U.S. Department of Energy Quality Assessment Program Data Evaluation Report

**R. E. Jaquish
R. R. Kinnison**

April 1984

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
201-225	A010
226-250	A011
251-275	A012
276-300	A013

U.S. DEPARTMENT OF ENERGY
QUALITY ASSESSMENT PROGRAM
DATA EVALUATION REPORT

R. E. Jaquish
R. R. Kinnison

April 1984

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

This report summarizes and evaluates the results from the analysis of the Quality Assessment Program (QAP) samples submitted to the QAP participants in November 1983. The data were evaluated using the Environmental Measurements Laboratory (EML) values as the known values and 3-sigma control limits previously established for the QAP program. Descriptive statistics and probability plots were developed using the MINITAB statistical program.

This report reviews the results submitted by 26 participating laboratories for 49 different radionuclide-media combinations. The participants reported 419 results, and of these 350 or 84% were within control limits.

For results that are outside the control limits as indicated in Table 3 of the report, participants should review their results for possible procedural, calibration or reporting errors. It is not possible to make definite conclusions about sources of analytical problems from this one set of data; however, there were some areas where there were differences between the participants and the known value. These were in the areas of ^{239}Pu in air filters and water, ^{40}K in soil and total uranium in vegetation. There were also excessive numbers of outliers for the ^{239}Pu in soil analysis. These situations will be reviewed further in subsequent reports.

TABLE OF CONTENTS

	<u>Page</u>
SUMMARY	iii
1.0 INTRODUCTION	1
2.0 PROCEDURES	3
2.1 PERFORMING CRITERIA	3
2.2 CROSS-CHECK SAMPLES	3
2.3 STATISTICAL ANALYSIS	3
3.0 EVALUATION	5
3.1 GENERAL	5
3.2 GAMMA EMITTERS - AIR AND WATER	5
3.3 GENERAL PROBLEM AREAS	6
4.0 CONCLUSION	9
APPENDIX	A.1

TABLES

	<u>Page</u>
1 Coefficients of Variation and Control Limits Used for Data Evaluation	11
2 Laboratory Identification	13
3 QAP Data Evaluation Report - Summary	15
4 QAP Data Evaluation Report - Laboratory Performance Summary	17
5 Summary of Analysis of Gamma Emitters in Air Filters and Water Samples	21

1.0 INTRODUCTION

The purpose of this report is to evaluate the results of radiochemical analysis performed on the Quality Assessment Program (QAP) test samples. This covers the results of the samples that were submitted to the participants in November 1983. The complete listing of results from all participants is reported in EML-426, "Semi-Annual Report of the Department of Energy, Operational Safety, Health and Environment Division - Quality Assessment Program," March 1, 1984.

The DOE Environmental Measurements Laboratory (EML) conducts the Quality Assessment Program. They prepare, thoroughly characterize and distribute test samples to the participants and report the analytical results. This program has been in existence since 1976. To increase the utilization of the information obtained from this program to upgrade the analytical capabilities of the participating laboratories, the Office of Operational Safety requested PNL to prepare an evaluation of the QAP data. It is intended that this report be a concise summary of the results that clearly indicates which analyses are outside control limits and need follow-up to determine reasons and take corrective action.

2.0 PROCEDURES

2.1 PERFORMANCE CRITERIA

Before the results of the current QAP study were analyzed, performance criteria in terms of control limits for each type of analysis were developed. Data from previous QAP studies were analyzed using descriptive statistical methods to determine the interlaboratory precision that had been demonstrated. Precision values and control limits from similar programs were also reviewed. A letter report was prepared and distributed to the QA Steering Committee and the DOE Operations Offices that described the rationale, procedures and recommended control limits. These recommended control limits were used for this report and are listed in Table 1.

2.2 CROSS-CHECK SAMPLES

The EML prepares and distributes real or synthetic environmental samples that are thoroughly analyzed by replicate analysis. These are not standards or standard reference materials, but are carefully homogenized samples for testing the precision and accuracy of the participating laboratories. The EML results are considered the "best estimate" of the radionuclide concentration of the samples and is used as the known value in this report.

