

RADIATION PROTECTION OFFICE
NORTH CAROLINA STATE UNIVERSITY

ENVIRONMENTAL RADIATION SURVEILLANCE REPORT
FOR THE PERIOD
JULY 1, 1992 - JUNE 30, 1993

RALTON J. HARRIS
ENVIRONMENTAL HEALTH PHYSICIST

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1. INTRODUCTION

The Environmental Radiation Surveillance Program exists to provide routine measurements of the university environment surrounding the PULSTAR Reactor. The specific objectives of this program include:

- 1) Providing information that assesses the adequacy of the protection of the university community and the public-at-large;
- 2) Meeting requirements of regulatory agencies;
- 3) Verifying radionuclide containment in the reactor facility;
- 4) Meeting legal liability obligations; and
- 5) Providing public assurance and acceptance.

2. AIR MONITORING (TABLES 2.1, 2.2, AND 2.3; FIGURES 2a THRU 2e)

Figures 2a thru 2e show bar graphs of gross beta activity (fCi/cubic meter vs. week number). The highest gross beta activity observed was 23.6 fCi m^{-3} and the yearly campus average was 14.8 fCi m^{-3} . Missing data for the Clark station (week #51 - 06/15/93 to 06/22/93) is due to an electric motor malfunction. Missing data for the Riddick station (weeks #7 & 8 - 08/11/92 to 08/25/92) is due to two separate electric power outages. Missing data for the Withers station (week #17 - 10/21/92 to 10/27/92) is due to roofing work which prevented access to the sampling station.

Table 2. 2. lists LLD values for several gamma emitters which would be indicative of fission product activity. LLD values, for the period 03/03/93 to 06/29/93, are increased by a factor of approximately 2 to 3 for the radionuclides in Table 2.2. This is due to a planned reduction in the sampling rate in an attempt to minimize the chances of pump malfunctions. These increased LLD values are far below any action level. No gamma activity due to any of these radionuclides was detected.

TABLE 2.1 LOCATION OF AIR MONITORING STATIONS

<u>SITE</u>	<u>DIRECTION</u> ¹	<u>DISTANCE</u> ² (meters)	<u>ELEVATION</u> ³ (meters)
BROUGHTON	SOUTHWEST	125	-17
DAVID CLARK LABS	WEST	500	-18
LIBRARY	NORTHWEST	192	+11
RIDDICK	SOUTHEAST	99	-14
WITHERS	NORTHEAST	82	-6

¹DIRECTION-DIRECTION FROM REACTOR STACK

²DISTANCE-DISTANCE FROM REACTOR STACK

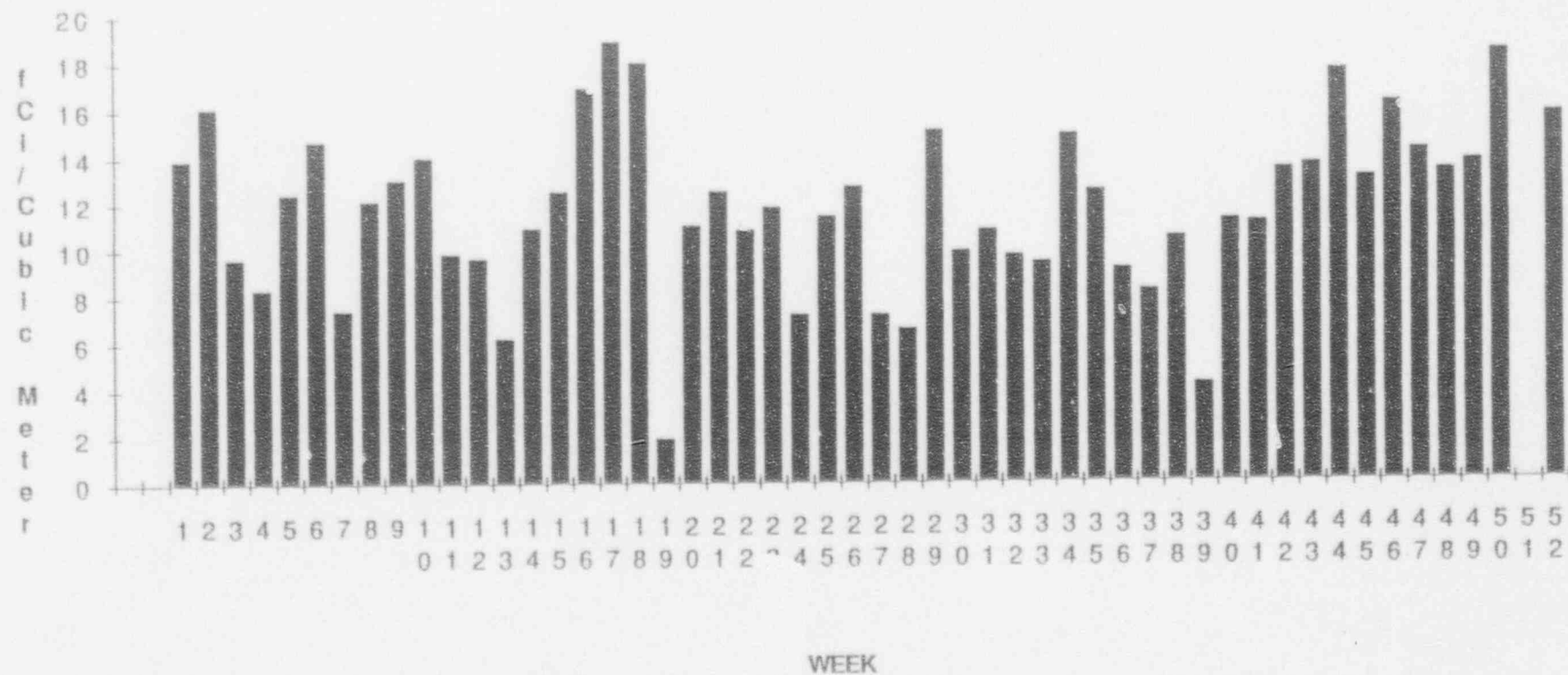
³ELEVATION-ELEVATION RELATIVE TO THE TOP OF THE REACTOR STACK

FIGURE 2a

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fci/CUBIC M
ALERT LEVEL=500 fci/CUBIC M
LLD=1 fci/CUBIC M

