that fall into each category is a measure of the laboratory's performance.

Table 3-4

Values Used for Calculating the Mean Range Control Limits[a]

No. of Observations	Central line factor (d_2)	Control limit factor (D_4)
2	1.128	3.267
3	1.693	2.575
4	2.059	2.282
5	2.326	2.115
6	2.534	2.004

Source: Rosenstein, M., and Goldin, A. S., 1964, "Statistical Technique for Quality Control of Environmental Radioassay," AQCS Report Stat - 1, U. S. Public Health Service, Winchester, MA.

Table 3-5

Analytical Precision for Various Analyses

Nuclide	Concentration (pCi/L or kg)	Standard Deviation, σ (single determination)
^{89}Sr, ^{131}I, ^{137}Cs, ^{140}Ba	5-100 > 100	5 pCi/L 5%
^{90}Sr	2-30 > 30	1.5 pCi/L 5%
K	$\geq$ 0.1[a]	5%
^{3}H	$\leq$ 4000 > 4000	5% 10%
^{226}Ra	$\geq$ 0.1 pCi/L	15%
^{239}Pu	$\geq$ 0.1[b]	10%
Gross Alpha	$\leq$ 20 > 20	5 pCi/L 25%
Gross Beta	$\leq$ 100 > 100	5 pCi/L 5%

(a) Units are g/L or g/kg.
(b) Units are pCi/L, pCi/g, or pCi/sample.

Table 3-6 summarizes the results of the replicate analyses performed by the analytical laboratory at the EERF for the years 1981 through 1986. The total number of replicate analyses performed each year is listed in the second column. Because large uncertainties in replicate measurements obscure the analysis of precision, any replicate analysis for which the 2-σ uncertainty exceeded 60 percent of the result was omitted from the table. The percent of the analyses within each range is given with the number of analyses below in parentheses. The distribution of the precision attained is consistent over the six year period and indicates no degradation in our laboratory's precision. The highest precision was realized in 1983 followed by 1986, the lowest in 1981. The distribution of precision for all replicate analyses (2,523), given near the bottom of Table 3-6, is similar to but somewhat less than the theoretical distribution listed on the last line. For example, while essentially all results should be within the $\leq (\overline{R} + 3\ \sigma_R)$ range, 7 percent exceeded this range. This departure from the theoretical distribution is shown clearly in Figure 3-3. The somewhat less than expected precision may be due to a failure to include all uncertainties in deriving the analytical precisions listed in Table 3-5. Although not many, some large deviations can be expected due to human (analyst) error when hundreds of samples are being analyzed. Quality control checks will minimize but not totally eliminate the latter.

Table 3-6

Summary of Replicate Analyses Results

Year	No. of Analyses	Range			
		$\leq (\overline{R} + \sigma_R)$	$\leq (\overline{R} + 2\ \sigma_R)$	$\leq (\overline{R} + 3\ \sigma_R)$	$> (\overline{R} + 3\ \sigma_R)$
1981	395	84% (332)	88% (348)	91% (360)	9% (35)
1982	559	84% (467)	88% (492)	93% (519)	7% (40)
1983	229	88% (201)	91% (209)	95% (218)	5% (11)
1984	274	83% (227)	88% (242)	93% (254)	7% (20)
1985	571	84% (482)	90% (516)	93% (530)	7% (41)
1986	495	84% (418)	92% (457)	94% (467)	6% (28)
All years	2,523	84% (2,127)	90% (2,264)	93% (2,348)	7% (175)
Theoretical Distribution		84%	97.5%	99.9%	0.1%

Note: Numbers of analyses in each range are given in parentheses.

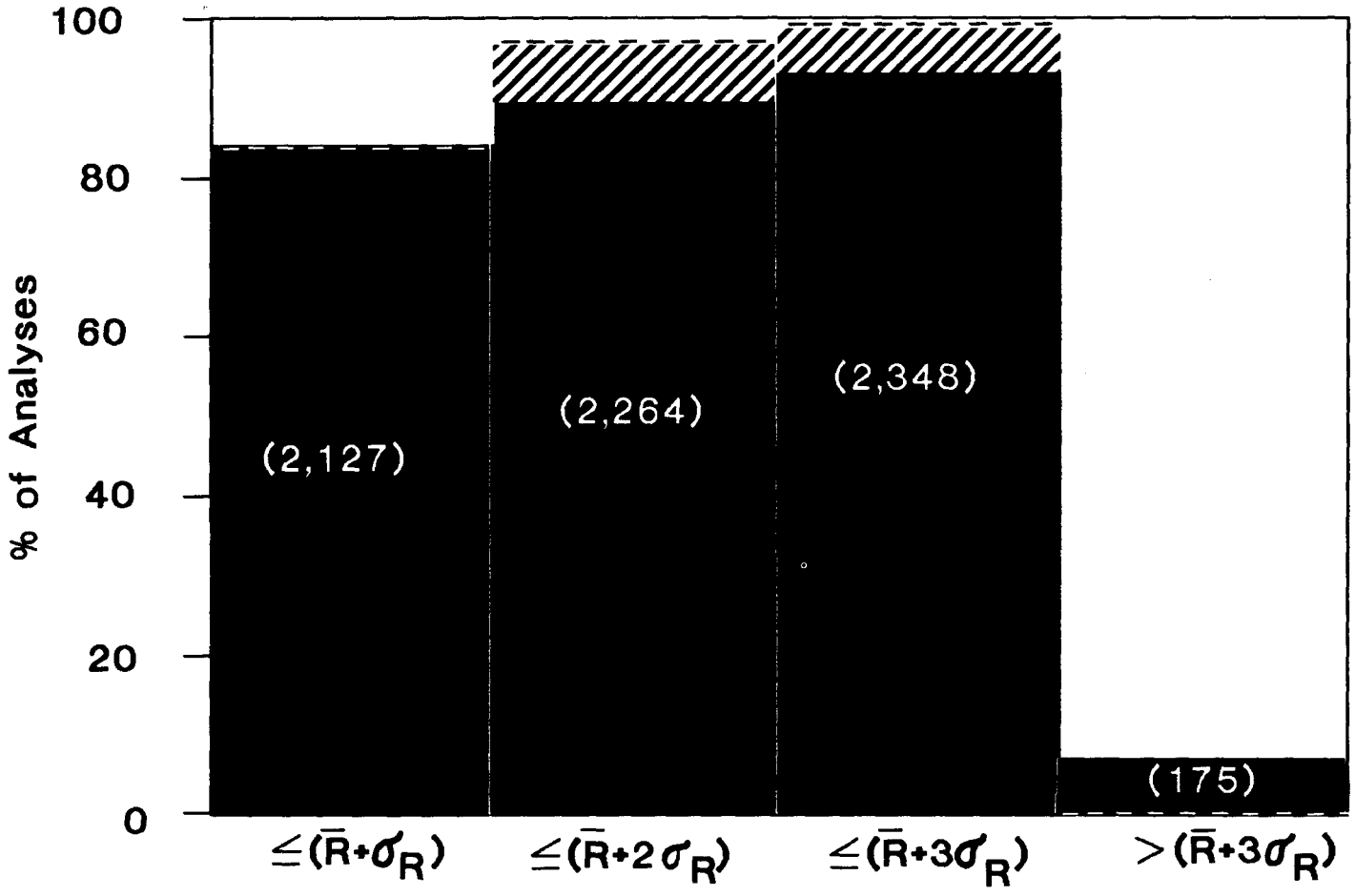

Figure 3-3. The percent of the results of the duplicate analyses within one, two, and three standard deviations of the mean range. The number of samples in each group are given in parentheses and the theoretical distribution is presented as a dash line.

4. Summary

This report compiles the results of the interlaboratory and intralaboratory quality assurance programs for the EERF's analytical chemistry laboratory during 1981 through 1986. The interlaboratory program, which consisted of participating in cross-check analyses with the EPA's EMSL-LV laboratory, the World Health Organization, and the Mound Facility, resulted in 544 analyses. The intralaboratory program consisted of 486 blind sample analyses and 2,523 replicate sample analyses. Cross-check and blind sample analyses were considered acceptable when the result of the analysis was within 20 percent of the known concentration. Some results that differed by more than 20 percent were judged to be acceptable because of low sample concentrations, the uncertainty in the measurement and known value, and the small absolute difference. The distribution of the analytical precision, determined by performing 2,523 replicate analyses (every tenth sample), was similar to but somewhat less, about 7 percent, than the expected theoretical distribution (see Table 3-6).

A summary of the results of all cross-check and blind sample analyses is presented in Table 4-1. A total of 1,030 analyses were performed in all programs. Overall, the results of 957 analyses, 93 percent, were within the acceptable range of error. This includes 119 analyses that differed from the known concentration by more than 20 percent but were judged acceptable according to the above criteria. This is a somewhat better performance than that observed during 1977-1980 (B179, B182), which reflects a dedicated effort to improve laboratory quality. The number of acceptable results was somewhat higher for the cross-check sample

analyses (96 percent) than for the blind sample analyses (89 percent). This is particularly evident for the milk sample analyses. The reason for this is uncertain, but may be because the analysts exercised more care when the sample was known to be a cross-check sample. Of the different sample media analyzed, air filters appear to have been the most difficult medium to analyze accurately (see Table 2-5). In general, these results reflect a satisfactory performance by the laboratory, although a negative bias appears to exist for some analyses and will be investigated.

The results of the EMSL-LV cross-check sample program are presented graphically in Figure 4-1, where the cumulative probability is plotted with the observed percent error in increments of 5 percent. The probability that the result of an analysis will be within a selected error of the true concentration during the six-year reporting period can be easily ascertained from the graph. For example, the probability that an analysis will yield a result within 25 percent of the correct concentration is seen to be 94 percent. About one percent of the analyses were in error by more than 50 percent. However, this graph does not consider those results judged acceptable because of low sample concentrations and the larger uncertainties in the results of those analyses.

In Figure 4-2, the percent coefficient of variation is plotted with the cumulative percent of samples. This figure gives an effective standard deviation for all sample types as calculated from the normalized variances measured with respect to each known value. Similar to the results shown in Figure 4-1, this figure shows coefficients of variation less than 20 percent for 80 percent of the samples. Approximately 1.5

Table 4-1

A Summary of the Results of All Quality Assurance Samples Analyzed During 1981 - 1986

Sample	Total Analyses	Number of analyses that differed from the expected value by: < 10%	< 20%	Number of Results Judged to be Acceptable[a]	Total Acceptable Results (%)
EMSL-LV Water	340	198	295	35	97
EMSL-LV Milk	62	42	51	7	94
EMSL-LV Food	60	40	54	4	97
EMSL-LV Other[b]	24	9	14	5	79
WHO Misc.[c]	48	29	47	1	100
Mound Water	10	9	10	0	100
Blind Water	416	211	310	62	89
Blind Milk	19	8	14	0	74
Blind Soil	51	30	43	5	94
Total	1,030	576	838	119	93

(a) These are samples, denoted in Appendixes A - J by asterisks, whose results differed from the known values by more than 20 percent but were judged acceptable because of low concentration, the uncertainty in the measurement and known values, and the small absolute difference.
(b) Samples include air filters (20) and soil (4).
(c) Samples include sediment/soil (9), water (8), milk (9), fish/total diet (13), and plants (9).

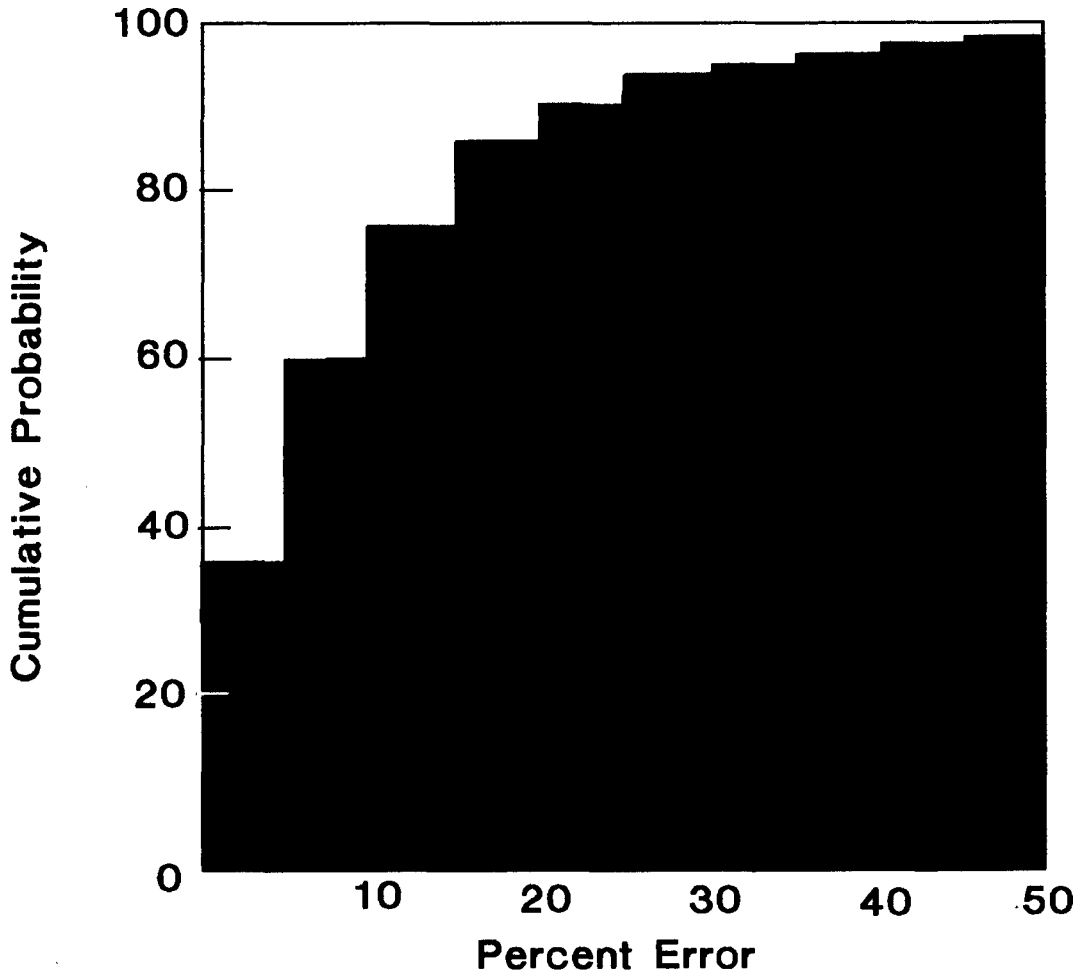

Figure 4-1. The cumulative probability vs. the percent sample measurement error.

