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Pre-Operational Environmental Radiation Survey of the National Superconducting Cyclotron Laboratory*

S. Carvalho
Cyclotron Laboratory, Michigan State University
and
Office of Radiation, Chemical and Biological Safety
Michigan State University
and
G.M. Crawley and E. Kashy
Cyclotron Laboratory, Michigan State University
and
W. Malchman
Office of Radiation, Chemical and Biological Safety

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1.0 Introduction

The National Superconducting Cyclotron Laboratory (NSCL)

1.1 General Description and Location

Michigan State University is constructing two coupled superconducting cyclotrons. When operational, the ion beams will have maximum energy ranging from 40 MeV per nucleon for uranium ions to 200 MeV per nucleon for nuclei lighter than calcium.

The facility is located on the East Lansing campus at the site of the present Cyclotron Laboratory. The cyclotron is in the eastern portion of the campus, in the "Science Complex," and in the proximity of the Chemistry, Biochemistry and Plant Science Buildings.

Expansion of the existing Cyclotron is being done by an addition to the present building to house the new laboratories, equipment, shops etc.

The NSCL is in a campus area considered to be a mixture of academic and multiple unit residential. Geographically, the only significant feature near the site is the Red Cedar River which flows westward through campus (about 400 yards north) and joins the Grand River in Lansing about 3 miles west of the campus.

1.2 Climate and Meteorology

The climatological summary for Lansing, where the nearest National Weather Service (NOAA) station is located, is also descriptive of East Lansing and is excerpted here:

"The climate at Lansing alternates between continental and semimarine, depending on meteorological conditions. The marine

type is due to the influence of the Lakes, which, in turn, is governed by the force and direction of the wind. When there is little or no wind, the weather becomes continental in character, which means pronounced fluctuation in temperature -- hot weather in summer and severe cold in winter. On the other hand, a strong wind from the Lakes may immediately transform the weather into a semi marine type. Precipitation is fairly well distributed through the year, and no conspicuous variation is noted in the seasonal march generally, although the curve shows about one inch less a month in winter than in summer, the heavier amounts in summer being due to thundershowers. The wettest months of the year are May and June. Snowfall for Lansing is moderate, averaging 51 inches per year. Tornadoes sometimes occur in the area, but their frequency is less than in states farther to the south and west. Destructive thunder and wind storms are not uncommon".

1.2.1. Climate during Surveillance

General understanding of climatological conditions during the surveillance period is necessary since the natural radioactivity levels are influenced by changes in temperature, precipitation and pressure.

The local climatological monthly summaries for the periods when the environmental program took place are presented in Tables 1 to 3.

1.2.2. Meteorology during Surveillance

Meteorological conditions play an important role in the dispersion of any pollutants released to the environment. Therefore,

Table 1. Summary of Local Climatological Data for February 1980

Local Climatological Data

FEBRUARY 1980
LANSING, MICHIGAN
NATIONAL WEATHER SERVICE OFC
CAPITAL CITY AIRPORT

MONTHLY SUMMARY

DEPARTMENT OF COMMERCE * UNITED STATES OF AMERICA *

LATITUDE 42 ° 47 'N LONGITUDE 84 ° 36 'W ELEVATION (GROUND) 841 FT. STANDARD TIME USED: EASTERN WBAN #14836

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE (1 FOG, 2 HEAVY FOG, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW)	SNOW, ICE PELLETS OR ICE ON GROUND AT 07AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 874 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	SUNSHINE PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	SKY COVER TENTHS MIDNIGHT TO MIDNIGHT	DATE
1	19	-4	8	-14	0	57	0		1	0	0	29.46	33	6.3	6.9	12	01	419	70	6	5	1
2	22	3	13	-9	3	52	0		1	0	0	29.46	34	1.3	3.3	9	02	471	79	6	7	2
3	17	-2	8	-14	0	57	0		1	T	T	29.46	34	6.0	6.2	18	35	559	93	1	3	3
4	25	1	13	-9	5	52	0		T	.01	.1	29.36	32	4.4	4.5	12	31	539	89	1	2	4
5	26	-1	13	-10	8	52	0		T	.01	.2	29.23	12	4.5	4.9	12	09	267	44	10	7	5
6	27	15	21	-2	15	44	0	1	T	.02	.3	29.44	05	9.2	9.9	15	05	509	83	10	9	6
7	29	8	19	-4	17	46	0		T	0	0	29.53	36	5.4	5.9	10	01	476	78	8	8	7
8	28	3	16	-7	11	49	0		T	.05	.6	29.27	27	.6	1.7	7	36	564	92	9	7	8
9	28	20	24	1	20	41	0	1	T	T	T	29.03	36	2.1	2.6	8	34	48	8	10	10	9
10	27	7	17	-6	14	48	0	2	1	.01	.3	28.87	20	8.2	8.5	20	21	0	0	10	9	10
11	24	13	19	-4	15	46	0		2	T	T	29.13	24	12.7	15.1	23	28	253	41	8	7	11
12	30	9	20	-3	16	45	0	1	2	0	0	29.21	25	9.1	9.5	17	24	468	75	7	8	12
13	29	12	21	-2	15	44	0		1	T	T	29.30	22	14.8	15.1	20	22	436	69	10	5	13
14	29	21	25	1	21	40	0	1 6	1	.11	1.5	29.12	29	4.0	5.8	14	25	48	8	10	10	14
15	26	20	23	-1	21	42	0	1	3	T	T	28.95	03	6.6	6.8	12	04	0	0	10	10	15
16	21	2	12	-12	10	53	0		3	T	.2	29.05	32	10.9	11.5	20	31	404	63	7	7	16
17	20	-1	10	-14	8	55	0	1	3	T	T	29.05	24	11.1	11.8	20	25	49	8	9	9	17
18	29	10	20	-4	13	45	0	1	3	T	0	28.95	21	14.0	14.5	22	19	474	74	8	9	18
19	40	29	35	10	24	30	0		3	T	0	28.85	21	11.5	12.4	20	21	0	0	10	10	19
20	39	34	37	12	35	28	0	1	T	T	T	28.99	22	5.5	7.1	13	17	0	0	10	10	20
21	44+	32	38+	13	34	27	0	2	T	.11	T	28.76	09	5.9	7.1	17	09	12	2	9	10	21
22	34	32	33	8	33	32	0	1	T	.50	T	28.96	05	3.6	9.4	20	09	0	0	10	10	22
23	36	32	34	9	33	31	0	1	T	T	T	29.05	25	6.6	6.8	15	25	0	0	10	10	23
24	34	26	30	4	24	35	0	1	1	.01	.5	29.08	27	16.0	16.4	25	26	31	5	10	9	24
25	26	10	18	-8	17	47	0	1	9	.02	.2	29.24	01	10.5	12.2	20	02	0	0	10	8	25
26	23	-2	11	-15	5	54	0		9	.09	.9	28.93	24	9.5	13.4	24	22	307	46	7	6	26
27	25	16	21	-6	14	44	0	1	9	.04	.5	29.01	29	13.2	15.8	22	22	346	52	6	8	27
28	22	10	16	-11	11	49	0	1	1	.01	.2	29.48	34	5.0	6.9	15	34	201	30	9	9	28
29	10	-7+	2+	-25	-11	63	0	1					01	10.1	10.2	16	03	528	79	2	3	29

SUM	SUM				TOTAL	TOTAL		TOTAL	TOTAL								TOTAL	%	SUM	SUM
789	348				1308	0	NUMBER OF DAYS	.99	5.5	29.16	27	3.2	9.0	25	26	7409	FOR	233	225
AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION	DEP.						DATE:	24	18396	POSSIBLE	AVG.	AVG.	
27.2	12.0	19.6	-4.4	15	122	0	.01 INCH 13	-0.63									MONTH	8.0	7.8	
					SEASON TO DATE		SNOW, ICE PELLETS													
					TOTAL	TOTAL	> 1.0 INCH 1	GREATEST IN 24 HOURS AND DATES								GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE				
NUMBER OF DAYS					5150	0	THUNDERSTORMS 0	PRECIPITATION			SNOW, ICE PELLETS									
MAXIMUM TEMP.		MINIMUM TEMP.			DEP.	DEP.	HEAVY FOG 2	.61	21-22		1.5					3		19+		
> 90 °	< 32 °	< 32 °	< 0 °				CLEAR 3	PARTLY CLOUDY 6			CLOUDY 20									
0	23	28	6		86	0														

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

WINDS UNDER FASTEST MILE HEADING ARE FASTEST OBSERVED 1-MIN. WINDS.

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	RESULTANT WIND SPEED M.P.H.
01	7	29.16	18	17	14	86	8.8	27	3.3
04	7	29.15	16	16	12	85	6.6	26	2.7
07	7	29.16	16	15	13	87	6.9	27	2.3
10	8	29.18	20	19	15	83	8.5	29	2.4
13	8	29.17	24	23	17	73	11.6	29	5.3
16	8	29.14	26	24	17	69	11.8	28	4.4
19	8	29.16	22	20	16	78	9.2	25	3.1
22	8	29.17	19	19	15	84	8.8	26	3.3

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3							T	T									T		T	T	.01	T	T	T	3
4																								T	4
5																									5
6	T	T	.01	T	T	T															T	T	T	T	6
7	T	T	T	.01	T	.01	T	T	T				T	T	T	.01	T	T			T	T	T	T	7
8										.01	.01	T													8
9			T	T	.01	.01	T	T	T	T	T	T	T	T	T		T	T							9
10	T									T	T	.01	T						T						10
11	T	T	T	T	T	T	T	T	T	T	T	T	T												11
12																									12
13					T	T	T		T	T	T	T													13
14					T	.01	.01	.01	.01	.01	.01	.01	.01	T	T	T	.01	T	.01	.01	T	T	T			14
15													T	T	T	T	T	T	T	T	T	T	T	T	15
16		T	T							T	T	T											T	T	16
17																									17
18	T	T	T																		T	.01	.06	.04	18
19							T	T	T															T	19
20	T																							T	20
21												.03	.01	T	T	T	T								21
22	.01	T		.08	.19	.07	.05	.02	.01	.03	T	T	T	T	T	T	T								22
23						T	T		T	T	T	T	T	T	T	T	T	T	T	.01	T				23
24	T	T								T	T	T	T	T	T	T				T	.01	.01	T	T	24
25															T	T									25
26																									26
27	T	.01	.02	.01	.02	.01	.02	T	T	T	T	T	T	T	.01	T	T	.02	T			T	T	.01	27
28				T	T	T	T																		28
29	.01	T	T																						29

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Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 03/28/80 475

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS OF FT.	VISIBILITY WHOLE MILES	VISIBILITY TENTHS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01											
01	2	UNL	10			02	01	-10	57	34	6
04	0	UNL	9			-01	-01	-09	68	30	5
07	3	UNL	9			-01	-01	-08	72	32	5
10	10	38	9			10	09	02	70	34	7
13	1	UNL	9			16	14	05	62	01	10
16	6	40	9			18	15	06	59	33	7
19	9	45	9			13	13	10	98	29	4
22	3	UNL	9			08	08	05	97	32	4
DAY 02											
01	8	40	9			10	09	03	73	32	3
04	3	UNL	9			04	03	-03	72	00	0
07	8	45	9			08	07	02	76	29	3
10	10	50	9			12	11	04	70	27	4
13	8	55	11			19	16	03	49	01	6
16	0	UNL	11			20	16	04	50	06	4
19	6	40	10			11	10	06	90	16	3
22	10	40	10			13	12	08	80	00	0
DAY 03											
01	9	45	9			14	14	11	88	33	7
04	9	45	9			08	06	-08	48	35	3
07	7	45	9			02	01	-05	72	34	4
10	0	UNL	9			09	07	-01	63	34	4
13	1	UNL	11			15	13	03	59	36	7
16	0	UNL	10			16	13	03	56	33	8
19	1	UNL	10			09	07	-02	61	31	5
22	1	UNL	10			09	07	-01	63	33	5
DAY 04											
01	0	UNL	9			03	03	-02	79	31	4
04	6	17	9			02	02	-02	93	00	0
07	10	28	9			11	10	07	84	30	4
10	0	UNL	11			17	16	11	77	33	10
13	0	UNL	13			22	19	09	57	32	7
16	0	UNL	13			23	20	09	55	32	6
19	0	UNL	13			15	13	07	70	00	0
22	0	UNL	13			07	07	04	87	00	0
DAY 05											
01	0	UNL	9			05	04	00	80	00	0
04	0	UNL	9			01	01	-03	83	00	0
07	0	UNL	7			00	00	-04	83	00	0
10	10	UNL	7			13	12	07	77	09	4
13	10	250	7			24	21	14	66	11	8
16	10	80	7			26	23	16	66	16	10
19	10	80	5		S	23	22	17	78	11	6
22	10	30	2	8	S	21	20	16	81	12	6
DAY 06											
01	10	19	5		S	20	20	18	92	09	10
04	10	23	5		SF	19	19	19	96	08	7
07	10	23	7			19	18	14	81	06	8
10	10	UNL	7			20	19	16	94	05	8
13	9	UNL	7			26	23	14	60	04	10
16	10	200	7			27	23	12	53	05	13
19	8	200	7			21	20	15	78	02	8
22	3	UNL	7			16	16	14	92	02	5
DAY 07											
01	10	23	6		S	20	20	19	96	01	8
04	10	23	5		S	20	20	19	96	36	8
07	10	21	3		S	18	18	17	96	34	6
10	9	28	7			19	19	17	92	34	5
13	9	25	7			25	23	18	75	34	4
16	7	23	10			29	26	19	66	04	7
19	3	UNL	10			19	19	16	88	32	3
22	2	UNL	7			15	15	13	92	00	0
DAY 08											
01	0	UNL	7			09	09	07	91	29	3
04	0	UNL	7			06	06	03	87	00	0
07	0	UNL	7			03	03	-02	79	00	0
10	7	UNL	7			17	14	04	56	00	0
13	10	200	7			26	24	18	72	27	5
16	9	250	7			28	25	19	69	10	4
19	10	250	7			21	20	17	84	00	0
22	10	100	7			21	20	18	88	00	0
DAY 09											
01	10	32	7			21	21	19	92	00	0
04	10	35	2	8	S	21	21	19	92	00	0
07	10	25	2		S	20	20	19	96	05	4
10	10	12	1		SF	22	22	21	96	04	3
13	10	15	2	8	S	26	25	22	85	00	0
16	10	25	2	8	S	27	25	21	78	26	13
19	10	46	3		F	20	19	17	88	32	4
22	10	46	3		SF	20	20	18	92	00	0
DAY 10											
01	2	UNL	1	8	F	12	11	08	84	00	0
04	10	0	0	4	F	11	11	11	100	00	0
07	5	UNL	0	4	F	07	07	07	100	17	3
10	10	32	1	8	F	19	19	19	100	16	5
13	10	15	4		SF	24	24	24	100	21	11
16	10	80	8			26	24	18	72	20	15
19	10	80	8			22	20	13	68	20	9
22	10	25	5		S	21	20	15	78	20	16
DAY 11											
01	10	32	3		S	21	20	16	81	21	13
04	6	32	8			17	17	15	92	22	11
07	10	32	5		S	17	17	15	92	19	14
10	10	15	1	8	S	20	20	18	92	21	12
13	10	80	5		S	22	20	15	74	27	16
16	8	80	8			22	20	14	71	28	17
19	8	80	8			16	15	12	84	26	9
22	7	55	11			14	14	12	92	26	11
DAY 12											
01	0	UNL	11			11	11	09	92	27	6
04	0	UNL	7			12	12	09	88	25	6
07	10	50	7			16	16	15	96	26	5
10	5	UNL	7		F	21	21	19	92	23	7
13	5	UNL	8			27	25	21	78	26	13
16	5	UNL	8			29	26	20	69	24	12
19	9	23	7			25	23	18	75	25	9
22	0	UNL	7			17	17	15	92	21	8
DAY 13											
01	0	UNL	7			16	15	12	84	22	12
04	0	UNL	7			13	13	11	92	21	10
07	7	UNL	7			14	14	13	96	21	12
10	10	90	7			18	17	13	81	21	13
13	10	45	7			23	21	15	71	20	15
16	10	45	7			28	25	17	63	23	16
19	10	45	7			27	24	18	69	21	16
22	10	45	7			27	25	20	75	24	11
DAY 14											
01	10	28	7			27	25	21	78	24	9
04	10	11	7			27	26	23	85	26	8
07	10	6	2		F	27	27	25	92	34	7
10	10	28	3		SF	26	25	22	85	33	6
13	10	35	8			28	25	18	66	35	5
16	8	UNL	8			29	26	19	68	25	5
19	10	32	8			24	23	18	78	00	0
22						23	22	20	88	00	0
DAY 15											
01	10	UNL	7			21	21	19	92	00	0
04	10	23	7			22	21	19	88	03	3
07	10	15	2		SF	21	21	21	100	05	4
10	10	25	2	8	SF	22	22	21	96	04	7
13	10	11	1	8	SF	25	24	22	88	03	8
16	10	10	1	8	SF	26	25	23	88	02	10
19	10	10	1	8	SF	22	22	21	96	03	8
22	10	15	1	8	SF	21	21	20	96	36	7
DAY 16											
01	10	23	7			21	21	19	92	34	8
04	4	UNL	8			14	14	11	88	32	6
07	2	UNL	8			09	09	06	97	35	6
10	2	UNL	13			15	14	11	84	31	11
13	7	28	13			20	18	10	65	31	11
16	10	45	7			19	17	08	62	34	11
19	2	UNL	7			14	12	05	67	29	11
22	6	55	7			11	10	07	84	30	10
DAY 17											
01	6	45	9			02	02	-02	93	26	6
04	10	45	9			09	09	07	91	24	7
07	0	UNL	9			05	05	02	87	24	5
10	10	35	5		SF	13	13	11	92	23	10
13	10	16	4		SF	18	17	14	84	24	12
16	10	25	4		S	18	17	12	77	27	14
19	9	23	4		S	14	13	09	80	23	14
22	10	21	4		S	12	12	09	88	21	14
DAY 18											
01	10	17	5		S	12	13	11	92	23	12
04	10	21	7			14	14	12	92	23	8
07	10	17	7			12	12	10	92	22	13
10	4	UNL	7		F	16	16	13	88	20	9
13	8	250	7			23	21	14	68	22	13
16	9	250	7			29	25	15	56	21	12
19	10	100	7			26	23	15	63	19	15
22	10	55	7			27	24	17	66	19	19
DAY 19											
01	10	55	7			30	26	19	84	22	15
04	10	55	7			31	28	20	88	22	12
07	10	55	7			32	28	20	84	20	12
10	10	45	7			34	30	22	82	23	11
13	10	45	7			37	32	24	84	22	11
16	10	45	7			39	34	25	87	20	9
19	10	50	7			38	33	28	73	16	9
22	10	25	7			36	34	32	85	18	10
DAY 20											
01	10	38	7			35	34	32	89	17	11
04	10	15	5		F	36	35	33	89	20	5
07	10	3	1	8	LF	35	35	35	100	19	5
10	10	3	0	8	F	35	35	35	100	21	7
13	10	5	2	8	F	36	36	36	100	25	7
16	10	7	2	8	F	38	38	38	100	23	6
19	10	7	2	8	F	36	36	36	100	30	4
22	10	5	1	8	F	35	35	35	100	27	4
DAY 21											
01	10	1	0	4	F	33	33	33	100	32	4
04	10	0	0	4	F	33	33	33	100	00	0
07	10	0	0	4	F	33	33	33	100	00	0
10	10	32	1	8	F	35	35	35	100	09	7
13	10	32	2	8	F	39	38	37	93	08	8
16	9	32	4		F	42	39	35	76	11	11
19	7	250	4		F	39	37	35	86	10	10
22	10	7	2		RF	34	34	34	100	08	9
DAY 22											
01	10	8	2		RF	34	34	33	96	08	13
04	10	6	2		RWF	34	34	33	96	11	15
07	10	7	2		RF	34	34	34	100	08	7
10	10	2	1		RF	34	34	34	100	03	6
13	10	4	4		SF	34	34	34	100	03	6
16	10	8	4		F	33	33	33	100	34	8
19	10	2	3	12	F	33	33	32	96	29	4
22	10	4	3		F	32	32	32	100	29	5
						33	33	32	96	29	7
DAY 23											
01	10	4	2		F	32	32	31	96	27	6
04	10	3	2		F	32	32	31	96	28	6
07	10	4	2		F	32	32	32	100	00	0
10	10	8	2		F	33	33	33	100	24	5
13	10	11	4		SF	35	34	33	92	26	5
16	10	10	4		SF	35	35	34	96	25	8
19	10	9	4		F	36	35	34	92	24	8
22	10	28	2	8	F	34	34	34	100	25	9
DAY 24											
01	10	8	3		LF	33	33	32	96	27	18
04	10	23	7			28	27	23	82	28	12
07	10	28	8			28	26	21	75	27	16
10	10	20	2	8	S	27	27	25	92	27	12
13	10	45	7			32	30	25	75	27	19
16	9	25	7		SW	32	30	25	75	27	14
19	10	50	7			32	29	23	69	26	11
22	8	55	8			29	27	21	72	31	12
DAY 25											
01	9	55	9			26	24	20	78	28	5
04	7	55	9			23	22	20	88	31	3
07	1	UNL	7			22	22	20	92	04	5
10	10	11	4		SF	23	22	20	88	05	11
13	10	15	2	8	SF	22	21	17	81	02	17
16	10	15	1	8	SBS	22	21	17	81	01	14
19	10	11	1	8	SBS	19	19	17	92	03	15
22	9	32	7			15	13	07	70	35	15
DAY 26											
01	0	UNL	8			08	07	00	70	36	11
04	0	UNL	8			04	03	-04	89	30	8
07	6	38	8			01	01	-04	79	27	5
10	3	UNL	9			14	12	02	59	00	0
13	8	28	9			19	17	11	71	24	14
16	10	32	9			21	19	12	68	23	19
19	10	80	9			19	17	08	62	20	19
22	10	28	3		SBS	18	15	12	84	22	17
DAY 27											
01	10	23	4		SBS	18	18	16	92	23	15
04	10	10	2	8	S	21	21	19	92	23	13
07	10	25	3		S	24	24	22	92	29	14
10	1	UNL	7			20	18	11	88	32	18
13	7	25	8		SW	23	20	13	85	32	18
16	7	40	8			22	19	10	80	30	15
19	8	UNL	8			20	17	09	82	32	10
22	10	UNL	8			18	16	10	71	31	7
DAY 28											
01	10	250	9			15	14	09	77	34	4
04	10	35	6		S	15	14	10	80	06	4
07	9	120	7		S	13	13	12	96	00	0
10	10	32	7		S	16	15	10	77	08	3
13	10	80	7			20	18	10	68	29	7
16	9	32	7		S	20	18	10	69	32	7
19	10	20	2		SW	19	19	16	88	32	12
22	10	15	2		SW	12	12	10	92	02	11
DAY 29											
01	10	5	0	12	SF	07	07	06	96	02	12
04	0	UNL	9			-02	-03	-13	59	01	7
07	0	UNL	9			-05	-05	-16	58	36	7
10	0	UNL	9			-03	-04	-15	56	36	10
13	0	UNL	9			04	02	-13	44	36	12
16	8	UNL	9			08	06	-10	43	36	13
19	6	UNL	10			03	01	-13	47	02	6
22	0	UNL	10			-01	-02	-13	56	36	4