CLARK

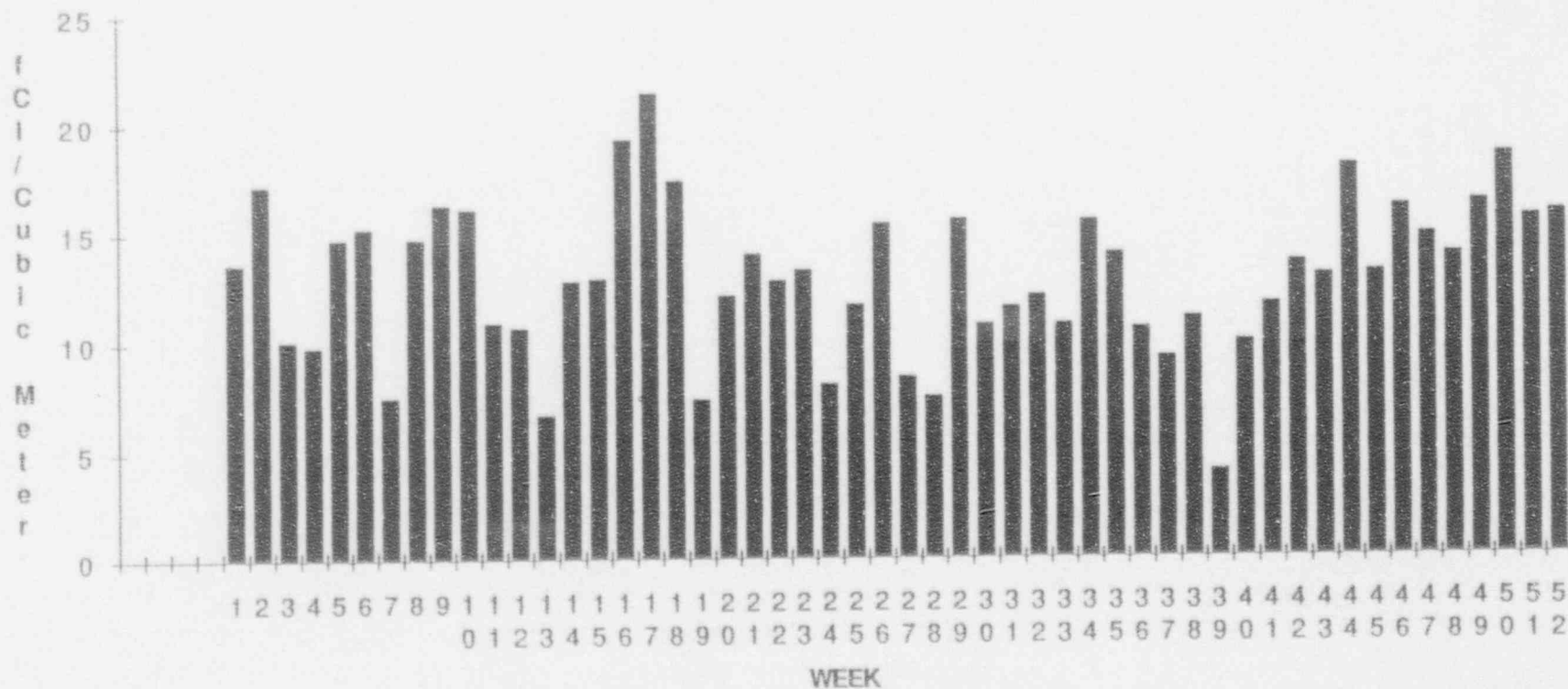


WEEK NUMBER FROM JULY 01, 1992 THROUGH JUNE 29, 1993
JULY 01 BEGINS AT WEEK #1

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/CUBIC M
ALERT LEVEL=500 fCi/CUBIC M
LLE~1 fCi/CUBIC M

BROUGHTON

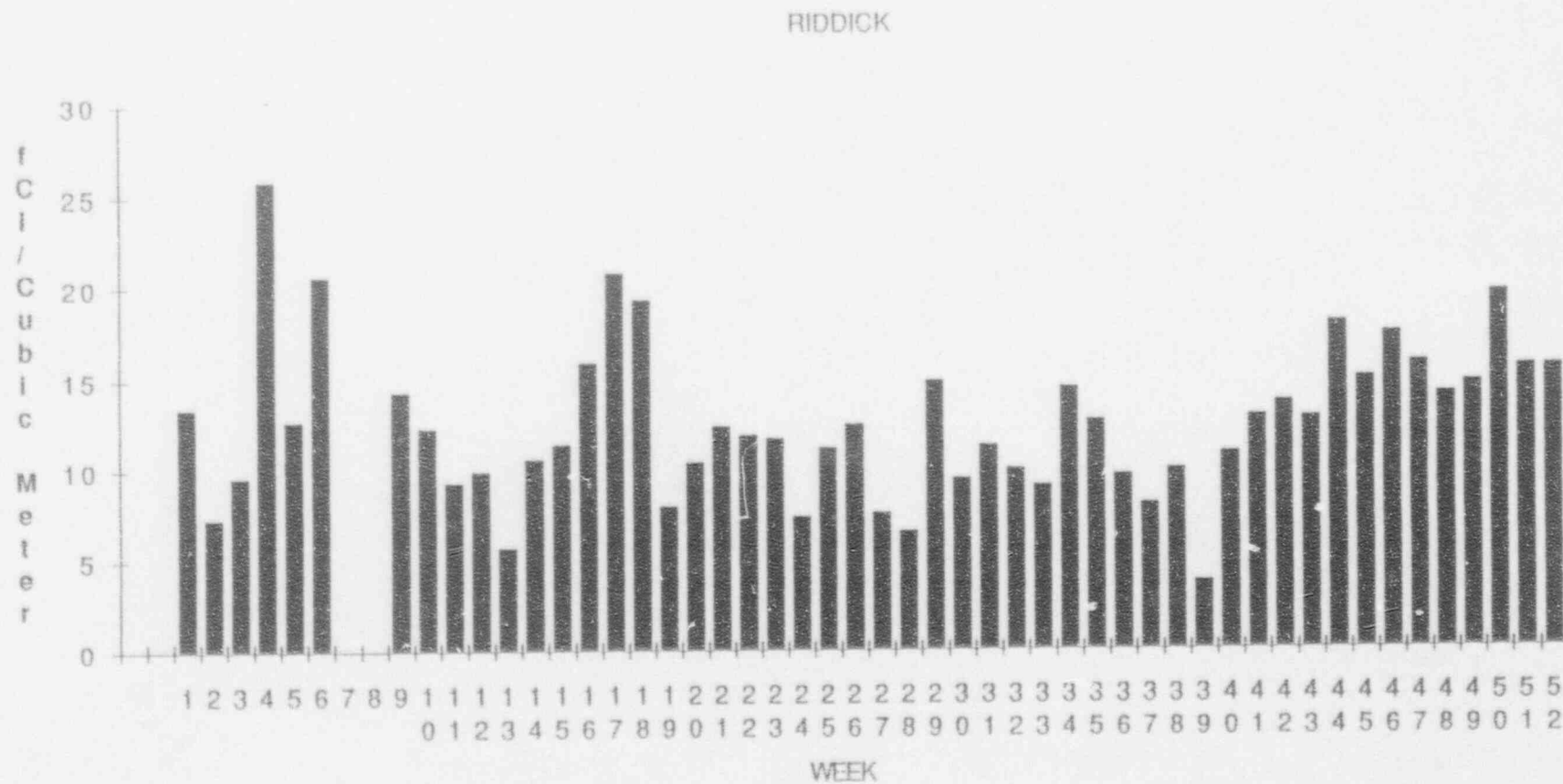


WEEK NUMBER FROM JULY 01, 1992 THROUGH JUNE 29, 1993
JULY 01 BEGINS AT WEEK #1

FIGURE 2c

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fci/CUBIC M
ALERT LEVEL=500 fci/CUBIC M
LLD~1 fci/CUBIC M