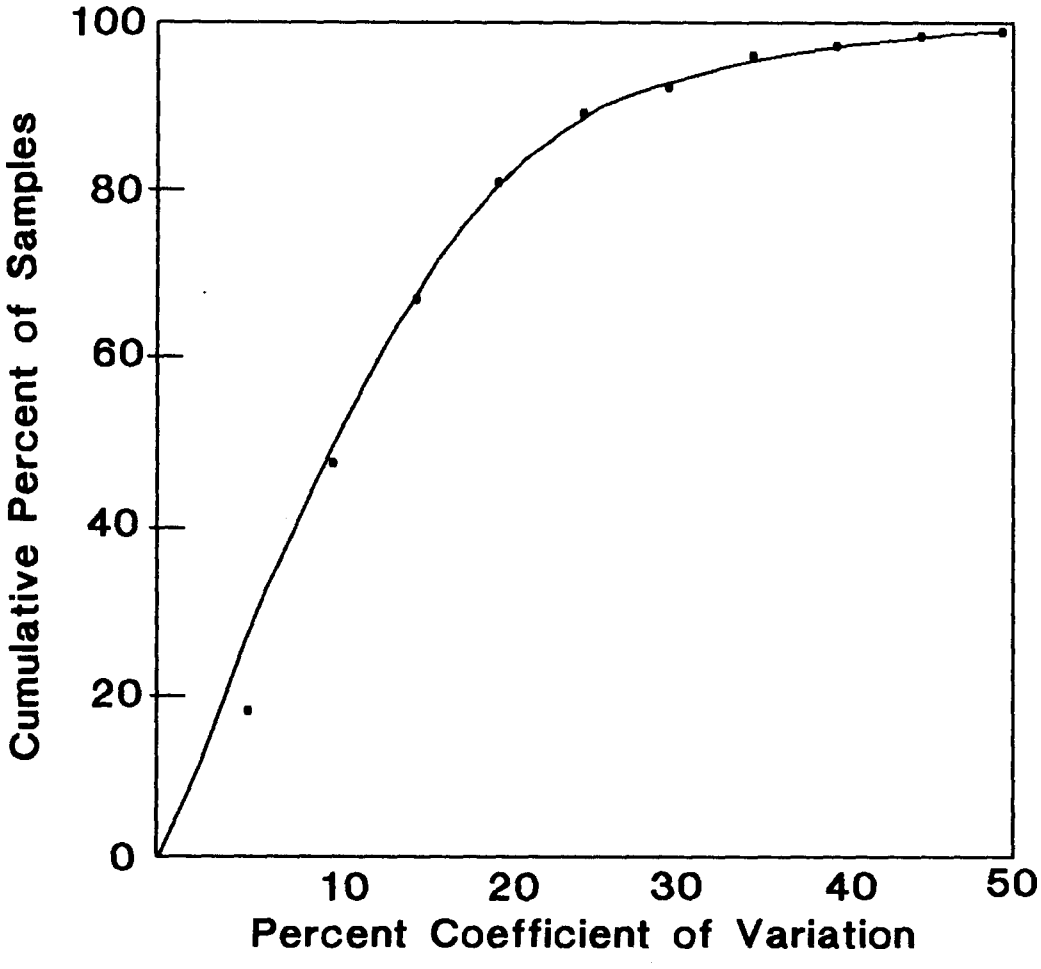

Figure 4-2. The cumulative probability vs. the sample coefficient of variation.

percent of the sample results had coefficients of variation greater than 50 percent.

The most important function of the quality assurance program described in this report is to identify problem areas in our analytical laboratory. If a problem exists, immediate remedial action is initiated. As is apparent in some of our reported results, errors can occur for many reasons -- improperly following a tested procedure, arithmetical errors in the calculations, permitting contamination to enter the sample during analysis, fluctuations in counting efficiencies and backgrounds, and using incorrect weights, absorption factors, and abundances. It requires continual alertness and expedient action to recognize and correct these problems when they arise.

This is the third report describing the performance of the EERF's quality assurance programs for the analytical chemistry laboratory. These reports describe the laboratory's performance over a period of ten years, 1977 through 1986. In accord with our belief that laboratory quality results should be public record, the EERF plans to issue similar brief reports in the future.

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Appendix A

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{3}H		
2/81	1840 1780 1850	1823	1760 ± 341	1.04	4.0
4/81	2260 2220 2300	2260	2710 ± 355	0.83	17
6/81	1810 1940 1850	1867	1950 ± 386	0.96	5.1
8/81	2510 2510 2510	2510	2630 ± 350	0.95	4.6
12/81	2780 2780 2950	2837	2700 ± 355	1.05	5.9
2/82	1890 1860 1860	1870	1820 ± 342	1.03	2.9
4/82	2560 2560 2560	2560	2860 ± 360	0.90	11
6/82	1850 1950 1940	1880	1830 ± 590	1.03	5.2
8/82	2820 2810 2810	2813	2890 ± 380	0.97	2.7
10/82	2250 2280 2320	2283	2560 ± 350	0.89	11
12/82	1940 1880 1880	1900	1990 ± 345	0.95	4.7

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{3}H		
2/83	2570 2570 2590	2577	2560 ± 350	1.01	0.75
4/83	3090 3090 3070	3083	3330 ± 360	0.93	7.4
6/83	1480 1480 1520	1493	1529 ± 336	0.98	2.6
8/63	1970 1950 1970	1963	1836 ± 342	0.93	7.0
10/83	1330 1330 1300	1320	1210 ± 329	0.92	9.2
12/83	2240 2170 2260	2223	2389 ± 351	0.93	7.1
2/84	2370 2380 2370	2373	2383 ± 350	0.99	0.45
10/84	2860 2840 2840	2847	2810 ± 356	1.01	1.3
12/84	3210 3190 3180	3193	3182 ± 360	1.00	0.53
2/85	3840 3830 3840	3837	3796 ± 360	1.01	1.1
6/85	2530 2570 2560	2533	2416 ± 338	1.05	5.7

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{3}H		
10/85	2210 2210 2240	2220	1974 ± 340	1.19	13
2/86	5250 5180 5210	5213	5227 ± 574	1.00	0.61
10/86	5220 5190 5190	5220	5973 ± 687	0.87	13
11/86	4700 4700 4680	4693	5257 ± 605	0.89	11

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{51}Cr		
2/81	< 10 < 10 < 10	< 10	0	- - -	-
6/81	< 10 < 10 < 10	< 10	0	- - -	-
2/82	< 10 < 10 < 10	< 10	0	- - -	-
6/82	< 10 < 10 < 10	< 10	23 ± 5	< 0.43	-
10/82	52 56 50	53	51 ± 5	1.03	5.9
2/83	50 52 48	50	51 ± 5	0.98	3.8
6/83	91 151 181	141	60 ± 6	2.35	149
10/83	49 51 51	50	51 ± 5	0.99	2.3
2/84	19 37 36	31	40 ± 5	0.77*	31
6/84	49 74 76	66	66 ± 5	1.0	19
10/84	< 30	< 30	40 ± 5	< 0.75	-

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{51}Cr		
2/85	30 66 38	45	48 ± 5	0.94	33
6/85	34 73 34	47	44 ± 5	1.06	42
10/85	< 30 < 30 < 30	-	21 ± 5	- - -	-
2/86	< 30 < 30 < 30	-	38 ± 6	< 0.79*	-
6/86	< 30 < 30 < 30	-	0.0	- - -	-
10/86	38 71 65	58	59 ± 6	0.98	24

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{60}Co		
2/81	23 21 20	21	25 ± 5	0.85	16
4/81 (A)	< 10 < 10 < 10	< 10	0	- - -	-
6/81	15 16 16	16	17 ± 6	0.92	8.3
2/82	12 13 17	14	20 ± 5	0.70*	32
4/82 (A)	< 20 < 20 < 20	< 20	0	- - -	-
6/82	24 27 26	26	29 ± 5	0.89	12
10/82	20 19 20	20	20 ± 5	0.98	2.9
2/83	28 24 22	25	22 ± 5	1.12	17
6/83	14 15 12	14	13 ± 6	1.05	11
10/83	19 18 21	19	19 ± 5	1.02	6.8
11/83	10 12 12	11	11 ± 5	1.03	9.1

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{60}Co		
2/84	12 14 11	12	10 ± 5	1.23*	27
6/84	31 30 31	31	31 ± 5	0.99	3.1
10/84	15 22 19	19	20 ± 5	0.93	16
10/84(A)	19 15 16	17	14 ± 5	1.19	23
2/85	19 21 22	21	20 ± 5	1.03	6.9
4/85	17 19 15	17	15 ± 5	1.13	17
10/85	18 20 19	19	18 ± 5	1.06	7.1
2/86	19 17 24	20	18 ± 5	1.11	20
4/86	11 13 10	11	10 ± 5	1.13	17
6/86	57 61 58	59	66 ± 6	0.89	11

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{60}Co		
10/86	19 27 25	24	24 ± 6	0.99	14
11/86	32 27 27	29	31 ± 6	0.92	11

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{65}Zn		
2/81	96 90 93	93	85 ± 5	1.09	9.9
6/81	< 10 < 10 < 10	< 10	0	- - -	-
2/82	< 10 < 10 < 10	< 10	15 ± 5	< 0.67*	-
6/82	17 15 13	15	26 ± 5	0.58	43
10/82	20 26 19	22	24 ± 5	0.90	16
2/83	24 22 17	21	21 ± 5	1.00	14
10/83	44 38 44	42	40 ± 5	1.05	8.7
2/84	47 38 54	46	50 ± 5	0.93	15
6/84	57 58 65	60	63 ± 5	0.95	7.4
10/84	134 136 136	135	147 ± 5	0.92	8.0
2/85	54 62 51	56	55 ± 5	1.01	8.5

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{65}Zn		
6/85	51 53 45	50	47 ± 5	1.06	9.2
10/85	26 15 15	19	19 ± 5	0.98	27
2/86	41 42 39	41	40 ± 6	1.02	3.5
10/86	87 87 69	81	85 ± 6	0.95	11

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{89}Sr		
1/81	17 17 17	17	16 ± 5	1.06	6.3
4/81 (A)	41 40 39	40	38 ± 6	1.05	5.7
5/81	33 30 36	33	36 ± 6	0.92	11
1/82	21 26 24	24	21 ± 5	1.13	16
4/82 (A)	26 26 27	26	24 ± 5	1.10	9.9
5/82	26 24 26	25	22 ± 6	1.15	16
9/82	26 26 24	25	25 ± 5	1.01	5.1
10/82 (A)	< 3 < 3 < 3	0	0	- - -	-
1/83	34 33 35	34	29 ± 5	1.17	17
6/83	59 58 59	59	57 ± 6	1.03	3.0
9/83	19 21 21	20	15 ± 5	1.36*	36

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{89}Sr		
11/83	15 17 15	16	17 ± 5	0.92	9.6
1/84	34 37 26	32	34 ± 5	0.95	15
4/84	25 26 28	26	23 ± 5	1.14	16
5/84	26 24 23	24	25 ± 6	0.97	5.6
6/84	20 19 20	20	25 ± 5	0.79*	21
7/84	25 22 25	24	25 ± 5	0.96	7.7
9/84	34 35 32	34	34 ± 6	0.99	3.8
10/84	7 12 11	10	11 ± 5	0.91	20
1/85	< 3 < 3 < 3	- - -	3 ± 3	- - -	-
4/85	7 6 4	6	10 ± 6	0.57*	44

