MLM-2317
TID-4500
Distribution Category UC-41

Annual Environmental Monitoring Report: Calendar Year 1975

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Issued: April 26, 1976

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PRINTED IN THE UNITED STATES OF AMERICA

Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Price: Printed Copy $4.00; Microfiche $2.25

MONSANTO RESEARCH CORPORATION
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MOUND LABORATORY
Miamisburg, Ohio 45342
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UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

U. S. Government Contract No. E-33-1-GEN-53

Foreword

This report was prepared by the Environmental Control Section of the Personnel Safety, Waste Management, and Environmental Control Function in the Administrative Services Department at Mound Laboratory. Sample analyses and data reduction were performed by the Radiological Surveillance group of the Environmental Control Section. Particulate samples off-site are collected by the Air Pollution Control Section of the Montgomery County Combined General Health District which acts as the Regional Air Pollution Control Agency in this region for the Ohio Environmental Protection Agency.

Table of Contents

	Page
INTRODUCTION	5
SUMMARY	8
ENVIRONMENTAL SURVEILLANCE	10
Air - Radioactive	10
Air - Nonradioactive	17
Water - Radioactive	17
Water - Nonradioactive	24
Foodstuffs and Vegetation - Radioactive	25
Soil and Silt - Radioactive	27
EVALUATION OF POTENTIAL DOSE TO THE PUBLIC	31
ACKNOWLEDGEMENT	36
REFERENCES	37
APPENDIX	
Applicable Standards	39
DISTRIBUTION	42

Introduction

Mound Laboratory is situated on 180 acres of land in Miamisburg, Ohio. This location is approximately 16 km (10 mi) southwest of Dayton. The predominant geographical feature in the five-county region surrounding the Laboratory is the Great Miami River which flows from the northeast to the southwest through Miamisburg. This river valley area is generally highly industrialized. The remainder of the region is predominantly agricultural with some light industry and scattered residential communities. The location and population of these communities are shown in Figure 1. The primary agricultural activity in the area is raising field crops such as corn and soybeans. Approximately 10% of the land area in agricultural use is devoted to pasturing livestock.[1]

Weather conditions in the area are described as moderate. The average annual precipitation is approximately 91 cm (36 in.) and is evenly distributed throughout the year. Winds are predominately from the south or west except during the summer months when a higher frequency is recorded from out of the southwest. The wind speed averages about 16 km/hr (10 mi/hr) annually.[2]

Mound Laboratory began operations in 1949. Its mission currently includes research, development, engineering, and production of components for the ERDA weapons program; research, development, and production of explosive materials; separation, purification, and sale of stable isotopes of the noble gases; and development, design, and fabrication of radioisotopic heat sources for medical application and space exploration. The radionuclides of primary concern currently being handled include plutonium-238 and tritium.

Conformance to regulations prescribed by ERDA pertaining to the safety of employees and the public have been demonstrated during the history of Mound Laboratory. The fundamental objectives of the Mound Laboratory Environmental Control Program, which has been in existence throughout the history of the Laboratory, is the containment of radioactive effluents to levels well within the existing standards. As part of this control function, effluents are monitored and controlled at each operating step resulting in detection of low-level releases of airborne or liquid wastes to the environment. Because of this early detection, control techniques can be taken thus ensuring that concentrations are well within existing standards.