STATION

LANSING MICH

YEAR & MONTH

80 02

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS, INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

Table 2. Summary of Local Climatological Data for March 1980

MARCH 1980
LANSING, MICHIGAN
NATIONAL WEATHER SERVICE OFC
CAPITAL CITY AIRPORT

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 42 ° 47 'N LONGITUDE 84 ° 36 'W ELEVATION (GROUND) 841 FT. STANDARD TIME USED: EASTERN WBAN #14836

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 07AM IN.	PRECIPITATION WATER EQUIVALENT IN	PRECIPITATION SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. - - - ELEV. 874 FEET M.S.L.	WIND RESULTANT DIR.	WIND RESULTANT SPEED M.P.H.	WIND AVERAGE SPEED M.P.H.	WIND FASTEST MILE SPEED M.P.H.	WIND FASTEST MILE DIRECTION	SUNSHINE MINUTES	SUNSHINE PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	SKY COVER TENTHS MIDNIGHT TO MIDNIGHT	DATE
1	15	-4	6	-21	8	59	0		1	0	0	29.60	36	7.3	7.5	20	N	423	63	5	3	1
2	25	-6	10	-17	1	55	0		1	0	0	29.38	25	5.7	6.3	17	W	510	76	4	3	2
3	33	11	22	-6	11	43	0		T	0	0	29.08	21	13.6	14.4	29	SW	502	74	5	3	3
4	41	22	32	4	24	33	0		T	0	T	28.89	22	5.1	7.5	14	SW	225	33	9	7	4
5	34	14	24	-4	23	41	0	1	1	.09	1.1	28.86	30	8.2	9.1	28	NW	244	36	10	8	5
6	27	9	18	-11	14	47	0	1 9	1	.03	.9	29.19	23	8.3	8.8	19	SW	363	53	8	6	6
7	31	10	21	-8	24	44	0		1	T	T	29.08	12	3.7	4.8	11	SE	219	32	10	10	7
8	32	14	23	-7	23	42	0	1 6	1	.11	2.1	28.88	03	6.3	8.8	15	E	258	37	10	8	8
9	36	16	26	-4	23	39	0	1	1	.02	.4	28.92	23	11.3	11.5	20	SW	602	86	6	5	9
10	43	18	31	1	28	34	0	1 8	3	T	T	28.65	26	16.1	19.8	36	NW	492	70	7	6	10
11	27	10	19	-12	10	46	0	1 8	2	T	T	29.06	29	17.8	19.6	33	W	419	60	5	4	11
12	30	6	18	-13	9	47	0		T	0	0	29.23	09	11.1	13.5	20	E	538	76	7	5	12
13	30	20	25	-6	22	40	0	1 6	T	.12	2.3	28.79	07	10.2	12.7	16	E	0	0	10	10	13
14	36	22	29	-3	23	36	0	1	2	.05	.5	29.08	29	14.4	14.8	26	NW	579	81	5	5	14
15	40	14	27	-5	21	38	0	1 8	T	0	.0	29.37	12	7.4	8.1	16	SE	703	99	5	3	15
16	55	30	43	10	33	22	0		T	0	T	29.06	18	15.9	16.7	24	S	241	34	9	7	16
17	48	29	39	6	39	26	0	1 4	0	.60	.6	28.79	27	4.7	11.2	26	NW	0	0	10	9	17
18	42	22	32	-1	26	33	0		0	0	0	29.19	26	11.3	13.4	25	W	701	97	2	1	18
19	53	34	44	10	29	21	0		0	0	0	29.14	20	15.3	15.5	28	SW	526	73	6	5	19
20	62	37	50	16	39	15	0		0	.08	0	28.86	21	9.8	11.4	20	SW	608	84	2	4	20
21	41	29	35	0	28	30	0	1	1	.22	.8	28.74	33	17.3	18.7	31	NW	408	56	9	8	21
22	40	25	33	-2	23	32	0		T	0	0	29.16	32	7.6	9.1	20	NW	619	84	5	4	22
23	41	31	36	0	27	29	0		T	0	0	29.15	14	9.8	10.4	17	SE	129	18	10	10	23
24	34	31	33	-3	32	32	0	1	0	.06	.1	28.91	03	9.0	10.6	22	NE	0	0	10	10	24
25	38	28	33	-4	26	32	0	1	T	0	0	29.14	33	7.9	8.8	17	NW	38	5	10	9	25
26	39	27	33	-4	28	32	0		T	0	0	29.31	05	1.7	2.9	8	SE	177	24	10	10	26
27	47	28	38	0	30	27	0	1	0	0	0	29.32	18	4.4	7.6	20	SE	562	75	9	9	27
28	47	32	40	2	35	25	0	1 8	0	.06	0	29.21	06	11.0	11.4	22	NE	483	64	10	10	28
29	46	31	39	0	33	26	0	1 8	0	.06	0	29.08	03	14.4	14.5	25	NE	529	70	9	9	29
30	50	30	40	1	31	25	0		0	T	T	28.96	06	11.3	11.9	26	NE	636	84	9	9	30
31	37	33	35	-5	34	30	0	1 4	0	.44	T	28.83	03	13.4	14.1	22	NE	0	0	10	10	31
	SUM 1200	SUM 653				TOTAL 1081	TOTAL 0		TOTAL 1.94	TOTAL 8.8	29.06	28	1.5	11.4	36	NW	TOTAL 11734	%	SUM 236	SUM 210	
	AVG. 38.7	AVG. 21.1	AVG. 29.9	DEP. -3.0	AVG. 24	DEP. 86	DEP. 0	NUMBER OF DAYS PRECIPITATION >.01 INCH 13	DEP. -0.42							DATE: 10		POSSIBLE 22207	MONTH 53	AVG. 7.6	AVG. 6.8	

NUMBER OF DAYS MAXIMUM TEMP. ≥90°	≤32°	MINIMUM TEMP. ≤32°	≤0°	SEASON TO DATE TOTAL	DEP.	NUMBER OF DAYS SNOW, ICE PELLETS ≥1.0 INCH 3	THUNDERSTORMS 0	HEAVY FOG 0	CLEAR 2	PARTLY CLOUDY 11	CLOUDY 18
0	8	28	2	6231	210						

GREATEST IN 24 HOURS AND DATES PRECIPITATION		SNOW, ICE PELLETS		GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
.60	17	2.8	13-14	3	9+

FOR THE MONTH:

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

STATION RETURNED TO FASTEST MILE WINDS EFFECTIVE MARCH 1ST, 1980.

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	RESULTANT WIND SPEED M.P.H.
01	5	29.07	27	26	22	84	8.6	25	1.5
04	5	29.06	26	25	22	86	9.6	27	1.4
07	6	29.07	25	24	22	89	10.2	32	.5
10	8	29.08	31	29	24	78	12.2	28	.8
13	8	29.06	35	31	25	69	14.0	27	2.7
16	8	29.03	36	32	25	67	14.9	30	3.3
19	8	29.04	32	30	25	76	11.1	30	1.3
22	7	29.06	30	28	24	82	10.9	29	1.1

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
5		T	T	T	T	.02	.02	.01	.02	.02	T	T				T	T	T							5
6	T												T		T	T									6
7			T							T	T	T				T	T	T	.01	.01	T	.01	T	T	7
8							T	T	T	.01	.05	.02	.01	.01	.01	T	T	T	T	T	T				8
9		T	T	T												T	T	T	T	T	T	.01	.01		9
10							T	T	T	T	T	T							T	T	T				10
11	.01	.02	T	.01	T	.01	T	.01	T	T	.02	.02	.01	T	T	T	.02	.01	T	T	.01	.02	T	T	11
12	.03	.06	.03	T	T	T	.05	.05	.03	.05	.09	.06	.03	.05	.02	.01	T	T	T	T	T			T	12
13																	.02	.01	.01	T	T				13
14	T	.09	.03	.01	.03	.03	.03	T	T																14
15																				T	.02	T	.06		15
16	T	T	T		.01	.01	.01	T	T	T	T	.01	.01	T	T	.01	T	T	T	T	T			T	16
17																									17
18	.01	T	T	.03	.02	T	T													T	.02	.01	.03		18
19																						T	T		19
20	T	T		.03	.06	.06	.05	.05	.04	.04	.04	.04	.02	.01	T	T									20
21																									21
22																									22
23																									23
24																									24
25																									25
26																									26
27																									27
28																									28
29																									29
30																									30
31																									31

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 04/30/80

OBSERVATIONS AT 3-HOUR INTERVALS

Day	Hour	Sky Cover Tenths	Ceiling Hnds. of Ft.	Visibility Whole Miles	Visibility 16ths Mile	Weather	Air °F	Wet Bulb °F	Dew Pt. °F	Rel. Hum. %	Wind Dir	Wind Speed Knots
01	01	3	UNL	9			-01	-02	-12	59	36	4
01	04	0	UNL	3			-03	-03	-12	65	33	4
01	07	4	UNL	9			-02	-02	-10	68	34	3
01	10	5	UNL	[illegible]			08	06	-04	58	01	6
01	13	7	UNL	[illegible]			14	11	-02	49	36	12
01	16	5	UNL	7			13	10	-05	44	36	11
01	19	0	UNL	7			07	05	-10	45	01	5
01	22	0	UNL	7			05	03	-07	57	35	7
02	01	0	UNL	9			01	00	-08	65	00	0
02	04	0	UNL	9			-04	-04	-10	75	00	0
02	07	0	UNL	9			-04	-04	-09	79	27	3
02	10	0	UNL	11			11	09	-01	58	21	6
02	13	6	40	11			20	17	08	60	30	6
02	16	3	UNL	11			24	20	10	55	27	10
02	19	10	UNL	11			20	18	12	71	25	9
02	22	4	UNL	11			16	14	08	71	24	10
03	01	0	UNL	9			14	13	08	77	24	10
03	04	0	UNL	9			12	11	07	80	24	10
03	07	0	UNL	9			11	11	08	88	21	10
03	10	2	UNL	9			22	19	09	57	22	12
03	13	4	UNL	9			30	25	12	47	21	13
03	16	8	UNL	9			33	27	13	44	22	14
03	19	5	UNL	9			29	24	13	51	18	17
03	22	2	UNL	9			25	22	14	63	20	14
04	01	3	UNL	9			23	21	16	74	21	12
04	04	0	UNL	9			23	22	18	81	23	8
04	07	10	120	9			24	23	19	81	23	8
04	10	10	45	9			29	27	21	72	23	6
04	13	7	250	9			37	32	24	59	23	5
04	16	10	28	3		S	37	33	27	67	18	4
04	19	10	100	2	9	F	32	32	32	100	05	4
04	22	10	100	3		F	31	31	31	100	07	4
05	01	10	11	5		F	33	32	31	92	00	0
05	04	10	7	4		SF	32	32	32	100	00	0
05	07	10	1	0	8	SF	31	31	31	100	35	3
05	10	10	9	1		SF	26	26	25	96	35	10
05	13	9	20	3			26	24	19	75	31	13
05	16	10	32	8			26	24	17	69	29	17
05	19	3	UNL	8			21	19	13	71	28	10
05	22	4	UNL	10			18	17	13	81	28	10
06	01	0	UNL	9			16	15	12	84	25	9
06	04	2	UNL	9			13	13	10	88	24	6
06	07	0	UNL	9			09	09	08	96	21	5
06	10	6	UNL	9			19	19	13	77	22	10
06	13	10	100	9			23	20	13	65	21	11
06	16	10	100	9			26	22	11	53	23	11
06	19	10	10	1		S	23	23	21	92	20	5
06	22	10	10	2	8	S	23	23	22	96	28	3
07	01	6	30	3		F	19	19	19	100	00	0
07	04	10	28	3		F	21	21	20	96	00	0
07	07	10	28	2	8	F	23	23	22	96	16	4
07	10	10	23	3		SF	27	26	24	88	00	0
07	13	10	80	7			31	28	23	72	13	8
07	16	10	15	3		ZLSF	30	29	26	85	17	9
07	19	10	8	2		SF	30	30	29	96	07	7
07	22	10	38	3		F	29	29	28	96	09	6
08	01	10	46	3		F	29	29	27	92	06	7
08	04	10	32	5		F	28	28	26	92	06	9
08	07	10	28	3		SF	28	27	23	82	06	9
08	10	10	3	0	8	SF	26	26	25	96	05	10
08	13	10	4	0	12	SF	27	27	26	96	02	9
08	16	9	17	8			31	29	24	75	36	3
08	19	7	250	8			23	22	19	85	00	0
08	22	2	UNL	7			17	17	15	92	27	8
09	01	0	UNL	11			17	17	16	96	26	6
09	04	0	UNL	11			17	17	16	96	24	6
09	07	1	UNL	2	8	F	16	16	16	100	22	8
09	10	7	UNL	2	8	F	23	23	23	100	23	9
09	13	10	230	7			32	29	24	72	23	14
09	16	4	UNL	8			36	32	26	67	22	12
09	19	10	10	1	8	S	34	31	27	76	22	12
09	22	10	25	3		SF	34	34	33	96	22	13
10	01	10	28	5		F	34	33	32	92	22	9
10	04	10	11	4		F	34	34	33	96	23	13
10	07	1	UNL	1	8	F	31	31	31	100	21	12
10	10	10	UNL	4		H	38	36	34	86	22	17
10	13	10	40	7			42	39	34	73	24	20
10	16	10	15	7		RWSW	33	32	29	85	30	26
10	19	10	30	5		SW	23	21	15	71	30	24
10	22	2	UNL	11			18	17	12	77	28	17
11	01	3	UNL	11			18	16	10	71	28	14
11	04	4	UNL	10			18	16	10	71	29	16
11	07	7	23	10			17	16	12	81	28	15
11	10	7	23	8		S	20	18	11	68	28	19
11	13	6	30	10			24	21	13	63	26	24
11	16	5	UNL	10			23	20	10	57	31	24
11	19	4	UNL	10			18	16	07	62	33	15
11	22	0	UNL	10			14	12	06	70	34	9
12	01	0	UNL	10			10	10	07	88	36	5
12	04	0	UNL	10			07	07	06	96	25	4
12	07	0	UNL	10			09	09	07	91	05	12
12	10	4	UNL	8			19	17	10	68	10	12
12	13	10	UNL	8			27	22	10	49	09	15
12	16	10	UNL	8			30	24	11	45	10	16
12	19	10	200	8			25	21	10	53	11	15
12	22	5	UNL	8			22	19	09	57	09	15
13	01	7	UNL	8			21	19	11	65	10	13
13	04	10	100	8			23	20	13	65	07	13
13	07	10	20	1	3	S	24	22	17	75	09	14
13	10	10	12	0	12	S	25	25	24	96	08	13
13	13	10	12	5		S	29	28	26	89	09	12
13	16	10	9	1	8	ZLS	29	29	28	96	08	9
13	19	10	5	1		SF	30	30	29	96	36	5
13	22	10	6	1	8	SF	26	26	25	96	33	9
14	01	9	80	4		SF	23	23	21	92	29	10
14	04	10	15	4		SF	25	25	23	92	29	14
14	07	10	20	7			27	25	20	75	31	14
14	10	8	40	9			30	28	23	75	30	12
14	13	7	40	9			35	31	24	64	28	13
14	16	2	UNL	9			36	33	27	70	27	20
14	19	0	UNL	10			31	29	24	75	27	14
14	22	0	UNL	8			26	25	23	88	29	6
15	01	0	UNL	8			19	19	17	92	18	3
15	04	0	UNL	4		GF	17	17	17	100	00	0
15	07	0	UNL	2	8	GF	14	14	14	100	06	4
15	10	9	UNL	8			30	26	18	61	11	8
15	13	5	UNL	8			36	31	23	59	10	11
15	16	3	UNL	8			40	35	26	57	12	10
15	19	2	UNL	8			35	32	26	70	13	6
15	22	1	UNL	8			32	30	25	75	13	14
16	01	1	UNL	8			31	29	24	75	16	11
16	04	0	UNL	8			30	28	25	82	15	15
16	07	3	UNL	8			31	30	27	85	15	12
16	10	10	UNL	7			44	39	32	63	17	14
16	13	10	100	7			53	45	36	53	19	17
16	16	10	120	7			51	44	37	59	18	14
16	19	10	80	7			49	44	39	69	19	17
16	22	10	50	7			50	47	44	80	20	16
17	01	10	23	3		RW	48	47	47	96	19	11
17	04	10	6	2		LF	46	46	46	100	18	12
17	07	10	5	2		RF	46	46	46	100	18	9
17	10	10	2	0	8	RF	45	45	45	100	00	0
17	13	10	7	5		RF	36	36	35	96	34	15
17	16	10	5	1		SF	33	33	32	96	32	10
17	19	10	15	4		SF	31	31	31	100	30	10
17	22	8	UNL	8			30	30	29	96	29	11
18	01	0	UNL	8			27	27	25	92	29	11
18	04	0	UNL	8			26	25	22	85	29	12
18	07	2	UNL	8			22	22	20	92	27	6
18	10	2	UNL	11			31	29	25	78	27	14
18	13	2	UNL	11			36	33	27	70	26	15
18	16	2	UNL	11			41	36	30	65	25	16
18	19	0	UNL	11			38	34	28	67	20	10
18	22	0	UNL	11			35	33	29	79	19	9
19	01	0	UNL	11			35	33	29	79	21	10
19	04	0	UNL	11			34	31	27	76	20	10
19	07	0	UNL	8			35	31	25	67	20	10
19	10	1	UNL	8			44	37	26	49	20	15
19	13	9	UNL	9			52	41	27	38	21	16
19	16	10	80	8			49	40	29	46	20	18
19	19	10	60	8			46	40	32	58	18	13
19	22	10	90	8			44	39	33	65	19	16
20	01	0	UNL	8			42	38	32	68	20	8
20	04	0	UNL	8			41	38	33	73	20	12
20	07	0	UNL	7			37	35	33	85	20	11
20	10	0	UNL	7			46	43	39	77	22	13
20	13	0	UNL	7			55	48	42	62	25	6
20	16	9	UNL	7			61	51	42	50	20	12
20	19	10	120	7			52	48	45	77	18	10
20	22	10	38	7			44	43	42	93	30	7
21	01	10	8	4		RF	38	38	37	96	36	15
21	04	10	3	2		SF	33	33	33	100	35	12
21	07	10	3	0	12	SF	32	32	32	100	35	20
21	10	10	19	7			32	31	30	92	33	15
21	13	9	30	7			33	30	26	75	30	20
21	16	8	38	8			33	29	23	67	31	20
21	19	7	40	8			31	28	23	72	31	18
21	22	3	UNL	11			32	28	21	64	30	10
22	01	0	UNL	11			29	26	20	69	31	12
22	04	0	UNL	11			27	25	19	72	32	12
22	07	0	UNL	11			25	23	19	78	31	10
22	10	3	UNL	10			31	28	21	66	35	14
22	13	5	UNL	10			36	32	25	64	33	7
22	16	10	UNL	10			38	33	24	57	30	4
22	19	7	200	10			37	33	27	67	00	0
22	22	8	250	10			31	29	25	78	13	4
23	01	6	UNL	10			31	29	26	92	15	7
23	04	6	140	10			31	29	26	82	14	6
23	07	10	120	7			31	30	27	85	15	8
23	10	10	150	7			35	32	27	73	16	12
23	13	10	40	7			38	33	26	62	15	14
23	16	10	60	7			38	34	27	65	13	11
23	19	10	80	7			35	32	28	76	12	8
23	22	10	70	7			35	33	29	79	09	6
24	01	10	46	7		R	34	33	32	92	13	5
24	04	10	35	4		F	33	33	32	96	08	4
24	07	10	2	1		RF	33	33	33	100	06	6
24	10	10	1	0	10	RF	33	33	33	100	04	10
24	13	10	3	1		RSF	33	33	33	100	04	10
24	16	10	5	1	8	SF	32	32	32	100	03	15
24	19	10	8	6		F	32	32	31	96	36	13
24	22	10	15	6		F	32	31	30	92	36	11
25	01	10	28	7			31	30	28	89	33	9
25	04	10	28	7			30	28	25	82	33	10
25	07	10	28	7			28	27	24	85	31	11
25	10	10	21	7			28	27	23	82	35	10
25	13	10	19	7			31	29	26	82	31	7
25	16	10	28	7			36	33	28	73	29	5
25	19	8	35	10			37	34	30	76	00	0
25	22	8	40	10			33	30	26	75	02	9
26	01	10	46	10			28	28	26	92	00	0
26	04	10	35	10			29	29	27	92	28	3
26	07	10	38	7			30	29	28	92	00	0
26	10	10	35	7			35	33	29	79	03	6
26	13	10	25	7			37	33	28	70	00	0
26	16	10	28	7			38	34	28	67	00	0
26	19	10	38	7			36	33	28	73	05	5
26	22	10	32	7			35	32	28	76	11	6
27	01	10	35	7			35	32	27	73	14	4
27	04	10	32	7			35	32	27	73	17	6
27	07	6	250	7			29	28	26	89	13	5
27	10	10	250	7			37	33	28	70	16	13
27	13	10	200	7			43	38	32	65	22	10
27	16	10	60	7			45	40	34	65	26	8
27	19	10	60	7			44	40	34	68	34	3
27	22	10	50	7			41	38	35	79	09	4
28	01	10	45	5		F	38	37	35	89	09	5
28	04	6	45	4		F	33	32	31	92	10	5
28	07	9	250	2	8	F	33	33	32	96	08	5
28	10	10	100	4		F	41	39	36	82	06	10
28	13	10	100	5		H	45	41	36	71	05	14
28	16	10	80	5		H	46	42	38	74	05	17
28	19	10	80	2	8	F	40	39	38	93	05	11
28	22	10	50	3		RF	36	36	35	96	05	12
29	01	10	50	3		RF	35	34	33	92	04	11
29	04	10	45	3		RF	35	34	33	92	03	12
29	07	10	45	3		F	34	33	32	92	02	13
29	10	10	60	5		F	36	35	34	92	03	13
29	13	10	70	5		H	45	41	37	74	02	15
29	16	8	UNL	5		H	46	41	35	66	03	22
29	19	8	UNL	7			38	35	30	73	05	9
29	22	7	30	7			33	32	31	92	03	6
30	01	10	28	7			35	33	30	82	00	0
30	04	9	45	9			33	32	30	89	06	9
30	07	4	UNL	7			30	29	28	92	07	10
30	10	10	UNL	7			42	37	31	65	06	8
30	13	10	250	7			49	41	31	50	09	13
30	16	10	80	7			50	42	33	52	07	12
30	19	10	80	7			41	38	35	79	03	16
30	22	10	32	7			37	35	31	79	05	15
31	01	10	25	7		R	37	35	33	85	06	12
31	04	10	23	4		R	36	35	34	92	06	15
31	07	10	8	2		RF	35	35	34	96	03	13
31	10	10	5	1	8	RSF	33	33	33	100	02	13
31	13	10	4	3		RSIPF	35	35	35	100	01	12
31	16	10	5	3		F	36	36	36	100	03	17
31	19	10	14	8			36	35	33	89	03	9
31	22	10	10	7			36	35	34	92	01	7