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{89}Sr		
5/85	35 40 44	40	39 ± 5	1.02	9.1
9/85	17 17 19	18	20 ± 6	0.88	13
10/85	28 25 29	27	27 ± 5	1.01	6.4
1/86	27 29 29	28	31 ± 6	0.91	9.1
4/86	5 3 4	4	7 ± 6	0.57*	45
5/86	7 4 5	5	5 ± 5	1.07	24
6/86	< 3 < 3 < 3	< 3	0	- - -	-
10/86	9 8 7	8.0	10 ± 6	0.80	21

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{90}Sr		
2/81	32 33 32	32	34 ± 1.8	0.95	5.1
4/81	31 33 31	32	28 ± 3	1.13	14
5/81	28 26 26	27	22 ± 3	1.21*	22
1/82	13 11 13	12	12 ± 1.5	1.03	8.3
4/82	13 12 13	13	12 ± 1	1.06	6.8
5/82	13 14 13	13	13 ± 3	1.03	4.4
9/82	14 14 13	14	14.5 ± 1.5	0.94	7.0
10/82	16 16 16	16	17.2 ± 1.5	0.93	6.1
1/83	17 16 15	16	17.2 ± 1.5	0.93	7.7
5/83	39 41 41	40	38 ± 2.2	1.06	6.6
9/83	9 9 9	9	10 ± 1.5	0.90	10

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{90}Sr		
11/83	9 8 8	8	8.3 ± 1.5	1.00	5.6
1/84	24 25 23	24	27 ± 3.0	0.89	12
4/84	24 21 20	22	23 ± 2.5	0.94	9.4
5/84	5.0 5.3 5.3	5.2	5.0 ± 1.7	1.04	4.9
9/84	16.6 16.5 19.2	17.4	19 ± 2	0.92	8.6
10/84	13.3 13.3 12.1	12.9	12.0 ± 1.7	1.08	7.9
1/85	28.8 31.5 28.6	29.6	30 ± 3	0.99	4.6
4/85	16.1 15.0 15.6	15.6	15 ± 3	1.04	4.8
5/85	11.4 13.0 14.0	12.8	15 ± 3	0.85	16
9/85	7.9 7.5 7.0	7.5	7 ± 1.7	1.07	8.5

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{90}Sr		
10/85	7.6 8.1 6.1	7.3	9.0 ± 1.4	0.81	21
1/86	15.8 14.7 15.9	15.5	15 ± 1.7	1.03	4.8
4/86	9.0 4.0 8.5	7.2	7 ± 2	1.02	32
10/86	4.0 4.0 4.2	4.1	4.0 ± 1.6	1.02	2.9

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{106}Ru		
2/81	< 25 < 25 < 25	< 10	0	- - -	-
6/81	< 25 < 25 < 25	< 10	15 ± 10	- - -	-
2/82	< 15 < 15 < 15	< 10	20 ± 10	- - -	-
6/82	< 25 < 25 < 25	< 10	0	- - -	-
10/82	32 47 40	40	30 ± 5	1.32	38
2/83	< 25 < 25 < 25	< 25	48 ± 5	< 0.52	-
6/83	< 25 < 25 < 25	< 25	40 ± 6	< 0.62	-
10/83	33 48 55	45	52 ± 5	0.87	22
2/84	52 53 51	52	61 ± 5	0.85	15
6/84	< 30 < 30 < 30	< 30	29 ± 5	- - -	-

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{106}Ru		
10/84	42 32 55	43	47 ± 5	0.91	22
2/85	< 30 < 30 < 30	< 30	25 ± 5	- - --	-
10/85	< 30	< 30	20 ± 5	- - -	-
2/86	< 30	< 30	0.0	- - -	-
10/86	60 55 65	60	74 ± 6	0.81	20

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{131}I		
4/81	25 23 25	24	30 ± 6	0.81	19
8/81	68 69 69	69	74 ± 7	0.93	6.0
12/81	59 57 57	58	76 ± 15	0.76	24
4/82	60 62 63	62	62 ± 6	0.99	2.1
6/82	4.9 4.7 4.6	4.7	4.4 ± 0.7	1.08	8.1
8/82	70 66 69	68	87 ± 9	0.79	22
12/82	38 36 36	37	37 ± 6	0.99	2.7
4/83	24 25 25	25	27 ± 6	0.91	8.8
9/83	11 11 13	12	14 ± 6	0.83	18
12/83	20 21 21	21	20 ± 6	1.03	4.1

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{131}I		
4/84	5 4 5	5	6 ± 8	0.78*	24
4/85	6.4 6.6 7.1	6.7	7.5 ± 6	0.89	11
8/85	28 29 29	29	30 ± 6	0.96	4.7
12/85	40 46 41	42	45 ± 6	0.94	8.2
2/86	9.3 8.4 7.7	8.5	9 ± 6	0.94	9.4
4/86	6.9 6.4 6.0	6.4	9 ± 6	0.71*	29
8/86	39 40 40	40	45 ± 7	0.88	12

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{134}Cs		
2/81	31 32 33	32	36 ± 5	0.89	11
4/81 (A)	10 12 11	11	10 ± 10	1.10	13
6/81	21 22 18	20	21 ± 10	0.97	8.7
2/82	23 25 20	23	22 ± 10	1.03	9.8
4/82 (A)	16 16 20	17	15 ± 3	1.16	20
6/82	33 34 33	33	35 ± 10	0.95	5.0
10/82	17 14 18	16	19 ± 5	0.86	17
10/82(A)	< 10 < 10 < 10	< 10	1.8 ± 10	- - -	-
2/83	16 15 15	15	20 ± 5	0.77*	24
6/83	55 52 51	53	47 ± 6	1.12	13

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{134}Cs		
10/83	14 12 14	13	15 ± 5	0.89	13
11/83	11 13 13	12	15 ± 5	0.82	19
6/84	48 47 48	48	47 ± 5	1.01	1.7
10/84	37 32 32	34	31 ± 5	1.09	12
10/84(A)	< 10	< 10	2 ± 5	- - -	-
10/84	32 32 37	34	31 ± 6	1.09	12
2/85	38 36 33	36	35 ± 6	1.02	6.7
4/85	14.0 17.7 17.8	16.5	15 ± 5	1.10	17
10/85	17.4 19.1 20.8	19.1	20 ± 5	0.96	9.6
10/85	19.1 24.1 18.0	20.4	18 ± 5	1.13	20
2/86	31.6 34.9 31.0	32.5	30 ± 6	1.08	11

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{134}Cs		
4/86	< 10 < 10 < 10	< 10	5 ± 5	- - -	-
10/86	34 21 34	30	28 ± 6	1.06	23
10/86	13.6 18.3 10.4	14.1	12 ± 6	1.18	32

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
2/81	< 10 < 10 < 10	< 10	4 ± 5	- - -	-
4/81 (A)	18 18 15	17	15 ± 10	1.13	16
6/81	34 36 40	37	31 ± 10	1.18	20
2/82	36 29 32	32	23 ± 10	1.41*	43
4/82 (A)	14 13 12	13	16 ± 3	0.81	19
6/82	27 30 28	28	25 ± 10	1.13	14
10/82	19 18 22	20	20 ± 5	0.98	8.7
10/82 (A)	33 34 31	33	20 ± 5	1.63	64
2/83	27 23 17	22	19 ± 5	1.18	27
6/83	33 27 28	29	26 ± 6	1.13	16

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
10/83	24 25 23	24	22 ± 5	1.09	9.8
11/83	16 17 16	16	15 ± 5	1.09	9.4
2/84	16 18 17	17	16 ± 6	1.06	8.1
10/84	22 23 23	23	24 ± 6	0.94	5.9
10/84(A)	19 17 17	18	14 ± 6	1.26*	27
2/85	26 26 25	26	25 ± 5	1.03	33
4/85	14 12 12	13	12.5 ± 5	1.01	7.7
6/85	23 20 15	19	20 ± 5	0.97	16
10/85	19 19 16	18	20 ± 5	0.90	11
10/85	17 17 19	18	18 ± 5	0.98	7.0

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
2/86	23 22 19	21	22 ± 6	0.97	8.1
4/86	< 5.0 < 5.0 < 5.0	< 5.0	5 ± 5	- - -	-
6/86	12 11 12	12	10 ± 5	1.17	17
10/86	44 50 42	45	44 ± 6	1.03	8.2
10/86	12.0 8.3 4.6	8.3	8 ± 6	1.04	38

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{226}Ra		
3/81	3.8 4.1 3.3	3.7	3.4 ± 0.5	1.10	14
4/81 (A)	16 15 15	15	15 ± 5	1.02	2.1
12/81	12 12 13	12	10 ± 2	1.22*	23
3/82	14 14 14	14	12 ± 2	1.17	19
4/82 (A)	11 11 11	11	11 ± 1	1.00	2.4
6/82	14 14 13	14	13 ± 2	1.05	4.0
9/82	11 11 11	11	11 ± 2	1.00	4.2
10/82(A)	13 13 13	13	13 ± 4	1.00	1.6
12/82	11 11 11	11	11 ± 2	1.00	0.0
3/83	12 12 12	12	13 ± 2	0.92	6.9

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{226}Ra		
6/83	4.3 4.1 4.2	4.2	4.8 ± 0.7	0.88	13
9/83	3.1 2.8 3.1	3.0	3.1 ± 0.5	0.97	5.6
11/83	4.6 4.6 4.6	4.6	5.1 ± 0.8	0.90	9.8
12/83	6.6 6.1 6.5	6.4	7.4 ± 1.1	0.86	14
3/84	4.0 4.0 3.9	4.0	4.1 ± 0.6	0.98	9.8
6/84	3.2 3.2 3.0	3.1	3.5 ± 0.5	0.90	11
10/84(A)	3.2 3.2 3.1	3.2	3.0 ± 5.0	1.06	5.8
12/84	6.7 7.3 7.2	7.1	8.6 ± 1.3	0.82	18
3/85	4.9 5.1 4.8	4.9	5.0 ± 0.8	0.99	2.8
4/85	3.5 4.2 3.7	3.8	4.1 ± 0.5	0.93	10

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{226}Ra		
6/85	2.7 2.9 2.9	2.8	3.1 ± 0.8	0.91	9.1
9/85	8.7 8.9 9.0	8.9	8.9 ± 1.3	1.00	1.5
10/85	5.3 5.4 4.9	5.2	6.3 ± 0.9	0.83	18
3/84	4.0 4.0 3.9	4.0	4.1 ± 0.7	0.97	3.4
4/84	4.0 3.8 3.7	3.8	4.0 ± 0.7	0.96	5.2
6/84	3.2 3.2 3.0	3.1	3.5 ± 0.6	0.90	11
9/84	4.7 4.5 4.7	4.6	4.9 ± 1	0.95	5.8
10/84	3.1 3.1 3.2	3.1	3.0 ± 0.5	1.04	4.7
12/84	6.7 7.3 7.2	7.1	8.6 ± 0.6	0.82	18
3/85	4.9 5.1 4.8	4.9	5.0 ± 0.8	0.99	2.8

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{226}Ra		
4/85	3.5 4.2 3.7	3.8	4.1 ± 1	0.93	10
6/85	2.7 2.9 2.9	2.8	3.1 ± 0.8	0.91	9.1
9/85	8.7 8.9 9.0	8.9	8.9 ± 1	1.0	15
10/85	5.3 5.4 4.9	5.2	6.3 ± 0.9	0.83	18
12/85	6.2 6.4 6.5	6.4	7.3 ± 1.3	0.87	13
3/86	3.7 4.0 4.0	3.9	4.1 ± 0.7	0.95	6.0
4/86	2.9 2.9 2.4	2.7	2.9 ± 0.9	0.94	10
6/86	8.1 8.1 8.4	8.2	8.6 ± 1.4	0.95	5.8

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{228}Ra		
3/81	6.4 5.4 3.9	5.2	7 ± 1	0.75*	32
4/81(A)	17 17 17	17	12 ± 4	1.42*	42
12/81	11 11 11	11	9 ± 1	1.22*	22
3/82	11 11 11	11	10 ± 2	1.10	9.1
4/82(A)	11 10 9	10	11 ± 1	0.91	12
6/82	9.0 9.6 8.8	9.1	9 ± 1	1.01	6.3
9/82	11 12 11	11	11 ± 2	1.03	5.3
10/82(A)	3.8 3.6 3.4	3.6	3.6 ± 1.0	1.00	4.5
12/82	< 1 < 1 < 1	< 1	0	- - -	-
3/83	< 1 < 1 < 1	< 1	0	- - -	-
6/83	< 1 < 1 < 1	< 1	0	- - -	-

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{228}Ra		
9/83	2.6 3.2 3.1	3.0	2.0 ± 0.3	1.48*	5.0
11/83	2.1 1.9 2.3	2.1	2.8 ± 0.4	0.75*	26
12/83	3.1 3.7 4.0	3.6	3.9 ± 0.6	0.92	12
3/84	1.8 1.7 1.5	1.7	2.0 ± 0.3	0.83	18
4/84	7.3 7.1 7.8	7.4	8.3 ± 1.2	0.89	11
6/84	1.9 1.7 1.7	1.8	2.0 ± 0.3	0.88	13
9/84	3.3 2.1 2.8	2.7	2.3 ± 0.3	1.19	29
10/84	1.9 2.7 2.2	2.3	2.1 ± 0.3	1.08	17
12/84	3.6 2.4 2.4	2.8	4.1 ± 0.6	0.68	35
3/85	7.4 8.2 6.7	7.4	9.0 ± 1.3	0.83	19