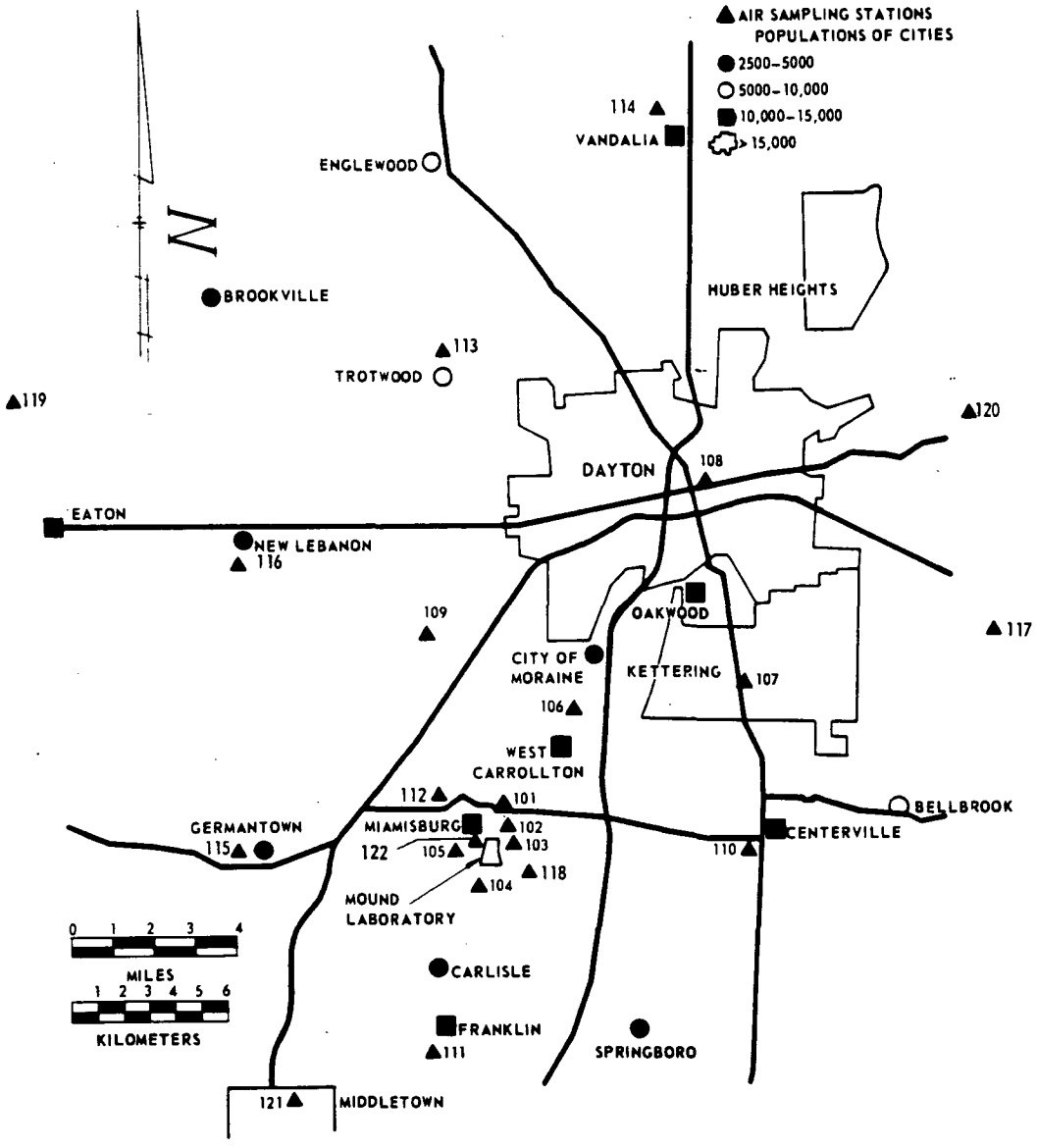

FIGURE 1 - Off-site air sampling locations

As part of the Environmental Program monitoring functions, air, water, foodstuff, and soil samples are collected from the environment at distances up to 45 km (28 mi) from the Laboratory boundaries. These samples are analyzed for the specific radionuclides handled at the Laboratory.

Radionuclides in particulate form are removed from air effluents by high efficiency particulate air filters (HEPA). The air effluents are filtered first at the points of origin, i.e. glove boxes, and just prior to the release point, i.e. the stack. The filtering system at the stack consists of two banks of HEPA filters in series, each with a collection efficiency of 99.9%. Radionuclides are removed from liquid effluents such as process waste liquids by chemical processing. Solid radioactive wastes are packaged and shipped off-site for burial at ERDA-approved burial sites. Airborne and liquid wastes generated in the processing of explosive materials are collected and disposed of according to the Army Materiel Command Regulation 385-100.

A new sanitary waste treatment plant was placed in operation during 1975. The plant provides secondary treatment in accordance with EPA requirements[3] using an activated sludge process operating in the extended aeration mode. All domestic sewage generated on-site is treated in this facility. The influent and effluent at the sewage treatment plant are also monitored for radioactivity to ensure no undetected release can occur to the environment via the sanitary sewage plant. The digested sludge from the sewage plant is shipped off-site for burial to an ERDA-approved burial site to ensure that no contaminated sludge is released to the environment. Nonradioactive solid wastes are disposed of according to a recycling and reclamation program implemented during the first quarter of 1974. White paper, scrap metal, and wood are sold for reclamation. General refuse is transported to the Franklin Reclamation Center, Franklin, Ohio, for processing and eventual use in recycled products. Waste solvents and chemicals are removed off-site by a commercial industrial-waste-disposal firm.

A quality control program for environmental analytical procedures has been in effect for several years. There are two parts to the program: internal and external. The internal portion consists of blank and duplicate analyses for each group of samples. The blank results have been consistently small and insignificant in comparison with sample results. The duplicate results for 1975 were also satisfactory. The external portion of the program consists of sending duplicate samples to an independent laboratory. These results for 1975 were also satisfactory. In summary, results indicate good analytical control.

The results of the analyses for calendar year 1975 are provided in this report. Error limits, when given, reflect uncertainties in the data due to counting statistics at the 95% confidence level.

Summary

The local environment surrounding Mound Laboratory was monitored for tritium and plutonium-238 released by Mound Laboratory. The results are reported for calendar year 1975. The environmental parameters analyzed included air, water, foodstuffs, soil, and silt. For radioactive species, the average concentrations of plutonium-238 and tritium were within the stringent standards adopted by the U.S. Energy Research and Development Administration. Data concerning nonradioactive species in air and water are also presented and compared to federal, state, and local standards, where applicable.

The average concentrations of plutonium-238 and tritium measured in air during CY-1975 were $<0.64 \times 10^{-17}$ μCi/ml and $<0.89 \times 10^{-11}$ μCi/ml, respectively. These correspond to <0.03% and <0.01% of their respective Radioactivity Concentration Guides (RCG's). The RCG's and their explanation are given in the Appendix.