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

- T TORNADO
- T THUNDERSTORM
- Q SQUALL
- R RAIN
- RW RAIN SHOWERS
- ZR FREEZING RAIN
- L DRIZZLE
- ZL FREEZING DRIZZLE
- S SNOW
- SP SNOW PELLETS
- IC ICE CRYSTALS
- SW SNOW SHOWERS
- SG SNOW GRAINS
- IP ICE PELLETS
- A HAIL
- F FOG
- IF ICE FOG
- GF GROUND FOG
- BD BLOWING DUST
- BN BLOWING SAND
- BS BLOWING SNOW
- BY BLOWING SPRAY
- K SMOKE
- H HAZE
- D DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS: MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION

LANSING MICH

YEAR & MONTH

80 03

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

Table 3. Summary of Local Climatological Data for April 1980

Local Climatological Data

APRIL 1980
LANSING, MICHIGAN
NATIONAL WEATHER SERVICE OFC
CAPITAL CITY AIRPORT

MONTHLY SUMMARY

LATITUDE 42 °47 'N LONGITUDE 84 °36 'W ELEVATION (GROUND) 841 FT. STANDARD TIME USED: EASTERN WBAN #14836

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE	SNOW, ICE PELLETS OR ICE ON GROUND AT 07AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. - - - ELEV. 874 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	SUNSHINE PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	SKY COVER TENTHS MIDNIGHT TO MIDNIGHT	DATE
1	43	35	39	-1	37	26	0	1	0	T	0	29.16	08	2.8	4.6	6	SE	0	0	10	10	1
2	56	36	46	5	38	19	0	1	0	.10	0	29.17	08	3.5	4.0	8	NE	541	71	6	6	2
3	46	30	38	-3	35	27	0	1 8	0	.58	0	29.02	10	10.7	11.5	22	E	253	33	10	8	3
4	42	30	36	-6	34	29	0		0	.02	T	28.73	31	10.1	13.1	24	E	31	4	10	8	4
5	56	30	43	1	32	22	0	2 4	0	0	0	29.03	27	9.5	9.6	28	W	768	99	1	0	5
6	62	38	50	7	37	15	0		0	0	0	29.07	20	9.9	11.2	17	S	692	89	8	7	6
7	57	44	51	8	44	14	0		0	.04	0	28.92	17	10.6	11.5	17	SW	117	15	10	10	7
8	61	47	54	10	51	11	0	1 3 8	0	.17	0	28.73	16	14.1	16.1	25	SW	317	40	10	10	8
9	49	33	41	-3	39	24	0	1	0	.11	T	28.65	20	13.4	14.1	26	SW	0	0	10	10	9
10	39	33	36	-8	34	29	0	1	0	.03	0	28.78	25	13.4	14.1	23	SW	0	0	10	10	10
11	46	35	41	-4	34	24	0	1 8	0	.08	0	29.04	25	5.6	9.6	24	W	136	17	10	10	11
12	48	31	40	-5	37	25	0	1	0	.03	0	28.92	27	10.2	14.0	27	W	80	10	10	9	12
13	44	25	35	-11	27	30	0	1 3 4	0	0	0	29.14	36	5.4	9.1	17	NE	564	71	7	5	13
14	39	31	35	-11	33	30	0	1	T	.23	.4	28.68	07	11.6	15.5	27	NE	0	0	10	10	14
15	42	30	36	-11	33	29	0		T	.10	T	28.59	29	9.3	14.0	21	NW	0	0	10	10	15
16	45	25#	35#	-12	18	30	0		0	0	0	29.26	34	7.2	9.1	18	NW	721	89	4	2	16
17	54	26	40	-7	29	25	0		0	T	0	29.35	26	4.2	5.6	13	NW	625	77	8	6	17
18	68	34	51	3	38	14	0		0	0	0	29.24	25	5.3	6.3	13	W	775	96	1	1	18
19	72	41	57	9	41	8	0		0	T	0	29.16	23	10.6	10.9	26	W	721	89	4	4	19
20	72	41	57	9	42	8	0		0	0	0	29.11	04	3.2	5.2	15	W	763	94	6	5	20
21	71	33	52	3	32	13	0		0	0	0	29.15	18	1.8	3.9	13	S	692	84	6	3	21
22	86#	51	69#	20	44	0	4		0	0	0	28.86	24	10.7	13.4	24	W	807	98	0	1	22
23	66	41	54	4	33	11	0		0	0	0	28.84	33	12.8	15.1	30	W	813	99	1	2	23
24	41	32	37	-13	32	28	0	1	T	.32	2.8	28.87	02	9.4	10.5	16	W	0	0	10	10	24
25	53	32	43	-7	34	22	0	1	T	.01	.1	29.01	30	8.2	8.9	14	W	816	98	4	4	25
26	52	30	41	-10	37	24	0	1	0	0	0	29.05	35	5.4	6.9	10	N	280	34	8	7	26
27	57	40	49	-2	41	16	0	1	0	.11	0	28.98	03	11.3	11.5	20	NE	241	29	10	10	27
28	57	43	50	-1	44	15	0	1	0	.37	0	28.83	05	12.0	14.2	19	NE	168	20	10	10	28
29	54	45	50	-1	46	15	0	1	0	.11	0	28.81	03	5.6	6.0	17	N	117	14	10	10	29
30	56	40	48	-4	46	17	0	1	0	T	0	28.90	36	3.1	3.2	10	N	84	10	10	8	30

	SUM	SUM				TOTAL	TOTAL		TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM
	1634	1062				600	4	NUMBER OF DAYS	2.41	3.3	28.97	29	1.6	10.1	30	N	11122	FOR	224	206
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION .01 INCH 16	DEP.						DATE: 23		POSSIBLE	MONTH	AVG.	AVG.
	54.5	35.4	45.0	-1.5	37	45	4		-0.49								24110	46	7.5	6.9

NUMBER OF DAYS				SEASON TO DATE		SNOW, ICE PELLETS		GREATEST IN 24 HOURS AND DATES			GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	> 1.0 INCH	1		PRECIPITATION	SNOW, ICE PELLETS		
≥ 90 °	≤ 32 °	≤ 32 °	≤ 0 °	DEP.	DEP.	THUNDERSTORMS	2		.60 3- 4	2.9 24-25	1	24
0	0	12	0	255	4	HEAVY FOG	1	PARTLY CLOUDY 7	CLOUDY 19			
						CLEAR 4						

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	RESULTANT WIND SPEED M.P.H.
01	6	28.97	41	39	37	85	8.4	24	.6
04	6	28.96	39	38	36	87	7.9	25	1.5
07	6	28.97	39	38	36	89	9.8	27	1.2
10	7	28.99	45	42	37	76	12.0	30	2.1
13	8	28.97	50	44	38	69	11.7	32	2.5
16	8	28.95	52	45	37	63	12.2	28	3.9
19	8	28.96	49	43	37	69	10.2	32	2.5
22	6	28.97	43	40	37	81	8.5	20	.9

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1												T	T												1
2					T	.03	.04	.03	T	T			T	T	.05	.17	.07	.12	.07	.05	.05				2
3							.02	T	T	T	T	T				T	T								3
4																									4
5																									5
6												.01	.03	T	T										6
7								.01	T			.01	.01	T	T			.03	.11	T	T	T		T	7
8								T	T		T	T	T		.01	T	.01	.02	.03	.01	T	.01	T	T	8
9	T	T	.01	T	T	.01	T	T	T																9
10						.01	.02	T	T										T	.01	.02	.02	.02	.01	10
11																									11
12	T	T	T	.02	.01	T	T	T	T	T	T														12
13						T	.04	.01	.06	.04	T	T	T	.04	.03	T	T	T	T	T	.01	T	T	T	13
14								T	T	T		.02	.01	.01		T	.01								14
15	.01	T	T	.01	.01	.01	.01											T							15
16																									16
17																								T	17
18																									18
19																									19
20	T																								20
21																									21
22																									22
23						T	T	.02	.02	.01	.01	.02	.04	.04	.03	.02	.02	.02	.01	.02	.01	.01	.02	T	23
24																									24
25	T	.01																	T	.01	.01	.05	.01	.03	25
26																			T	.01	.01	.04	.04	.01	26
27	T																								27
28	.07	.05	.04	.01	.04	.02	.03	T								T	.02	.04	.02	T	T	T	T		28
29	.02	.01	T	T	T	T	T	T	T		T	T													29
30				T																					30

\# EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM. DATA IN COLS. 8 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS. FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

MAXIMUM TEMP. EQUALS PREVIOUS RECORD FOR APRIL.

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 05/30/80

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY TENTHS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS

DAY 01

01	10	8	7			35	35	34	96	03	6
04	10	11	7			35	35	34	96	00	0
07	10	5	2	8	F	35	35	34	96	04	5
10	10	4	1	8	F	38	38	38	100	07	5
13	10	7	2	8	F	40	40	39	96	06	5
16	10	12	5		F	42	41	40	93	19	5
19	10	19	5		F	42	41	39	89	00	0
22	10	7	3		F	41	41	41	100	13	6

DAY 02

01	10	23	31		F	40	40	39	96	00	0
04	10	4	2		F	39	39	39	96	00	0
07	10	6	0	9	RF	39	39	39	100	00	0
10	10	3	0	12	F	42	42	42	100	05	4
13	UNL	7				51	46	41	69	06	8
16	UNL	7				54	45	35	49	13	6
19	UNL	7				50	42	35	57	09	6
22	UNL	7				37	35	33	95	05	4

DAY 03

01	UNL	7				36	35	33	89	09	7
04	UNL	7				33	32	30	95	10	6
07	UNL	9				32	30	27	82	12	9
10	200	9				42	39	35	76	13	13
13	45	7			R	42	40	37	83	10	16
16	23	1	8		RF	43	42	40	89	11	11
19	8	1			RF	41	41	40	96	09	10
22	5	3			F	41	41	41	100	05	8

DAY 04

01	10	0	0	4	F	38	38	38	100	07	5
04	10	7	2		F	42	42	42	100	25	12
07	10	11	4		RF	40	39	38	93	27	11
10	10	5	2	8	SIPF	35	35	34	96	33	13
13	10	21	7			38	36	34	86	34	13
16	10	23	7		L	38	36	33	82	32	18
19	10	70	7			39	35	29	67	32	13
22	0	UNL	7			32	30	27	82	27	6

DAY 05

01	UNL	11				31	30	28	89	28	7
04	UNL	11				32	30	26	79	27	2
07	UNL	11				33	31	27	79	26	5
10	UNL	11				44	40	34	68	25	9
13	UNL	11				53	45	37	55	27	17
16	UNL	11				54	45	36	51	28	16
19	UNL	11				49	43	35	59	27	11
22	UNL	11				38	36	33	82	00	0

DAY 06

01	UNL	11				42	38	33	71	24	9
04	UNL	11				40	37	33	76	22	7
07	UNL	11				38	36	34	86	19	6
10	UNL	10				53	47	40	82	21	12
13	250	10				59	49	39	68	23	10
16	250	10				61	50	39	68	23	10
19	250	10				56	46	36	67	17	12
22	100	10				51	45	38	81	16	9

DAY 07

01	8	100	11			51	45	38	61	15	8
04	8	80	11			44	40	36	74	25	4
07	7	80	11			46	42	38	74	14	9
10	10	45	10			51	46	41	69	16	13
13	10	40	8		R	50	49	48	93	17	11
16	10	19	7			54	52	50	86	19	14
19	10	UNL	8			56	53	51	83	17	12
22	10	250	8			53	52	51	93	17	9

DAY 08

01	10	100	7			57	54	51	80	17	12
04	10	250	7			50	49	48	93	13	9
07	10	100	8			54	51	48	80	15	17
10	10	100	7			57	54	51	80	16	18
13	10	28	7			57	56	55	93	13	14
16	10	28	7	8	RW	59	57	56	90	12	14
19	10	10	8			50	50	50	100	21	16
22	10	40	7			48	47	47	96	19	12

DAY 09

01	10	18	7		L	49	47	46	89	21	12
04	10	7	6		R	44	43	42	93	19	10
07	10	21	7		LF	43	42	42	96	18	14
10	10	32	7			44	43	41	89	21	13
13	10	23	6		R	44	42	40	86	17	16
16	10	17	4		R	41	39	36	82	20	16
19	10	5	3		SF	34	34	33	96	23	8
22	10	11	3		RSF	34	34	33	96	21	9

DAY 10

01	10	10	7			34	34	33	96	22	9
04	10	7	7			35	34	33	92	23	12
07	10	5	1	8	RF	34	34	34	100	24	8
10	10	14	7			36	35	34	92	27	8
13	10	12	7			38	37	35	89	26	15
16	10	8	7			37	36	35	92	27	17
19	10	14	7			37	36	34	89	27	15
22	10	23	7			37	35	33	85	25	14

DAY 11

01	10	15	7			36	35	33	89	24	9
04	10	15	7			36	34	32	85	26	9
07	10	16	7			35	33	31	85	25	10
10	10	19	7			37	35	32	82	25	10
13	10	20	7			41	38	34	76	23	7
16	10	25	7			45	41	35	68	23	8
19	10	45	5		RF	42	40	38	86	04	6
22	10	45	5		RF	39	39	38	96	07	8

DAY 12

01			7	2		RF	40	40	40	100	08	7
04			3	1		RF	45	45	45	100	16	8
07			4	0	12	RF	42	42	42	100	27	16
10			4	1	8	LF	37	37	37	100	29	13
13			8				41	40	38	89	28	12
16			13				43	39	35	73	28	19
19			9				37	35	32	82	26	13
22			9				34	31	27	76	28	9

DAY 13

01	0	UNL	10				29	28	26	89	27	6
04	0	UNL	10				30	29	28	92	29	7
07	1	UNL	10				29	29	28	96	24	4
10	3	UNL	10				38	34	27	65	33	7
13	9	35	10				41	35	26	55	01	8
16	10	40	10				43	37	27	53	01	10
19	10	45	10				39	35	28	65	06	13
22	2	UNL	9				33	31	27	79	03	8

DAY 14

01	100	9				33	31	28	82	08	12
04	12	9				32	31	29	89	07	13
07	6	9	12		SIPF	32	32	31	96	06	18
10	5	4			LF	33	33	32	96	05	18
13	8	7				35	35	34	96	08	17
16	7	6			L	38	38	37	96	06	10
19	15	11			LF	37	37	37	100	05	6
22						37	37	36	96	21	14

DAY 15

01	6	11	8		SF	33	33	33	100	20	10
04	11	3			SF	33	33	32	96	21	10
07	5	1			SF	33	33	33	100	24	9
10	8	7			S	35	35	35	100	31	10
13	15	7			S	38	38	37	96	29	12
16	20	7			R	40	38	35	82	31	16
19	45	7				40	36	31	70	32	15
22	25	7				34	32	28	79	35	15

DAY 16

01	4	UNL	15				30	27	21	69	33	14
04	0	UNL	15				27	25	20	75	33	9
07	0	UNL	15				28	24	15	58	36	12
10	0	UNL	15				31	25	13	47	34	14
13	0	UNL	15				37	30	15	41	35	8
16	3	UNL	15				42	34	19	40	00	0
19	9	UNL	15				43	34	17	35	00	0
22	2	UNL	13				35	30	22	59	15	6

DAY 17

01	5	UNL	10				32	30	25	75	00	0
04	0	UNL	10				28	27	23	82	00	0
07	1	UNL	8				31	30	27	86	18	7
10	200	9					43	37	27	53	24	10
13	200	10					52	42	30	43	29	5
16	200	8					53	43	31	43	30	8
19	100	8					50	44	37	61	29	5
22	1	UNL	11				43	39	35	73	26	4

DAY 18

01	0	UNL	13				39	36	33	79	24	6
04	0	UNL	10				40	37	33	76	23	7
07	0	UNL	7				39	37	35	86	25	5
10	2	UNL	7				53	47	40	62	28	6
13	2	UNL	7				62	51	40	45	29	7
16	1	UNL	9				65	51	38	37	20	3
19	0	UNL	8				63	53	43	48	27	6
22	0	UNL	8				50	46	42	74	18	4

DAY 19

01	0	UNL	8				47	44	41	90	21	4
04	0	UNL	8				43	41	39	86	23	3
07	0	UNL	7				46	44	41	83	23	5
10	0	UNL	7				64	52	41	43	24	15
13	0	UNL	7				69	55	43	39	24	16
16	10	UNL	8				70	54	38	31	22	17
19	8	UNL	8				65	53	42	43	27	6
22	6	UNL	11				60	50	40	48	21	10