2.3 STATISTICAL ANALYSIS

EML included in their report all data from the participants that had been received by February 8, 1984. The data were provided to PNL on tape for entry into the computer. Evaluation of the data consisted of two steps: 1) comparing all results to the control limits and 2) descriptive statistics on all results. Control limits were established for each analysis by using the coefficient of variation in Table 2 and multiplying these by the EML known values to obtain the allowable standard deviation (σ_0'). The control limits were calculated by using $3\sigma_0'$ for single analyses, $3\sigma_0'/\sqrt{2}$ for the mean of duplicates, and $3\sigma_0'/\sqrt{3}$ for the mean of triplicate analysis.

The results were evaluated to determine if they were within the known value plus or minus the control limits. The summaries of these evaluations are given in Tables 3 and 4.

All results were analyzed on the MINITAB statistical analysis program which produced box plots and normal probability plots for each type of analysis. The statistical parameters calculated included the mean, median, standard deviation, standard error of the mean, and maximum and minimum values. The plots displayed the properties of the data for observation of clusters and outliers. The probability plots provided information on the distribution of the data. Log normal plots were not used even though some plots suggested the data from the sample may be log-normally distributed. To keep the size of the report down, it was decided not to include all of the plots in this report, but to select one type of analysis to review in more detail and include plots for this group. For this report the group selected was the gamma emitters for air and water samples. These are included in the Appendix. Other groups will be included in subsequent reports.

3.0 EVALUATION

3.1 GENERAL

There were 26 laboratories that submitted data on the current set of QAP samples. These laboratories with their identification codes are listed in Table 2. A summary of the performance of laboratories submitting results on each type of analysis as compared to the control limits is given in Table 3. The laboratories reported 419 measurements of which 350 or 83.5% were within control limits. Five laboratories reported 30 or more results and two reported one result. The average was 13 results per laboratory.

Table 4 shows how each laboratory compared to the control limits on each type of analysis. Results marked with a dash (-) are within control limits, those with a dot (●) are outside control limits and those with a square (■) are extreme outliers. The extreme outliers are results that were outside limits by an order of magnitude or more. These may be due to a calculation or reporting error. In some cases it was obvious that these were due to reporting in the wrong units.

Laboratories that have results outside the 3-sigma control limits should review their procedures and calculations on those analyses to determine the source of the problem.

3.2 GAMMA EMITTERS - AIR AND WATER

There were 164 reported results from the analysis of eight gamma emitters in the air filter and water samples. There were 11 results outside the 3-sigma control limits with 4 of these being obvious errors in reporting data. The performance was similar for all eight samples with the data having a good fit to a normal distribution. The box plots, statistical parameters and normal probability plots for the gamma emitters in air and water are included in the Appendix. Laboratories that have results that are consistently above or below the known values, even if they are within control limits, should check their calibrations for a possible bias.

Results that deviated from the normal distribution as seen on the probability plots in the Appendix should also be checked.

The coefficient of variation (CV) was calculated for the gamma emitters using all data points and eliminating the extreme outliers. Using all data the CV was 12.4% and with 8 outliers eliminated, the average CV was 8.0%. This indicates that the 10% used as a coefficient of variation for calculating control limits is an adequate representation of the data being analyzed.

In all cases the mean of the participants was higher than the known value. The mean deviation for all gamma analyses was +2.4%. This could be due to difference in calibration standards between EML and the participants or the mean could be influenced high by a few laboratories that were biased high. This situation will be reviewed in the next study to see if the same trend exists.

3.3 GENERAL PROBLEM AREAS

There were three areas where the results reported by the participants were markedly different from the known value. The first of these was for ^{239}Pu in air filters and water. The number of results outside the control limits was not unusual; however, all but one of the 34 reported results were below the known value. This could be an anomaly, but it appears there is a real difference. This could be due to changes in the sample conditions during transit, calibration differences or analytical differences. Loss of sample to the wall of the container is a possibility for the water sample, but not the air filters. A bias was not observed in the plutonium results for soil, tissue and vegetation; however, there was a large proportion of outliers for ^{239}Pu in soil. Subsequent results will be reviewed to see if this trend continues.

The second area was that the ^{40}K values in soil and vegetation showed the known value to be higher than the participants in all but 1 of 27 results. The results were normally distributed. Further review of other QAP is needed to determine if there is a calibration difference between EML and the participants.