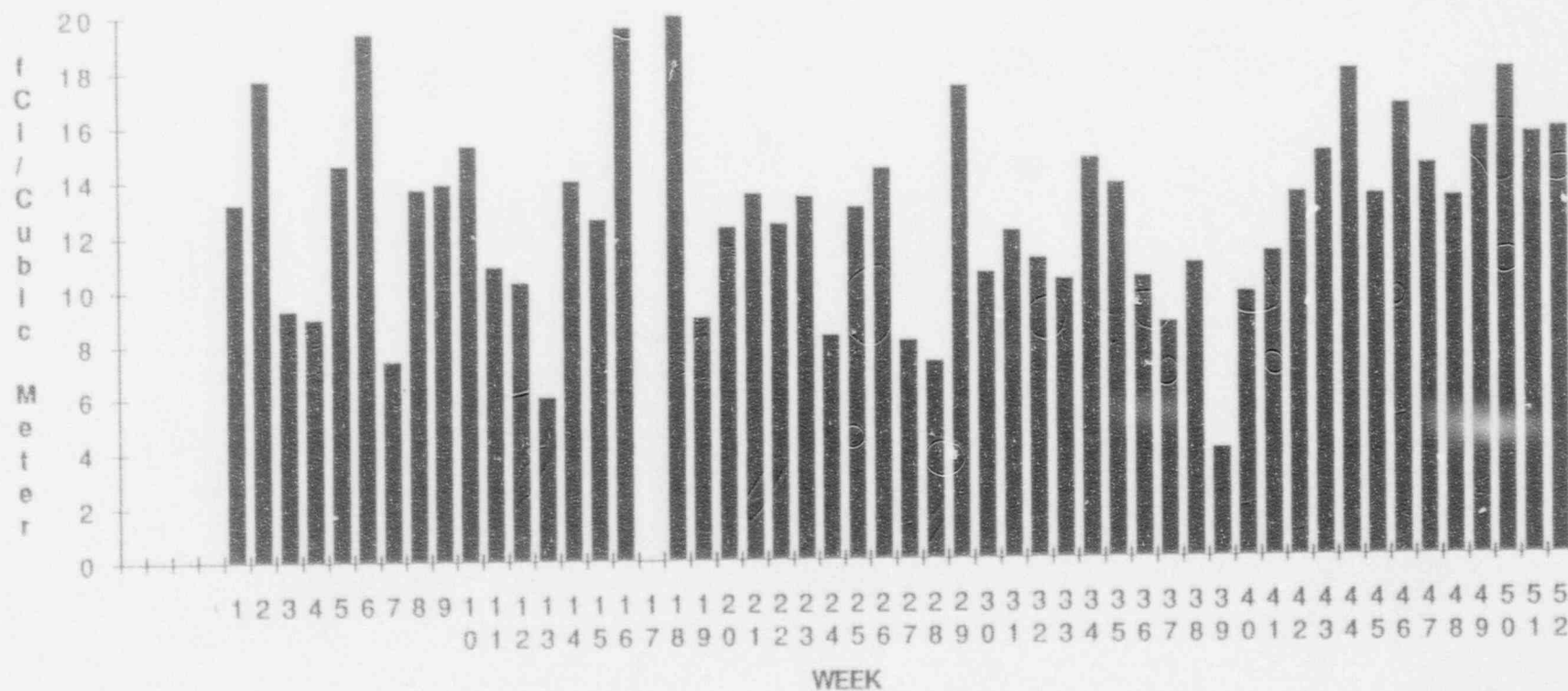
WEEK NUMBER FROM JULY 01, 1992 THROUGH JUNE 29, 1993

JULY 01 BEGINS AT WEEK #1

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/CUBIC M
ALERT LEVEL=500 fCi/CUBIC M
LLD 1 fCi/CUBIC M