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{228}Ra		
6/85	3.9 3.2 3.2	3.4	4.2 ± 0.6	0.82	20
9/85	4.6 3.6 4.5	4.2	4.6 ± 0.7	0.91	13
10/85	9.2 9.2 10.0	9.5	10 ± 2	0.95	7.3
12/85	5.5 7.2 9.7	7.5	7.3 ± 1	1.02	24
3/86	13 12 12	12	12 ± 2	1.03	5.0
6/86	11 14 13	13	17 ± 3	0.75*	26
10/86	4.6 4.5 3.7	4.3	5 ± 0.9	0.85	17

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			$^{238/234}U$		
4/81(A)	12 12 13	12	12 ± 12	1.03	4.8
8/81	22 22 21	22	23 ± 6	0.94	6.2
2/82	29 29 28	29	35 ± 6	0.82	18
4/82(A)	14 14 14	14	16 ± 4	0.88	15
8/82	30 27 27	28	30 ± 6	0.93	8.1
10/82(A)	14 14 15	14	16 ± 12	0.90	11
2/83	29 29 31	30	31 ± 6	0.96	5.3
8/83	27 26 25	26	26 ± 6	1.00	3.4
11/83	9 10 11	10	11 ± 6	0.91	12
2/84	15 15 15	15	15 ± 6	1.00	0.0

Appendix A(Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			$^{238}U/^{234}U$		
8/84	21 19 21	20	20 ± 6	1.02	5.0
10/84(A)	6 6 5	6	5.0	1.13	16
2/85	11 11 11	11	12 ± 7	0.92	8.3
4/85	6 6 6	6	7 ± 6	0.86	14
8/85	8 8 8	8	8 ± 6	1.00	0
2/86	8 8 8	8	9 ± 6	0.89	11
8/86	4 4 4	4	4	1.00	0

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{239}Pu		
1/81	3.0 3.0 3.0	3.0	3.9 ± 0.6	0.77*	23
7/81	5.3 5.2 5.0	5.2	5.8 ± 0.6	0.89	11
1/82	5.5 5.3 5.4	5.4	6.7 ± 0.7	0.81	19
7/82	7.0 7.0 7.0	7.0	6.9 ± 0.7	1.01	1.5
1/83	7.4 7.7 7.8	7.6	8.6 ± 0.9	0.89	11
7/83	9.3 8.2 9.0	8.8	8.9 ± 0.9	0.99	5.3
1/84	16 18 15	16	19 ± 2	0.86	15
7/84	11 13 12	12	12.5 ± 1.3	0.96	5.7
1/85	15 16 17	16	16 ± 2	1.00	7.3
7/85	10 9.2 9.3	9.5	10.6 ± 0.9	0.90	3.4

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{239}Pu		
1/86	6.7 6.2 6.2	6.4	7 ± 1	0.91	11
8/86	11 9.2 9.3	9.8	10.1 ± 0.9	0.97	7.1

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Alpha		
5/81	22 22 21	22	21 ± 5	1.03	3.9
3/81	21 22 21	21	25 ± 6	0.85	15
4/81 (A)	64 59 58	60	91 ± 22	0.66*	34
9/81	27 26 25	26	33 ± 8	0.79*	21
1/82	19 19 20	19	24 ± 6	0.81	20
5/82	26 26 25	26	28 ± 4	0.92	6.9
4/82 (A)	57+ 58 59	58	85 ± 12	0.68	32
7/82	19 19 19	19	16 ± 5	1.19	19
9/82	27 36 25	29	29 ± 7	1.01	17
11/82	18 19 19	19	19 ± 5	0.98	3.0

+ High solids.

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Alpha		
10/82(A)	39 39 37	38	55 ± 27	0.70*	30
1/83	26 26 27	26	29 ± 7	0.91	9.4
3/83	31 31 32	31	31 ± 8	1.01	1.7
5/83	10 10 10	10	11 ± 5	0.91	9.1
7/83	8 7 8	8	7 ± 5	1.10	12
9/83	5 5 7	6	5 ± 5	1.13	23
11/83	12 10 13	12	14 ± 5	0.83	19
11/83	19 17 18	18	22 ± 6	0.82	19
4/84	4 4 4	4	3 ± 6	1.3*	33
9/84	7 7 6	7	5 ± 5	1.3*	3.5
11/84	6 6 6	6	7 ± 5	0.86	14

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Alpha		
10/84(A)	12 12 10	11	14 ± 5	0.81	20
11/84	17 15 16	16	20 ± 5	0.80	20
1/85	5.6 5.6 5.9	5.7	5 ± 6	1.14	14
5/85	11 12 12	12	12 ± 6	0.97	5.4
9/85	8.0 8.2 7.8	8.0	8 ± 6	1.00	2.0
11/85	12 11 11	11	10 ± 6	1.13	12
1/86	3.9 3.8 3.9	3.9	3 ± 6	1.29*	29
4/86	15 13 15	14	17 ± 6	0.84	17
5/86	8.6 8.5 9.4	8.8	8 ± 6	1.10	12
9/86	17 17 16	17	15 ± 6	1.11	10

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Alpha		
10/86	34 33 33	33	40 ± 12	0.83	17

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Beta		
5/81	11 11 11	11	14 ± 5	0.79*	21
3/81	27 25 28	27	25 ± 5	1.07	8.3
4/81 (A)	126 127 123	125	141 ± 14	0.89	11
9/81	26 26 25	26	28 ± 5	0.92	8.5
1/82	33 32 32	32	32 ± 5	1.01	1.8
5/82	29 29 29	29	29 ± 3	1.00	0.0
4/82 (A)	111 104 102	106	106 ± 3	1.00	3.7
7/82	18 20 16	18	23 ± 5	0.78*	23
9/82	46 51 54	50	40 ± 5	1.26	27
11/82	22 23 23	23	24 ± 5	0.94	5.9

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Beta		
10/82(A)	57 65 67	63	81 ± 10	0.78	23
1/83	26 27 28	27	31 ± 5	0.87	13
3/83	21 20 23	21	28 ± 5	0.76*	24
5/83	52 46 52	50	57 ± 5	0.88	13
7/83	14 16 16	15	22 ± 5	0.70*	31
9/83	8 8 8	8	9 ± 5	0.89	11
11/83	14 14 13	14	16 ± 5	0.85	15
4/84	63 61 55	60	67 ± 5	0.89	12
5/84	6 6 5	6	6 ± 6	0.94	5.6
9/84	13 13 13	13	16 ± 5	0.81	19

Appendix A (Continued)

EMSL-LV Cross-Check Water Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Beta		
10/84(A)	56 56 56	56	64 ± 5	0.88	13
11/84	17 15 16	16	20 ± 5	0.80	20
11/85	17 15 16	16	20 ± 6	0.80	20
5/85	8 8 7	8	11 ± 6	0.70*	31
9/85	9 8 7	8.0	8 ± 5	1.0	10
10/85	71 69 68	69	75 ± 5	0.92	7.7
1/86	10 9 9	9	13 ± 6	0.72*	28
4/86	36 35 35	35	35 ± 5	1.01	17
5/86	13 13 11	12	15 ± 6	0.82	16
11/86	39 39 39	39	51 ± 6	0.76	24

Notes: (1) R - The ratio of the average EERF value divided by the known value.
(2) Coeff. of var. (percent) - The percent of the coefficient of variation.
(3) Date (A) - Blind performance evaluation study for radionuclides in water.
(4) Asterisks (*) indicate results which differed from the EMSL-LV values by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and known values, and the small absolute difference.

Appendix B

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			K (mg/L)		
1/81	1420 1450 1430	1433	1550 ± 134	0.93	7.6
7/81	1450 1570 1530	1517	1600 ± 153	0.95	6.1
10/81	1432 1375 1363	1390	1530 ± 154	0.91	9.4
4/82	1290 1360 1380	1343	1410 ± 137	0.95	5.4
10/82	1910 1900 1930	1913	1560 ± 155	1.23	23
2/83	1560 1560 1530	1550	1512 ± 151	1.03	2.7
6/83	1530 1540 1530	1533	1486 ± 148	1.05	3.2
6/84	1523 1521 1604	1549	1496 ± 149	1.04	6.2
6/85	1558 1590 1529	1559	1525 ± 137	1.02	2.8
			^{60}Co		
4/82	32 31 33	32	30 ± 10	1.07	7.2

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{89}Sr		
1/81	< 5 < 5 < 5	< 5	0	- - -	- - -
7/81	22 25 22	23	25 ± 5	0.92	9.8
10/81	15 15 13	14	23 ± 5	0.62	38
4/82	23 25 26	25	25 ± 5	0.99	5.2
10/82	< 5 < 5 < 5	< 5	0	- - -	- - -
2/83	38 39 38	38	37 ± 5	1.04	3.8
6/83	24 24 27	25	25 ± 5	1.00	5.7
10/83	15 17 16	16	14 ± 2	1.14	15
3/84	7 6 5	6	6 ± 1	1.00	14
6/84	20 19 20	20	25 ± 5	0.79*	21
10/84	19 19 16	18	22 ± 5	0.82	19

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{89}Sr		
6/85	9 11 8	9	11 ± 6	0.85	22
10/85	50 50 48	49	48 ± 9	1.03	3.8
6/86	< 5 < 5 < 5	< 5	0	- - -	-
10/86	9 8 7	8	9 ± 6	0.89	15

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{90}Sr		
1/81	19 19 19	19	20 ± 3	0.95	5.0
7/81	17 18 19	18	17 ± 2	1.06	7.6
10/81	18 21 20	20	18 ± 2	1.09	12
4/82	17 18 16	17	16 ± 2	1.06	8.1
10/82	19 18 20	19	19 ± 2	1.00	3.7
2/83	17 18 17	17	18 ± 2	0.96	4.5
6/83	16 17 18	17	16 ± 2	1.06	8.1
10/83	11 9 12	11	15 ± 5	0.71*	30
6/84	15 16 15	15	17 ± 2	0.90	10
10/84	14 13 14	14	16 ± 2	0.85	15

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{90}Sr		
6/85	11 9 10	10	11 ± 2	0.91	13
1/86	24 22 22	23	19 ± 2	1.19	20
10/86	< 1 < 1 < 1	< 1	0 ± 2	- - -	-

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{131}I		
1/81	29 31 31	30	26 ± 10	1.17	17
7/81	< 10 < 10 < 10	< 10	0	- - -	-
10/81	51 44 48	48	52 ± 11	0.92	10
7/82	< 10 < 10 < 10	< 10	5 ± 1	- - -	-
10/82	< 15 < 15 < 15	< 15	42 ± 6	< 0.36	-
2/83	52 52 50	51	55 ± 6	0.93	6.9
6/83	29 30 27	29	30 ± 6	0.96	6.1
10/83	45 33 32	37	40 ± 8	0.93	17
3/84	7 6 5	6	6 ± 1	1.00	14
6/84	46 41 46	44	43 ± 6	1.02	6.3
10/84	36 41 37	38	42 ± 6	0.90	11

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{131}I		
1/85	3.2 6.3 7.8	6	9 ± 2	0.64*	31
6/85	20 17 10	16	11 ± 6	1.42*	58
2/86	9 8 8	8	9 ± 6	0.93	9.4
6/86	44 46 44	45	41 ± 7	1.09	8.6
10/86	51 57 58	55	49 ± 7	1.13	15

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
1/81	41 41 39	40	43 ± 9	0.94	6.6
7/81	27 27 30	28	31 ± 5	0.90	11
10/81	28 29 34	30	25 ± 5	1.21*	24
4/82	34 37 35	35	28 ± 5	1.26*	27
10/82	37 41 37	38	34 ± 5	1.13	14
2/83	26 27 29	27	26 ± 5	1.05	7.0
6/83	48 52 49	50	47 ± 5	1.06	6.7
10/83	28 33 30	30	33 ± 5	0.92	10
6/84	37 35 31	34	35 ± 5	0.98	7.4
10/84	33 30 37	33	32 ± 5	1.04	9.9
6/85	12 9 13	11	11 ± 5	1.03	16

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
6/86	38 38 43	40	31 ± 6	1.28*	30
10/86	59 63 71	64	39 ± 6	1.65	66
			^{140}Ba		
1/81	< 10 < 10 < 10	< 10	0	- - -	-
7/81	< 10 < 10 < 10	< 10	0	- - -	-
10/81	< 10 < 10 < 10	< 10	0	- - -	-
4/82	< 10 < 10 < 10	< 10	0	- - -	-
10/82	< 10 < 10 < 10	< 10	0	- - -	-
2/83	< 10 < 10 < 10	< 10	0	- - -	-

Appendix B (Continued)

EMSL-LV Cross-Check Milk Samples (pCi/L)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{140}Ba		
6/83	1530 1540 1530	1533	1486 ± 74	1.03	3.2
10/84	1391 1443 1515	1450	1517 ± 76	0.96	3.5

Notes:
(1) R - The ratio of the average EERF value divided by the known value.
(2) Coeff. of var. (percent) - The percent of the coefficient of variation.
(3) Asterisks(*) indicate results which differed from the EMSL-LV values by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and known values, and the small absolute difference.