DAY 20

01	70	7				52	50	48	86	11	3
04	UNL	7				48	46	45	89	25	3
07	UNL	7				45	45	45	100	00	0
10	UNL	7				63	54	47	56	02	5
13	UNL	11				68	55	44	42	02	7
16	UNL	13				70	54	40	34	35	6
19	UNL	13				64	50	36	35	07	8
22	UNL	20				49	42	34	56	10	4

DAY 21

01	UNL	20				44	39	32	63	10	5
04	UNL	10				36	35	33	89	06	3
07	UNL	8				39	38	36	89	00	0
10	UNL	8				61	45	24	24	17	5
13	250	11				68	51	34	29	00	0
16	90	11				68	51	32	26	26	6
19	UNL	11				66	50	32	28	21	4
22	UNL	20				59	47	35	41	18	4

DAY 22

01	0	UNL	20				54	46	38	55	19	8
04	0	UNL	10				53	46	38	57	20	10
07	0	UNL	10				57	47	37	47	21	13
10	0	UNL	10				71	58	48	44	25	16
13	0	UNL	10				83	64	51	33	28	16
16	0	UNL	10				85	62	45	25	29	13
19	0	UNL	10				78	61	49	36	24	8
22	4	UNL	10				72	58	48	43	19	9

DAY 23

01	0	UNL	10				64	55	48	56	28	10
04	0	UNL	10				54	46	38	55	33	17
07	0	UNL	10				41	36	30	65	33	18
10	1	UNL	10				48	40	29	48	34	16
13	1	UNL	10				55	44	30	39	35	12
16	1	UNL	10				58	45	30	35	29	12
19	2	UNL	10				53	41	25	34	32	13
22	2	UNL	10				43	38	31	63	07	7

DAY 24

01	8	70	10				39	36	33	79	08	7
04	80	10					36	33	29	76	07	6
07	5	0	12	S			33	33	32	96	04	8
10	3	0	8	SF			32	32	32	100	03	10
13	5	0	8	SF			33	33	33	100	36	12
16	5	1		S			34	34	34	100	35	12
19	5	1		S			33	33	33	100	36	10
22	5	0	12	S			32	32	32	100	36	8

DAY 25

01	10	4	2		SF	33	33	33	100	32	7
04	9	46	4		F	34	34	33	96	31	7
07	2	UNL	6		F	33	33	32	96	30	7
10	0	UNL	7			43	40	36	76	35	7
13	5	UNL	9			48	42	36	83	28	7
16	7	45	9			52	42	30	43	28	10
19	1	UNL	9			49	43	35	61	29	8
22	3	UNL	9			38	36	34	86	28	9

DAY 26

01	UNL	7				33	32	31	92	27	4
04	UNL	6	F			31	31	30	96	26	4
07	UNL	4	F			34	34	33	96	34	6
10	11	7				44	42	39	83	34	7
13	19	9				46	43	40	80	34	7
16	32	9				49	45	41	74	02	7
19	32	9				49	45	41	74	03	8
22	40	9				47	45	42	83	35	5

DAY 27

01	10	5	5		F	45	45	45	100	05	7
04	10	6	5		F	43	42	42	96	05	10
07	10	6	7		F	41	41	40	96	01	9
10	40	7	7			45	43	40	93	03	10
13	45	7	7			50	46	41	71	03	7
16	45	7	7			54	46	37	53	03	12
19	45	7	7		R	51	44	37	59	03	12
22	28	5			R	44	43	42	93	03	13

DAY 28

01	10	5	4		RF	44	44	44	100	01	15
04	10	5	4		RF	44	44	44	100	02	15
07	10	4	2		RF	44	44	44	100	04	14
10	10	13	7			46	44	42	86	10	15
13	10	25	7			48	45	42	80	07	12
16	10	32	9			55	48	41	59	10	9
19	10	10	2		R	49	48	48	96	04	12
22	10	6	3		RF	48	48	48	100	04	7

DAY 29

01	10	5	3		RF	46	46	46	100	02	6
04	10	5	3		F	46	46	46	100	05	4
07	10	5	3		F	46	46	46	100	05	7
10	10	9	7			49	48	47	93	07	6
13	10	28	9			50	48	46	86	02	8
16	10	32	7		L	50	48	47	89	36	7
19	10	12	3		RF	47	47	47	100	04	4
22	10	5	3		LF	46	46	46	100	00	0

DAY 30

01	10	25	4		F	46	46	46	100	36	3
04	10	2	1	8	LF	46	46	46	100	00	0
07	10	3	1		LF	46	46	46	100	36	4
10	10	5	5		F	48	48	48	100	01	6
13	9	38	7			53	49	46	77	00	0
16	10	20	7			53	49	46	77	33	4
19	9	45	8			55	50	45	69	36	5
22	2	UNL	7			43	42	42	96	00	0

STATION

LANSING MICH

YEAR & MONTH

80 04

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS, INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

wind speed and direction information is needed to help in the interpretation of the data obtained. Tables 4 to 13 give weekly distributions of wind speeds and directions for the area. Wind roses for the weekly periods when sampling took place are also shown in Figures 1 and 2. The positions of the spokes show the direction from which the wind was blowing, the length of the segments indicate the percentage of the time in various groups.

Table 4 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	FEB 13 - FEB 20			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.0	2.33	0.0	0.0
NNE	0.47	4.21	0.0	0.0
NE	0.0	6.54	0.0	0.0
ENE	0.0	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0
ESE	0.0	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0
SSE	0.0	0.93	0.0	0.0
S	0.0	5.14	2.80	0.0
SSW	0.0	8.88	9.35	0.0
SW	0.0	3.74	15.42	0.0
WSW	0.0	7.01	5.14	0.0
W	0.0	7.01	0.47	0.0
WNW	0.0	2.80	0.93	0.0
NW	0.47	4.21	3.74	0.0
NNW	0.47	3.27	0.93	0.0
Calm = 3.74%				

*Based on 214 observations taken over a week period.

Table 5 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	FEB 20 - FEB 27			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.0	2.38	1.98	0.0
NNE	0.0	2.38	5.95	0.0
NE	0.0	1.59	0.79	0.0
ENE	0.0	2.38	0.79	0.0
E	0.0	5.16	2.38	0.0
ESE	0.0	0.79	1.19	0.0
SE	0.0	0.0	0.0	0.0
SSE	0.0	0.0	0.0	0.0
S	0.0	1.98	0.79	0.0
SSW	0.0	4.37	1.98	0.0
SW	0.0	2.38	3.57	0.0
WSW	0.40	4.76	3.17	0.0
W	0.79	9.52	8.33	0.40
WNW	0.40	6.75	7.54	0.0
NW	0.79	2.38	2.78	0.0
NNW	0.0	2.78	1.59	0.0
Calm = 4.76				

*Based on 252 observations taken over a week period.

Table 6 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	FEB 27 - MAR 5			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.91	12.79	6.85	0.0
NNE	0.46	2.74	2.28	0.0
NE	0.0	0.91	0.0	0.0
ENE	0.91	2.74	0.0	0.0
E	1.37	0.91	0.46	0.0
ESE	0.0	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0
SSE	0.0	0.0	0.0	0.0
S	0.0	0.91	1.37	0.0
SSW	0.46	5.48	2.74	0.0
SW	0.0	5.48	5.02	0.0
WSW	0.0	5.48	0.46	0.0
W	0.46	4.11	1.83	0.0
WNW	0.0	4.28	7.31	0.0
NW	0.0	3.19	5.02	0.0
NNW	1.37	3.65	3.19	0.0
Calm = 6.85				

*Based on 219 observations taken over a week period.

Table 7 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	MAR 5 - MAR 12			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.44	3.04	2.17	0.0
NNE	0.0	3.48	0.44	0.0
NE	0.0	1.30	1.30	0.0
ENE	0.87	8.26	0.0	0.0
E	0.0	1.30	3.04	0.0
ESE	0.0	0.87	2.61	0.0
SE	0.44	1.74	0.87	0.0
SSE	0.0	0.44	0.0	0.0
S	0.0	1.30	0.87	0.0
SSW	0.0	2.17	3.91	0.0
SW	0.44	9.10	6.96	0.0
WSW	0.0	5.22	2.17	0.44
W	1.30	4.35	3.04	2.61
WNW	0.44	0.87	6.96	1.74
NW	0.44	1.74	2.17	0.44
NNW	0.0	1.74	1.30	0.0
Calm = 5.65				

*Based on 230 observations taken over a week period.

Table 8 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

Direction	MAR 12 - MAR 19 Speed in Knots			
	1-3	4-10	11-21	≥22
N	0.0	2.21	0.44	0.0
NNE	0.0	0.44	0.0	0.0
NE	0.0	0.88	0.44	0.0
ENE	0.44	2.21	0.44	0.0
E	0.0	5.37	9.29	0.0
ESE	0.0	2.65	3.98	0.0
SE	0.0	1.33	3.54	0.0
SSE	0.0	0.44	3.98	0.0
S	0.44	2.21	9.29	0.0
SSW	0.0	5.31	5.75	0.0
SW	0.44	0.44	0.88	0.0
WSW	0.0	0.44	1.33	0.0
W	0.0	3.54	7.52	0.0
WNW	0.0	4.87	7.96	0.0
NW	0.0	3.10	1.77	0.0
NNW	0.0	2.65	1.77	0.0
Calm = 2.21				

*Based on 226 observations taken over a week period.

Table 9 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	MAR 19 - MAR 26			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.0	4.00	7.50	0.0
NNE	0.0	2.50	4.00	0.0
NE	0.0	4.50	1.00	0.0
ENE	0.0	4.00	0.0	0.0
E	0.0	2.50	0.0	0.0
ESE	0.0	3.00	0.0	0.0
SE	0.0	3.50	1.50	0.0
SSE	0.0	4.00	3.00	0.0
S	0.0	1.50	3.00	0.0
SSW	0.0	4.00	8.50	0.0
SW	0.0	1.50	2.00	0.0
WSW	0.0	1.00	0.0	0.0
W	0.50	0.0	0.0	0.0
WNW	0.0	3.50	1.50	0.0
NW	0.50	4.50	6.50	0.0
NNW	1.00	4.50	4.50	0.0
Calm = 6.50				

*Based on 200 observations taken over a week period.

Table 10 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	MAR 26 - APR 2			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.46	2.29	0.92	0.0
NNE	0.46	7.34	12.84	0.46
NE	0.46	11.01	8.72	0.0
ENE	0.0	8.72	6.88	0.0
E	0.0	4.59	1.83	0.0
ESE	0.46	1.38	0.0	0.0
SE	0.0	5.05	0.0	0.0
SSE	0.46	0.46	1.38	0.0
S	0.0	4.13	0.46	0.0
SSW	0.0	0.0	0.0	0.0
SW	0.0	1.83	0.0	0.0
WSW	0.0	0.92	0.0	0.0
W	0.46	0.46	0.0	0.0
WNW	0.0	0.0	0.0	0.0
NW	0.46	0.0	0.0	0.0
NNW	1.38	0.0	0.0	0.0
Calm = 13.76				

*Based on 218 observations taken over a week period.

Table 11 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	APR 2 - APR 9			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.0	0.86	0.0	0.0
NNE	0.0	0.43	0.0	0.0
NE	0.0	4.29	0.0	0.0
ENE	0.0	3.43	0.0	0.0
E	0.0	5.58	0.86	0.0
ESE	0.0	2.58	5.58	0.0
SE	0.0	4.29	3.00	0.0
SSE	0.0	2.58	6.44	0.0
S	0.0	4.29	13.30	0.43
SSW	0.0	2.15	8.15	0.0
SW	0.0	5.58	1.29	0.0
WSW	0.0	2.15	0.43	0.0
W	0.0	4.72	5.58	0.0
WNW	0.0	0.86	0.86	0.0
NW	0.0	0.43	2.58	0.0
NNW	0.0	0.43	2.15	0.0
Calm = 5.58				

*Based on 233 observations taken over a week period.

Table 12 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

	APR 9 - APR 16			
	Speed in Knots			
Direction	1-3	4-10	11-21	≥22
N	0.0	4.00	2.22	0.0
NNE	0.0	0.84	0.0	0.0
NE	0.0	0.84	7.67	0.0
ENE	0.0	4.00	6.67	0.89
E	0.0	3.11	2.22	0.0
ESE	0.0	0.0	0.0	0.0
SE	0.0	1.33	0.0	0.0
SSE	0.44	1.33	0.0	0.0
S	0.0	1.78	5.78	0.44
SSW	0.0	4.89	6.22	0.0
SW	0.0	3.11	1.78	0.0
WSW	0.44	4.44	0.89	0.0
W	0.0	7.56	11.11	0.0
WNW	0.44	3.56	4.44	0.0
NW	0.0	4.44	3.56	0.0
NNW	0.0	1.78	1.78	0.0
Calm = 0.89				

*Based on 225 observations taken over a week period.

Table 13 : Distribution of Wind Speed and Direction at the NSCL (frequency given in percentages)*

Direction	APR 16 - APR 23			
	Speed in Knots			
	1-3	4-10	11-21	≥22
N	0.0	2.62	4.19	0.0
NNE	0.0	3.66	0.0	0.0
NE	0.0	1.05	0.0	0.0
ENE	0.52	1.57	0.52	0.0
E	0.0	2.62	0.0	0.0
ESE	1.5	0.52	0.0	0.0
SE	0.0	1.05	0.0	0.0
SSE	0.52	1.05	0.0	0.0
S	0.52	7.33	0.0	0.0
SSW	0.52	9.95	0.52	0.0
SW	0.52	4.19	1.57	0.0
WSW	1.05	6.81	3.66	0.0
W	0.0	4.71	5.24	0.0
WNW	0.52	5.76	2.09	0.0
NW	0.0	2.62	2.09	0.0
NNW	0.0	2.62	6.28	0.0
Calm = 9.95				

*Based on 191 observations taken over a week period.

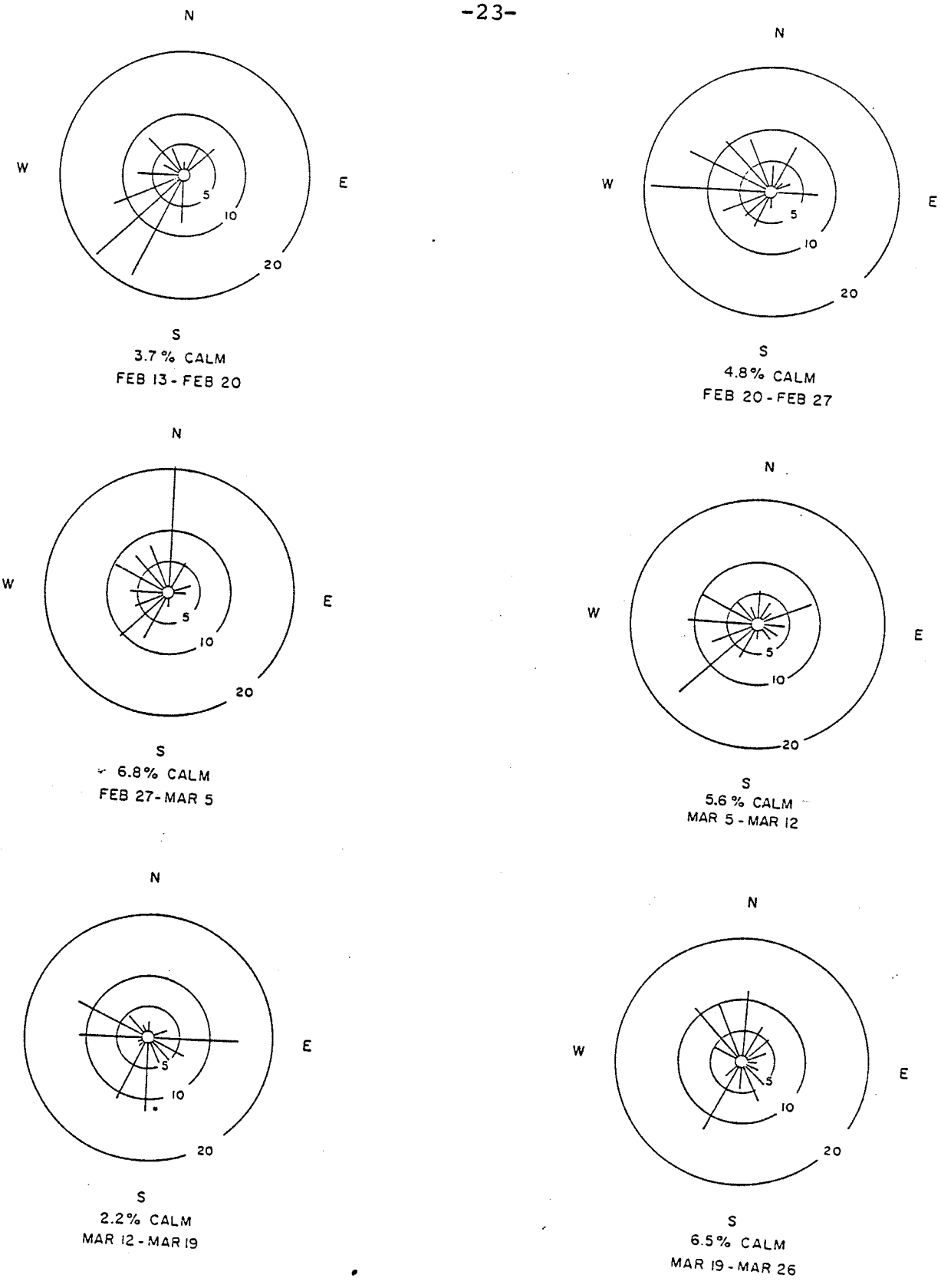

Figure 1. Wind Roses for the NSCL Area during February 13th to March 26th

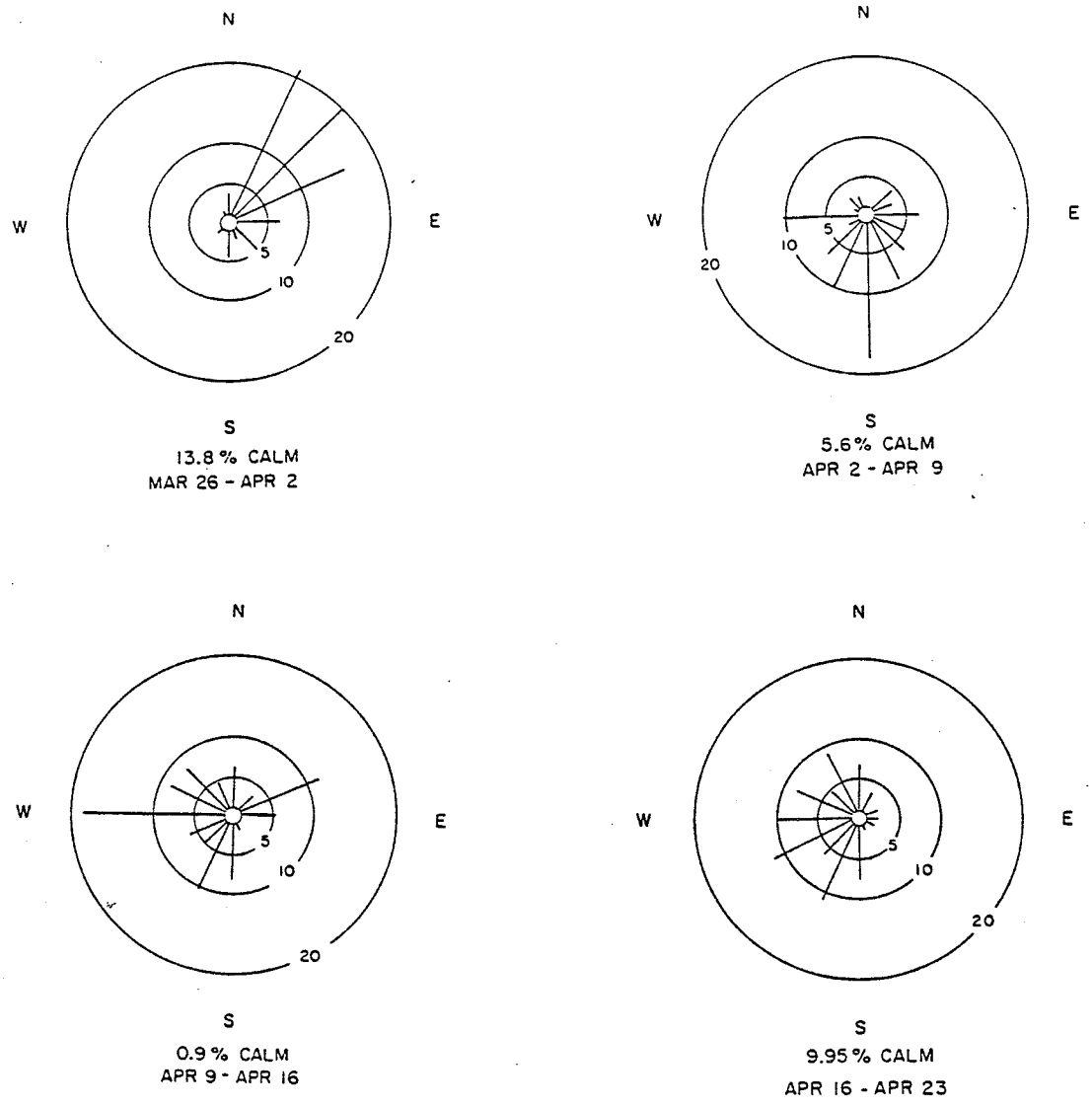

Figure 2. Wind Roses for the NSCL Area during March 26th to April 23rd

2. The Pre-operational Environmental Surveillance Program at the NSCL

Many objectives for environmental surveillance programs have been expressed before[1,2,3,4,5,6,7]. According to Denham[8], the 4 primary purposes are:

"1) to assess the actual or potential radiation dose to persons in the site environs.