WITHERS

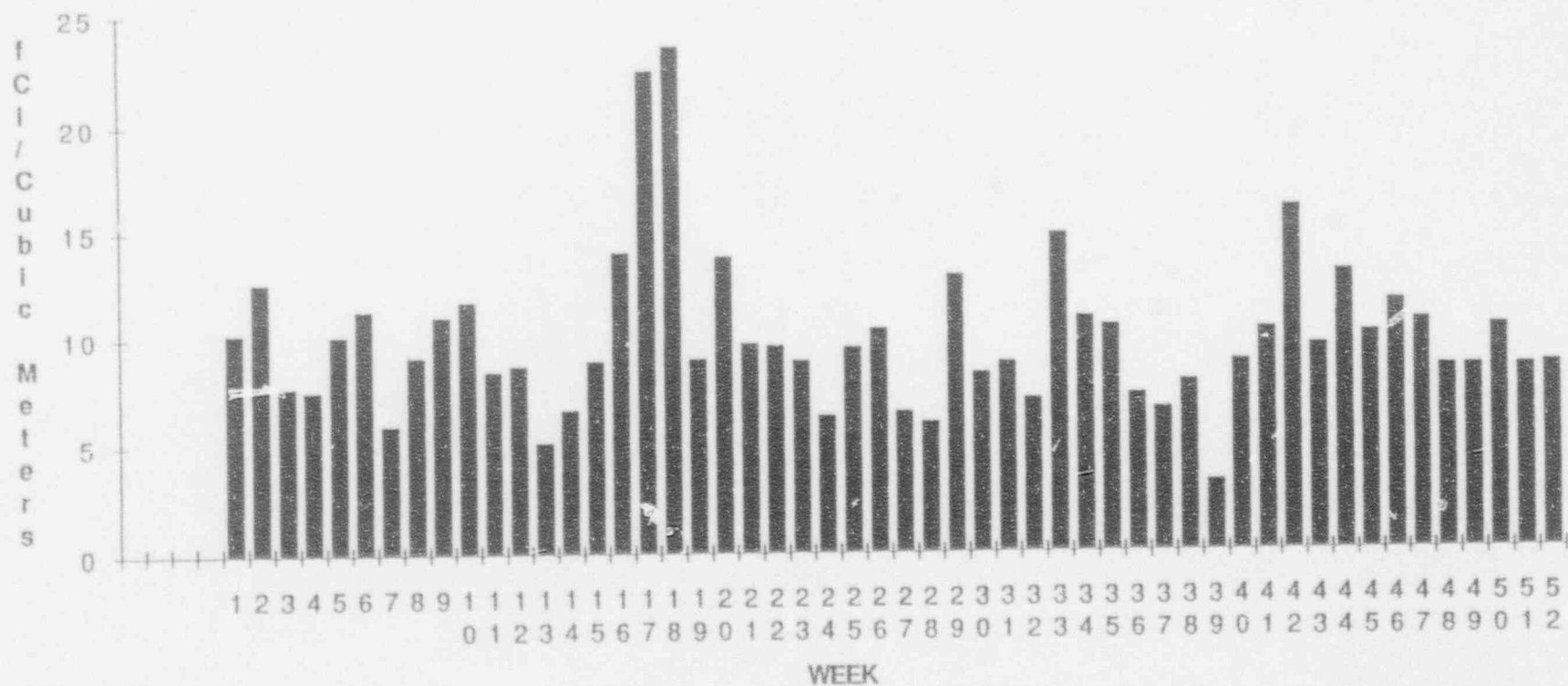


WEEK NUMBER FROM JULY 01, 1992 THROUGH JUNE 29, 1993
JULY 01 BEGINS AT WEEK #1

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/CUBIC M
ALERT LEVEL=500 fCi/CUBIC M
LLD~1 fCi/CUBIC M

D. H. HILL LIBRARY



WEEK NUMBER FROM JULY 01, 1992 THROUGH JUNE 29, 1993

JULY 01 BEGINS AT WEEK #1

TABLE 2.2

TABLE 2.2 AERIALLY TRANSPORTED GAMMA ACTIVITY										(G m E-3)		NUCLIDES							
SAMPLING PERIOD		Co-57	Co-60	Nb-95	Zr-95	Ru-103	Ru-106	Cs-137	Ce-141	Ce-144									
1992																			
07/01 - 07/07		0.08	0.15	0.14	0.25	0.15	1.00	0.11	0.2	0.61									
07/07 - 07/15		0.07	0.12	0.11	0.20	0.11	0.85	0.18	0.15	0.53									
07/15 - 07/22		0.08	0.14	0.12	0.21	0.11	0.93	0.12	0.15	0.56									
07/22 - 07/28		0.08	0.16	0.13	0.23	0.11	0.96	0.12	0.15	0.64									
07/28 - 08/04		0.07	0.13	0.10	0.19	0.10	0.91	0.10	0.14	0.57									
08/04 - 08/11		0.09	0.17	0.14	0.23	0.12	1.1	0.12	0.16	0.69									
08/11 - 08/18		0.11	0.21	0.20	0.27	0.15	1.4	0.16	0.18	0.82									
08/18 - 08/25		0.14	0.24	0.22	0.30	0.19	1.7	0.19	0.24	1.1									
08/25 - 09/01		0.09	0.16	0.21	0.21	0.12	1.1	0.12	0.17	0.70									
09/01 - 09/08		0.12	0.21	0.19	0.27	0.16	1.3	0.16	0.21	0.94									
09/08 - 09/15		0.07	0.12	0.10	0.18	0.10	0.88	0.10	0.13	0.56									
09/15 - 09/22		0.11	0.19	0.17	0.25	0.15	1.3	0.15	0.19	0.85									
09/22 - 09/29		0.09	0.16	0.15	0.21	0.13	1.1	0.13	0.17	0.72									
09/29 - 10/06		0.07	0.13	0.11	0.19	0.10	0.91	0.12	0.14	0.57									
10/06 - 10/13		0.07	0.13	0.12	0.18	0.11	0.96	0.11	0.14	0.59									
10/13 - 10/21		0.07	0.13	0.11	0.19	0.10	0.89	0.12	0.13	0.55									
10/21 - 10/27		0.12	0.23	0.22	0.34	0.20	1.7	0.21	0.24	0.96									
10/27 - 11/03		0.10	0.21	0.15	0.28	0.15	1.3	0.17	0.19	0.74									
11/03 - 11/09		0.11	0.20	0.18	0.25	0.14	1.3	0.16	0.19	0.81									
11/09 - 11/17		0.08	0.14	0.13	0.24	0.13	1.1	0.12	0.18	0.62									
11/17 - 11/24		0.09	0.16	0.14	0.22	0.12	1.2	0.15	0.15	0.65									
11/24 - 12/01		0.07	0.14	0.10	0.19	0.10	0.96	0.13	0.14	0.56									
12/01 - 12/07		0.09	0.18	0.14	0.21	0.13	1.2	0.15	0.17	0.67									
12/07 - 12/15		0.06	0.12	0.12	0.21	0.13	0.84	0.10	0.18	0.51									
12/15 - 12/21		0.09	0.16	0.15	0.28	0.16	1.1	0.14	0.21	0.66									
12/21 - 12/29		0.07	0.11	0.13	0.23	0.13	0.83	0.10	0.20	0.52									

ALL DATA IN TABLE 2.2 ARE LLD VALUES.