Appendix C

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			K (mg/kg)		
3/81	2550 2530 2540	2540	2640 ± 132	0.96	3.8
7/81	2570 2550 2600	2570	2640 ± 132	0.97	2.6
11/81	2300 2440 2330	2360	2730 ± 464	0.86	14
7/82	2290 2270 2350	2302	2400 ± 120	0.96	4.3
11/82	2930 2890 2820	2880	2780 ± 140	1.04	4.0
3/83	2640 2510 2600	2580	2592 ± 130	1.00	2.1
1/84	3010 2970 3010	2997	2730 ± 136	1.10	9.8
6/84	2624 2690 2499	2604	2605 ± 170	1.00	3.0
11/85	1339 1393 1388	1373	1382 ± 138	0.99	1.9
7/85	1443 1420 1494	1452	1514 ± 151	0.96	4.6

Appendix C (Continued)

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			K (mg/kg)		
1/86	920 990 990	967	950 ± 80	1.02	3.9
8/86	1111 1068 1159	1113	1150 ± 67	0.97	4.6
			^{60}Co		
11/81	39 39 42	40	30 ± 7	1.33*	34
4/82	31 31 27	30	30 ± 7	0.99	6.3

Appendix C (Continued)

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{89}Sr		
3/81	53 52 51	52	47 ± 5	1.11	11
7/81	48 51 51	50	44 ± 5	1.14	14
11/81	35 39 35	36	38 ± 5	0.96	6.6
7/82	35 34 34	34	26 ± 5	1.32*	32
11/82	< 5 < 5 < 5	< 5	0	- - -	-
3/83	38 42 36	39	35 ± 5	1.10	13
11/84	26 34 38	33	34 ± 5	0.96	15
6/84	25 22 28	25	25 ± 5	1.00	9.8
1/85	14 22 16	17	34 ± 5	0.51	50
7/85	26 26 27	26	33 ± 5	0.80	21

Appendix C (Continued)

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{89}Sr		
1/86	23 19 20	21	25 ± 6	0.83	19
7/86	20 22 21	21	30 ± 6	0.70*	30
			^{90}Sr		
3/81	34 31 31	32	29 ± 2	1.10	11
7/81	32 31 31	31	31 ± 2	1.01	1.9
11/81	23 23 25	24	23 ± 2	1.03	5.0
7/82	22 23 22	22	20 ± 2	1.12	12
11/82	26 25 26	26	27 ± 2	0.95	7.7
3/83	31 29 30	30	28 ± 2	1.07	7.7
1/84	24 24 22	23	20 ± 2	1.17	17

Appendix C (Continued)

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{90}Sr		
6/84	20 19 21	20	20 ± 2	1.00	4.1
1/85	26 24 24	25	26 ± 3	0.95	6.3
7/85	28 29 28	28	26 ± 3	1.09	9.2
1/86	13 9 9	10	10 ± 2	1.03	18
7/86	2.4 1.9 2.0	2.1	1.9 ± 0.2	1.11	16
			^{131}I		
3/81	130 120 128	126	119 ± 12	1.06	6.9
7/81	78 84 84	82	82 ± 8	1.00	3.5
11/81	< 10 < 10 < 10	< 10	0.0	- - -	-
7/82	83 82 87	84.0	94 ± 9	0.89	11

Appendix C (Continued)

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{131}I		
11/82	24 27 21	24	25 ± 6	0.96	11
3/83	29 35 41	35	37 ± 7	0.95	14
1/84	15 17 12	15	20 ± 6	0.73*	29
6/84	41 46 45	44	39 ± 6	1.13	14
1/85	36 36 43	38	35 ± 6	1.10	13
7/85	36 30 38	35	35 ± 6	0.99	9.8
1/86	23 18 22	21	20 ± 6	1.05	12
7/86	37 54 54	48	30 ± 6	1.61	67
			^{137}Cs		
3/81	46 55 50	50	53 ± 5	0.95	8.6
7/81	42 41 43	42	45 ± 5	0.93	6.9

Appendix C (Continued)

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
11/81	27 29 33	30	33 ± 5	0.90	13
7/82	24 22 21	22	20 ± 5	1.12	13
11/82	29 30 30	30	27 ± 5	1.10	10
3/83	36 34 40	37	31 ± 5	1.18	20
1/84	21 19 15	18	20 ± 5	0.92	15
6/84	26 23 28	26	25 ± 5	1.03	8.6
1/85	35 34 31	33	29 ± 5	1.15	16
7/85	32 30 31	31	29 ± 5	1.07	7.4

Appendix C (Continued)

EMSL-LV Cross-Check Food Samples (pCi/kg)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
1/86	18 13 16	16	15 ± 6	1.04	14
7/86	23 24 24	24	20 ± 6	1.18	19

Notes: (1) R - The ratio of the average EERF value divided by the known value.
(2) Coeff. of var. (percent) - The percent of the coefficient of variation.
(3) Asterisks(*) indicate results which differed from the EMSL-LV values by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and known values, and the small absolute difference.

Appendix D

EMSL-LV Cross-Check Air Filter Samples (pCi/filter)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			Gross Alpha		
9/81	25 26 23	25	25 ± 3	0.99	5.2
3/82	24 25 23	24	27 ± 4	0.89	12
9/82	24 24 25	24	32 ± 8	0.76*	24
11/82	25 26 27	26	27 ± 7	0.96	4.8
3/83	26 27 28	27	26 ± 7	1.04	5
			Gross Beta		
9/81	126 140 125	130	65 ± 5	2.01	156
3/82	56 56 61	58	55 ± 5	1.05	6.5
9/82	84 96 95	92	67 ± 5	1.37	38
11/82	64 67 66	66	59 ± 6	1.11	12
3/83	70 72 68	70	68 ± 5	1.03	3.8

Appendix D (Continued)

EMSL-LV Cross-Check Air Filter Samples (pCi/filter)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{90}Sr		
9/81	14 17 17	16	16 ± 2	1.00	8.8
3/82	12 11 11	12	16 ± 2	0.73*	27
9/82	17 17 15	16	20 ± 2	0.82	19
11/82	14 15 16	15	16 ± 2	0.94	8.1
3/83	15 15 16	15	20 ± 2	0.77*	24
			^{137}Cs		
9/81	33 33 35	34	19 ± 5	1.77	77
3/82	28 29 29	29	23 ± 5	1.25*	25
9/82	30 29 29	29	27 ± 5	1.09	8.8

Appendix D (Continued)

EMSL-LV Cross-Check Air Filter Samples (pCi/filter)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{137}Cs		
11/82	38 37 38	38	26 ± 5	1.45	40
3/83	35 37 38	37	27 ± 5	1.36	36

Notes:
(1) R - The ratio of the average EERF value divided by the known value.
(2) Coeff. of var. (percent) - The percent of the coefficient of variation.
(3) Asterisks (*) indicate results which differed from the EMSL-LV values by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and known values, and the small absolute difference.

Appendix E

EMSL-LV Cross-Check Soil Samples (pCi/g)

Date	EERF Values	EERF Average	Known Value	R	Coeff. of Var. (percent)
			^{210}Pb		
9/82	4.7 3.8 3.8	4.1	5.2 ± 1.3	0.79*	23
			^{226}Ra		
9/82	5.8 5.7 5.9	5.8	5.2 ± 1.8	1.12	12
			^{230}Th		
9/82	5.5 5.6 6.1	5.7	5.7 ± 0.9	1.00	4.6
			^{238}U		
9/82	2.1 2.1 2.1	2.1	2.4 ± 0.3	0.88	13

Notes: (1) R - The ratio of the average EERF value divided by the known value.
(2) Coeff. of var. (percent) - The percent of the coefficient of variation.
(3) Asterisks (*) indicate results which differed from the EMSL-LV values by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and unknown values, and the small absolute difference.

Appendix F

WHO International Reference Center Intercomparison Sample Analyses

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
	Liquid Milk (No. G041) February 1981 (pCi or g per L)			
^{90}Sr	5 ± 4 5 ± 3 5 ± 2	6.0 ± 0.4	0.83	17
^{134}Cs	35 ± 14 36 ± 14 31 ± 14	36 ± 4	0.94	8.1
^{137}Cs	324 ± 35 307 ± 32 300 ± 32	280 ± 10	1.11	11
Ca	1.3 ± 0.1 1.3 ± 0.1 1.3 ± 0.1	1.25 ± 0.03	1.04	4.0
K	1.6 ± 0.2 1.6 ± 0.2 1.6 ± 0.2	1.49 ± 0.04	1.07	7.4
	Drinking Water (No. G336) June 1981 (pCi/L)			
^{3}H	5015 ± 450 5586 ± 450 5322 ± 450	5670 ± 230	0.94	7.6
^{90}Sr	8.1 ± 0.1 8.2 ± 0.1 8.4 ± 0.1	7.4 ± 0.5	1.11	11
^{106}Ru-^{106}Rh	< 100 < 100 < 100	110 ± 15	- - -	- - -
	Soil Sample (No. G477) November 1981 (pCi/kg dry)			
^{90}Sr	< 1000 < 1000 < 1000	146 ± 16	- - -	- - -
^{137}Cs	330 ± 75 330 ± 65 330 ± 65	349 ± 35	0.95	5.4

Appendix F (Continued)

WHO International Reference Center Intercomparison Sample Analyses

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
	(Continued) Soil Sample (No. G477) November 1981 (pCi/kg dry)			
^{40}K	27000 ± 2000 26000 ± 2000 27000 ± 2000	28,400 ± 2700	0.94	6.3
U (Total)	1299 ± 603 1268 ± 520 1176 ± 533	Not Reported	- - -	- - -
^{228}Th	941 ± 258 921 ± 275 893 ± 245	Not reported	- - -	- - -
^{230}Th	852 ± 235 830 ± 250 667 ± 200	Not reported	- - -	- - -
^{232}Th	874 ± 240 949 ± 260 912 ± 228	Not reported	- - -	- - -
	Total Diet (No. G660) February 1, 1982 (pCi/kg)			
^{90}Sr	< 14	11 ± 1	- - -	- - -
^{137}Cs	19 ± 16	15 ± 1	1.27*	27
^{226}Ra	9 ± 3	3 ± 1	3.0	200
Natural U	2.7 ± 1.3	1.8 ± 0.5	1.50*	50
Ca (g/kg)	2.1 ± 0.2	2.1 ± 0.1	1.00	0.00
K (g/kg)	5.4 ± 0.5	6.3 ± 0.2	0.86	14

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Appendix F (Continued)

WHO International Reference Center Intercomparison Sample Analyses

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
	Dried Seafish (No. H264) June 1983 (Bq/g or g/kg)			
^{40}K	11.5 11.6 11.5	11.1 ± 0.7	1.04	3.9
^{90}Sr	0.094 0.094 0.110	0.12 ± 0.01	0.83	20
^{134}Cs	0.41 0.40 0.42	0.49 ± 0.03	0.84	17
^{137}Cs	4.4 4.4 4.3	4.2 ± 0.02	1.04	4.4
Ca	50 49 49	52 ± 2	0.95	5.8
K	15 15 15	13 ± 1	1.15	10
Sr	0.32 0.31 0.31	0.34 ± 0.03	0.92	8.6
	Mineral Water (No. G972 and G973) March 1983 (Bq/L)			
^{226}Ra	0.326 0.363 0.366	0.350 ± 0.03	1.00	1.9
^{234}U	1.99 2.03 1.98	2.23 ± 0.03	0.90	10
^{235}U	0.04 0.04 0.05	0.05 ± 0.02	0.87	20
U (mg/L)	84.0	86 ± 10	0.98	- - -

Appendix F (Continued)

WHO International Reference Center Intercomparison Sample Analyses

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
	Sea Fish (No. H264) December 1983 (Bq/kg or g/kg)			
^{90}Sr	3.9 3.5 3.5	4.6 ± 0.2	0.79*	21
^{134}Cs	15 15 16	18 ± 1	0.85	15
^{137}Cs	163 162 160	155 ± 9	1.04	4.4
Sr (g/kg)	0.32 0.31 0.31	0.34 ± .03	0.92	8.0
Ca (g/kg)	50 49 49	52 ± 2	0.95	5.9
K (g/kg)	15 15 15	13.3 ± 0.9	1.13	10
	River Sediment (No. H519) February 1984 (Bq/kg)			
^{40}K	518 518 529	549 ± 25	0.95	5.1
^{54}Mn	22 22 22	21 ± 2	1.05	2.5
^{58}Co	6.4 7.7 7.0	8.3 ± 1.3	0.85	17
^{60}Co	6.1 6.9 6.5	7.0 ± 1	0.93	8.5

Appendix F (Continued)