The third area where the known was markedly different from the participants was total uranium in vegetation in micrograms (UUG). The reported errors for the participants were high, but the results were normally distributed except for the EML result. There were only six participants reporting this analysis. Because of the small number of observations, no speculation as to the reason for this discrepancy is proposed.

For these three groups of data where the participants differed from the known, it is suggested that the participants and EML review their results for possible bias.

4.0 CONCLUSION

This is the first summary and evaluation of this type prepared on the QAP data. Most of the analyses were within the expected limits, except for the cases noted. The overall results of the analysis of gamma emitters in air and water showed good agreement with the known values. All values which are outside the control limits, as shown in Table 4, should be reviewed for possible procedural, calibration or reporting errors. The results of the data analysis did not suggest the need to make any changes in the control limits at this time. As additional QAP studies are evaluated, it will be possible to further define problem areas by identifying trends in the data.

Those areas where there appeared to be problems will be reviewed in more detail in the next report.

TABLE 1. Coefficients of Variation and Control Limits Used for Data Evaluation

<u>Measurement</u>	Standard Values Coefficient of Variation (a)	Control Limits (b) Number of Replicates		
		<u>1</u>	<u>2</u>	<u>3</u>
Gamma Emitters	10%	±30%	±21%	±17%
Strontium	10%	±30%	±21%	±17%
Uranium - Radiochemistry	10%	±30%	±21%	±17%
Uranium - Total	15%	±45%	±32%	±26%
Plutonium	15%	±45%	±32%	±26%
Americium	15%	±45%	±32%	±26%
Tritium	10%	±30%	±21%	±17%
Radium	15%	±45%	±32%	±26%

(a) Coefficient of variation (CV) = $\frac{\sigma_0}{\bar{x}}$ (100)

(b) Control limit for mean of n replicates

$$\pm 3 \frac{CV}{\sqrt{n}}$$

Further explanation of the derivation of the coefficients of variation and control limits are presented in the letter report "Recommended Analytical Performance Criteria for QAP Sample Analysis," R. E. Jaquish and R. R. Kinnison, March 1984.

TABLE 2. Laboratory Identification

QAP Code (a)	MTB Code (b)	Laboratory
AA	1	Environmental Measurements Laboratory (Known Values)
AN	3	Argonne National Laboratory
BA	4	Bettis Atomic Power Plant
BE	5	Bendix Field Engineering Grand Junction, Co.
BN	7	Brookhaven National Laboratory - Robert Miltenburger
BP	8	Pacific Northwest Laboratory - OSB
BZ	9	Pacific NW Contractor (U.S. Testing, Richland, WA)
CS	10	Rockwell International - Criticality Safeguards
EN	11	Exxon Nuclear Idaho Company, Inc.
FN	12	Fermi National Accelerator Laboratory
GA	13	Goodyear Atomic Corporation
KA	15	Knolls Atomic Power Laboratory
LA	16	U. of California - Los Alamos Scientific Laboratory
LL	18	U. of California - Lawrence Livermore Laboratory
ML	19	Monsanto Research Corporation - Mound Facility
NL	20	Nation Lead Company of Ohio
OR	21	Oak Ridge National Laboratory
PA	22	Mason & Hanger-Siles Mason Company, Inc.
PI	23	General Electric Company - Neutron Devices
PR	25	Princeton Plasma Physics Laboratory
RE	24	Reynolds Electrical Engineering Company, Inc.
RF	26	Rockwell International - Rocky Flats
SA	28	Sandia Laboratory - Organization 3311
SR	30	Savannah River Plant
UC	31	Union Carbide Corporation - Nuclear Division
UK	32	Union Carbide Corporation - ORGUP-K-25
UY	33	Union Carbide Corporation - Y-12 Plant