TABLE 2.2 1992-93

TABLE 2.2 AERIALY TRANSPORTED GAMMA ACTIVITY				(fCi m E-3)					
					NUCLIDES				
SAMPLING PERIOD	Co-57	Co-60	Nb-95	Zr-95	Ru-103	Ru-106	Cs-137	Ce-141	Ce-144
1992-93									
12/29 - 01/05	0.09	0.17	0.17	0.28	0.18	1.20	0.14	0.24	0.69
01/05 - 01/11	0.08	0.15	0.15	0.26	0.15	1.00	0.13	0.20	0.66
01/11 - 01/19	0.07	0.13	0.11	0.20	0.10	0.84	0.10	0.14	0.47
01/19 - 01/26	0.08	0.15	0.12	0.20	0.11	1.00	0.13	0.16	0.59
01/26 - 02/01	0.09	0.17	0.15	0.24	0.13	1.1	0.14	0.18	0.67
02/01 - 02/09	0.08	0.12	0.13	0.22	0.14	0.97	0.11	0.21	0.57
02/09 - 02/17	0.08	0.16	0.14	0.24	0.15	1.2	0.12	0.20	0.65
02/17 - 02/24	0.11	0.18	0.16	0.27	0.17	1.4	0.15	0.24	0.84
02/24 - 03/02	0.12	0.21	0.21	0.36	0.23	1.7	0.18	0.35	1.00
03/02 - 03/09	0.10	0.15	0.17	0.33	0.22	1.3	0.14	0.31	0.76
03/09 - 03/16	0.09	0.18	0.17	0.30	0.19	1.2	0.14	0.27	0.74
03/16 - 03/23	0.11	0.18	0.16	0.28	0.19	1.4	0.16	0.27	0.79
03/23 - 03/30	0.09	0.16	0.13	0.24	0.16	1.2	0.13	0.19	0.68
03/30 - 04/07	0.16	0.33	0.25	0.46	0.26	2.2	0.26	0.37	1.3
04/07 - 04/13	0.25	0.41	0.36	0.64	0.39	3.4	0.37	0.49	1.9
04/13 - 04/20	0.19	0.36	0.28	0.48	0.27	2.5	0.28	0.35	1.5
04/20 - 04/27	0.18	0.34	0.26	0.44	0.26	2.2	0.25	0.32	1.3
04/27 - 05/04	0.18	0.32	0.48	0.76	0.55	2.5	0.29	0.87	1.60
05/04 - 05/11	0.17	0.34	0.43	0.73	0.56	2.6	0.28	0.76	1.5
05/11 - 05/18	0.17	0.33	0.37	0.64	0.46	2.5	0.26	0.65	1.4
05/18 - 05/25	0.16	0.33	0.33	0.54	0.41	2.3	0.27	0.59	1.4
05/25 - 06/02	0.11	0.20	0.21	0.34	0.21	1.7	0.18	0.28	0.97
06/02 - 06/08	0.14	0.23	0.25	0.40	0.24	2.00	0.21	0.31	1.2
06/08 - 06/15	0.13	0.27	0.23	0.39	0.26	1.9	0.21	0.34	1.1
06/15 - 06/22	0.20	0.38	0.32	0.48	0.33	2.8	0.33	0.36	1.4
06/22 - 06/29	0.22	0.43	0.33	0.52	0.34	3.00	0.35	0.43	1.9

ALL DATA IN TABLE 2.2 ARE LLD VALUES.

TABLE 2.3 REGULATORY LIMITS, ALERT LEVELS, AND BACKGROUND LEVELS FOR
AIRBORNE RADIOACTIVITY (fCi m⁻³)

<u>NUCLIDE</u>	<u>REGULATORY LIMIT</u>	<u>ALERT LEVEL</u>	<u>AVERAGE N.C. BACKGROUND LEVEL</u>
GROSS ALPHA	20	10	4
GROSS BETA	1000	500	100
Cs-137	5 x 10 ⁵	10	2
Ce-144	2 x 10 ⁵	100	0
Ru-106	2 x 10 ⁵	30	0
I-131	1 x 10 ⁵	10	0

Reference: Environmental Radiation Surveillance Report 1986-88, State of N.C.
Radiation Protection Section

3. MILK (TABLE 3.1)

Milk samples are collected each month from the Campus Creamery, the Lake Wheeler Road Dairy and the Randleigh Dairy Farm.

The FDA's Preventive Action Guide (PAG) for I-131 is 1.5×10^4 pCi/liter for infants. All analyses during this period show activities at least three (3) orders of magnitude below the PAG.

The analyses are performed in duplicate and the higher value is reported in each case.

TABLE 3.1 I-131 IN COWS' MILK (pCi liter⁻¹ $\pm 1 \sigma$) LLD ~ 3 pCi liter⁻¹

<u>DATE</u>	<u>pCi liter⁻¹</u>		
	<u>CAMPUS CREAMERY</u>	<u>LAKE WHEELER</u>	<u>RANDLEIGH</u>
JULY 1992	≤ 2.0	≤ 2.0	≤ 2.0
AUGUST 1992	≤ 2.0	≤ 2.0	≤ 2.0
SEPTEMBER 1992	≤ 2.0	≤ 2.0	≤ 2.0
OCTOBER 1992	≤ 2.0	≤ 2.0	< 2.0
NOVEMBER 1992	≤ 2.0	≤ 2.0	≤ 2.0
DECEMBER 1992	≤ 2.0	≤ 2.0	≤ 2.0
JANUARY 1993	≤ 3.0	≤ 3.0	≤ 3.0
FEBRUARY 1993	≤ 3.0	≤ 3.0	≤ 3.0
MARCH 1993	≤ 3.0	≤ 3.0	≤ 3.0
APRIL 1993	≤ 3.0	≤ 3.0	≤ 3.0
MAY 1993	≤ 3.0	≤ 3.0	≤ 3.0
JUNE 1993	≤ 3.0	≤ 3.0	≤ 3.0

4. SURFACE WATER (TABLES 4.1 AND 4.2)

Table 4.1 gives the gross alpha and beta activities for water from Rocky Branch at points where it enters (ON) and exits (OFF) the campus. The LLD values for gross alpha and beta activities are $\sim 0.4 \text{ pCi liter}^{-1}$ and $\sim 0.4 \text{ pCi liter}^{-1}$, respectively. For gross alpha activity the Alert Level is 5 pCi liter^{-1} and the Regulatory Limit is $15 \text{ pCi liter}^{-1}$. For gross beta activity the Alert Level is $12.5 \text{ pCi liter}^{-1}$ and the Regulatory Limit is $50 \text{ pCi liter}^{-1}$. Samples with gross alpha or beta activities exceeding these Alert Levels would require gamma analysis to identify the radionuclides present. The LLD values in Table 4.2 are for the second quarter of 1993.

TABLE 4.1 GROSS ALPHA AND BETA ACTIVITY IN SURFACE WATER ($\text{pCi liter}^{-1} \pm 2 \sigma$)

*LLD $\alpha \sim 0.4 \text{ pCi liter}^{-1}$ LLD $\beta \sim 0.4 \text{ pCi liter}^{-1}$

<u>DATE</u>	<u>LOCATION</u>	<u>pCi liter⁻¹</u>	
		<u>GROSS ALPHA</u>	<u>GROSS BETA</u>
THIRD QUARTER 1992	ON	< 0.3	1.4 ± 0.3
	OFF	< 0.3	< 0.4
FOURTH QUARTER 1992	ON	< 0.3	< 0.4
	OFF	< 0.3	1.7 ± 0.4
FIRST QUARTER 1993	ON	< 0.4	1.6 ± 0.4
	OFF	< 0.4	0.44 ± 0.3
SECOND QUARTER 1993	ON	< 0.4	1.7 ± 0.4
	OFF	< 0.4	< 0.5

*LLD VALUES ARE DETERMINED QUARTERLY

TABLE 4.2 LOWER LIMITS OF DETECTION FOR SEVERAL GAMMA EMITTERS IN
SURFACE WATER FROM NCSU ERSI ANALYSIS

<u>NUCLIDE</u>	<u>LLD (pCi liter⁻¹)</u>
Co-60	0.4
Zn-65	0.7
Cs-137	0.3
Cs-134	0.4
Sr-85	0.4
Ru-103	0.3
Ru-106	3.0
Nb-95	0.4
Zr-95	0.5

*LLD VALUES ARE FOR THE 2ND QUARTER OF 1993

5. VEGETATION (TABLE 5.1 and 5.2)

Table 5.1 gives gross beta activities for grass samples collected on the NCSU Campus. The reported activities are all below the Alert Level of 20 pCi gram⁻¹. Table 5.2 lists LLD values for several gamma emitters. No gamma activity due to any of these radionuclides has been observed in campus vegetation. The beta and gamma activities are reported as pCi per gram of green vegetation.