WHO International Reference Center Intercomparison Sample Analyses

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
	(Continued) River Sediment (No. H519) February 1984 (Bq/kg)			
^{90}Sr	< 37 < 37 < 37	24.0 ± 1	- - -	- - -
^{106}Ru	205 200 205	229 ± 20	0.89	11
^{134}Cs	40 40 41	45 ± 3	0.90	10
^{137}Cs	303 303 303	318 ± 18	0.95	4.7
	Tritium in Rainwater (No. 40 PM300) June 1984 (Bq/L)			
^{3}H	163 ± 7 163 ± 7 163 ± 7	165 ± 5	0.99	12
	Tritium in Ground Water (No. 41 P300) June 1984 (Bq/L)			
^{3}H	33,152 33,115 33,004	32,700 ± 700	1.01	12
	Liquid Milk (No. 42L300) February 1985 (Bq/L)			
^{3}H	102 102 103	89 ± 3	1.15	15
^{90}Sr	0.27 0.31 0.28	0.31 ± 0.02	0.92	9.3

Appendix F (Continued)

WHO International Reference Center Intercomparison Sample Analyses

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
	(Continued) Liquid Milk (No. 42L300) February 1985 (Bq/L)			
^{137}Cs	0.70 0.78 0.78	0.68 ± 0.04	1.11	12
^{40}K (g/L)	1.8 1.8 1.9	1.6 ± 0.1	1.15	15
	Intercomparison on Aquatic Plants (No. 45V300) November 1986 (Bq/kg)			
^{40}K	881 907 933	770 ± 46	1.18	18
^{54}Mn	54 54 56	51 ± 4	1.07	7.4
^{58}Co	15 15 19	14 ± 2	1.17	21
^{60}Co	10 10 10	12 ± 2	0.83	17
^{90}Sr	39 33 41	42 ± 2	0.90	13
^{103}Ru	110 101 102	87 ± 8	1.20	20
^{106}Ru	401 393 390	426 ± 34	0.93	7.4

WHO International Reference Center Intercomparison Sample Analyses

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
		(Continued)		
		Intercomparison on Aquatic Plants (No. 45V300) November 1986 (Bq/kg)		
^{134}Cs	99 100 101	103 ± 7	0.97	3.0
^{137}Cs	412 425 430	390 ± 25	1.08	8.5

Notes:
(1) R - The ratio of the average EERF value divided by the reference value.
(2) Coeff. of var. (percent) - The percent of the coefficient of variation.
(3) Asterisks (*) indicate results which differed from the reference values by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and known values, and the small absolute difference.

Appendix G

Interlaboratory Collaborative Study - Mound Facility*

Results, pCi/L Water

Nuclide	EERF Values	Reference Value	R	Coeff of Var. (percent)
		Sample No. 1		
^{60}Co	93 ± 5 92 ∓ 5	99 ± 2	0.93	6.4
^{106}Ru	57 ± 21 74 ∓ 21	61 ± 1	1.07	16
^{134}Cs	158 ± 7 155 ∓ 7	161 ± 4	0.97	3.0
^{137}Cs	202 ± 6 210 ∓ 7	203 ± 5	1.01	2.5
		Sample No. 2		
^{60}Co	93 ± 5 92 ∓ 5	99 ± 2	0.93	6.4
^{137}Cs	390 ± 7 378 ∓ 7	394 ± 9	0.97	2.9
		Sample No. 3		
^{60}Co	11 ± 4	9.8 ± 0.2	1.12	10
^{137}Cs	21 ± 4 20 ∓ 4	19.9 ± 0.5	1.03	3.9
		Sample No. 4		
^{134}Cs	83 ± 5 79 ∓ 5	80 ± 2	1.01	3.1
^{137}Cs	100 ± 5 111 ∓ 5	100 ± 2	1.06	8.2

* See: Casella, V. R. and Bishop, C. T., "Determination of Radionuclides in Drinking Water by Gamma Spectrometry: An Interlaboratory Collaborative Study," Mound Facility, Miamisburg, OH, MLM-2948, UC-4 (August 12, 1982).

Appendix H

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{3}H		
1/22/81	4.2 ± 0.3	4.1	1.04
1/22/81	2.3 ± 0.2	2.5	0.94
4/16/81	824.3 ± 28.0	851.0	0.97
4/23/81	1.9 ± 0.2	2.1	0.91
4/28/81	1.3 ± 0.2	1.1	1.23 *
7/ 7/82	2.1 ± 0.2	2.7	0.78 *
7/ 7/82	5.1 ± 0.3	5.4	0.94
7/ 7/82	5.0 ± 0.3	5.4	0.92
12/ 8/82	1.1 ± 0.2	1.0	1.12
3/ 1/83	1.1 ± 0.2	1.0	1.06
6/29/83	1.0 ± 0.2	1.0	0.98
9/12/83	9.2 ± 0.4	10.2	0.90
10/19/83	5.2 ± 0.3	5.2	1.00
3/15/84	9.1 ± 0.4	9.7	0.93
7/17/84	3.5 ± 0.2	3.3	1.05
8/23/84	10.5 ± 0.5	10.8	0.97
1/29/85	25.6 ± 1.0	26.0	0.99
4/12/85	1.5 ± 0.2	1.1	1.28

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{3}H (Continued)		
4/14/85	1.5 ± 0.2	1.4	1.06
8/26/85	1.4 ± 0.2	1.4	1.03
4/21/86	25.2 ± 1.0	25.8	0.98
8/15/86	12.4 ± 0.5	12.2	1.02
10/20/86	12.2 ± 0.5	12.5	0.98
	^{40}K		
4/ 6/81	1076.0 ± 98.0	1200.0	0.90
9/26/83	403.3 ± 48.4	377.0	1.07
	^{60}CO		
9/26/83	54.7 ± 5.5	50.0	1.09
3/11/86	47.0 ± 9.3	42.0	1.12
	^{65}ZN		
9/26/83	39.0 ± 7.4	33.0	1.18
	^{89}SR		
2/17/82	25.8 ± 1.9	21.5	1.20

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{89}SR (Continued)		
5/ 7/82	15.4 ± 1.8	11.0	1.40 *
6/29/82	79.3 ± 9.2	59.0	1.34
9/ 3/82	25.0 ± 7.8	24.5	1.02
3/ 4/83	104.2 ± 4.1	97.5	1.07
3/ 4/83	122.3 ± 4.0	98.0	1.25
5/ 6/83	66.8 ± 5.0	57.0	1.17
9/ 1/83	19.2 ± 1.4	15.0	1.28 *
4/10/84	38.1 ± 1.9	36.0	1.06
5/16/84	37.7 ± 5.7	49.0	0.77 *
6/26/84	25.8 ± 3.1	28.0	0.92
8/29/84	26.5 ± 4.4	23.0	1.15
10/30/84	< 5.0	0.0	----
5/10/85	40.5 ± 2.4	39.0	1.04
2/19/86	32.2 ± 3.0	39.7	0.81
3/19/86	13.3 ± 3.5	12.9	1.03
3/19/86	12.7 ± 2.4	12.9	0.98
3/19/86	14.6 ± 1.4	12.9	1.13
3/19/86	13.1 ± 1.8	12.9	1.02

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{89}SR (Continued)		
3/19/86	12.1 ± 1.8	12.9	0.94
3/19/86	13.9 ± 2.4	12.9	1.08
3/19/86	13.8 ± 1.0	12.9	1.07
3/19/86	13.0 ± 2.6	12.9	1.01
3/19/86	13.7 ± 1.9	13.0	1.06
	^{90}SR		
2/17/82	69.4 ± 5.0	67.0	1.04
4/16/82	34.3 ± 4.0	32.5	1.05
5/ 7/82	5.9 ± 0.7	6.9	0.86
6/29/82	34.9 ± 6.8	33.5	1.04
8/11/82	38.1 ± 5.5	65.0	0.59
9/ 3/82	16.6 ± 3.5	14.5	1.15
3/ 4/83	72.9 ± 3.3	62.0	1.18
3/ 4/83	65.7 ± 3.4	62.0	1.06
5/ 6/83	35.0 ± 2.7	38.0	0.92
9/ 1/83	9.6 ± 0.8	10.0	0.96
4/10/84	13.7 ± 1.3	18.0	0.76 *

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{90}Sr (Continued)		
5/16/84	42.7 ± 2.9	45.0	0.95
6/26/84	16.0 ± 1.9	17.7	0.90
8/29/84	14.5 ± 2.7	17.6	0.82
10/30/84	18.9 ± 4.6	17.5	1.08
5/10/85	13.0 ± 1.6	15.0	0.87
2/19/86	33.5 ± 2.3	34.0	0.98
3/19/86	5.2 ± 2.0	4.5	1.15
3/19/86	5.8 ± 1.5	4.5	1.30 *
3/19/86	3.6 ± 1.1	4.5	0.81
3/19/86	4.9 ± 1.3	4.5	1.08
3/19/86	4.1 ± 1.8	4.5	0.91
3/19/86	5.8 ± 1.7	4.5	1.29 *
3/19/86	4.8 ± 0.8	4.5	1.07
3/19/86	5.1 ± 1.3	4.5	1.14
3/19/86	3.5 ± 1.5	4.5	0.78 *
3/19/86	5.2 ± 2.7	4.5	1.16
	^{131}I		
2/18/81	124.5 ± 4.5	138.0	0.90

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{131}I (Continued)		
4/14/81	69.0 ± 1.4	75.0	0.92
2/ 2/82	32.7 ± 5.8	31.0	1.05
4/ 6/82	35.7 ± 5.6	36.5	0.98
6/ 7/82	32.2 ± 0.5	37.1	0.87
8/ 4/82	39.9 ± 0.6	46.5	0.86
9/10/82	64.1 ± 3.3	74.0	0.87
10/12/82	88.4 ± 1.5	95.5	0.93
11/ 2/82	58.4 ± 0.7	60.0	0.97
4/22/83	32.7 ± 2.8	37.0	0.88
5/20/83	60.9 ± 1.6	97.0	0.63
6/ 3/83	105.7 ± 77.3	160.0	0.66 *
10/13/83	54.0 ± 0.8	61.5	0.88
4/ 9/84	72.4 ± 5.4	82.0	0.88
7/30/84	146.4 ± 7.8	146.0	1.00
10/22/84	76.6 ± 5.7	86.0	0.89
2/ 6/85	55.6 ± 1.1	67.0	0.83
5/13/85	81.7 ± 13.2	68.0	1.20
6/24/85	59.1 ± 0.0	59.0	1.00

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{131}I (Continued)		
9/12/85	80.9 ± 8.7	96.0	0.84
3/11/86	50.2 ± 0.7	57.0	0.88
3/11/86	65.9 ± 14.3	58.0	1.14
10/20/86	49.4 ± 0.9	46.0	1.07
	^{137}CS		
4/ 6/81	29.7 ± 8.6	32.0	0.93
9/26/83	24.3 ± 3.6	23.0	1.06
5/13/85	45.1 ± 8.3	38.0	1.19
3/11/86	49.2 ± 9.4	38.0	1.29 *
	^{210}PB		
9/18/81	40.1 ± 6.3	43.3	0.93
5/14/82	17.8 ± 7.4	22.0	0.81
7/ 9/82	22.7 ± 7.1	22.6	1.00
9/20/83	2.7 ± 3.1	3.4	0.78 *
11/ 1/83	8.6 ± 2.6	6.8	1.26 *

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{210}Pb (Continued)		
12/ 1/83	27.7 ± 3.1	27.0	1.02
12/ 1/83	46.0 ± 3.8	40.0	1.15
1/15/84	4.3 ± 0.5	3.4	1.26 *
1/15/84	4.5 ± 0.5	3.5	1.29 *
1/25/84	32.6 ± 2.9	27.8	1.17
3/ 2/84	44.2 ± 4.2	36.3	1.22 *
3/ 2/84	38.7 ± 3.5	28.7	1.35
6/22/84	26.2 ± 3.6	21.0	1.25 *
6/22/84	32.1 ± 3.6	24.0	1.34
7/30/84	8.4 ± 1.6	8.6	0.98
7/30/84	25.0 ± 3.2	26.0	0.96
11/ 1/84	42.0 ± 4.7	41.0	1.02
11/29/84	44.5 ± 7.1	46.0	0.97
5/14/85	44.1 ± 5.4	40.0	1.10
	^{210}Po		
5/14/82	8.4 ± 1.4	22.6	0.37
7/ 9/82	12.5 ± 2.0	22.6	0.55
10/ 1/82	10.3 ± 1.7	10.4	0.99

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{210}Po (Continued)		
9/20/83	1.8 ± 0.4	3.4	0.54
11/ 1/83	6.4 ± 1.0	6.8	0.95
12/ 1/83	24.0 ± 2.0	27.0	0.89
12/ 1/83	42.5 ± 2.9	40.0	1.06
1/15/84	3.5 ± 0.3	3.4	1.03
1/15/84	3.0 ± 0.2	3.5	0.86
1/25/84	24.4 ± 1.7	27.8	0.88
2/ 9/84	1066.0 ±106.0	915.0	1.17
3/ 2/84	36.9 ± 2.7	36.3	1.02
3/ 2/84	29.3 ± 2.1	28.7	1.02
6/22/84	23.6 ± 2.0	21.0	1.12
6/22/84	27.3 ± 2.1	24.0	1.14
7/30/84	24.6 ± 1.7	26.0	0.95
7/30/84	7.3 ± 0.6	8.6	0.85
11/ 1/84	53.9 ± 3.9	41.0	1.32
11/29/84	10.5 ± 0.9	46.0	0.23
5/14/85	57.1 ± 4.9	40.0	1.43
	^{222}Rn		
11/20/84	248.8 ± 24.9	237.0	1.05