(a) Code used in Quality Assessment Program Reports

(b) Numerical code used in MINITAB statistical program

TABLE 3. QAP Data Evaluation Report - Summary

26 Participating Laboratories

March 1984

<u>Media</u>	<u>Nuclide</u>	<u>EML Known Value</u>	<u>Mean of Participants (a)</u>	<u>Control Limits (b)</u>	<u>Number Outside Limits</u>	<u>Number Performing Analysis</u>
Air	BE7	0.312E+04	0.326E+04	.936E+03	1	13
	CR51	0.313E+04	0.319E+04	.939E+03	1	13
	CO60	0.343E+03	0.359E+03	.103E+03	1	14
	SR90	0.244E+01	0.288E+01	.732E+00	1	5
	CS137	0.393E+03	0.395E+03	.118E+03	2	14
	PU239	0.212E+01	0.182E+01	.054E+00	0	13
	AM241	0.169E+01	0.152E+01	0.761E+00	0	4
	U234	0.209E+01	0.235E+01	0.627E+00	0	2
	U238	0.212E+01	0.220E+01	0.636E+00	0	2
	UPCI	0.421E+01	0.421E+01	0.189E+01	1	1
	UUG	0.610E+01	0.573E+01	0.270E+01	3	8
Water	H3	0.694E+02	0.713E+02	0.208E+02	1	19
	CR51	0.423E+02	0.426E+02	0.127E+02	2	19
	MN54	0.459E+01	0.477E+01	0.138E+01	1	18
	CO60	0.447E+01	0.456E+01	0.134E+01	1	19
	SR90	0.220E+00	0.243E+00	0.660E-01	3	8
	CS137	0.546E+01	0.552E+01	0.164E+01	2	19
	PU239	0.150E-01	0.118E-01	0.675E-03	2	15
	AM241	0.260E-01	0.242E-01	0.117E-01	1	6
	U234	0.610E-02	0.660E-02	0.183E-02	0	4
	U238	0.600E-02	.590E-02	0.180E-02	0	4
	UPCI	0.121E-01	0.190E-01	0.545E-02	1	1
	UUG	0.175E-01	0.197E-01	0.787E-02	2	9
Soil	K40	0.126E+02	0.946E+01	0.378E+01	6	14
	SR90	0.258E+01	0.246E+01	0.774E+00	1	8
	CS137	0.100E+01	0.126E+01	0.300E+00	3	19
	RA226	0.660E+00	0.853E+00	0.297E+00	1	7
	PU238	0.400E-01	0.420E-01	0.180E-01	3	12
	PU239	0.110E-01	0.173E-01	0.495E-02	6	14
	AM241	0.600E-02	0.720E-02	0.270E-02	2	4
	U234	0.740E+00	0.735E+00	0.222E+00	1	4
	U238	0.810E+00	0.667E+00	0.243E+00	0	3

TABLE 3. QAP Data Evaluation Report - Summary (Continued)

<u>Media</u>	<u>Nuclide</u>	<u>EML Known Value</u>	<u>Mean of Participants^(a)</u>	<u>Control Limits^(b)</u>	<u>Number Outside Limits</u>	<u>Number Performing Analysis</u>
Soil	UUG	0.225E+01	0.184E+01	0.101E+01	3	9
Tissue	SR90	0.444E+01	0.558E+01	0.133E+01	0	4
	CS137	0.178E+01	0.191E+01	0.534E+00	3	12
	PU238	0.740E-01	0.740E-01	0.333E-01	0	9
	PU239	0.190E-01	0.238E-01	0.855E-02	2	10
	AM241	0.140E-01	0.198E-01	0.630E-02	1	4
Vegetn	K40	0.139E+02	0.760E+01	0.417E+01	6	9
	SR90	0.356E+01	0.358E+01	0.107E+01	0	5
	CS137	0.138E+01	0.146E+01	0.414E+00	3	12
	RA226	0.110E-01	-	0.495E-02	3	3
	PU238	0.650E-01	0.600E-01	0.293E-01	0	10
	PU239	0.160E-01	0.178E-01	0.720E-02	2	10
	AM241	0.113E-01	0.143E-01	0.508E-02	1	3
	U234	0.140E-01	0.700E-02	0.420E-02	2	2
	U238	0.130E-01	0.100E-01	0.390E-02	0	2
	UPCI	0.270E-01	-	0.122E-01	1	1
	UUG	0.390E-01	0.191E-01	0.176E-01	4	6

(a) All values included except extreme outliers.

(b) Control limits for single analysis. For replicate analysis limits, see Table 1.