TABLE 5.1 GROSS BETA ACTIVITY IN CAMPUS VEGETATION *LLD ~ 0.5 pCi g⁻¹

<u>SAMPLE DATE</u>	<u>SAMPLE LOCATION</u>	<u>(pCi g⁻¹ ± 2σ)</u>
DECEMBER 1992	NORTH CAMPUS	2.4 ± 0.1
DECEMBER 1992	SOUTH CAMPUS	4.0 ± 0.2
DECEMBER 1992	EAST CAMPUS	2.8 ± 0.1
DECEMBER 1992	WEST CAMPUS	2.4 ± 0.1
APRIL 1993	NORTH CAMPUS	2.4 ± 0.1
APRIL 1993	SOUTH CAMPUS	3.8 ± 0.2
APRIL 1993	EAST CAMPUS	2.3 ± 0.1
APRIL 1993	WEST CAMPUS	2.3 ± 0.1

*LLD values are determined semiannually

Table 5.2

LLD VALUES FOR GAMMA EMITTERS IN VEGETATION

<u>NUCLIDE</u>	<u>LLD (pCi gram⁻¹)*</u>
Co-60	0.01
Zn-65	0.02
Cs-137	0.01
Cs-134	0.01
Sr-85	0.01
Ru-103	0.01
Nb-95	0.01
Zr-95	0.02

*LLD VALUES ARE FOR THE 2ND QUARTER OF 1993

6. THERMOLUMINESCENT DOSIMETERS (TLDs) (TABLE 6.1)

TLD analysis is contracted to Teledyne Isotopes for determination of ambient gamma exposures. The dosimeters are CaSO_4 doped with dysprosium and have a manufacturer-stated sensitivity of 0.5 ± 0.15 mR (90% C.L.). Exposures are integrated over a three-month period at each of the five air monitor stations listed in Table 2.1 and also at the top of the PULSTAR Reactor stack. A control station is located in 214 David Clark Laboratories. Table 6.1 gives the data for these seven (7) sampling locations. Data for the period 07/13/92 to 09/30/92 was lost by the contractor and is not available.

The observed exposures are those expected to be produced by background radiations in this area of North Carolina. The data of Table 6.1 agrees well with the state-wide average exposure rate of ~ 18 - 20 mR per quarter year.

TABLE 6.1 ENVIR. TLD EXP.

TABLE 6.1 ENVIRONMENTAL TLD EXPOSURES (mR/QUARTER YEAR $\pm 2\sigma$)							
DATE	WITHERS	RIDDICK	BROUGHTON	LIBRARY	DAVID CLARK	PULSTAR STACK	CONTROL
* 04/07/92 - 07/13/92	16.8 \pm 2.3	22.6 \pm 2.2	17.0 \pm 1.8	20.8 \pm 2.1	13.5 \pm 1.2	12.3 \pm 3.2	15.8 \pm 2.2
** 07/13/92 - 09/30/92			CONTRACTOR LOST DATA				
09/30/92 - 12/30/92	4.5 \pm 1.0	24.7 \pm 5.0	17.1 \pm 1.8	19.1 \pm 3.3	13.6 \pm 0.8	11.6 \pm 0.9	15.0 \pm 1.6
***12/30/92 - 04/08/93	4.7 \pm 0.4	7.0 \pm 0.6	4.8 \pm 0.6	5.6 \pm 0.3	4.1 \pm 0.7	3.6 \pm 0.3	4.7 \pm 0.2
04/07/93 - 06/27/93			DATA NOT YET AVAILABLE FOR THESE DATES				
* THIS DATA WAS UNAVAILABLE FOR INCLUSION IN THE 1991-92 REPORT.							
** THIS DATA WAS LOST BY THE CONTRACTOR							
***THE DATA FOR THE PERIOD 12/30/92 TO 04/08/93 WAS REPORTED BY THE CONTRACTOR IN UNITS OF mR/MONTH.							

7. QUALITY CONTROL INTERCOMPARISON PROGRAM

The Environmental Radiation Surveillance Laboratory of the Radiation Protection Office has participated in the U. S. EPA Environmental Laboratory Intercomparison Studies Program during this reporting period. The objective of this program is to provide laboratories performing environmental radiation measurements with unknowns to test their analytical techniques. The results of the intercomparison studies are given in Table 7.1 a-g. All samples are analyzed in triplicate and reported as an average value with an experimental sigma (1s).

Appendix 1 gives an explanation of the quantities listed in the tables and an example calculation.

TABLE 7.1a GROSS ALPHA ACTIVITY AIR FILTER - INTERCOMPARISON STUDY
- 28 AUGUST 1992

The known value for gross alpha activity is 30.0 pCi/filter with an expected laboratory precision of 8.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

ALPHA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)	
QA	29.0	28.0	29.0	0.58	0.074	28.67	-0.48	-0.29

STATISTICAL SUMMARY OF 189 PARTICIPANTS

Statistic	Respondents	Non-outliers
Mean	31.25	Grand Avg 30.87
Std. Dev.	6.10	5.27
Variance	37.20	27.77
% Coef. of Var.	19.52	17.07
% deviation of mean from known value	4.17	2.92
Norm. dev. of mean from known value	0.21	0.17
Median	30.00	30.00
% deviation of median from known value	0.00	0.00
Norm. dev. of median from known value	0.00	0.00

TABLE 7.1b GROSS BETA ACTIVITY AIR FILTER - INTERCOMPARISON STUDY -
28 AUGUST 1992

The known value for gross beta activity is 69.0 pCi/filter with an expected laboratory precision of 10.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

BETA

				Exper.	Rng anal		Normalized deviation	
<u>Lab</u>	<u>Res. 1</u>	<u>Res. 2</u>	<u>Res. 3</u>	<u>Sigma</u>	<u>(R + SR)</u>	<u>Average</u>	<u>(grand-avg)(known)</u>	
CA	75.0	75.0	73.0	1.15	0.118	74.33	0.41	0.92