The average concentrations of plutonium-238 and tritium in the Great Miami River during CY-1975 were 0.3×10^{-10} μCi/ml and $<1.9 \times 10^{-6}$ μCi/ml, respectively. These correspond to 0.002% and <0.19% of their respective RCG's.

Additionally, data concerning tritium and plutonium-238 in surface water, community drinking water, foodstuffs, soil, and silt are presented. From the analyzed data, there is no evidence of other than negligible uptakes of radioactive species from air, water, soil, or silt by plant or animal life.[4] There is also no evidence of other than negligible reentrainment of radioactive species from soil or silt.

Also included is a plutonium-238 deposition inventory in waterways and a preliminary soil inventory of plutonium-238 based on soil core sampling around Mound Laboratory.[5] This study gives a preliminary evaluation in quantities of plutonium-238 in the environment from Laboratory operations.

Mound Laboratory has been issued a National Pollutant Discharge Elimination System discharge permit. Analyses indicate general compliance with permit conditions with the exception of three oil and grease values. These values are reported, but are suspect because of analytical problems. All results indicate that Mound effluent streams have no significant effect on the Great Miami River and certainly do not

cause Ohio Stream Standards to be exceeded.

These data demonstrate our compliance with various regulatory agency standards and that the operation of Mound Laboratory has a negligible effect on the environment.

Environmental Surveillance

AIR - RADIOACTIVE

An off-site air sampling network consisting of 21 continuously operating air-sampling stations (22 for plutonium-238) was used for the first six months of CY-1975. Because of funding reductions, however, this number was reduced to 12 (13 for plutonium-238) during the last six months of CY-1975. During the first half of the year, eight sampling stations were located within a 1.6-km (1-mi) radius of the Laboratory. The original 13 samplers located in or near population centers were reduced to four during the last half of the year. The remaining sampler (#119) is still used and is approximately 44.8 km (28 mi) from the Laboratory in the least prevailing wind direction. This site should receive no measurable contribution from Mound operations and serves as a baseline sample for comparison purposes. The samplers currently in operation sample critical distances and directions based on the diffusion model developed for Mound Laboratory. The sampling sites are shown in Figure 1.

Two types of samples are collected at each sampling station, a particulate air sample for plutonium-238 analysis and a bubbler sample for tritium oxide analysis. The particulate sample is collected on a 200-mm diameter Microsorban disk by a continuously operating (24 hr, 7 days per week) high-volume air sampler. The air is sampled at the average rate of 1.3×10^6 cm^3/min (~45 ft^3/min). The Microsorban disk is changed weekly thus represents a sample of approximately 13,000 m^3 of air. Plutonium-238 analyses are performed on a monthly composite.

The analytical scheme for plutonium-238 incorporates the following basic steps: addition of a known amount of plutonium-242 tracer, ignition to 600°C, dissolution with nitric acid, separation of plutonium with anion exchange resin, electrodeposition of plutonium, and finally alpha spectrometry. The results reported represent total concentrations of the analyzed radionuclides including contribution from atmospheric fallout.

The average off-site plutonium-238 air concentration was $<0.64 \times 10^{-17}$ $\mu Ci/ml$ which is <0.03% of the RCG. The RCG used for comparison is the guide for the soluble form of the isotope and for the general population. This is the most restrictive RCG for plutonium-238 and is applied since

the solubility of the measured particles in the human body is unknown. The results are summarized in Table 1. Samples reported as less than (<) the Minimum Detection Limit (MDL) are, for averaging purposes, considered to be the value of MDL. Actually, the true value lies somewhere between natural background and MDL.

Also included in Table 1 are ratios of plutonium-238 to plutonium-239 for each sampling location. A ratio greater than ~0.2 would indicate a concentration of plutonium-238 greater than that from atmospheric fallout and thus would indicate influence from Laboratory operations.[6]

The gas bubbler sample is also collected on a continuous basis by bubbling air at approximately 3×10^3 cm^3/min through 200 ml of ethylene glycol. Ethylene glycol is used because this material eliminates evaporation and freezing problems associated with sample collection.[7] Any tritium (oxide) in the air is collected in the solution. The sampling and analysis are directed to tritium oxide since the RCG for the oxide is 200 times more restrictive than for elemental tritium.[8] A sample representing ~30 m^3 of air is collected and an aliquot representing 1.5 m^3 is counted in a liquid scintillation spectrometer. The average concentration of tritium oxide measured during CY-1975 was less than 0.89×10^{-11} μCi/ml which is less than 0.01% of RCG. The RCG used for comparison is the guide for the general population and for soluble form, which is the most restrictive RCG for tritium. The results are summarized in Table 2.

Table 3 shows values of background for plutonium-238 and tritium in air.

An on-site perimeter network consisting of five continuous, high-volume air samplers is used to further assess the effectiveness of control systems. The on-site sampling locations are shown in Figure 2. Particulate samples are collected by the on-site samplers at approximately the same flow rate as the off-site samplers, i.e. 1.3×10^6 cm^3/min, and are analyzed in the same manner. The tritium samplers operate at slightly less air flow, i.e. approximately 2×10^3 cm^3/min, and are analyzed in the same manner as off-site samplers.