TABLE 4. QAP Data Evaluation Report - Laboratory Performance Summary

	LABORATORIES																									
NUCLIDES	AN	BA	BE	BN	BP	BZ	CS	EN	FN	GA	KA	LA	LL	ML	NL	OR	PA	PI	PR	RE	RE	SA	SB	UC	UK	UY
Air																										
BE7	-		-			-	•	-	-	-			-			-				-		-	-	-		
CR51	-		-			-	•	-	-	-			-			-						-	-	-		-
CO60	-		•			-	-	-	-	-			-			-				-		-	-	-		-
SR90	-	-				-		•												-						
CS137	-		•			-	•	-	-	-			-			-				-		-				
PIU239	-		-			-	-	-		-		-	-	-			-	-		-				-	-	
AM241	-		-									-								-						
U234	-							-																		
U238	-							-																		
UPCI																	•									
UUG			•			-				-					-		•			-					•	-
Water																										
H3	-	-	-	-	-	-		-			-	■	-	-		-	-	-	-	-		-	-			-
CR51	-	-	-	-		-	-	-	-	-	-	■	-			-	-			-	•	-	-	-		-
MN54	-	-	-	-		-	-	-	-	-	-	■	-			-	-			-	-		-	-		-
CO60	-	-	-	-		-	-	-	-	-	-	■	-			-	-			-	-	-	-	-		-
SR90	-	•				•		-			-	■				-	-			-		-	-	-		-
CS137	-	-	-	-		-	-	-	-	-	-	■	-			-	-			-	•	-	-	-		-
PU239	-		•			-		-		-		■	-	-		-	-	-		-	-			-	-	
AM241	-		-									■				-	-			-	-					
U234	-	-						-						-												
U238	-	-						-						-												
UPCI																	-									
UUG			-			-				-		■			-					-				-	■	-

TABLE 4. QAP Data Evaluation Report - Laboratory Performance Summary (Continued)

LABORATORIES																										
NUCLIDES	AN	BA	BE	BN	BP	BZ	CS	EN	FN	GA	KA	LA	LL	ML	NL	OR	PA	PI	PR	RE	RE	SA	SB	UC	UK	UY
<u>Soil</u>																										
K40	-	-		●		-	-			-	-	●	-			-				●		-		-		●
SR90	-	-				●		-			-	-				-							●			
CS137	-	-	-	-		-	●	-	-	-	-	●	-			-				-	●	-	-	-		-
RA226	-		-	-						-			-			-				●						
PU238			●			-		-		-		-	-	-		-		-		●	●				-	
PU239			●			-		-		●		●	-	-		-	●	-		●	●			-	-	
AM241			-													-				■	■					
U234								●						-							-					
U238								-						-							-					
UUG			-							-		-	●		-		-			●				-		●
<u>Tissue</u>																										
SR90		-				●										-				-						
CS137	●	-		-		-	-	-		-		-				■				●	-		-			
PU238	-					-		-		-		-		-		-				-	-					
PU239	-					-		-		●		-		-		-	●			-	-					
AM241												●				-				-	-					
<u>Vegetation</u>																										
K40	●	-		●		-	●			●		●				-				●						
SR90		-				-		-								-				-						
CS137	●	-		-		-	-	-		-		-				-				●	●		-			
RA226	■			LT																		LT				
PU238	-		-			-		-		-		-		-		-				-	-					
PU239	-		-			-		-		●		-		-		-	●			-	-					

TABLE 4. QAP Data Evaluation Report - Laboratory Performance Summary (Continued)

NUCLIDES	LABORATORIES																							
	AN	BA	BE	BN	BP	BZ	CS	EN	FN	GA	KA	LA	LL	ML	NL	OR	PA	PI	PR	RE	RF	SA	SB	UC
AM241												●				-				-	LT			
U234								-						-										
U238								-						-										
UPCI																	●							
UUG			-			●				●		●					-			●				
Measurements Within Limits	27	15	19	9	1	26	8	30	9	22	9	10	16	15	3	29	6	5	1	26	13	10	11	14
Total Measurements	31	16	24	11	1	30	13	32	9	26	9	27	17	15	3	30	12	5	1	34	19	10	12	14

- Analysis within control limits

● Analysis outside control limits

■ Extreme outliers

LT Results reported as "less than"

A blank indicates that no analysis was performed.