2) to test the compliance or non-compliance of observed data with standards and regulations expressed in annual doses.

3) to verify that effluent controls are adequate and have not deteriorated and

4) to check for long term build up and to predict environmental trends from plant-released radioactivity."

In order to fully understand the results of an environmental program during the operational phase of a nuclear facility, baseline environmental data are needed for comparison with later operational studies. Therefore a pre-operational program was established for the NSCL with the purpose of assessing "background" levels and their variations in environmental media, in the area surrounding the laboratory.

The study was conducted based on the two population exposure pathways considered the most important, which are the air and water.

2.1 Air Sampling

Radioactive air particles are measured because of the health hazard associated with their inhalation, deposition on surfaces or ingestion. Air monitors are used for environmental

and laboratory monitoring of airborne radioactivity.

The most common type of air sampling is done by membrane filtration. By this technique, a known volume of air is passed through a collecting medium with a vacuum pump. The deposited radioactivity is then measured with appropriate instrumentation. A flowmeter is used to record the flow rate (or total flow) through the system.

The collecting medium can be chosen from a variety of filters, for instance glass fiber, paper and cellulose-asbestos fiber. Collection efficiency, resistance to air flow and particle size selectivity are some of the considerations during selection of a filter[5]. Long sampling times can be the cause of a marked decrease in the air flow if proper filter selection is not accomplished. In those cases a combination of high collection efficiency and low pressure drop when loaded are desirable filter characteristics.

Glass fiber filters are often used in air samplers for environmental studies. Some of their advantages include reduced hygroscopicity and higher collection efficiencies at a comparable pressure drop. One of the major problems is in the quality control, due to the variability in the composition and properties of the glass fiber filters (glass, glass fiber, fiber mat and packing). Therefore, the chemical analysis is hindered. The loss of filter fibers during sample collection is another disadvantage[9].

Advantages and disadvantages have to be balanced out so that the filter which is best adapted to the individual air sampling requirements can be chosen.

The filters collected can be used in a variety of ways, such as for particle size studies, autoradiography, or can be

counted individually for beta or alpha radioactivity. For gross alpha counting, high surface retention filters are desirable to minimize penetration, and loading should be kept below $1 mg/cm^2$ to minimize self-absorption[9]. If gamma-spectrometry is to be used, a sample size of 300 m^3 of air is recommended. By continuous sampling at 1 cubic foot per minute, one week is necessary to acquire about 300 m^3 total volume[1].

Small volume continuous air samplers are used when long sampling times are involved. In those cases or when heavy dust loadings are present, variations of flow-rate can result in errors, even though small, in calculating the volume of air sampled. Initial and final flow-rate readings are usually recorded and the average result is used as representative of the flow during the sampling period[10].

Changes with temperature and pressure can also lead to errors due to changes in the flowmeter calibration. All flow rates can be corrected to standard conditions by using the equation below:

$$F = \frac{273}{760} \times \frac{(P_L)}{(273+T)} \times Fm \qquad \text{equation 1}$$

where,

F is the corrected flow-rate

P_L is the local pressure (mmHg)

T is the local temperature (^oC)

Fm is the measured flow-rate

Once the sampling equipment is decided upon, the location of the unit(s) must then be considered. For nuclear power plants operational programs, it is recommended

that low volume air samplers be placed at each of the three locations where the offsite ground level concentration predicted is the highest. In addition, one sample from each of one to three communities from one to ten miles radius from the plant, and at a distant control site 20 or more miles away in the prevailing upwind direction[1]. Such recommendations were used as guidelines for establishing the sampling stations for the pre-operational program at the NSCL.

The selection of the locations can be performed by using the plot in Figure 3, which positions the sampling sites at a distance from the release point based on the height of radionuclide release, in combination with prevalent wind direction and stability condition data. The predominant stability condition (Pasquil Atmospheric Stability Condition) of the time of the year during monitoring can be used[1,11].

2.1.1. Materials and Methods

Atmosphere sampling for the pre-operational program at the NSCL was performed by using two low volume air samplers*, properly sheltered in wooden boxes made especially for the weather conditions of the season, that is, from February 13th to April 23rd, 1980.

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*Air sampling kit. cat. no. 4-25004. Bendix Environmental and process Instrument Division. Lewisburg, WV.
RAS-2 Air Sampler. Eberline Instrument Corporation, Santa Fe, NM

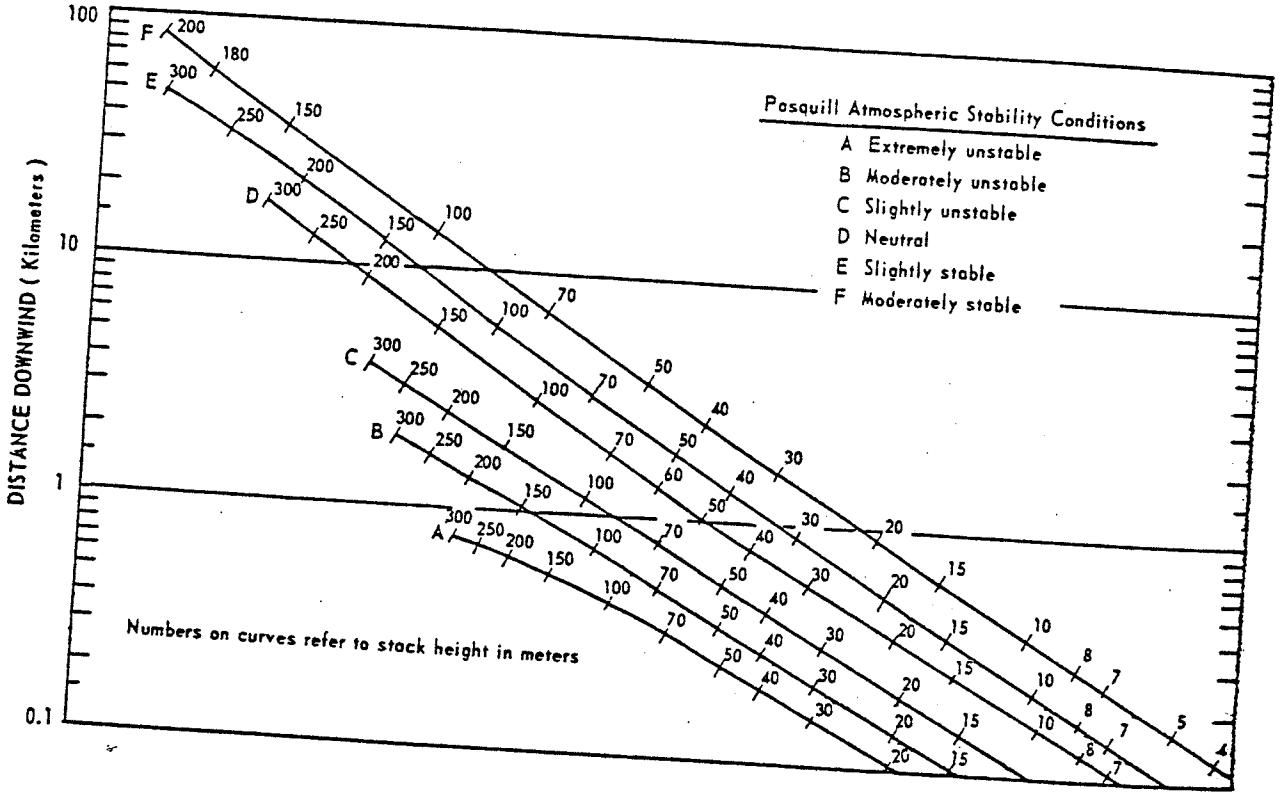

Figure 3. Estimated distance of maximum ground level concentrations as a function of Pasquill atmospheric stability conditions and stack height in meters[11].

Each sampler was randomly assigned to a location every week, so that, at the end of a nine week period of sampling, the background radioactivity level could be determined at all the chosen locations. The air samplers were continuously operated for a week before the filter* was collected. The samplers were checked for proper operating conditions prior to use. The calibration curve supplied with each sampler, that is, flow-rate reading versus vacuum at intake was also checked. From those tests, both samplers showed similar performance characteristics and were considered to be operating at these specifications during the course of the experiment.

The experimental layout is shown in Table 14, where one can see how the locations were assigned to the weekly sampling periods.

The locations selected are presented in Figures 4, 5, and 6 and they are:

Location 1: Owen Hall (Co-Ed Dormitory);

Location 2: Pesticide Research Bldg.;

Location 3: Shaw Hall (Co-Ed Dormitory);

Location 4: Veterinary Clinic;

Location 5: McDonald Middle School; and

Location 6: M.S.U. Credit Union (close to Spartan Village: University housing for married students.).

*Gelman, Type A/E glass fiber filter, 47mm, nominal pore rating of 1μm. Gelman Sciences Inc., Ann Arbor, MI

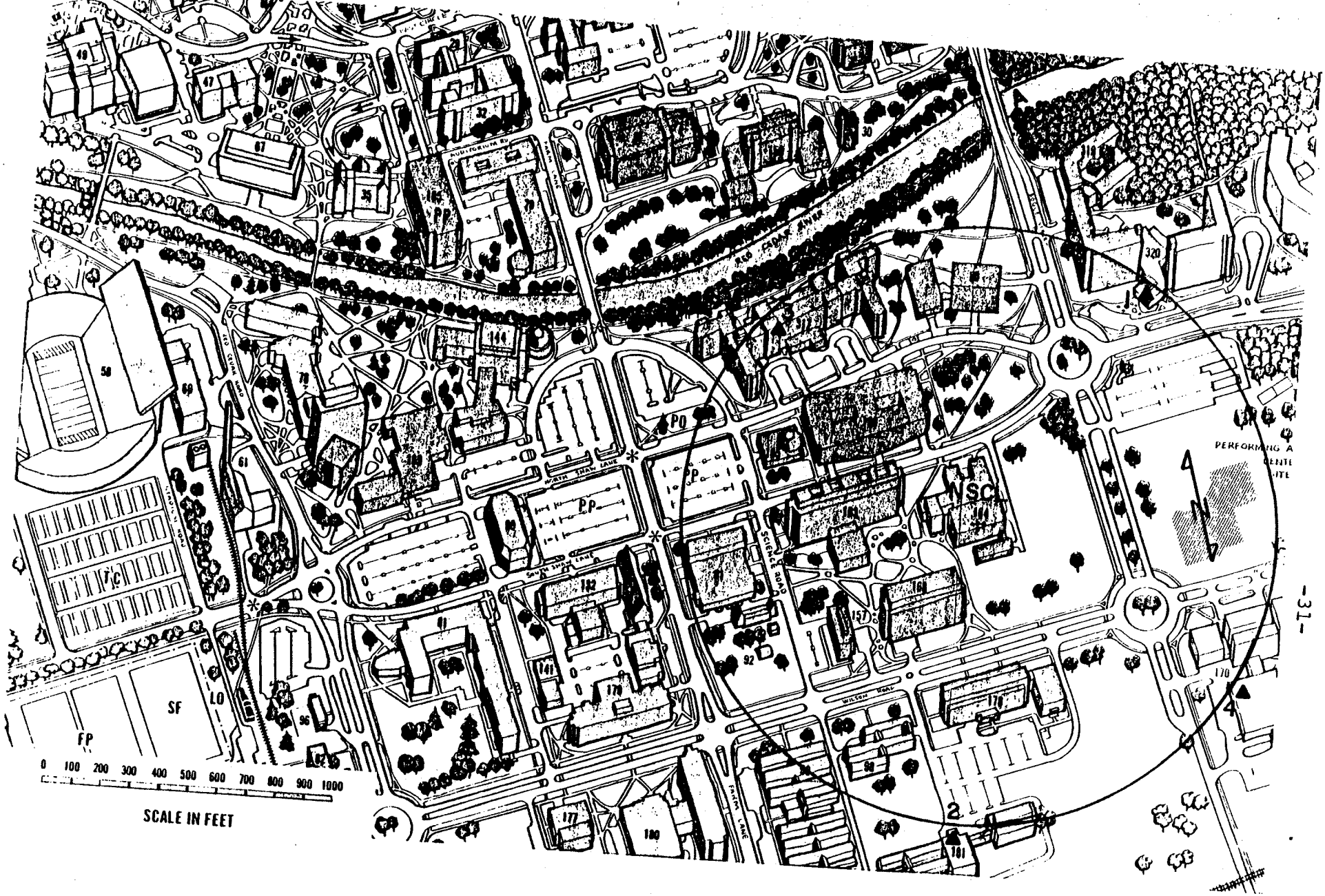

Figure 4. Air and Water Sampling Stations

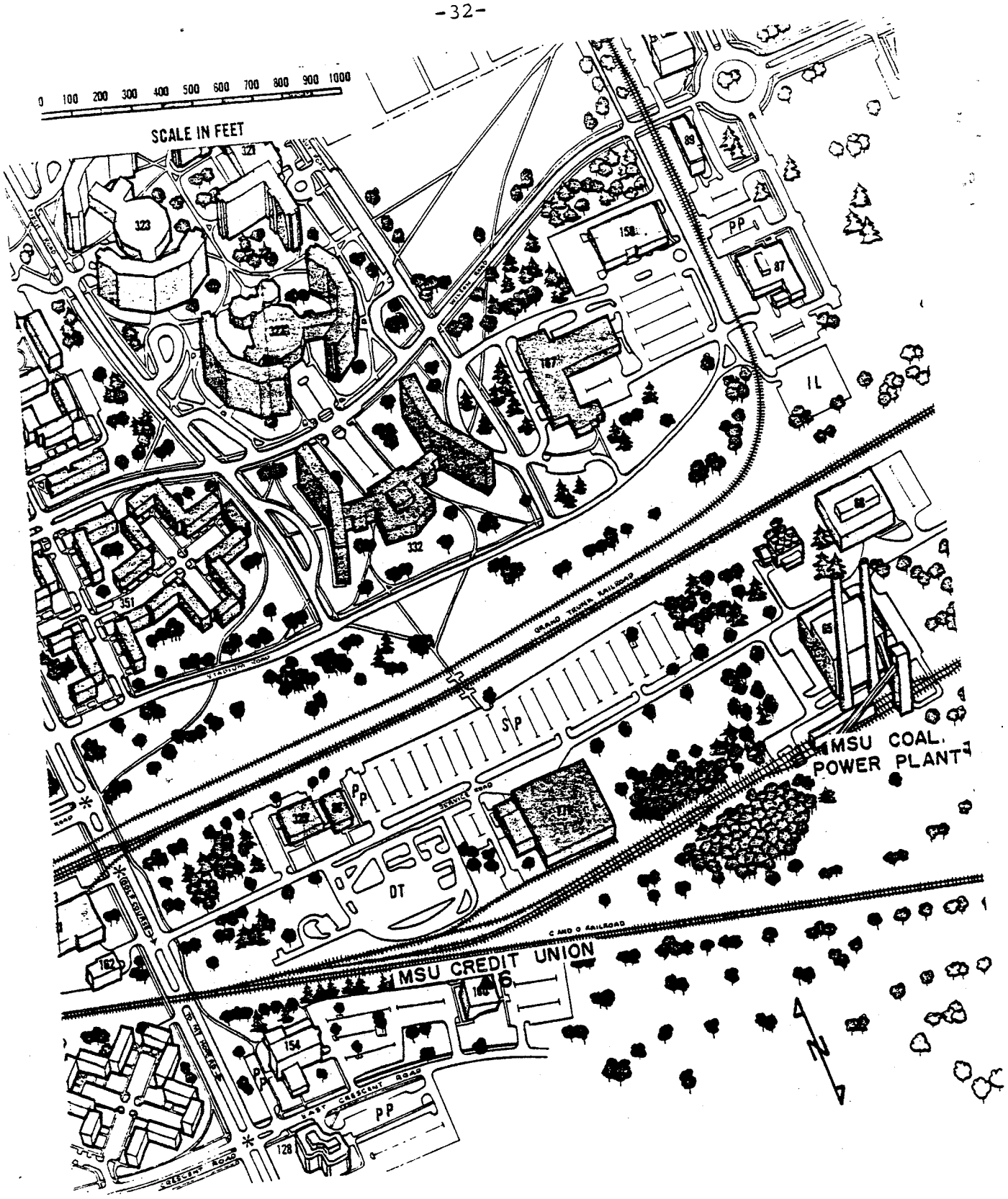

Figure 5. Air Monitoring Stations No. 6

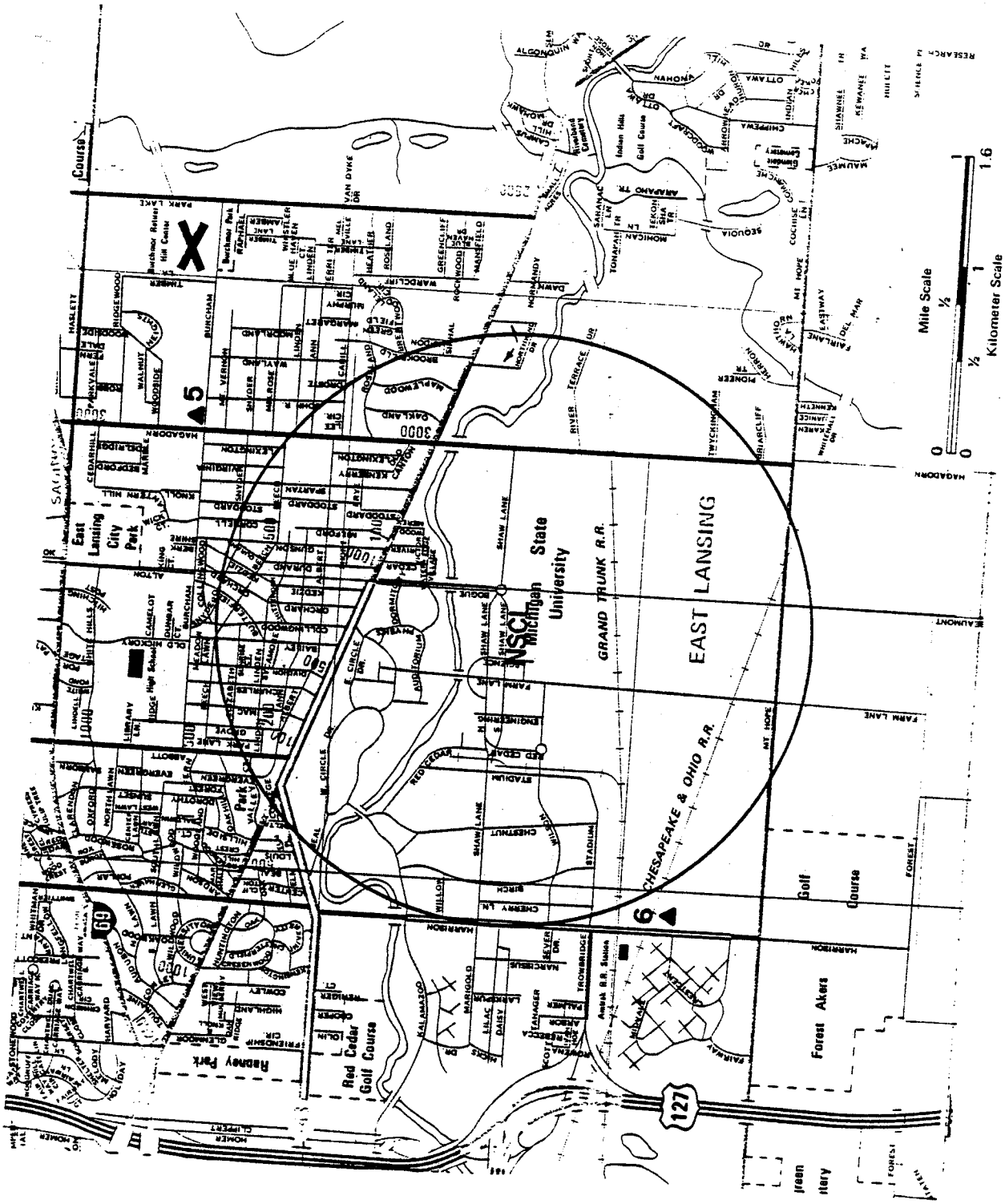

Figure 6. Air Monitoring Stations No. 5 and 6.

Table 14. Air Monitoring Experimental Design

SAMPLER					
I			II		
LOCATIONS					
4	1	2	3	5	6
WEEKS					
8	9	1	4	6	8
4	3	7	9	2	5
2	5	6	7	3	1

Locations 1 to 4 are 350m distant from the NSCL. This distance was determined using stability condition D and represents the distance where the offsite ground level concentration of the released radioactivity is the highest. According to Turner[11], stability condition D should be assumed for overcast winter days (or nights).