The average plutonium-238 concentration measured on-site was 28×10^{-17} μCi/ml which is 0.4% of the RCG. The results are summarized in Table 4.

The average on-site tritium oxide concentration was $<3.0 \times 10^{-11}$ μCi/ml which is <0.02% of the RCG. The results are summarized in Table 5.

The RCG's used for on-site comparisons are those applicable for incidently exposed individuals in the population. The total amounts of plutonium-238 and tritium discharged to the atmosphere were 0.022 mCi and 8,859 Ci, respectively. Comparison of these quantities to the RCG is not valid.

Table 1

CONCENTRATIONS OF PLUTONIUM IN
AIR AT OFF-SITE SAMPLING LOCATIONS IN 1975

Location	Number of Samples	^{238}Pu Range (10^{-17} μCi/ml)	^{238}Pu Average[a,d] (10^{-17} μCi/ml)	Percent of RCG[b]	^{239}Pu Average[c,d] (10^{-17} μCi/ml)	$^{238}Pu/^{239}Pu$
101	52	0.37 - 5.6	2.3 ±0.22	0.12	2.9 ±0.25	0.79
102	52	0.58 - 3.0	1.4 ±0.17	0.07	2.9 ±0.25	0.48
103	52	0.45 - 3.1	1.3 ±0.17	0.07	2.3 ±0.22	0.57
104	52	0.23 - 9.4	1.4 ±0.17	0.07	2.2 ±0.22	0.64
105	41	0.08 - 5.4	0.94 ±0.14	0.05	1.9 ±0.20	0.49
106	13	0.27 - 0.35	0.32 ±0.08	0.02	3.8 ±0.29	0.08
107	25	0.16 - 1.6	0.62 ±0.12	0.03	3.6 ±0.28	0.17
108	52	0.11 - 1.6	0.75 ±0.13	0.04	1.9 ±0.20	0.39
109	25	0.08 - 0.86	0.33 ±0.08	0.02	3.7 ±0.28	0.09
110	52	<0.079 - 0.47	<0.23 ±0.07	<0.01	1.9 ±0.20	<0.12
111	52	<0.079 - 0.53	<0.33 ±0.08	<0.02	2.2 ±0.22	<0.15
112	52	0.12 - 0.49	0.35 ±0.15	0.02	3.1 ±0.26	0.11
113	25	0.14 - 0.18	0.16 ±0.06	0.01	4.0 ±0.29	0.04
114	22	0.15 - 0.21	0.18 ±0.06	0.01	4.0 ±0.29	0.05
115	52	<0.079 - 0.38	<0.17 ±0.06	<0.01	2.6 ±0.24	<0.07
116	25	0.10 - 0.13	0.12 ±0.05	0.01	3.5 ±0.28	0.03
117	21	0.15 - 0.74	0.48 ±0.10	0.02	3.4 ±0.27	0.14
118	52	0.14 - 0.76	0.44 ±0.10	0.02	1.8 ±0.20	0.24
119	50	<0.079 - 0.20	<0.14 ±0.06	<0.01	1.9 ±0.20	<0.07
120	25	0.17 - 0.18	0.18 ±0.06	0.01	3.5 ±0.28	0.05
121	25	0.14 - 0.18	0.16 ±0.06	0.01	3.7 ±0.28	0.04
122	44	0.64 - 7.4	1.7 ±0.19	0.09	1.6 ±0.19	1.1

[a] Minimum Detection Limit (MDL) for ^{238}Pu in air is 0.079 x 10^{-17} μCi/ml which is 0.004% of the RCG.

[b] Radioactivity Concentration Guide (RCG) = 2000 x 10^{-17} μCi/ml for the soluble form of ^{238}Pu and the general population.

[c] Minimum Detection Limit (MDL) for ^{239}Pu in air is 0.046 x 10^{-17} μCi/ml.

[d] Error limits are counting statistics only at 95% C.L.

Table 2

CONCENTRATIONS OF TRITIUM OXIDE IN AIR
AT OFF-SITE SAMPLING LOCATIONS IN 1975

Location	Number of Samples	Range (10^{-11} μCi/ml)	Average[a,c] (10^{-11} μCi/ml)	Percent of RCG[b]
101	52	<0.72 - 4.2	<1.3 ±0.27	<0.02
102	52	<0.72 - 4.9	<1.6 ±0.30	<0.02
103	52	<0.72 - 5.2	<1.4 ±0.28	<0.02
104	52	<0.72 - 2.7	<0.9 ±0.23	<0.01
105	52	<0.72 - 6.8	<1.1 ±0.25	<0.02
106	27	<0.72 - 1.1	<0.73 ±0.20	<0.01
107	27	<0.72 - 1.4	<0.79 ±0.21	<0.01
108	52	<0.72 - 2.1	<0.78 ±0.21	<0.01
109	27	<0.72 - 1.8	<0.80 ±0.21	<0.01
110	52	<0.72 - 1.6	<0.74 ±0.21	<0.01
111	52	<0.72 - 1.3	<0.74 ±0.21	<0.01
112	52	<0.72 - 4.6	<1.0 ±0.21	<0.01
113	27	<0.72 - 1.3	<0.76 ±0.21	<0.01
114	23	<0.72 - 1.4	<0.77 ±0.21	<0.01
115	52	<0.72 - 1.7	<0.75 ±0.21	<0.01
116	27	<0.72 - 1.2	<0.74 ±0.21	<0.01
117	23	<0.72 - 1.3	<0.77 ±0.21	<0.01
118	52	<0.72 - 1.8	<0.89 ±0.23	<0.01
119	51	<0.72 - 1.3	<0.74 ±0.21	<0.01
120	27	<0.72 - 0.87	<0.72 ±0.20	<0.01
121	27	<0.72 - 1.0	<0.73 ±0.20	<0.01