**TABLE 5. Summary of Analysis of Gamma Emitters
in Air Filters and Water Samples**

<u>Media</u>	<u>Nuclide</u>	<u>Number Analyzing</u>	<u>Known</u>	<u>Mean^(a)</u>	<u>Variation %</u>	<u>Std Dev^(a)</u>
Air	BE7	13	3120	3258	+4.4	448
	CR51	13	3130	3190	+1.9	473
	CO60	14	343	359	+4.7	47
	CS137	14	393	395	+0.5	49
Water	CR51	19	42.3	42.6	+0.7	6.5
	MN54	18	4.59	4.77	+3.9	0.43
	CO60	19	4.47	4.56	+2.0	0.39
	CS137	19	5.46	5.52	+1.1	0.68

(a) All data included except extreme outliers.

APPENDIX

BOX PLOTS, NORMAL PROBABILITY PLOTS AND STATISTICAL PARAMETERS FOR GAMMA EMITTERS IN AIR FILTERS AND WATER^(a)

(a) For plotting purposes, all LA water data corrected by a factor of 1000.

Be-7 LAB	IN AIR CONC	DATA LAB	CONC	DESCRIPTIVE STATISTICS CONC	
AA	3120	UC	3070	N	18
AN	3480	UC	3070	MEAN	3251
BE	3830	GA	3600	MEDIAN	3210
BZ	3220	GA	3720	TMEAN	3297
EN	3200	CS	1920	STDEV	436
OR	3400	FN	3000	SEMEAN	103
OR	3400	FN	2940	MAX	3850
SA	3460	LL	3850	MIN	1920
SR	3180	RE	3060	Q3	3510
				Q1	3067

CORRELATION OF CONC AND NORM.DEV= 0.921

CR-51 IN AIR DATA				DESCRIPTIVE STATISTICS	
LAB	CONC	LAB	CONC	CONC	
AA	3130	UC	3390	N	19
AN	3790	UY	3100	MEAN	3176
BE	2850	UY	3600	MEDIAN	3220
BZ	3220	GA	3510	TMEAN	3241
EN	3300	GA	3480	STDEV	460
OR	3200	CS	1640	SEMEAN	106
OR	3200	FM	2800	MAX	3790
SA	3350	FM	2820	MIN	1640
SR	3140	LL	3520	Q3	3490
UC	3490			Q1	3100

CORRELATION OF CONC AND NORM.DEV = 0.884

CO-60 IN AIR DATA
LAB CONC LAB CONC

AA	343	UC	344
AB	369	UY	370
BE	469	UY	430
BZ	374	GA	365
EN	380	GA	360
OR	330	CS	254
OR	340	FN	331
SA	317	FN	333
SK	339	LL	375
UC	344	RE	385

DESCRIPTIVE STATISTICS
CONC

N	20
MEAN	356.6
MEDIAN	352.0
TMEAN	357.2
STDEV	46.1
SEMEAN	10.3
MAX	469.0
MIN	254.0
Q3	374.7
Q1	334.5

CORRELATION OF CONC AND STND. DEV = 0.929

CS-137 IN AIR DATA
LAB CONC LAB CONC

AA	393	UC	390
AN	402	UY	380
BE	513	UY	360
BZ	392	GA	356
EA	420	GA	356
OR	400	CS	266
UR	420	FN	366
SA	401	FN	382
SR	390	LL	471
UC	402	RE	416

DESCRIPTIVE STATISTICS
CONC

N	20
MEAN	394.5
MEDIAN	395.5
TMEAN	395.1
STDEV	47.9
SEMEAN	10.7
MAX	513.0
MIN	266.0
Q3	414.0
Q1	371.0

CORRELATION OF CONC AND NORM.DEV= 0.929

CR-51 IN WATER DATA

LAB	CONC	LAB	CONC
AA	42.3	SA	46.1
AN	44.0	SK	35.2
PA	41.9	UC	41.6
BE	46.0	UY	47.0
BZ	45.2	GA	49.5
EN	43.0	BN	43.6
LA	46.7	CS	43.2
LA	48.1	FN	52.0
LA	41.0	KA	43.4
OR	41.0	LL	44.6
RF	22.0	RE	36.5