The yearly prevalent wind was reported to be southwesterly, averaging about 11 mph according to a past climatological survey by the U.S. Department of Commerce. This wind direction was used as a basis for locating the sampling stations 5 and 6, at about 1 mile from the NSCL. Location 7 shown in figure 7 was selected to be sampled only after all others were, and was not randomly assigned to the "weeks" referred to previously. Location 7 (Holt High School) is about 15 miles from the NSCL

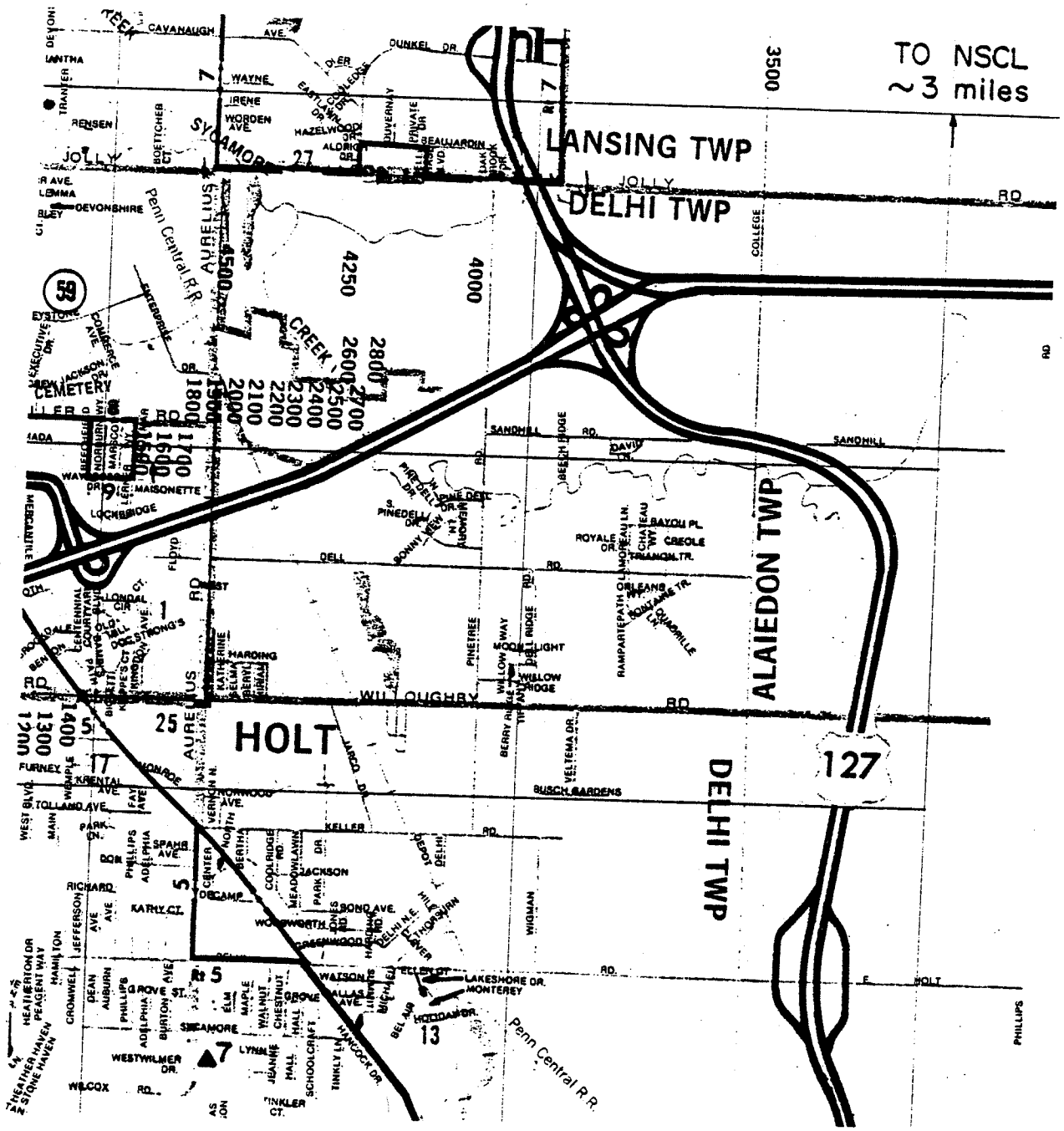

Figure 7. Air Monitoring Control Station

in the prevalent upwind direction, and it was thought to be a suitable "control" location for further studies to be carried out during the operational phase. Due to the fact that location 7 was not included in the randomization procedure, it will not be included in the statistical model selected for analysis of the samples and the results from this location will not be statistically compared to the results from the other 6 locations.

The air sampling procedure is summarized below in 5 phases.

Phase 1: Air samplers were assigned to the chosen locations every week. At the end of the weekly sampling period the 2 filters were collected and the samplers were placed in the next assigned location (as shown in Table 14). The flow rate was recorded at the beginning and end of the sampling period and an average value was calculated. Flow rate variation ranged from 58 lpm to 60 lpm. Flow rate readings were corrected for temperature and pressure to standard conditions. Elapsed time was also recorded (a timer was installed in the samplers, so that power outages during the week were detected and the total sampling time could be accurately known). The volume being sampled was calculated by multiplying the corrected average flow rate by the total sampling time.

Phase 2: Equipment to be used for filter analysis was calibrated every week before counting. The equipment consisted of: a) low background proportional counter,* operating at 43% efficiency (betas) and 32% (alpha) efficiency and calibrated using a ^{90}Sr (βmax=0.546 MeV) beta source and ^{241}Am (5.48 MeV, 85.2%) alpha

*Beckman Lowbeta II, model #1600. Beckman Instruments Incorporated, Fullerton, CA.

source. Such sources are normally used for environmental work and b) a Ge(Li) detector[+] used with a ND660[‡] system. A mixed radionuclide gamma-ray standard[**], placed in the same position as filters, was used for the gamma-system absolute calibration. The efficiency curve is shown in Figure 8. A blank filter background count was taken for 1 hour for the filters, prior to their usage.

Phase 3: Precisely 30 minutes after the sampling time ended, the filter was counted on the Ge(Li) detector for 30 minutes. The detector was completely enclosed in a 2 inch lead shield during counting. The data for the gamma analysis, accumulated on floppy disks were used to plot a spectrum to check on the naturally occurring radioactive particles deposited on the filters which were short lived plus any contribution of short lived contaminants that might be in the air. After the "30 minutes" spectrum was recorded, 3.5 additional hours of counting were stored so that better counting statistics would be achieved. Therefore, the second spectrum contained the data accumulated for 4 hours total, beginning 30 minutes after the sampling time ended. It was used to identify and quantify the longer lived radionuclides present in the filter.

Phase 4: Gross alpha counting of the filter was performed 27 hours after the end of the sampling period, and gross beta counting 2 days after. A blank filter was used as the background so that the net counts could be reported. Time intervals of 50 minutes

+Ortec, 4.5% Eff., model #8101-0325, 2.8 keV Resolution. Ortec Incorporated, Oak Ridge, TN.

‡Nuclear Data System, ND660. Nuclear Data Inc., Schaunburg, IL.

**NBS standard Reference Material 4215-F No. 24, 1978.

were used for counting and filters were usually counted for 5 consecutive intervals.

Phase 5: The information accumulated on the floppy disks were read into a Xerox Sigma-7 computer located at the NSCL. Files were made of each spectrum and saved for later analysis. Such

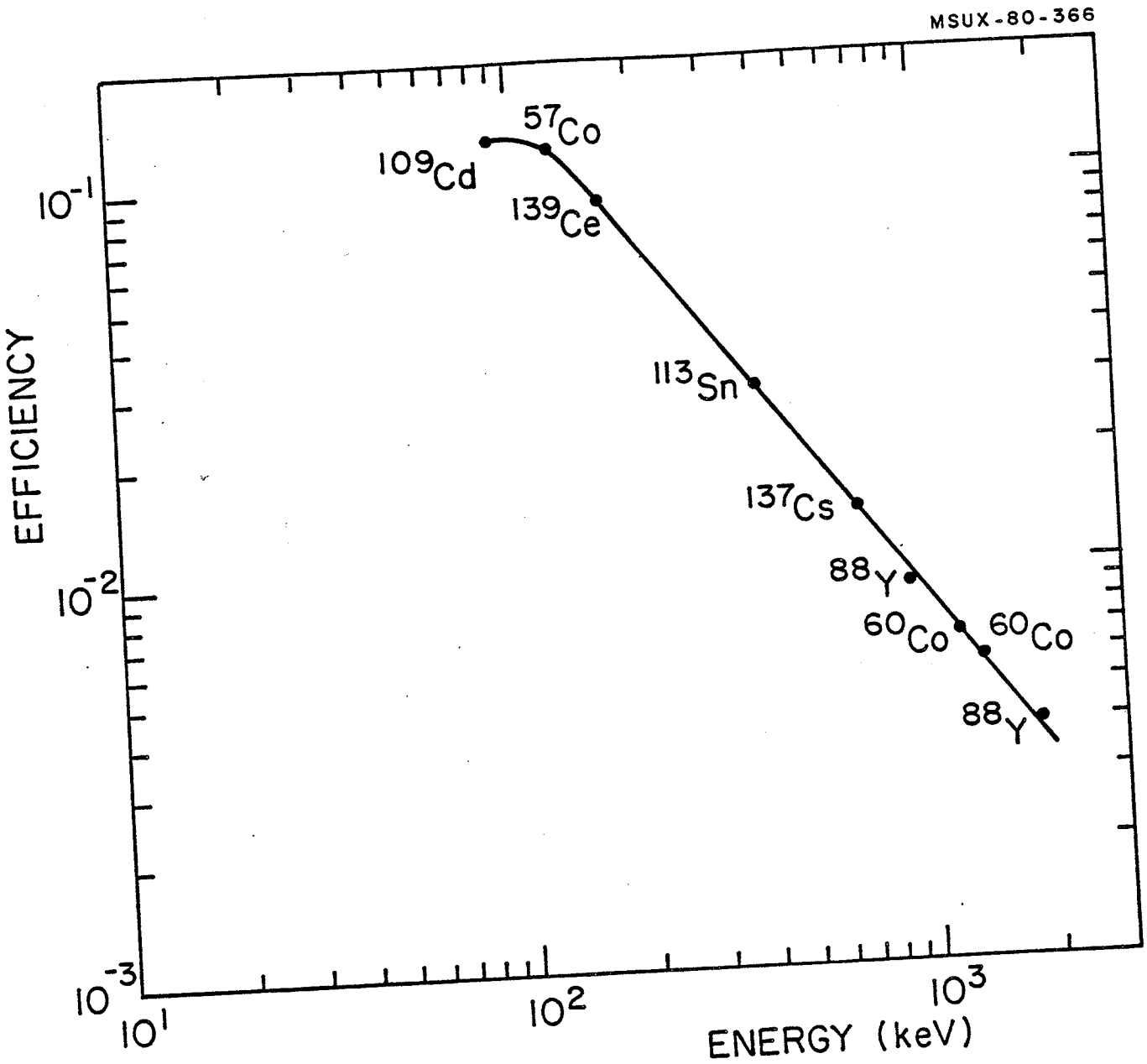

Figure 8. Efficiency Curve for Ge(Li) Used

analysis was performed by using a fitting program[13] which gives the net area (counts) for each peak fitted and the percent error in the area. From these data, the activity in picoCuries (pCi) was determined by dividing the number of counts by the counting time and, peak efficiency and the conversion factor 2.22 dpm/pCi. Once the activity was determined for each long-lived radionuclide identified, not part of the Uranium or Thorium series, the concentration (C) expressed in pCi per m^3 of air was determined, according to Helgeson[12], by

$$C = \frac{A}{cV(1-b)} \qquad \text{equation 2}$$

where A = activity (pCi)

c = filter collection efficiency (0.99)

V = total volume (m^3)

b = absorption factor of particles in filter media (zero for γ's)

A geometrical correction due to the finite sample size was also used.[36]

The concentration equation, in case of short lived radionuclides, due to saturation during sampling, may be calculated by

$$C = \frac{A\, e^{-\lambda_i t_d}}{cV\, T_i\, (1-b)} \qquad \text{equation 3}$$

where,

λ_i = the decay constant of the i^{th} radionuclide

t_d = the delay time before counting

T_i = the half-life of the i^{th} radionuclide

A, C, V, b = as in the previous equation.

The decay correction during sampling, $(1-e^{-\lambda_i t_s})$ will be equal to 1 in this case, since t_s (sampling time) is large and

$e^{-\lambda_i t_s} = e^{\infty} = 0$.

2.1.2. Results

Gross Beta Analysis

Gross beta counting was performed 2 days after the filter was removed. It is recommended that particulate sample filters should be analysed for gross beta after at least 24 hours to allow for radon and thoron daughter decay[1].

The activity per cubic meter of air (pCi/m^3) was calculated based on the knowledge of the average flow rate, the sampling time, the filter collection efficiency and the counting efficiency for the beta particles in question and it is reported in Table 15 in modified scientific notation. Two filters (week of Apr. 2-9 and 9-16) were not used due to problems during sampling. Vandalism and a blown fuse during a power outage were the causes.

Three regression analyses were performed on the data for the filters collected. The SPSS* program "Regression" was used. The mathematical models (first order) with independent variables L for "locations" and W for "weeks" are of the form:

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*SPSS = Statistical Package for the Social Sciences

Table 15: Air Monitoring Gross β Concentrations[a]

WEEK	LOCATION	(pCi/m^3) MEAN±SD
FEB 13-20	4	3.2(E-2)±1.3(E-3)
FEB 13-20	5	4.5(E-2)±2.9(E-3)
FEB 20-27	1	2.1(E-2)±6.4(E-4)
FEB 20-27	5	2.3(E-2)±5.7(E-4)
FEB 27 - MAR 5	4	2.0(E-2)±8.4(E-4)
FEB 27 - MAR 5	3	1.9(E-2)±2.0(E-3)
MAR 5 - MAR 12	1	2.1(E-2)±8.0(E-4)
MAR 5 - MAR 12	6	2.2(E-2)±2.7(E-3)
MAR 12 - MAR 19	2	1.6(E-2)±1.3(E-3)
MAR 12 - MAR 19	5	1.8(E-2)±1.0(E-3)
MAR 19 - MAR 26	2	1.6(E-2)±1.5(E-3)
MAR 19 - MAR 26	3	1.9(E-2)±4.0(E-4)
MAR 26 - APR 2	4	1.7(E-2)±9.9(E-4)
MAR 26 - APR 2	6	1.5(E-2)±2.4(E-4)
APR 2 - APR 9	1	1.5(E-2)±4.6(E-4)
APR 9 - APR 16	6	6.0(E-3)±5.2(E-4)
APR 16 - APR 23	7	3.1(E-2)±3.4(E-3)

a The lower limit of detection (LLD) as defined in HASL-300 was calculated to be 4.8(E-3) pCi/m^3 at the 95% confidence level.

model 1:

$$Y = \beta_o + \beta_1 L_1 + \ldots \beta_6 L_6 + \gamma_1 W_1 + \ldots \gamma_9 W_9 + \varepsilon \quad \text{equation 4}$$

model 2: equation 5

$$Y = \beta_o + \beta_1 L_1 + \ldots \beta_6 L_6 + \varepsilon$$

model 3: equation 6

$$Y = \beta_o + \gamma_1 W_1 + \ldots + \gamma_9 W_9 + \varepsilon$$

where,

Y is the dependent variable in pCi/m^3

β and γ's are regression parameters

L represents the locations where the samplers were placed

W represents the time periods sampling took place

ε is the error term

The null hypothesis tested in the first model was for "no week or location effect" on Y; in the second, for "no location effect", and in the 3rd, for "no week effect." Due to limitations on the length of time and number of samplers available for the pre-operational program, the experimental design does not allow for any statistical testing of the interaction effect of weeks and location upon the dependent variable. Therefore, the models used assume no interaction term.

The ANOVAs* ran based on each model are presented in Appendix I. According to the results under all the hypothesis tested, the F test showed no significance at the 0.05 level. Therefore, statistically one can say that the best estimate of the mean gross beta concentration on the filters is the mean value, which is equal

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*Analysis of Variance

to 2.0×10^{-2} pCi/m^3 with an estimated standard error of 2.2×10^{-3} for all locations and sampling periods in question. The filter in location 7 was not included in the analysis as discussed before, and its result was not used in the determination of the mean value.

Figure 9 shows the individual values measured for the weekly periods and locations sampled. The bars represent the maximum and minimum values obtained experimentally.

Gross Alpha Analysis

The gross α activity per cubic meter of air was determined, as for the gross β analysis, based on the flow rate, the sampling time, the filter collection efficiency and the counting efficiency of the counter. Table 16 gives the gross concentration detected for the filters collected in the weekly periods assigned.

The same mathematical models as explained by Neter and Wasserman[14] were used in the statistical analysis testing therefore the "no week or location effect", "no location effect and "no week effect" on the dependent variable Y. Due to the design limitations described before, the models used assume no interaction term. The ANOVAs are presented in the Appendix II.

According to the results, under all the hypothesis tested, no significance was shown for the F test at the 0.05 level. Therefore, one can say that statistically, the best estimate of the mean gross α concentration, for all the locations and weeks (with exception of the filter 7 data), is the mean value. The mean value was determined to be 6.2×10^{-3} pCi/m^3 with an estimated standard error equal to 7.7×10^{-4}.

Figure 9 shows the individual values measured for all the

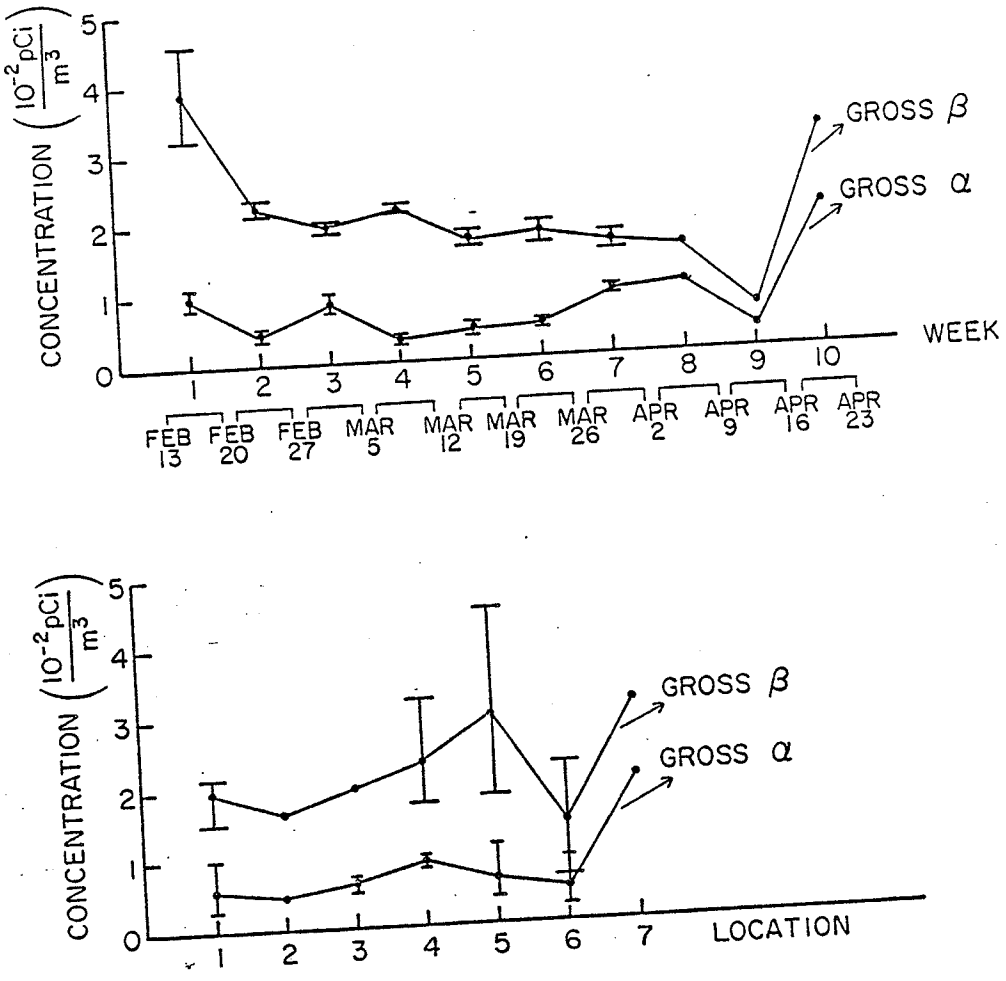

Figure 9. Gross Beta and Alpha Concentrations by Location and by Sampling Periods

Table 16 : Air Monitoring Gross Alpha Concentrations[a]

WEEK	LOCATION	PCi/m^3 (Mean±SD)
FEB 13 - FEB 20	4	7.8(E-3)±5.8(E-4)
FEB 13 - FEB 20	5	1.1(E-2)±3.2(E-3)
FEB 20 - FEB 27	1	4.6(E-3)±3.9(E-4)
FEB 20 - FEB 27	5	3.7(E-3)±7.0(E-4)
FEB 27 - MAR 5	4	9.9(E-3)±8.7(E-4)
FEB 27 - MAR 5	3	7.5(E-3)±9.4(E-4)
MAR 5 - MAR 12	1	3.0(E-3)±2.7(E-4)
MAR 5 - MAR 12	6	2.4(E-3)±1.5(E-4)
MAR 12 - MAR 19	2	4.5(E-3)±2.6(E-4)
MAR 12 - MAR 19	5	3.8(E-3)±3.4(E-4)
MAR 19 - MAR 26	2	4.1(E-3)±1.6(E-4)
MAR 19 - MAR 26	3	5.0(E-3)±6.2(E-4)
MAR 26 - APR 27	4	8.5(E-3)±2.9(E-4)
MAR 26 - APR 27	6	9.6(E-3)±8.8(E-4)
APR 2 - APR 9	1	9.9(E-3)±1.1(E-3)
APR 9 - APR 16	6	2.8(E-3)±3.7(E-4)
APR 16 - APR 23	7	2.0(E-2)±2.3(E-3)

[a]The lower limit of detection (LLD), as defined in HASL-300[10], was calculated to be 2.0(E-3) pCi/m^3 at the 95% confidence level.

week periods and locations sampled. The bars in these figures represent the maximum and minimum values obtained experimentally.