[a] Minimum Detection Limit (MDL) for tritium oxide in air is 0.72×10^{-11} μCi/ml, which is 0.01% of the RCG.

[b] Radioactivity Concentration Guide (RCG) = 7000×10^{-11} μCi/ml for the general population and for soluble form of tritium.

[c] Error limits are counting statistics only at 95% C.L.

Table 3

CONCENTRATIONS OF BACKGROUND LEVELS
OF TRITIUM AND PLUTONIUM-238 IN 1975

Plutonium-238 in Air[a]	$0.3 \pm 0.1 \times 10^{-17}$ μCi/ml
Plutonium-238 in Surface Water[b]	7×10^{-13} μCi/ml
Tritium-Oxide in Air[c]	0.2×10^{-11} μCi/ml
Tritium-Oxide in Surface Water[d]	$0.5 \pm 0.2 \times 10^{-6}$ μCi/ml

[a] References 12, 13
[b] Reference 14
[c] Reference 15
[d] Reference 16

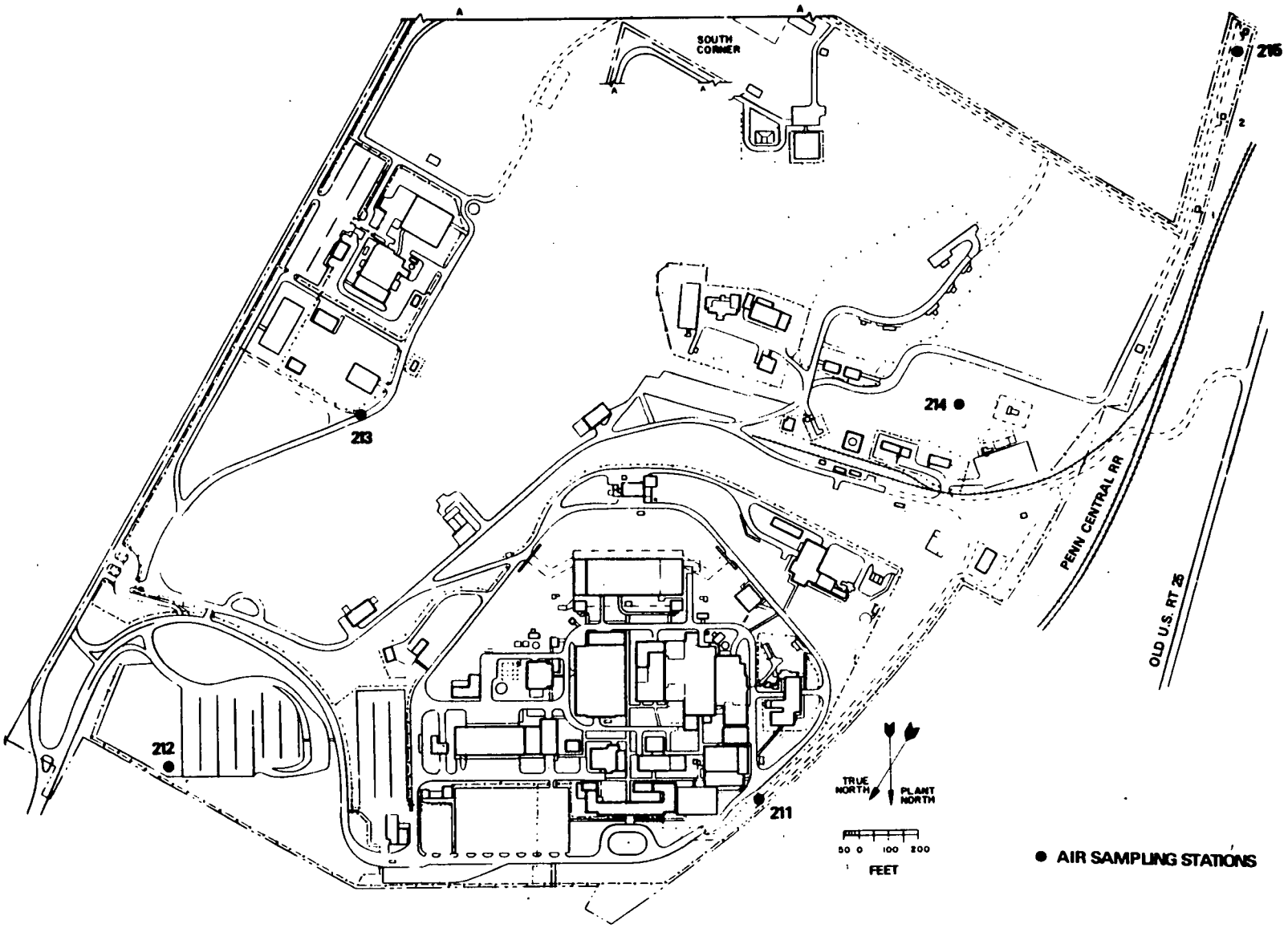

FIGURE 2 - On-site air sampling locations

Table 4

CONCENTRATION OF ^{238}Pu IN
AIR AT ON-SITE SAMPLING LOCATIONS IN 1975

Location	Number of Samples	^{238}Pu Range (10^{-17} μCi/ml)	^{238}Pu Average[a,d] (10^{-17} μCi/ml)	Percent of RCG[b]	^{239}Pu Average[c] (10^{-17} μCi/ml)	$^{238}Pu/^{239}Pu$
211	52	6.8 - 72.9	21.2 ±0.72	0.3	2.2 ±0.23	9.6
212	49	2.3 - 14.2	5.2 ±0.36	0.07	2.1 ±0.23	2.5
213	52	8.7 - 1095.9	103.3 ±1.6	1.5	4.1 ±0.32	25.2
214	44	1.3 - 17.3	6.7 ±0.41	0.1	2.5 ±0.25	2.7
215	51	1.7 - 9.1	3.8 ±0.31	0.05	2.2 ±0.23	1.7

[a] Minimum Detection Limit (MDL) for ^{238}Pu in air is 0.089 x 10^{-17} μCi/ml which is 0.0012% of the RCG.

[b] Radioactivity Concentration Guide (RCG) = 7000 x 10^{-17} μCi/ml for the soluble form of plutonium-238 for individuals in the population.

[c] Minimum Detection Limit (MDL) for ^{239}Pu is 0.052 x 10^{-17} μCi/ml.

[d] Error limits are counting statistics only at 95% C.L.

Table 5

CONCENTRATION OF TRITIUM OXIDE IN
AIR AT ON-SITE SAMPLING LOCATIONS IN 1975

Location	Number of Samples	Range (10^{-11} μCi/ml)	Average[a,c] (10^{-11} μCi/ml)	Percent of RCG[b]
211	52	<1.2 - 10.0	<3.1 ±0.55	<0.02
212	50	<1.2 - 9.0	<3.3 ±0.56	<0.02
213	52	<1.2 - 11.7	<3.1 ±0.55	<0.02
214	52	<1.2 - 29.0	<3.4 ±0.58	<0.02
215	51	<1.2 - 8.3	<2.0 ±0.44	<0.01

[a] Minimum Detection Limit (MDL) for tritium oxide in air is 1.22×10^{-11} μCi/ml which is 0.006% of the RCG.

[b] Radioactivity Concentration Guide (RCG) = $20{,}000 \times 10^{-11}$ μCi/ml for individuals in the population and soluble form of tritium.

[c] Error limits are counting statistics only at 95% C.L.

AIR - NONRADIOACTIVE