DESCRIPTIVE STATISTICS

	CONC
N	22
MEAN	42.92
MEDIAN	43.50
TMEAN	43.51
STDEV	6.02
SEMEAN	1.28
MAX	52.00
MIN	22.00
Q3	46.25
Q1	41.00

CORRELATION OF CONC AND NORM.DEV= 0.895

MM-54 IN WATER DATA
LAB CONC LAB CONC

AA	4.59	SR	4.15
AN	4.43	UC	5.75
BA	4.74	UY	5.20
BE	5.00	GA	4.70
BZ	4.79	BN	4.60
EN	4.50	CS	4.71
LA	4.92	FN	4.77
LA	4.97	KA	4.60
LA	4.63	LL	4.70
UH	4.20	RE	4.42
RF	5.00		

DESCRIPTIVE STATISTICS
CONC

N	21
MEAN	4.710
MEDIAN	4.710
TMEAN	4.751
STDEV	0.391
SEMEAN	0.085
MAX	5.750
MIN	4.150
Q3	4.945
Q1	4.545

CORRELATION OF CONC AND NORM.DEV= 0.954

CO-60 IN WATER DATA			
LAB	CONC	LAB	CONC
AA	4.47	SA	4.70
AN	4.60	SR	4.25
BA	4.39	UC	4.42
BE	5.00	UY	4.90
BZ	4.55	GA	4.50
EN	4.40	BN	4.56
LA	4.63	CS	4.50
LA	4.48	FN	4.48
LA	4.38	KA	4.32
OR	4.00	LL	4.48
RF	5.00	RE	4.22

DESCRIPTIVE STATISTICS	
	CONC
N	22
MEAN	4.545
MEDIAN	4.480
TMEAN	4.510
STDEV	0.352
SEMEAN	0.075
MAX	5.000
MIN	4.000
Q3	4.608
Q1	4.367

CORRELATION OF CONC AND NORM.DEV = 0.873

CS-137 IN WATER DATA

LAB	CONC	LAB	CONC
AA	5.46	SA	5.40
AM	5.40	SR	4.95
BA	5.97	UC	6.76
OE	6.50	UY	6.00
BZ	5.64	GA	5.25
EN	5.40	BN	5.51
LA	5.97	CS	5.66
LA	5.94	FN	5.55
LA	5.64	KA	5.74
OR	5.00	LL	5.71
RF	3.50	RE	5.37

DESCRIPTIVE STATISTICS
CONC

N	22
MEAN	5.562
MEDIAN	5.595
TMEAN	5.604
STDEV	0.630
SEMEAN	0.134
MAX	6.780
MIN	3.500
Q3	5.970
Q1	5.392

CORRELATION OF CONC AND NORM.DEV= 0.918

LAR

CONCENTRATION OF CS-137 IN WATER

DISTRIBUTION

No. of
Copies

No. of
Copies

OFFSITEOFFSITE

5 S. P. Mathur
Office of Operational Safety
Public Safety Division
Mail Stop J-125/PE-243
U.S. Department of Energy
Washington, D.C. 20545

M. V. Sastry
Office of Operational Safety
Mail Stop G-150/PE-21.1
U.S. Department of Energy
Washington, D.C. 20545

C. Sanderson
U.S. Department of Energy
Environmental Measurements Lab
376 Hudson Street
New York, NY 10014

W. E. Keheley
U.S. Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, CA 94612

Mr. D. Mercer
U.S. Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87115

Jerry J. Nelsen
U.S. Department of Energy
Environmental Protection Group
9800 South Cass Avenue
Argonne, IL 60439

Jeffrey M. Steele
Office of Naval Reactors
Mail Stop NE-60
Washington, D.C. 20585

Stanley S. Stief
U.S. Department of Energy
Environmental Protection Branch
P.O. Box E
Oak Ridge, TN 37830

M. Marcy Williamson
U.S. Department of Energy
Radiological and Environmental
Sciences Laboratory
550 Second Street
Idaho Falls, ID 83401

S. R. Wright
U.S. Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, SC 29801

27 DOE Technical Information Center

ONSITE

2 DOE Richland Operations Office

D. R. Elle
H. E. Ransom/P. K. Clark

51 Pacific Northwest Laboratory

J. B. Brown
R. E. Jaquish (38)
W. E. Kennedy, Jr.
R. R. Kinnison
L. J. Kirby
K. R. Price
R. G. Schreckhise
Publishing Coordination (2)
Technical Information (5)