STATISTICAL SUMMARY OF 189 PARTICIPANTS

<u>Statistic</u>	<u>Respondents</u>	<u>Non-outliers</u>
Mean	72.79	Grand Avg 71.98
Std. Dev.	11.62	6.43
Variance	134.92	41.38
% Coef. of Var.	15.96	8.94
% deviation of mean from known value	5.49	4.32
Norm. dev. of mean from known value	0.33	0.46
Median	72.00	71.83
% deviation of median from known value	4.35	4.11
Norm. dev. of median from known value	0.25	0.44

TABLE 7.1c ¹³⁷Cs ACTIVITY AIR FILTER INTERCOMPARISON STUDY -
28 AUGUST 1992

The known value for Cesium-137 activity is 18.0 pCi/filter with an expected laboratory precision of 5.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

¹³⁷Cs

<u>Lab</u>	<u>Res. 1</u>	<u>Res. 2</u>	<u>Res. 3</u>	<u>Exper.</u> <u>Sigma</u>	<u>Rng anal</u> <u>(R + SR)</u>	<u>Average</u>	<u>Normalized deviation</u> <u>(grand-avg)/(known)</u>	
QA	17.00	17.00	17.00	0.00	0.000	17.00	-0.93	-0.35

STATISTICAL SUMMARY OF 169 PARTICIPANTS

<u>Statistic</u>	<u>Respondents</u>	<u>Non-outliers</u>
Mean	235.16	Grand Avg 19.68
Std. Dev.	1954.83	2.94
Variance	3821351.09	8.62
% Coef. of Var.	831.29	14.92
% deviation of mean from known value	1206.42	9.32
Norm. dev. of mean from known value	0.11	0.57
Median	19.67	19.67
% deviation of median from known value	9.26	9.26
Norm. dev. of median from known value	0.00	0.57

TABLE 7.1d GROSS ALPHA ACTIVITY IN WATER - INTERCOMPARISON STUDY
-18 SEPTEMBER 1992

The known value for gross alpha activity is 45.0 pCi/liter with an expected laboratory precision of 11.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

GROSS ALPHA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)/(known)	
CA	43.0	45.0	43.0	1.15	0.107	43.67	1.14	-0.21

STATISTICAL SUMMARY OF 219 PARTICIPANTS

Statistic	Respondents	Grand Avg	Non-outliers
Mean	37.75		36.46
Std. Dev.	15.78		11.52
Variance	248.99		136.73
% Coef. of Var.	41.80		31.59
% deviation of mean from known value	- 16.12		- 18.97
Norm. dev. of mean from known value	- 0.46		- 0.74
Median	35.00		34.67
% deviation of median from known value	- 22.22		- 22.96
Norm. dev. of median from known value	- 0.63		- 0.90

TABLE 7.1e GROSS BETA ACTIVITY IN WATER - INTERCOMPARISON STUDY
-18 SEPTEMBER 1992

The known value for gross beta activity is 50.0 pCi/liter with an expected laboratory precision of 5.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

GROSS BETA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)(known)	
CA	48.0	49.0	48.0	0.577	0.118	48.33	-0.097	-0.579

STATISTICAL SUMMARY OF 219 PARTICIPANTS

<u>Statistic</u>	<u>Respondents</u>	<u>Non-outliers</u>
Mean	59.38	Grand Avg 48.61
Std. Dev.	114.45	9.14
Variance	13098.83	83.51
% Coef. of Var.	192.75	18.80
% deviation of mean from known value	18.76	-2.78
Norm. dev. of mean from known value	0.08	-0.15
Median	49.00	48.67
% deviation of median from known value	-2.00	-2.67
Norm. dev. of median from known value	-0.01	-0.15

TABLE 7.1f TRITIUM IN WATER - INTERCOMPARISON STUDY - 23 OCTOBER 1992

The known value for tritium activity is 5962.0 pCi/liter with an expected laboratory precision of 596.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

³ H								
<u>Lab</u>	<u>Res. 1</u>	<u>Res. 2</u>	<u>Res. 3</u>	<u>Exper.</u>	<u>Rng anal</u>	<u>Average</u>	<u>Normalized deviation</u>	
				<u>Sigma</u>	<u>(R + SR)</u>		<u>(grand-avg)/(known)</u>	
CA	4402.0	4379.0	3936.0	262.66	0.462	4239.00	-5.11	-5.01

STATISTICAL SUMMARY OF 172 PARTICIPANTS

<u>Statistic</u>	<u>Respondents</u>	<u>Grand Avg</u>	<u>Non-outliers</u>
Mean	6201.84		5997.40
Std. Dev.	4667.63		565.83
Variance	21786750.49		320164.99
% Coef. of Var.	75.26		9.43
% deviation of mean from known value	4.02		0.59
Norm. dev. of mean from known value	0.05		0.06
Median	5953.33		5961.67
% deviation of median from known value	- 0.15		0.01
Norm. dev. of median from known value	0.00		0.00

TABLE 7.1g TRITIUM IN WATER - INTERCOMPARISON STUDY - 19 JUNE 1992*

The known value for tritium activity is 2125.0 pCi/liter with an expected laboratory precision of 347.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

³ H								
<u>Lab</u>	<u>Res. 1</u>	<u>Res. 2</u>	<u>Res. 3</u>	<u>Exper.</u>	<u>Rng anal</u>	<u>Average</u>	<u>Normalized deviation</u>	
				<u>Sigma</u>	<u>(R + SR)</u>		<u>(grand-avg)/(known)</u>	
CA	2468.0	2564.0	2539.0	49.81	0.163	2523.67	2.11	1.99

STATISTICAL SUMMARY OF 179 PARTICIPANTS

<u>Statistic</u>	<u>Respondents</u>	<u>Grand Avg</u>	<u>Non-outliers</u>
Mean	2188.82		2101.61
Std. Dev.	814.49		221.34
Variance	663389.97		48993.22
% Coef. of Var.	37.21		10.53
% deviation of mean from known value	3.00		-1.10
Norm. dev. of mean from known value	0.08		-0.11
Median	2094.33		2090.00
% deviation of median from known value	-1.44		-1.65
Norm. dev. of median from known value	-0.04		-0.16

*These results have been included in this report as they were received after submission of the 1991-92 report.

8. CONCLUSIONS

The data obtained during this period do not show any fission product activities. The observed environmental radioactivity is due primarily to radon progeny, primordial radionuclides (e.g., K-40) and those radionuclides (e.g., Be-7) which originate in the upper atmosphere as the result of cosmic ray interactions. These facts justify the conclusion that the PULSTAR Reactor facility continues to operate safely and does not release fission product materials into the environment.

9. ACKNOWLEDGMENTS

This office is greatly indebted to Mr. Bill Crocker for his untiring efforts in collecting the environmental samples. Great appreciation is also expressed to Mr. Thomas Brackin for his work in repairing the air samplers.