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	$^{222}_{RN}$ (Continued)		
11/20/84	505.9 ± 30.4	474.0	1.07
2/ 1/85	282.0 ± 28.2	264.0	1.07
2/27/86	235.1 ± 48.4	206.0	1.14
4/ 8/86	164.1 ± 47.6	154.0	1.07
	$^{226}_{RA}$		
7/20/81	50.5 ± 0.3	21.5	2.35
7/20/81	26.6 ± 0.2	10.8	2.47
7/20/81	29.2 ± 0.2	21.5	1.36
7/20/81	4.0 ± 0.1	2.7	1.48 *
7/20/81	7.4 ± 0.1	2.7	2.75
7/20/81	14.7 ± 0.1	10.8	1.37
9/18/81	53.9 ± 0.3	50.1	1.08
10/ 1/81	9.2 ± 0.1	8.3	1.11
12/18/81	3.5 ± 0.1	9.0	0.39
3/ 2/82	14.1 ± 0.1	12.0	1.18
3/12/82	11.4 ± 0.1	11.6	0.98
4/22/82	23.5 ± 0.2	19.1	1.23 *

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{226}Ra (Continued)		
5/17/82	25.4 ± 0.2	23.9	1.06
6/16/82	25.3 ± 0.2	25.7	0.98
9/10/82	7.4 ± 0.1	8.0	0.93
9/10/82	10.2 ± 0.1	10.5	0.97
6/17/83	5.3 ± 0.1	4.8	1.10
9/10/83	2.8 ± 0.1	2.0	1.40 *
5/ 4/84	6.7 ± 0.1	7.4	0.91
12/21/84	8.5 ± 0.1	8.6	0.99
7/30/85	3.3 ± 0.1	3.0	1.10
9/13/85	9.4 ± 0.1	8.9	1.06
9/17/85	4.2 ± 0.1	4.1	1.02
3/ 3/86	0.5 ± 0.0	0.4	1.04
3/ 4/86	0.5 ± 0.0	0.4	1.07
3/ 4/86	0.5 ± 0.0	0.4	1.20
3/ 5/86	0.5 ± 0.0	0.4	1.11
3/17/86	4.0 ± 0.0	4.1	0.98
9/ 8/86	9.7 ± 0.1	8.6	1.13
10/30/86	4.4 ± 0.1	4.5	0.97

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{228}RA		
10/ 1/81	15.1 ± 1.7	11.7	1.29 *
12/18/81	10.4 ± 1.4	10.1	1.02
3/ 2/82	35.6 ± 2.9	27.0	1.32
3/12/82	9.6 ± 1.8	10.2	0.94
4/22/82	19.3 ± 1.4	18.0	1.07
5/17/82	37.2 ± 2.2	51.9	0.72
6/16/82	27.4 ± 2.9	23.9	1.14
9/10/82	11.2 ± 1.2	11.0	1.02
6/17/83	< 1.0	0.0	----
9/10/83	3.1 ± 0.7	3.1	1.00
11/16/83	22.0 ± 1.3	22.0	1.00
12/13/83	39.1 ± 2.0	37.0	1.06
12/13/83	10.7 ± 1.1	9.2	1.16
12/21/84	3.3 ± 0.7	4.1	0.80
9/13/85	4.4 ± 0.9	4.6	0.97
9/17/85	7.8 ± 1.0	7.9	0.99
3/11/86	16.1 ± 1.8	13.0	1.24 *
9/ 8/86	11.8 ± 1.2	16.3	0.72 *

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	$^{228}_{TH}$		
3/15/85	3.7 ± 0.3	4.0	0.92
	$^{230}_{TH}$		
2/13/81	50.5 ± 3.5	65.3	0.77
9/18/81	26.2 ± 0.8	31.1	0.84
6/17/82	9.2 ± 0.7	7.5	1.23 *
8/11/82	9.1 ± 0.5	7.5	1.21 *
10/13/82	9.1 ± 0.5	7.5	1.21 *
12/ 1/82	6.4 ± 0.4	6.5	0.99
2/ 8/83	14.5 ± 0.6	13.0	1.11
5/ 5/83	13.8 ± 1.2	13.2	1.05
5/ 5/83	13.8 ± 0.6	13.2	1.05
5/ 5/83	16.9 ± 1.0	13.2	1.28 *
8/ 1/83	8.8 ± 0.3	6.6	1.33 *
8/ 1/83	8.3 ± 0.4	6.6	1.25 *
8/ 1/83	6.8 ± 0.4	6.6	1.03
11/16/83	4.7 ± 0.3	6.6	0.71 *
5/14/84	8.1 ± 0.3	6.6	1.23 *

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	$^{230}_{TH}$ (Continued)		
5/14/84	6.9 ± 0.4	6.6	1.05
5/14/84	8.0 ± 0.4	6.6	1.22 *
6/25/84	7.5 ± 0.4	6.6	1.13
6/25/84	7.6 ± 0.4	6.6	1.15
6/25/84	9.1 ± 0.6	6.6	1.38 *
12/10/84	7.0 ± 0.5	6.6	1.06
5/24/85	8.2 ± 0.6	13.0	0.63
	$^{232}_{TH}$		
2/ 1/82	35.7 ± 2.9	36.5	0.98
8/28/84	4.1 ± 0.4	3.6	1.14 *
8/28/84	3.2 ± 0.3	3.6	0.90
8/28/84	3.6 ± 0.2	3.6	0.99
3/15/85	3.9 ± 0.3	3.0	1.28 *
1/21/86	1.0 ± 0.1	0.9	1.10
2/24/86	1.5 ± 0.1	1.2	1.26
	$^{234}_{U}$		
6/ 1/81	17.8 ± 1.7	21.8	0.81

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{234}U (Continued)		
11/13/81	25.2 ± 3.3	27.2	0.93
2/ 1/82	24.4 ± 3.0	27.3	0.89
4/21/82	4.6 ± 0.6	5.1	0.90
5/ 4/82	9.2 ± 1.2	10.9	0.84
6/17/82	1.3 ± 0.2	1.3	0.98
8/11/82	3.1 ± 0.5	3.1	1.00
10/13/82	7.6 ± 0.9	7.8	0.98
12/ 1/82	5.9 ± 0.9	8.1	0.73 *
2/ 8/83	10.8 ± 1.3	10.5	1.03
5/ 5/83	10.0 ± 1.1	10.9	0.92
5/ 5/83	10.9 ± 1.2	10.9	1.00
5/ 5/83	11.7 ± 1.6	10.9	1.08
8/ 1/83	3.9 ± 0.4	4.4	0.88
8/ 1/83	3.4 ± 0.5	4.4	0.77 *
8/ 1/83	3.7 ± 0.4	4.4	0.83
11/16/83	10.1 ± 1.2	10.9	0.93
11/16/83	11.4 ± 1.3	10.9	1.05
11/16/83	10.8 ± 1.3	10.9	0.99

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{234}U (Continued)		
5/14/84	27.3 ± 3.0	27.2	1.01
5/14/84	25.3 ± 3.0	27.2	0.93
5/14/84	26.7 ± 3.2	27.2	0.98
8/28/84	5.1 ± 0.6	4.4	1.16
8/28/84	5.1 ± 0.7	4.4	1.15
8/28/84	3.8 ± 0.5	4.4	0.86
10/29/84	2.3 ± 0.2	2.2	1.04
12/10/84	4.3 ± 0.6	4.4	0.98
3/15/85	2.4 ± 0.3	3.0	0.78 *
5/24/85	5.3 ± 0.7	4.4	1.21 *
12/ 6/85	2.7 ± 0.3	3.0	0.88
1/21/86	3.1 ± 0.3	3.1	1.00
2/24/86	1.9 ± 0.2	2.0	0.96
	^{235}U		
6/ 1/81	1.0 ± 0.1	1.1	0.89
11/13/81	1.4 ± 0.2	1.3	1.10
2/ 1/82	1.3 ± 0.2	1.3	1.03

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{235}U (Continued)		
4/21/82	0.2 ± 0.1	0.2	0.79 *
5/ 4/82	0.4 ± 0.1	0.5	0.76 *
6/17/82	0.1 ± 0.1	0.1	1.86 *
8/11/82	0.1 ± 0.1	0.1	0.96
10/13/82	0.3 ± 0.1	0.4	0.75 *
12/ 1/82	0.5 ± 0.1	0.4	1.36 *
2/ 8/83	0.4 ± 0.1	0.5	0.74 *
5/ 5/83	0.4 ± 0.1	0.5	0.87
5/ 5/83	0.5 ± 0.1	0.5	0.98
5/ 5/83	0.5 ± 0.2	0.5	0.92
8/ 1/83	0.1 ± 0.1	0.2	0.67 *
8/ 1/83	0.1 ± 0.1	0.2	0.50 *
8/ 1/83	0.1 ± 0.1	0.2	0.37 *
11/16/83	0.5 ± 0.1	0.5	1.03
11/16/83	0.5 ± 0.1	0.5	1.09
11/16/83	0.5 ± 0.1	0.5	0.91
5/14/84	1.0 ± 0.1	1.3	0.77
5/14/84	0.8 ± 0.1	1.3	0.62

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{235}U (Continued)		
5/14/84	0.9 ± 0.1	1.3	0.66
8/28/84	0.2 ± 0.1	0.2	0.74 *
8/28/84	0.2 ± 0.1	0.2	0.82
8/28/84	0.1 ± 0.1	0.2	0.48 *
10/29/84	0.1 ± 0.1	0.1	0.70 *
12/10/84	0.2 ± 0.1	0.2	1.03
5/24/85	0.2 ± 0.1	0.2	0.84
12/ 6/85	0.1 ± 0.1	0.1	0.72 *
1/21/86	0.1 ± 0.1	0.1	0.63 *
2/24/86	0.1 ± 0.1	0.1	0.93
	^{238}U		
6/ 1/81	18.1 ± 1.7	22.5	0.80
11/13/81	26.2 ± 3.4	28.2	0.93
2/ 1/82	24.7 ± 3.1	28.1	0.88
4/21/82	4.5 ± 0.6	5.0	0.90
5/ 4/82	9.2 ± 1.2	11.3	0.81
6/17/82	1.1 ± 0.2	1.3	0.88

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{238}U (Continued)		
8/11/82	2.8 ± 0.5	3.2	0.89
10/13/82	7.9 ± 0.9	8.0	0.99
12/ 1/82	3.6 ± 0.6	8.4	0.43
2/ 8/83	11.0 ± 1.3	10.9	1.01
5/ 5/83	11.4 ± 1.6	11.3	1.01
5/ 5/83	10.6 ± 1.2	11.3	0.94
5/ 5/83	10.9 ± 1.2	11.3	0.97
8/ 1/83	2.9 ± 0.4	4.5	0.65 *
8/ 1/83	4.3 ± 0.4	4.5	0.96
8/ 1/83	3.8 ± 0.4	4.5	0.83
11/16/83	10.7 ± 1.2	11.3	0.95
11/16/83	11.1 ± 1.3	11.3	0.98
11/16/83	10.6 ± 1.2	11.3	0.94
5/14/84	26.2 ± 2.9	28.3	0.93
5/14/84	26.5 ± 3.2	28.3	0.94
5/14/84	25.2 ± 2.9	28.3	0.89
8/28/84	3.6 ± 0.5	4.5	0.79 *
8/28/84	4.9 ± 0.7	4.5	1.09

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{238}U (Continued)		
8/28/84	4.5 ± 0.6	4.5	1.00
10/29/84	2.3 ± 0.2	2.3	0.99
12/10/84	4.6 ± 0.6	4.5	1.02
3/15/85	2.5 ± 0.3	3.0	0.84
5/24/85	5.4 ± 0.7	4.5	1.21 *
12/ 6/85	2.6 ± 0.3	4.8	0.54
1/21/86	3.0 ± 0.3	3.2	0.92
2/24/86	1.9 ± 0.2	2.1	0.88
	^{238}PU		
6/24/81	< 0.02	0.0	----
12/ 1/82	7.9 ± 0.9	9.4	0.84
2/ 8/83	9.8 ± 1.3	9.5	1.03
8/ 1/83	8.9 ± 1.0	9.5	0.94
8/ 1/83	9.3 ± 1.2	9.5	0.98
8/ 1/83	7.3 ± 0.9	9.5	0.76 *
11/16/83	9.3 ± 1.2	9.5	0.98
11/16/83	9.7 ± 1.2	9.5	1.02