The Mound steam power supply has been converted from fuel oil to natural gas on an interruptable basis. During unusually cold weather, natural gas supply to Mound is interrupted and fuel oil with much less than 1% sulfur content is burned. Except for these occasions, virtually all sulfur dioxide emissions have been eliminated. None of the present operations at Mound Laboratory involve amounts of material which would lead to significant particulate, carbon monoxide, photochemical oxidant, or hydrocarbon emissions from stationary sources. Therefore, no sampling for these nonradioactive pollutants is done at this time.

WATER - RADIOACTIVE

Water sampling locations along the bank of the Great Miami River were selected according to guidelines proposed by the U.S. EPA.[9] The locations, shown in Figure 3, provide samples which are representative of river water after suitable mixing of the effluent from Mound has occurred. Water samples are collected at these locations five days per week and are subjected to specific analyses for plutonium-238 and tritium oxide.

The plutonium-238 river water analyses have been upgraded to allow lower detection of plutonium-238 in water. Large volume water samples are analyzed by compositing daily samples for a semiannual analysis. The average volume of water analyzed was 19 liters. The average concentration of plutonium-238 measured in the Great Miami River was 0.3×10^{-10} μCi/ml which is 0.002% of the RCG for the general population and the most restrictive form (soluble) of plutonium-238. These results are summarized in Table 6.

Tritium oxide analyses are performed on a weekly composite of daily samples. The average concentration of tritium oxide measured in the Great Miami River was $<1.9 \times 10^{-6}$ μCi/ml which is <0.2% of the RCG for the general population and for the most restrictive form of tritium. The results are summarized in Table 7.

Results of plutonium-238 and tritium analyses for three off-site sampling locations on the abandoned Miami-Erie Canal and adjacent ponds are reported in Tables 8 and 9, respectively. These values represent levels from the site drainage ditch which discharges into the off-site canal-pond system prior to mixing with the Great Miami River. These values, as expected, are higher than those concentrations found in the Great Miami River where mixing and dilution occur.