The graphs in this report are available due to the assistance of Mr. Worth Bowman, and the entire arrangement and typing are due to the excellent efforts of Mrs. Ginger Davis.

APPENDIX 1

The vertical columns in Tables 7 are identified as columns 1-8 from left to right.

Column 1:	Laboratory identification code (e.g., QA).
Columns 2, 3, 4:	Laboratory results given in triplicate.
Column 5:	Standard deviation (1s) of the experimental results.
Column 6:	Normalized range value in "mean range + standard error of the range".
Column 7:	Average value of the triplicate analysis.
Column 8:	Normalized deviation from the grand average value of all laboratories expressed in σ_m units.
Column 9:	Normalized deviation from the known value expressed in σ_m units.

The following example calculation gives a set of data, the mean value, the experimental sigma, and the range. These statistics provide measures of the central tendency and dispersion of the data.

The normalized range is computed by first finding mean range, R , the control limit, CL , and the standard error of the range, σ_R . The normalized range measures the dispersion of the data (precision) in such a form that control charts may be used. Control charts allow one to readily compare past analytical performance with present performance. In the example, the normalized range equals 0.3 which is less than 3 which is the upper control level. The precision of the results is acceptable.

The normalized deviation is calculated by computing the deviation and the standard error of the mean, σ_m . The normalized deviation allows one to measure central tendency (accuracy) readily through the use of control charts. Trends in analytical accuracy can be determined in this manner. For this example, the normalized deviation is -0.7 which falls between +2 and -2 which are the upper and lower warning levels. The accuracy of the data is acceptable.

Finally, the experimental error of all laboratories, the grand average, and the normalized deviation from the grand average are calculated in order to ascertain the performance of all the laboratories as a group. Any bias in methodology or instrumentation may be indicated by these results.

EXAMPLE CALCULATIONS

Experimental data:

known value = μ = 3273 pCi ³H/liter urine on September 24, 1974

Expected laboratory precision = σ = 357 pCi/liter

Laboratory	Sample	Result
D	x ₁	3060 pCi/liter
D	x ₂	3060 pCi/liter
D	x ₃	3240 pCi/liter

Mean = \bar{x}

$$\bar{x} = \frac{\sum_{i=1}^N x_i}{N} = \frac{9360}{3} = 3120 \text{ pCi/liter}$$

where N = number of results = 3

Experimental sigma = s

$$s = \sqrt{\frac{\sum_{i=1}^N (x_i)^2 - \frac{\left(\sum_{i=1}^N x_i\right)^2}{N}}{N - 1}}$$

$$s = \sqrt{\frac{(3060)^2 + (3060)^2 + (3240)^2 - \frac{(3060 + 3060 + 3240)^2}{3}}{2}}$$

$$s = 103.9 \text{ pCi/liter}$$

Range = r

$$r = | \text{maximum result} - \text{minimum result} |$$

$$r = | 3240 - 3060 | = 180 \text{ pCi/liter}$$

$$\text{for } r \leq R, \quad x = 0$$

$$\text{then} \quad r = w\bar{R} + x\sigma_R = w\bar{R}$$

$$\text{or} \quad w = \frac{r}{\bar{R}}$$

$$\text{therefore } w + x = w + 0 = \frac{r}{\bar{R}}$$

$$\text{since } r < \bar{R}, (180 < 604.4)$$

$$w + x = \frac{180}{604.4}$$

$$w + x = 0.30$$

Normalized deviation of the mean from the known value = ND

Deviation of mean from the known value = D

$$D = \bar{x} - \mu$$

$$= 3120 - 3273$$

$$D = -153 \text{ pCi/liter}$$

Standard error of the mean = σ_m

$$\sigma_m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{357}{\sqrt{3}}$$

$$\sigma_m = 206.1 \text{ pCi/liter}$$

$$ND = \frac{D}{\sigma_m}$$

$$= \frac{-153}{206.1}$$

$$ND = -0.7$$

Control limit = CL

$$CL = (\mu \pm 3\sigma_m)$$

Warning Limit = WL

$$WL = (\mu \pm 2\sigma_m)$$

Range Analysis (RNG ONLY)*

Mean range = \bar{R}

$$\bar{R} = d_2 \sigma$$

where $d_2^{**} = 1.693$ for $N = 3$

$$= (1.693) (357)$$

$$\bar{R} = 604.4 \text{ pCi/liter}$$

Control limit = CL

$$CL = \bar{R} + 3\sigma_R$$

$$= D_4 \bar{R}$$

where $D_4^{**} = 2.575$ for $N = 3$

$$= (2.575) (604.4)$$

$$CL = 1556 \text{ pCi/liter}$$

Standard error of the range = σ_R

$$\sigma_R = (R + 3\sigma_R - \bar{R}) \div 3$$

$$= (D_4 \bar{R} - \bar{R}) \div 3$$

$$= (1556 - 604.4) \div 3$$

$$\sigma_R = 317.2 \text{ pCi/liter}$$

Let range = $r = w\bar{R} + x\sigma_R = 180 \text{ pCi/liter}$

Define normalized range = $w + x$

for $r > \bar{R}$, $w = 1$

$$\text{then } r = w\bar{R} + x\sigma_R = \bar{R} + x\sigma_R$$

$$\text{or } x = \frac{r - \bar{R}}{\sigma_R}$$

$$\text{therefore } w + x = 1 + x = 1 + \frac{r - \bar{R}}{\sigma_R}$$

*Rosenstein, M., and A. S. Goldin, "Statistical Techniques for Quality Control of Environmental Radioassay," AQCS Report Stat-1, U.S. Department of Health Education and Welfare, PHS, November 1964.

**From table "Factors for Computing Control Limits," Handbook of Tables for Probability and Statistics, 2nd Edition, The Chemical Rubber Co., Cleveland, Ohio, 1968, p. 454.

Experimental sigma (all laboratories) = s_t (See Figure 2)

$$s_t = \sqrt{\frac{\sum_{i=1}^N (x_i)^2 - \frac{\left(\sum_{i=1}^N x_i\right)^2}{N}}{N - 1}}$$

$$= \sqrt{\frac{162639133 - \frac{(49345)^2}{15}}{14}}$$

$$s_t = 149 \text{ pCi/liter}$$

Grand average = GA

$$GA = \frac{\sum_{i=1}^N x_i}{N}$$

$$= \frac{49345}{15}$$

$$GA = 3290 \text{ pCi/liter}$$

Normalized deviation from the grand average = ND'

Deviation of the mean from the grand average = D'

$$D' = \bar{x} - GA$$

$$= 3120 - 3290$$

$$D' = -170 \text{ pCi/liter}$$

$$ND' = \frac{D'}{\sigma_m}$$

$$= \frac{-170}{206.1}$$

$$ND' = -0.8$$