Gamma Isotopic Analysis

"Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility"[7].

In the case of the NSCL pre-operational study, this kind of analysis will provide information on the concentration of the radionuclides present in the filtered air at the time period sampling was performed. The spectrum collected for each filter analysed was studied and due to the similarities found among them, one was chosen as representative of the time period and locations being sampled, during the NSCL pre-operational surveillance. Due to the high ^{40}K which could be collected in the filters, the blank filters were counted and quantitated for the radionuclides orginally present before sampling was performed. In this way, the filter background can be subtracted from the amount detected. The filter background spectrum and the sample spectrum representative of the 2 types of analysis done are shown in Figure 10 and 11. Energies (in keV) were taken from Nuclear Data Tables [15].

The results of the filters analysed are shown in Tables 17 and 18. They were reported by location and by week (so that it would be easier to detect possible differences).

Spectrometric analysis of the filters collected during the first 2 weeks were disregarded. It seemed at first that the 300 m^3 total volume sampled was too low to collect enough activity

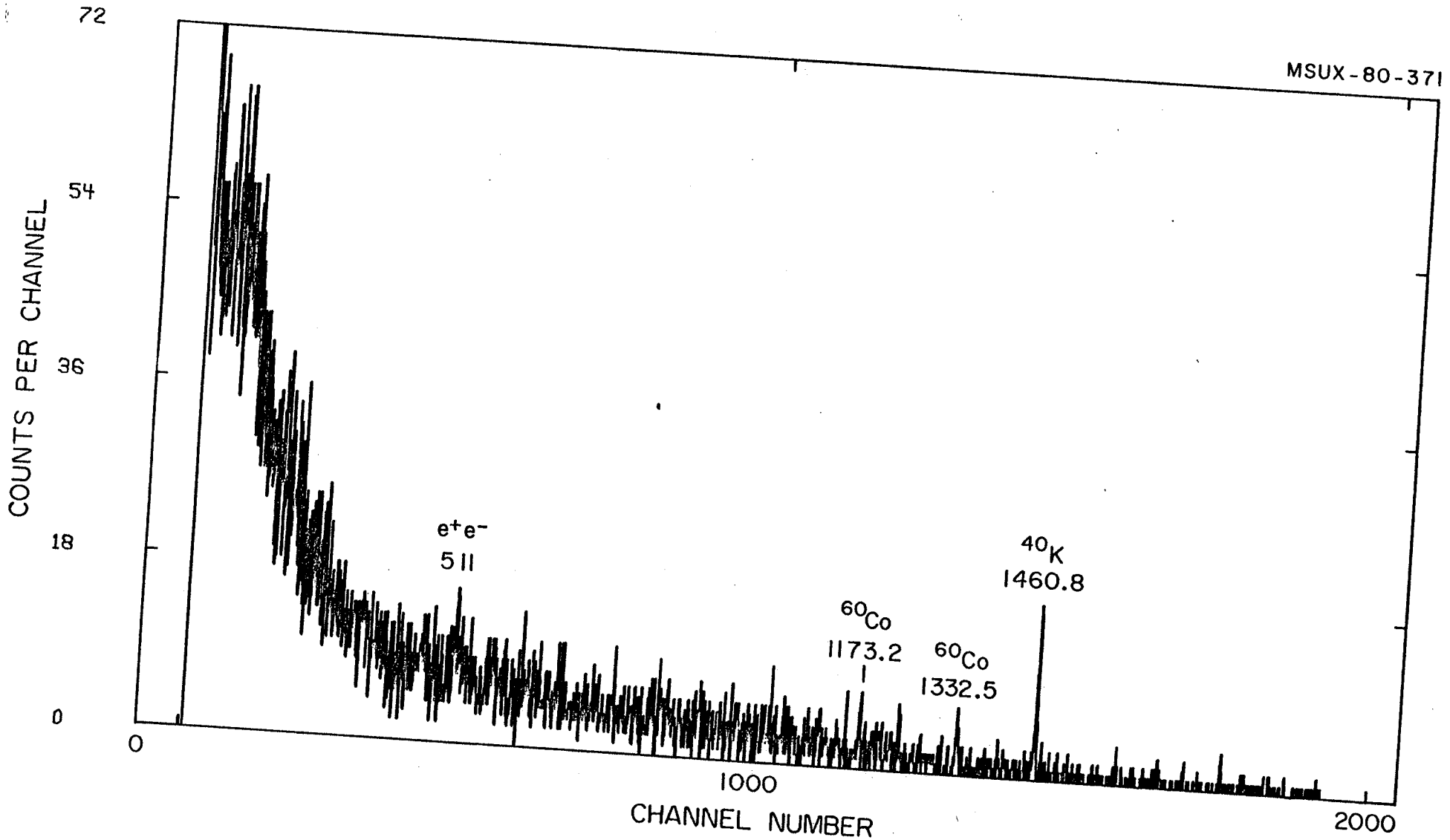

Figure 10. Ge(Li) Detector Spectrum of Gamma-Rays for the Glass Fiber Filter

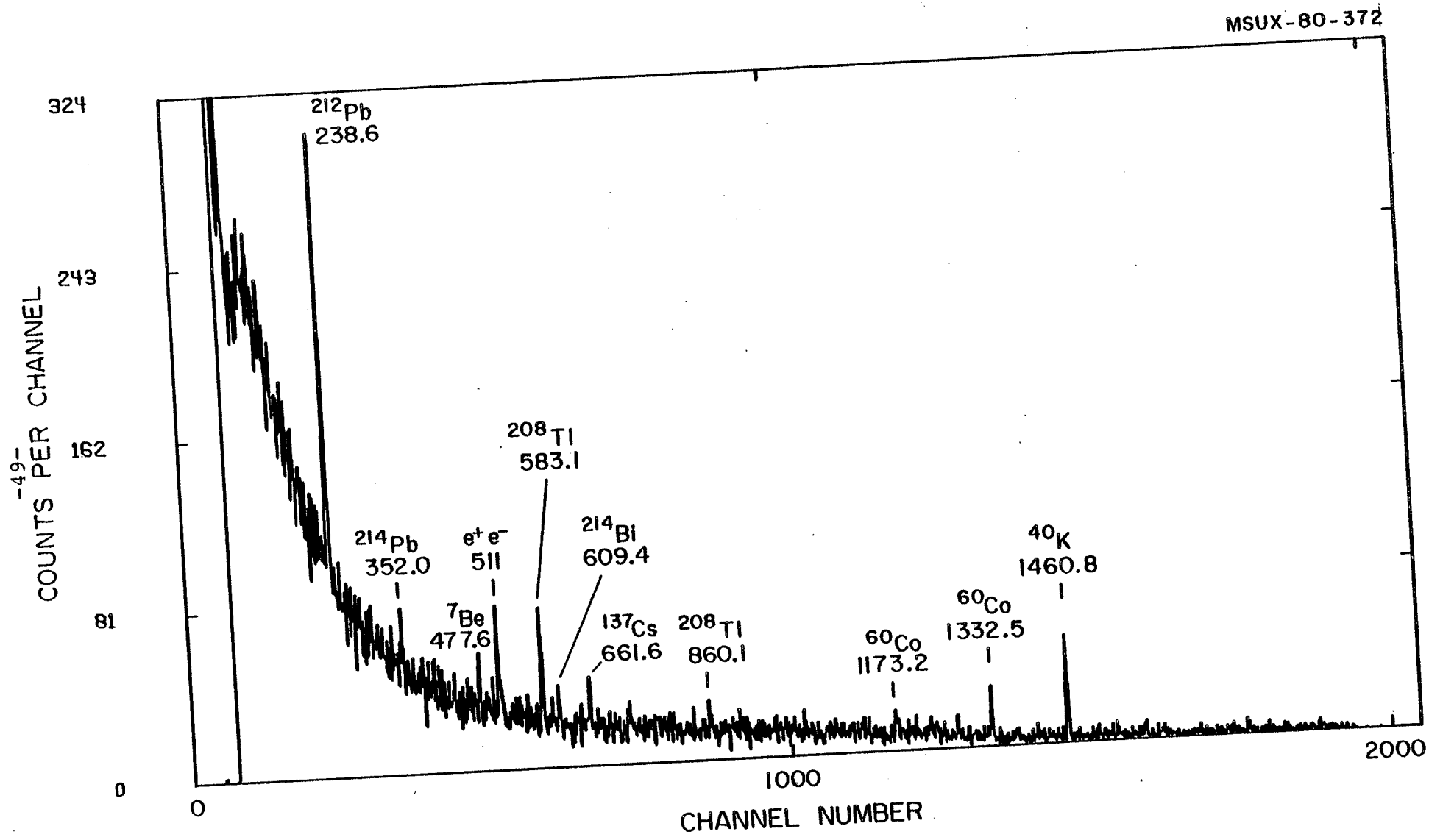

Figure 11. Ge(Li) Detector Spectrum of Gamma-Rays for the Filter Sample

in the filters to show in the spectrum. Therefore, the sample size was increased to about 600m^3 total volume thereafter. Also, problems associated with the detector initially used conclusively eliminated the data collected in the first weeks. The detector was then changed to the one already specified on page . The combination of the replacement detector and increased total volume brought the desirable improvement to the analysed spectra.

Tables 17 and 18 show only the concentrations for ^{40}K, ^{60}Co, ^{137}Cs and ^{7}Be. The natural background contribution of the Uranium (^{214}Pb, ^{214}Bi) and Thorium (^{208}Tl, ^{212}Pb, ^{228}Ac) series and the problems associated with their quantification, for the experimental set up used in the NSCL pre-operation program, will be discussed later.

The blank filters analysed before their use showed the presence of ^{40}K and ^{60}Co. The average amounts in the blank filter as well as the amounts collected after sampling are presented in Table 19.

Table 17: Radionuclides identified by "location"

LOCATION[b]	AVERAGE CONCENTRATION (pCi/m^3) ± ERROR[a]			
	^{40}K	^{60}Co	^{137}Cs	^{7}Be
1*	1.4(E-1)±1.0(E-2)	5.5(E-2)±8.0(E-3)	ND[c]	1.1 (E-2)±2.3(E-3)
2	1.2(E-1)±1.6(E-2)	5.1(E-2)±5.5(E-3)	ND	8.4 (E-2)±2.2(E-3)
3	1.2(E-1)±1.1(E-2)	5.9(E-2)±5.5(E-3)	1.5(E-2)±2.4(E-3)	9.2 (E-3)±2.8(E-3)
4*	1.2(E-1)±1.4(E-2)	5.1(E-2)±9.9(E-3)	ND	1.2 (E-2)±1.9(E-3)
5+	1.4(E-1)±7.3(E-3)	5.5(E-2)±5.1(E-3)	ND	1.1 (E-2)±2.1(E-3)
6	1.3(E-1)±5.1(E-2)	4.4(E-2)±6.2(E-3)	ND	9.5 (E-3)±2.9(E-3)
7+	1.3(E-1)±9.8(E-3)	3.7(E-2)±4.4(E-3)	1.8(E-2)±1.5(E-3)	1.5 (E-2)±4.4(E-3)

a The error term represents only the error in the peak area, given by the fitting program used.

b Numbers represent averages of 3 filters per location unless specified by *, meaning 2 filters or +, meaning only 1.

c ND = not detectable. It means that the fitting program used was not able to fit a Gaussian to the peak even though it was seen in some of the cases in the spectrum plotted. In those cases usually the statistics were very poor.

Table 18 : Radionuclides identified by "week"

WEEK[b]	AVERAGE CONCENTRATION (pCi/m^3) ± ERROR[a]			
	^{40}K	^{60}Co	^{137}Cs	^{7}Be
3	1.2 (E-1) ±1.5 (E-2)	5.5 (E-2) ±1.2 (E-2)	ND[c]	8.8 (E-3) ±1.9 (E-3)
4	1.4 (E-1) ±1.7 (E-2)	5.1 (E-2) ±1.0 (E-2)	ND	1.0 (E-2) ±3.1 (E-3)
5	1.2 (E-1) ±1.5 (E-2)	5.1 (E-2) ±7.3 (E-3)	ND	9.5 (E-3) ±3.1 (E-3)
6	1.2 (E-1) ±1.1 (E-2)	ND	1.5(E-2) ±2.4 (E-3)	9.5 (E-3) ±2.0 (E-3)
7	1.8 (E-1) ±5.1 (E-3)	ND	ND	1.1 (E-2) ±2.2 (E-3)
8[d]	1.3 (E-1) ±8.4 (E-3)	ND	ND	ND
9[d]	1.2 (E-1) ±7.0 (E-2)	ND	ND	ND
10	1.3 (E-1) ±9.9 (E-3)	3.7 (E-2) ±4.4 (E-3)	1.8(E-2) ±1.5 (E-3)	1.5 (E-2) ±4.4 (E-3)

a The error term represents only the error in the peak area, given by the fitting program used.

b Numbers represent averages of 2 filters per week.

c ND = not detectable. It means that the fitting program used was not able to fit a Gaussian to the peak even though in some of the cases, it was seen in the spectrum plotted. In those cases usually the statistics were very poor.

d Data shown represent only 1 filter since the other was not used due to blown fuse and vandalism problems mentioned before.

Table 19: Glass Fiber Filter Radionuclide Content

	AVERAGE pCi ± ERROR[a]	
	^{40}K [b]	^{60}Co [b]
Blank Filters	7.7(E+1)±8.0	2.6(E+1)±5.1
Used Filters	7.7(E+1)±1.9(E+1)	3.0(E+1)±1.1(E+1)

a The error term represents only the error in the peak area, given by the fitting program used.

b The LLD values for ^{40}K and ^{60}Co were calculated to be 4.4(E+1) and 2.3(E+1) pCi respectively (α=0.05).

2.1.3. Discussion and Conclusions

The interpretation of the results of any air sampling program should take into consideration the contribution of natural airborne radioactivity. Such contribution results in a large portion from the uranium and thorium decay series. ^{238}U and ^{232}Th are present in the earth's crust and decay to ^{222}Rn and ^{220}Rn respectively, which are inert gases and enter the atmosphere by diffusion through the soil. The daughter products of both isotopes are electrically charged when formed and they tend to attach themselves to the dust particles normally present in the atmosphere. Thus, they become the only significant natural radionuclides leading to widespread exposure through inhalation[16].

The concentration of the ^{222}Rn and ^{220}Rn daughters depend on many geological and meteorological factors. Some are: the soil content of ^{222}Rn and ^{220}Rn and its porosity, changes in atmospheric pressure, wind speed and direction, rainfall and soil moisture content, freezing conditions of the soil, atmospheric stability and

weather effects.[17,18,19] In addition, hourly and daily variations, as well as seasonal variations, have been reported[20,21].

The extremely variable natural radioactivity in the air samples and its dependence upon so many interrelated factors, make their analysis and predictions very difficult.

Methods for determination of radon daughters in air, particularly $^{218}Po(t_{1/2}=3.05$ min); $^{214}Pb(t_{1/2}=26.8$ min); $^{214}Bi(t_{1/2}=19.7$ min); $^{214}Po(t_{1/2}=1.6\times10^{-4}S)$; $^{212}Pb(t_{1/2}=10.64h)$; and $^{212}Bi(t_{1/2}=60.5$ min), have been developed[22,23,24,25]. In those methods, the radon daughters are almost always determined by measurement of the alpha activity of the air filter, as a function of time after the end of sampling.[25] They also use short sampling and counting times (1 to 30 min).

The NSCL experimental set up used long sampling and counting times due to the interest in determining any long lived, contaminant present during longer periods of time. Long sampling at a low-flow rate is thus more representative of the period being sampled. Therefore, in order to go into determination of radon daughter concentrations in an accurate way, a special experiment would be required.

The results of the gross beta analysis are of the same order of magnitude as the values reported by the Environmental Radiation Ambient Monitoring System (ERAMS) program.[16] They reported network averages of airborne particulates collected continuously at 21 sampling stations over the country. From July 1973 to June 1976 values ranged from 1.7×10^{-2} to 2.0×10^{-1} pCi/m^3 (Fall 1975 and Spring 1974 respectiveley). Winter values were 1.8×10^{-2} to 2.1×10^{-2} (1976), 6.5×10^{-2} to 1.0×10^{-1} (1975) and 2.8×10^{-2} to 1.0×10^{-1} (1974). Unfortunately, more specific data on gross betas in airborne particulates, collected for different areas of the country,

were not available.

The statistical analysis performed on the gross alpha and beta data showed the absence of any significant difference, that is, their concentration in the air did not change, either from one location sampled to another or from week to week. Nevertheless, by looking at the F values at the ANOVA tables in the Appendices, one can see some indication of temporal variation as compared to no effects due to location. The experimental design limitations, with so few degrees of freedom left for the error term should tell us to be careful in making any definite conclusions towards proving that effect.

The ICRP* and NCRP+ have recognized that in many cases, identification and quantification of radionuclides can be time-consuming and expensive. Therefore, "if it is known that certain of the more dangerous radionuclides are not present, MPC‡ levels for mixtures of unknown radionuclides can be prepared. The committees have published such a table for 168-hour occupational exposures. The most general case, which excludes no radionuclides, requires that mixed radionuclides do not exceed a concentration of 0.4 pCi/m^3 of air."[26] In this way, the "gross" counts are used as a screening procedure.

The peaks identified in the gamma spectra collected, with enough counts to be accepted by the fitting program were ^{40}K, ^{60}Co, ^{7}Be, and ^{137}Cs plus the uranium and thorium series decay products

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*International Commission on Radiological Protection

+National Council on Radiation Protection and Measurements

‡Maximum Permissible Concentration

discussed earlier.

The average amounts of ^{40}K and ^{60}Co detected in the samples were too close to that originally present in the blank filter to be considered as part of the radionuclides contributing to the air radioactivity levels being measured around the NSCL.

Naturally occurring cosmogenic radionuclides are continuously generated by cosmic-ray interactions in the atmosphere. The radionuclides on the air filters usually include cosmogenic ^{7}Be ($t_{\frac{1}{2}}$=53.3 days).

The typical range of ^{7}Be in surface air has been reported to be from $2x10^{-2}$ to $20x10^{-2}$ pCi/m^3, with a mean value equal to $6x10^{-2}$ pCi/m^3.[5] Results of the NSCL environmental surveillance are in reasonable agreement with those values. More detailed studies on ^{7}Be concentrations in air and terrestrial ecosystem, its comparison with patterns of larger atmospheric nuclear detonations, as well as its latitudinal distribution have been reported.[27,28,29]

^{137}Cs is a very important fission product because if its long physical half life (30 years) and its uptake and retention in biological system. Principal sources of ^{137}Cs in the environment are the atmospheric testing of nuclear weapons, nuclear power reactors, nuclear fuel reprocessing facilities and accidental releases.[30] It is mainly found deposited near the soil surface in concentrations which vary with erosion and leaching and their gradual depletion by decay.[5] UNSCEAR estimates that "the average integrated deposits of ^{137}Cs in the northern and southern temperate latitudes are 128 and 35 nCi/m^2, respectively.[16]

Results of the air sampling program at the NSCL showed small

amounts of ^{137}Cs collected in 2 of the filters analyzed. Values were 1.5×10^{-2} pCi/m^3 and 1.8×10^{-2} pCi/m^3 of air. Both samples were taken during different weeks, one on campus and the other at the "control" location, about 15 miles from the NSCL. With only 2 filters showing detectable amounts of ^{137}Cs it would be difficult to discuss the existence of trends among location and time period during which sampling took place. Also, no value could be chosen as representative of the ^{137}Cs concentration in the air surrounding the NSCL area.