The total amounts of plutonium-238, tritium, and uranium-233 discharged to the Great Miami River were 18 mCi, 58 Ci, and 17 mCi, respectively. These values in terms of RCG's are 0.3%, 1.8% and 0.05% of the most restrictive RCG for individuals in the population. From the uranium-233 concentrations found in the effluent streams, estimated concentrations off-site from Mound operations would be negligible. This can be

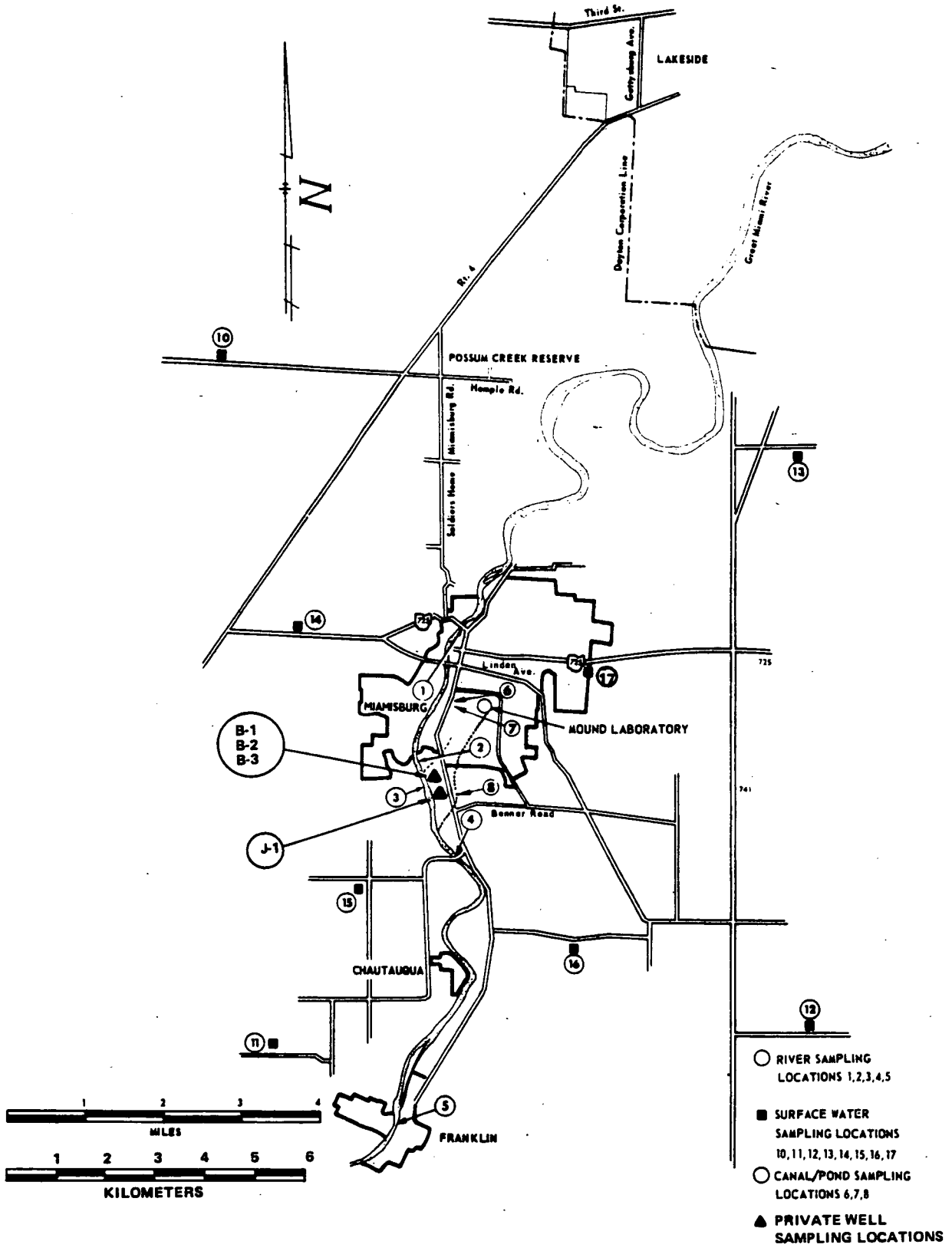

FIGURE 3 - Off-site water sampling locations

Table 6

CONCENTRATION OF ^{238}Pu IN
THE GREAT MIAMI RIVER IN 1975

Location	Number of Samples	Range (10^{-10} μCi/ml)	Average[b,d] (10^{-10} μCi/ml)	Percent of RCG[c]
1	210	0.15 - 0.23	0.19 ±0.02	0.0010
2	210	0.32 - 0.35	0.34 ±0.03	0.0017
3[a]	210	(0.23)	0.23 ±0.03	0.0012
4	210	0.25 - 0.79	0.52 ±0.04	0.0026
5	210	0.06 - 0.43	0.24 ±0.03	0.0012

[a] Only one composite.

[b] Minimum Detection Limit (MDL) for ^{238}Pu in water is 0.01×10^{-10} μCi/ml which is 0.00005% of the RCG.

[c] Radioactivity Concentration Guide (RCG) = $20,000 \times 10^{-10}$ μCi/ml for the general population and the soluble form of plutonium-238.