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	^{238}PU (Continued)		
11/16/83	8.5 ± 1.0	9.5	0.90
11/20/84	5.2 ± 0.7	5.0	1.03
12/10/84	8.2 ± 1.1	9.5	0.86
5/24/85	8.8 ± 1.0	9.5	0.93
10/ 7/85	0.2 ± 0.1	0.1	1.35 *
10/ 7/85	< 0.02	0.0	----
12/ 6/85	4.9 ± 0.6	4.8	1.02
	^{239}PU		
3/17/81	8.3 ± 0.8	19.6	0.43
3/17/81	3.8 ± 0.4	3.9	0.97
3/17/81	15.9 ± 1.7	19.6	0.81
3/17/81	4.2 ± 0.5	3.9	1.07
3/17/81	4.0 ± 0.5	3.9	1.03
3/17/81	18.9 ± 2.2	19.6	0.96
6/ 1/81	11.2 ± 1.0	13.5	0.83
6/24/81	20.0 ± 2.5	22.9	0.87
7/ 7/81	4.7 ± 0.5	5.7	0.83

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R	
		$^{239}_{PU}$ (Continued)		
7/ 7/81	4.0 ± 0.4	5.7	0.69	
7/ 7/81	4.4 ± 0.4	5.7	0.77	*
7/ 7/81	5.0 ± 0.5	5.7	0.88	
6/17/82	7.0 ± 0.9	6.5	1.08	
8/11/82	6.0 ± 0.7	6.5	0.93	
10/13/82	6.5 ± 0.8	6.5	0.99	
5/ 5/83	11.3 ± 3.1	11.4	0.99	
5/ 5/83	12.9 ± 1.5	11.4	1.13	
5/ 5/83	11.7 ± 1.3	11.4	1.02	
5/14/84	7.3 ± 0.8	11.4	0.64	
5/14/84	12.8 ± 1.6	11.4	1.13	
5/14/84	11.1 ± 1.3	11.4	0.97	
6/25/84	4.5 ± 0.6	4.0	1.11	
6/25/84	4.2 ± 0.7	4.0	1.05	
6/25/84	4.8 ± 0.6	4.0	1.18	
8/28/84	5.1 ± 0.7	4.0	1.28	*
8/28/84	4.3 ± 0.7	4.0	1.07	
8/28/84	5.1 ± 0.6	4.0	1.28	*
3/15/85	8.2 ± 1.1	11.0	0.74	*

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	$^{239}_{PU}$ (Continued)		
1/21/86	2.6 ± 0.4	2.0	1.32 *
2/24/86	2.7 ± 0.3	2.7	1.01
	GROSS ALPHA		
8/18/81	19.5 ± 2.7	22.8	0.85
8/18/81	9.3 ± 1.9	11.4	0.82
8/18/81	11.4 ± 1.7	11.4	1.00
11/20/81	18.0 ± 2.8	21.0	0.86
4/26/82	9.9 ± 1.4	11.4	0.87
5/21/82	31.1 ± 2.7	44.0	0.71
7/ 9/82	20.2 ± 2.2	19.1	1.06
7/16/82	17.6 ± 2.1	16.0	1.10
9/17/82	23.9 ± 2.3	29.0	0.82
11/19/82	18.0 ± 2.0	19.0	0.95
11/22/82	53.7 ± 3.1	56.7	0.95
1/21/83	24.4 ± 2.3	29.0	0.84
3/18/83	24.2 ± 2.3	31.0	0.78
7/15/83	7.3 ± 1.4	7.0	1.04

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	GROSS ALPHA (Continued)		
9/ 2/83	6.8 ± 1.3	5.0	1.36
10/29/84	61.0 ± 3.3	59.0	1.03
3/25/85	39.2 ± 2.7	38.0	1.03
5/14/85	60.4 ± 3.3	59.0	1.02
7/26/85	7.6 ± 1.2	11.5	0.66
8/27/85	5.9 ± 1.1	4.8	1.22 *
11/22/85	9.7 ± 1.5	10.0	0.97
8/25/86	69.7 ± 3.6	59.0	1.18
	GROSS BETA		
8/18/81	65.7 ± 4.7	68.0	0.97
8/18/81	61.7 ± 6.0	68.0	0.91
8/18/81	131.8 ± 6.5	136.0	0.97
11/20/81	21.9 ± 2.5	23.0	0.95
4/26/82	53.4 ± 4.1	54.5	0.98
5/21/82	41.6 ± 3.3	46.4	0.90
7/ 9/82	30.4 ± 3.3	27.0	1.13
7/16/82	30.9 ± 3.1	23.0	1.34

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

Date	EERF Value	Known Value	R
	GROSS BETA (Continued)		
9/17/82	52.9 ± 4.0	40.0	1.32
11/19/82	17.5 ± 2.2	24.0	0.73
11/22/82	52.5 ± 3.4	53.0	0.99
1/21/83	22.7 ± 2.4	31.0	0.73
3/15/83	9.5 ± 0.9	8.3	1.14
3/15/83	87.0 ± 2.6	83.0	1.05
3/15/83	22.3 ± 1.3	21.0	1.06
3/15/83	41.4 ± 1.7	42.0	0.99
3/18/83	17.1 ± 2.0	28.0	0.61
7/15/83	20.9 ± 2.7	22.0	0.95
9/ 2/83	18.2 ± 2.6	17.5	1.04
11/ 3/83	7.9 ± 2.0	7.0	1.13
10/29/84	31.3 ± 2.3	39.0	0.80
3/25/85	48.9 ± 3.5	38.0	1.29
5/14/85	74.6 ± 4.3	77.0	0.97
7/26/85	27.6 ± 3.1	38.0	0.73
8/27/85	19.8 ± 2.6	19.0	1.04
11/22/85	11.9 ± 2.0	13.0	0.92
8/25/86	60.1 ± 3.5	75.0	0.80

RESULTS OF INTRALABORATORY BLIND ANALYSES OF WATER SAMPLES

NOTES

(1) Units are nCi/L for H-3 and pCi/L for all other radionuclides.

(2) R - The ratio of the average EERF value divided by the known value. Small inconsistencies in the R value are due to rounding.

(3) Asterisks (*) indicate results which differed from the Known value by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and Known values, and the small absolute difference.

Appendix I

RESULTS OF INTRALABORATORY BLIND ANALYSES OF MILK SAMPLES

Date	EERF Value	Known Value	R
	^{60}Co		
2/11/81	18.0 ± 3.4	18.0	1.00
	^{89}Sr		
1/21/81	36.6 ± 1.3	32.9	1.11
5/ 8/86	10.0 ± 2.9	15.0	0.67
7/17/86	23.4 ± 1.4	29.0	0.81
	^{90}Sr		
1/21/81	23.8 ± 0.8	22.5	1.06
9/16/85	30.6 ± 2.4	43.0	0.71
5/ 8/86	35.4 ± 2.3	30.0	1.18
7/17/86	30.9 ± 1.1	28.0	1.10
	^{131}I		
2/11/81	61.8 ± 8.0	63.0	0.98
6/16/81	14.6 ± 4.2	18.0	0.81
6/16/81	9.7 ± 0.1	18.0	0.54

RESULTS OF INTRALABORATORY BLIND ANALYSES OF MILK SAMPLES

Date	EERF Value	Known Value	R
	^{131}I (Continued)		
6/16/81	8.8 ± 0.1	18.0	0.49
7/17/81	15.0 ± 0.2	23.0	0.65
9/16/85	81.6 ± 6.9	69.0	1.18
5/ 8/86	53.4 ± 11.5	55.0	0.97
8/14/86	108.7 ± 12.9	100.0	1.09
	^{137}CS		
9/16/85	49.6 ± 8.1	47.0	1.06
5/ 8/86	81.3 ± 11.1	75.0	1.08
8/14/86	66.2 ± 8.3	74.0	0.89

NOTES

(1) Units are pCi/L.

(2) R - The ratio of the average EERF value divided by the known value. Small inconsistencies in the R value are due to rounding.

Appendix J

RESULTS OF INTRALABORATORY BLIND ANALYSES OF SOIL SAMPLES

Date	EERF Value	Known Value	R
	^{40}K		
12/15/80	19.0 ± 1.7	19.5	0.97
	^{137}CS		
12/15/80	0.5 ± 0.1	0.5	1.12
	^{210}PB		
1/ 1/81	19.5 ± 3.1	18.6	1.05
1/ 6/84	442.2 ± 32.7	433.0	1.02
1/ 6/84	435.9 ± 60.2	433.0	1.01
1/19/84	417.4 ± 40.5	433.0	0.96
1/19/84	241.9 ± 19.6	433.0	0.56
2/ 7/84	437.0 ± 55.5	433.0	1.01
2/ 7/84	510.7 ± 40.3	433.0	1.18
2/21/84	397.5 ± 38.2	433.0	0.92
2/21/84	445.6 ± 42.8	433.0	1.03
3/15/84	450.4 ± 40.5	433.0	1.04
3/15/84	420.2 ± 38.2	433.0	0.97

RESULTS OF INTRALABORATORY BLIND ANALYSES OF SOIL SAMPLES

Date	EERF Value	Known Value	R
	^{210}Po		
1/ 1/81	15.4 ± 2.0	18.6	0.83
1/ 1/81	23.9 ± 3.0	36.9	0.65
1/ 6/84	442.9 ± 46.9	433.0	1.02
1/19/84	495.8 ± 40.2	433.0	1.15
1/19/84	286.4 ± 20.9	433.0	0.66
2/ 7/84	435.3 ± 29.6	433.0	1.01
2/ 7/84	489.5 ± 41.1	433.0	1.13
2/21/84	486.8 ± 42.8	433.0	1.12
2/21/84	419.7 ± 37.8	433.0	0.97
3/15/84	408.8 ± 29.8	433.0	0.94
3/15/84	449.9 ± 36.0	433.0	1.04
	^{228}TH		
9/ 1/83	1.7 ± 0.1	1.9	0.89
9/ 1/83	1.8 ± 0.2	1.9	0.92
10/21/83	0.7 ± 0.1	0.9	0.76 *
10/21/83	1.0 ± 0.1	0.9	1.06
3/14/84	0.8 ± 0.1	0.9	0.86

RESULTS OF INTRALABORATORY BLIND ANALYSES OF SOIL SAMPLES

Date	EERF Value	Known Value	R
	$^{228}_{TH}$ (Continued)		
3/14/84	0.7 ± 0.1	0.9	0.74 *
	$^{230}_{TH}$		
9/ 1/83	1.0 ± 0.1	1.2	0.86
9/ 1/83	1.0 ± 0.1	1.2	0.87
10/21/83	0.7 ± 0.1	0.8	0.91
10/21/83	0.7 ± 0.1	0.8	0.84
3/14/84	0.8 ± 0.1	0.8	0.99
3/14/84	0.7 ± 0.1	0.8	0.86
	$^{232}_{TH}$		
12/15/80	1.8 ± 0.3	1.9	0.96
10/21/83	0.8 ± 0.1	0.9	0.90
10/21/83	0.8 ± 0.1	0.9	0.89
3/14/84	0.7 ± 0.1	0.9	0.83
3/14/84	0.8 ± 0.1	0.9	0.93
	$^{234}_{U}$		
9/ 1/83	1.1 ± 0.2	1.1	1.00

RESULTS OF INTRALABORATORY BLIND ANALYSES OF SOIL SAMPLES

Date	EERF Value	Known Value	R
	^{234}U (Continued)		
9/ 1/83	1.1 ± 0.2	1.1	1.08
10/21/83	0.9 ± 0.1	0.9	0.98
10/21/83	0.9 ± 0.2	0.9	1.04
3/14/84	0.8 ± 0.1	0.9	0.93
3/14/84	0.6 ± 0.1	0.9	0.68 *
2/ 7/85	0.9 ± 0.1	1.1	0.85
	^{238}U		
9/ 1/83	1.0 ± 0.2	1.0	0.94
9/ 1/83	1.1 ± 0.2	1.0	1.02
10/21/83	0.7 ± 0.1	0.8	0.85
10/21/83	0.9 ± 0.2	0.8	1.07
3/14/84	0.6 ± 0.1	0.8	0.72 *
3/14/84	0.7 ± 0.1	0.8	0.88
2/ 7/85	1.0 ± 0.1	1.0	0.91
	^{239}PU		
10/22/81	2.2 ± 0.2	2.6	0.83

RESULTS OF INTRALABORATORY BLIND ANALYSES OF SOIL SAMPLES

Date	EERF Value	Known Value	R
	$^{239}_{PU}$ (Continued)		
9/ 1/83	0.2 ± 0.1	0.2	0.95
9/ 1/83	0.2 ± 0.1	0.2	0.80
12/14/84	2.4 ± 0.3	2.6	0.91
2/ 7/85	0.3 ± 0.1	0.2	1.24 *
7/26/85	2.4 ± 0.3	2.6	0.93
10/ 1/85	< 0.02	0.0	----
10/31/85	2.3 ± 0.3	2.6	0.90

NOTES

(1) Units are pCi/g of dried soil.

(2) R - The ratio of the average EERF value divided by the known value. Small inconsistencies in the R value are due to rounding.

(3) Asterisks (*) indicate results which differed from the known value by more than 20 percent but were judged acceptable because of low sample concentration, the uncertainty in the measurement and Known values, and the small absolute difference.