When low level radionuclides emit both beta particles and gamma rays, as in the case of ^{137}Cs a method of choice for counting is selected. Even though assay by beta particle counting is desirable due to the higher counting efficiencies of most beta detectors, the efficiency is energy dependent. This factor turns out to be a source of error mainly when gross activity measurements are performed. Since the sample being counted in those cases contains a mixture of unknown radionuclides, an arbitrary standard has to be selected. Such standard may not have the same spectrum characteristics of the nuclides in the sample. Therefore, the arbitrary choice of the standard introduces the largest uncertainty mainly in thick samples due to the energy dependence of factors such as self-absorption[5].

According to a NCRP report[5], the end point energies of environmental betas range from about 0.02 to 3 MeV which correspond to a difference in beta-ray range of about 1.5 g cm^{-2}. Therefore, the true disintegration rate inferred may be seriously in error.

For alpha particles, most are in the energy range of 4 to 8 MeV, and the results are usually in agreement with the ones for a 5 Me

alpha standard within a factor of two.[5]

The errors from gross activity measurements may increase as the number of radionuclides in the sample, with different energies, increase. Values averaging 75% higher for the calibration standard have been reported when fission product mixtures were the principal beta emitters.[5]

Total counting should be used only as a screening procedure since it provides a rapid measure of natural radioactivity plus any abnormal levels of radioactivity. Otherwise, samples should be measured by gamma-ray spectrometry and by specific radiochemical analyses.

Still gross alpha and beta analyses are helpful provided that the radionuclide composition of the contaminant and natural activity is specified so that its significance can be assessed without ambiguity.

2.2 Water Sampling

Water sampling for the pre-operational program at the NSCL was performed at 2 different locations at the Red Cedar River. The storm drainage from the laboratory flows into this river, which goes through the M.S.U. campus.

The purpose of such sampling was the determination of any long-lived contaminants present in the river at the time of sampling or the background levels of the samples if no contamination was found.

Gross alpha and beta, and gamma spectrometric analysis were performed.

This initial data collected will provide the NSCL with a baseline measurement of surface water radioactivity to be compared against future results to be taken when the laboratory starts operation.

2.2.1. Materials and Methods

Surface water (first 6 inches) grab samples were collected from 2 locations in the Red Cedar River, as shown in Figure 4. Location A, upstream from the laboratory will provide control data for comparison with location B, downstream from the NSCL and distant enough to allow for mixing. Usually, as a rule of thumb, the discharge-to-downstream site distance, should be at least 10 times the river width.[1]

Sampling was performed once a week, at both location, for a period of 4 weeks (April to first week of May, 1980). The experimental design lay out is shown in Table 20.

Table 20: Water Sampling Experimental Design

	SAMPLES LOCATION	
WEEK	A	B
1	A1	B1
2	A2	B2
3	A3	B3
4	A4	B4

The samples, collected in glass bottles, were acidified with nitric acid as recommended by the American Public Health Association.[3]

This is done to reduce the possibility of the loss of radionuclides on the walls of the collection bottle. Most environmental samples are close to neutral and acidification to 0.1 to 0.5N is adequate.[5] More detailed considerations on sample treatment problems is given by the NCRP.[5]

Due to the unavailability of a Ge(Li) detector which could be used with a Marinelli breaker, the 3.5 liters of surface water recommended for gamma isotopic analysis[1] were evaporated on a 2 inches planchet and then a spectrum was collected. The sample preparation procedure was as follows:

Phase 1: Collected water samples from each location were separately evaporated in large beakers by slow heating on a hot plate to near dryness. Stirring rods were used during the phase.

Phase 2: Each residue was then transferred to a separate metal planchet. Distilled water was used to wash the beakers residues into the planchets.

Phase 3: The planchets were slowly evaporated to dryness on a hot plate and allowed to cool.

The whole procedure took 3 days. Because of that, counting had to be performed when samples were ready. Thus, no short lived radionuclide could be expected to be identified.

A blank planchet was used for background and counted in both detectors (same ones used for the air sampling phase), that is internal proportional counter and a Ge(Li) detector. Calibration was performed as specified before in the sampling section of the report. Counting times for blank planchets were five-50 minute

intervals for gross beta and alpha and 1 hour to accumulate a spectrum using the Ge(Li).

Five days after sample collection, the planchets were counted for gross alpha and beta, for five-50 minute intervals (consecutive) each. Six days after collection, the planchets were counted in the Ge(Li) for gamma-spectrometric analysis, for periods of 3 hours each.

2.2.2. Results

Gross Beta and Alpha Analysis

The activity per liter of surface water collected was calculated based on known values of the total volume sampled and the counter efficiency for the particles in question. Gross alpha analysis was disregarded. The 3.5 liters of water used for gamma isotopic analysis, when evaporated produced a sample planchet too thick to be analyzed for alphas without going into large errors due to self absorption. Thus, only gross beta counts were recorded. Results are reported in Table 21.

Table 21: Water Monitoring Gross Beta Concentration

	pCi/l (Mean±SD)[a]	
	LOCATION	
WEEK	A	B
1	25(E-1)±1.3(E-1)	20(E-1)±6.0(E-2)
2	20(E-1)±1.6(E-1)	21(E-1)±1.2(E-1)
3	13(E-1)±8.0(E-2)	16(E-1)±1.2(E-1)
4	24(E-1)±1.1(E-1)	16(E-1)±7.0(E-2)

[a]The LLD value calculated for the gross beta analysis was 4.5(E-1) pCi/l

The statistical model underlying the design is of the form:

$$Y_{ij} = \mu + L_i + W_j + E_{(ij)} \qquad \text{equation 7}$$

where,

Y_{ij} = dependable variable in pCi/l

μ = overall mean

L_i = the effect of the i^{th} location on Y

W_j = the effect of the j^{th} week on Y

$E_{(ij)}$ = error term

The model assumes no interaction term, so the effects due to interaction of the i^{th} location with the j^{th} week will be confounded with the random error.

An ANOVA was performed on the data to check for any significant differences among the locations and weeks when sampling took place. The ANOVA table is presented in Appendix III. According to the results, no significance was found for locations or weeks, at the 0.05 level. Therefore, one can express the results of the gross beta analysis by saying that the best estimate of the mean gross beta concentration in the surface water collected, is the mean value, which is equal to 19(E-1) pCi/l with an estimated standard error equal to 1.5(E-1), for all the locations and sampling periods in question.

Gamma Isotopic Analysis

The spectrum collected for each planchet was analyzed. Due to the similarities among the spectra, one was chosen to represent both locations sampled. The fitting program used was SAMPO, as mentioned earlier in this report.

Figure 12 shows the blank planchet background spectrum and

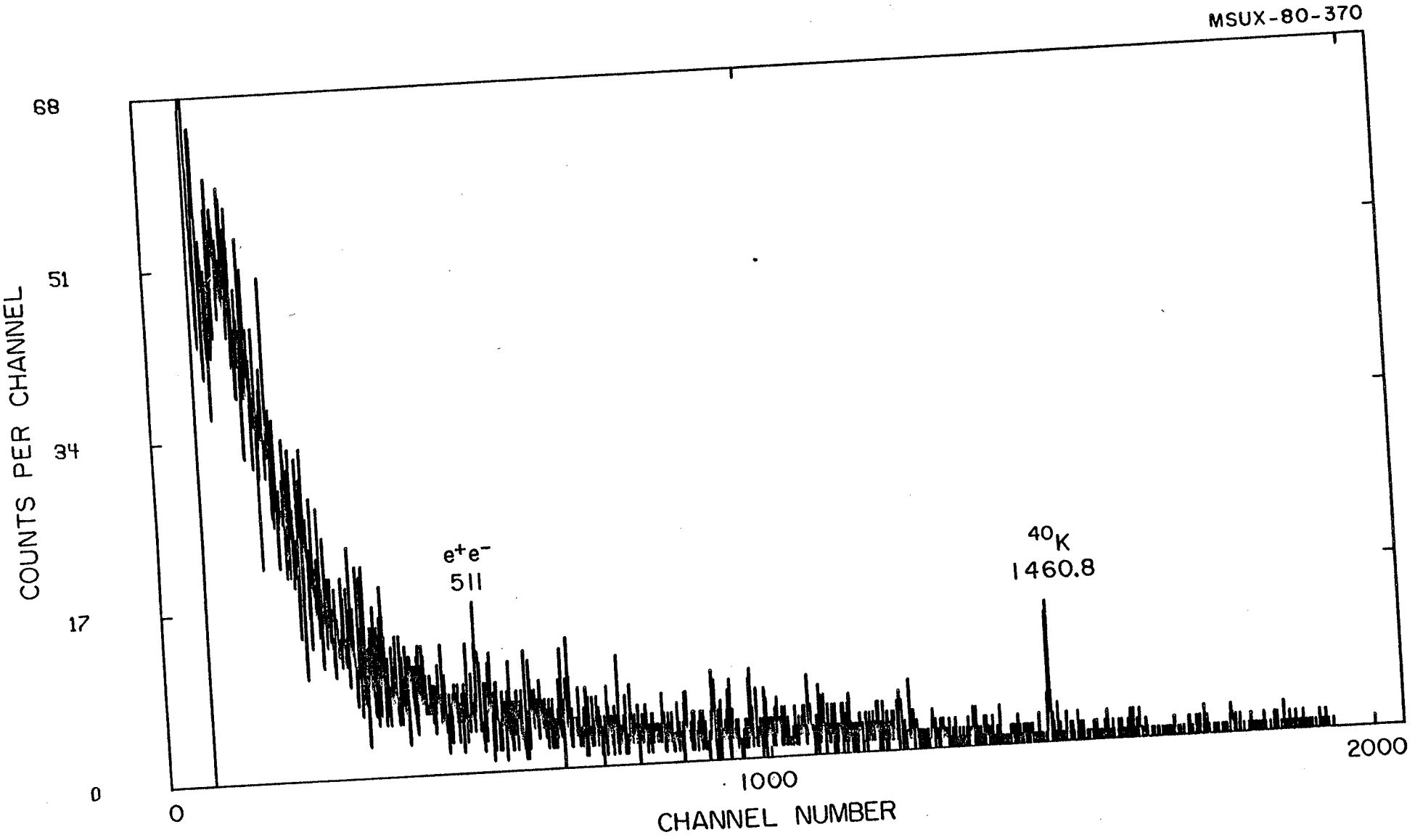

Figure 12. Ge(Li) Detector Spectrum of Gamma-Rays for the Blank Planchet

Figure 13, the one representative of the water sampling study.

The results of the identification and quantification of the radionuclides are shown in Tables 22 and 23, by week and location respectively. As in the air sampling study, no quantification of the radon daughters present was carried out.

The concentration, in pCi/l of the long-lived radionuclides detected was calculated by

$$C = \frac{cpm}{E \times V \times 2.22 \frac{dpm}{pCi}} \qquad \text{equation 8}$$

where,

cpm = counts under the peak (area)/counting time (min).

E = detector efficiency

V = volume of water sampled (in liters)

A correction for geometry due to the finite sample size was also used.[36]

Table 24 shows the results of the blank planchet background compared to the water samples, by week.

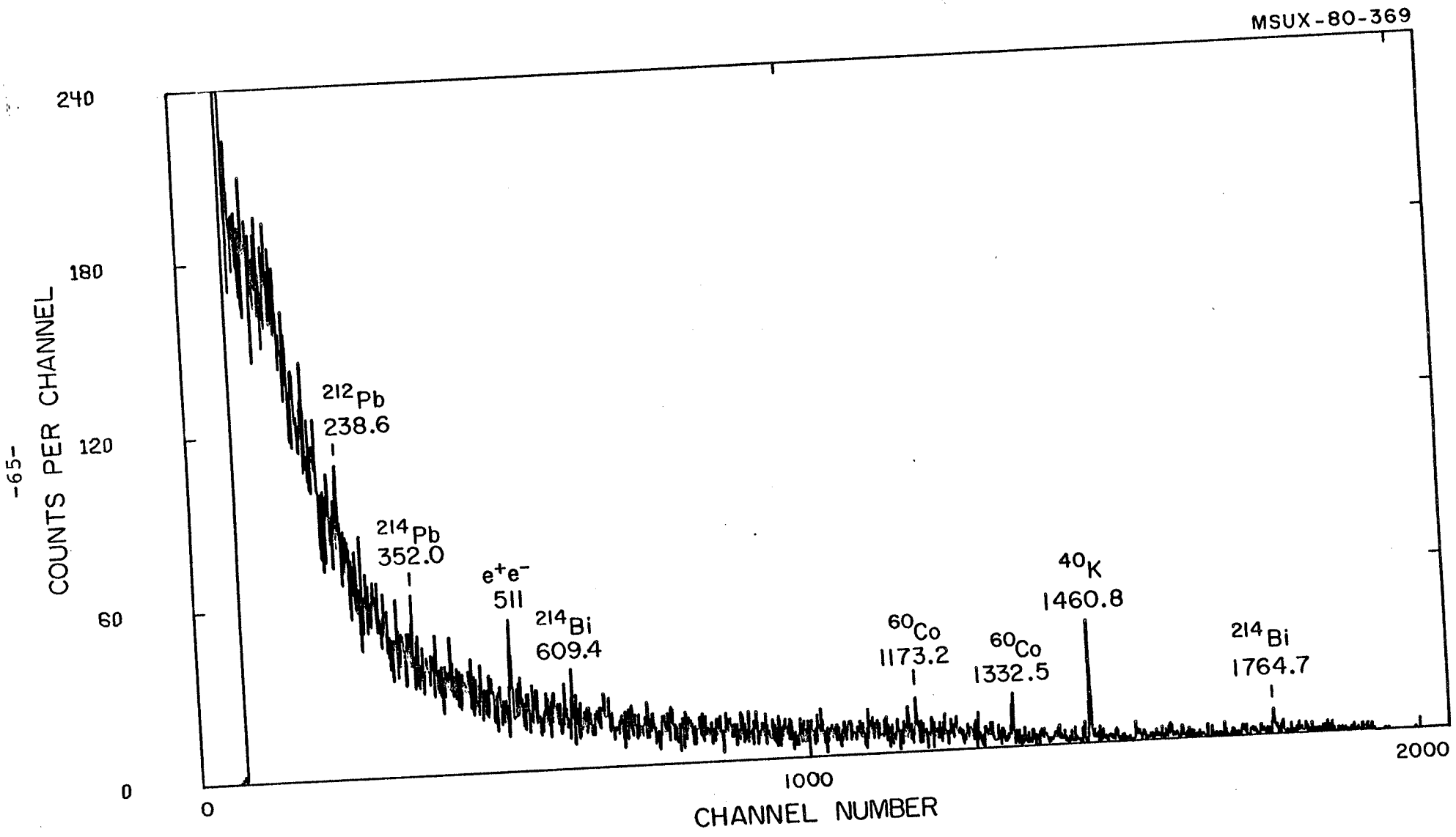

Figure 13. Ge(Li) Detector Spectrum of Gamma-Rays for the Water Sample

Table 22: Radionuclides Concentrations Detected by "Week"

	Concentration (pCi/l±error)[a]		
WEEK	^{40}K	^{60}Co	^{137}Cs
1	1.6(E+1)±2.4	4.4±1.1	---
2	2.5(E+1)±2.4	8.4±1.7	4.0±0.6
3	2.2(E+1)±2.0	4.0±1.0	3.6±0.6
4	2.2(E+1)±2.2	1.7±0.5	---

a The error term represents only the error in the peak area, given by the fitting program used.

Table 23: Radionuclides Concentrations Detected by "Location"

	Concentration (pCi/l±error)[a]	
	LOCATION	
	A	B
^{40}K	2.1(E+1)±3.5	2.2(E+1)±2.9
^{60}Co	4.8±1.6	5.9±1.6
^{137}Cs	3.6±0.6	4.0±0.6

a The error term represents only the error in the peak area, given by the fitting program used.

Table 24: ^{40}K Activity in the Planchet and Samples[a]

		pCi of $^{40}K \pm$ Error[b]
WEEKLY SAMPLES	BLANK	5.9(E+1)±1.8(E+1)
	1	5.5(E+1)±8.4
	2	7.7(E+1)±7.3
	3	7.7(E+1)±7.0
	4	7.7(E+1)±7.3(E+1)

[a]The lowest limit of detection (LLD) as defined by HASL-300[10], was calculated to be 104 pCi for ^{40}K.

[b]The error term represents only the error in the peak area, given by the fitting program used.

2.2.3. Discussion and Conclusion

Radon-222, one of the naturally occurring radionuclides discussed before, may be formed in aquatic systems through on enrichment of ^{226}Ra decays, it produces ^{222}Rn which as a noble gas can easily migrate into water.

The flux of ^{222}Rn depends on many things such as changes in atmospheric conditions, initial ^{226}Ra concentration, depth of water and/or ice covering, and porosity of the substrate in which the gas is trapped.[32]

Radon daughters (^{214}Pb, ^{214}Bi) can be detected in surface water samples. Concentrations though, are dependent on the factors mentioned above.

According to a NCRP report[29], "Radon in streams is dissipated to the atmosphere in such way that its concentration decreases exponetially with distance, increasing abruptly at points where radon-bearing water flows in". Also, abrupt decreases in flow rate tend to deposit sediments with their load of attached or contained radionuclides. ^{137}Cs has been found in layer amounts in the bottom sediments at the intersection of the Susquehanna River and the Chesapeake Bay (in Maryland), as reported by Riel.[33]

Due to the many factors controling the variability of the natural radioactivity detected in the water samples, no quantification was performed for the pre-operational program at the NSCL. Thus, only identification of the peaks was carried out and quantification was left for the longer lived radionuclides present in the sample due to nuclear explosions and nuclear facilities.

Even though ^{40}K is naturally radioactive, its quantification was possible (long half life) and necessary in order to evaluate the amount present in the sample as compared to the blank planchet used. The results shown on Table 24 indicate that no difference can really be accounted for.

Results of the gross beta analysis show an average of about 2 pCi/l.

Water sampling conducted at the Argonne National Laboratory and assayed for total activity (by counting the residue obtained on evaporation) showed valued ranging from 5 to 10 pCi/l of natural beta activity. Uranium decay products and ^{40}K were the main contributors.[34] When fallout is high and radioactivity is added to the water directly from the air, values are increased.

Again, as discussed before in the air sampling section of this report, the accuracy of gross beta analysis may be hindered by energy dependent factors such as self absorption. In the case of thick samples, the error may be very large. Other factor, the desirable homogeneity of the evaporated sample, is hard to acquire when large volume is evaporated. In this case, variation in the sample thickness and the deposition of the radionuclides in different layers of the sample may introduce more errors, in gross beta counting.

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APPENDICES

APPENDIX I: GROSS BETA ANALYSIS. AIR MONITORING

Table I.1: ANOVA for "no weeks or locations effect"

	S.S.	df	M.S.	F	F_c 0.05
Treatments (locations and weeks)	1.06(E-3)	13	8.15(E-5)	3.26*	3.81
Error	5.0(E-5)	2	2.40(E-5)		

*not significant at the 0.05 level[35]

Table I.2: ANOVA for "no weeks effect"

	S.S	df	M.S.	F	F_c 0.05
Locations	4.0(E-4)	5	---	---	
Weeks	6.6(E-4)	8	8.25(E-5)	3.3*	4.46
Error	5.0(E-5)	2	2.50(E-5)		

*not significant at the 0.05 level[35]

Table I.3: ANOVA for "no locations effect"

	S.S	df	M.S.	F
Weeks	1.01(E-3)	8	---	---
Locations	5.0(E-5)	5	1.0(E-5)	<1*
Error	5.0(E-5)	2	2.5(E-5)	

*not significant

APPENDIX II: GROSS ALPHA ANALYSIS. AIR MONITORING

Table II.1: ANOVA for "no weeks or locations effect"

	S.S	df	M.S.	F	F_c 0.05
Treatments (weeks and locations)	1.3(E-4)	13	1.0(E-5)	2.0*	3.81
Error	1.0(E-5)	2	5.0(E-5)		

*not significant at the 0.05 level[35]

Table II.2: ANOVA for "no weeks effect"

	S.S	df	M.S.	F	F_c 0.05
Weeks	9.0(E-5)	8	1.12(E-5)	2.25*	4.46
Locations	4.0(E-5)	5	---		
Error	1.0(E-5)	2	5.0(E-6)		

*not significant at the 0.05 level[35]

Table II.3: ANOVA for "no locations effect"

	S.S	df	M.S.	F
Weeks	1.2(E-4)	8	1.5(E-5)	
Locations	1.0(E-5)	5	2.0(E-6)	<1*
Error	1.0(E-5)	2	5.0(E-6)	

*not significant

APPENDIX III: GROSS BETA ANALYSIS. H_2O SAMPLING

Table III.1: Two-way ANOVA

Source	DF	S.S.	M.S.	F	F_c 0.05
Locations	1	0.0760	0.076	<1*	10.13
Weeks	3	0.6235	0.208	1.54	9.28
LW and/or Error	3	0.4040	0.135		

*not significant at the 0.05 level[35]