[d] Error limits are counting statistics only at 95% C.L.

Table 7

CONCENTRATION OF TRITIUM IN
THE GREAT MIAMI RIVER IN 1975

Location	Number of Samples	Range (10^{-6} μCi/ml)	Average[a,c] (10^{-6} μCi/ml)	Percent of RCG[b]
1	210	<0.5 - 7.7	<1.5 ±0.19	<0.15
2	210	<0.5 - 17.5	<2.1 ±0.23	<0.21
3	210	<0.5 - 13.9	<1.9 ±0.22	<0.19
4	210	<0.5 - 19.8	<2.1 ±0.23	<0.21
5	210	<0.5 - 14.5	<1.7 ±0.20	<0.17

[a] Minimum Detection Limit (MDL) for tritium in water is 0.5×10^{-6} μCi/ml which is 0.05% of the RCG.

[b] Radioactivity Concentration Guide (RCG) = 1000×10^{-6} μCi/ml for the general population and the soluble form of tritium.

[c] Error limits are counting statistics only at 95% C.L.

Table 8

CONCENTRATION OF ^{238}Pu IN
CANAL/POND AREA IN 1975

Location[a]	Number of Samples	Range (10^{-10} μCi/ml)	Average[b,d] (10^{-10} μCi/ml)	Percent of RCG[c]
6 (North Pond)	210	0.63 - 3.8	2.2 ±0.08	0.01
7 (North Canal)	210	0.83 - 5.9	3.4 ±0.10	0.02
8 (South Canal)	210	8.1 - 19.9	14.0 ±0.20	0.07

[a]Locations are shown in Figure 3.

[b]Minimum Detection Limit (MDL) for ^{238}Pu in water is 0.01 x 10^{-10} μCi/ml which is 0.00005% of the RCG.

[c]Radioactivity Concentration Guide (RCG) = 20,000 x 10^{-10} μCi/ml for the general population and soluble form of plutonium-238.

[d]Error limits are counting statistics only at 95% C.L.

Table 9

CONCENTRATION OF TRITIUM IN
CANAL/POND AREA IN 1975

Location[a]	Number of Samples	Range (10^{-6} μCi/ml)	Average[b,d] (10^{-6} μCi/ml)	Percent of RCG[c]
6 (North Pond)	210	19 - 72	37 ±1.0	3.7
7 (North Canal)	210	18 - 87	39 ±1.0	3.9
8 (South Canal)	210	17 - 96	43 ±1.0	4.3

[a]Locations are shown in Figure 3.

[b]Mimimum Detection Limit (MDL) for tritium in water is 0.5 x 10^{-6} μCi/ml which is 0.05% of the RCG.

[c]Radioactivity Concentration Guide (RCG) = 1000 x 10^{-6} μCi/ml for the general population and soluble form of tritium.

[d]Error limits are counting statistics only at 95% C.L.

readily seen by comparing plutonium-238 quantities found in the effluent streams with concentrations found off-site.

Eight additional surface water locations such as ponds are sampled annually. These samples, used for plutonium-238 determination, are large volume water samples of approximately 40 liters each. The large volume of sample increases the sensitivity of the analysis. A smaller aliquot (10 ml) was taken for the tritium oxide analysis. The average concentrations of plutonium-238 and tritium oxide at these locations were 0.65×10^{-10} μCi/ml and $<1.2 \times 10^{-6}$ μCi/ml, respectively, which are 0.003% and 0.12% of their respective RCG's for the general population. The results of the surface water monitoring program are summarized in Tables 10 and 11.

Table 10

SUMMARY OF SURFACE WATER MONITORING
FOR PLUTONIUM-238 IN 1975

Location	Number of Samples	Average[a,c] (10^{-10} μCi/ml)	Percent of RCG[b]
10	1	1.4 ±0.02	0.007
11	1	1.5 ±0.02	0.008
12	1	0.67 ±0.02	0.003
13	1	0.34 ±0.01	0.002
14	1	0.41 ±0.01	0.002
15	1	0.66 ±0.02	0.003
16	1	0.09 ±0.01	0.0006
17	1	0.14 ±0.01	0.0007

[a] Minimum Detection Limit (MDL) for ^{238}Pu in water is 0.003×10^{-10} μCi/ml. The MDL = 0.000015% of the RCG.

[b] Radioactivity Concentration Guide (RCG) for ^{238}Pu in water = $20,000 \times 10^{-10}$ μCi/ml for the general population and soluble form of plutonium-238.

[c] Error limits are counting statistics only at 95% C.L.

In addition, background levels of plutonium-238 and tritium oxide for surface water are shown in Table 3.

Drinking water from communities in the surrounding area is sampled and analyzed semiannually for tritium oxide with the exception of drinking water from Miamisburg which was sampled and analyzed monthly for tritium oxide. These communities are shown in Figure 1.

Table 11

SUMMARY OF SURFACE WATER MONITORING
FOR TRITIUM IN 1975

Location	Number of Samples	Average[a,c] (10^{-6} μCi/ml)	Percent of RCG[b]
10	1	0.9 ±0.1	0.09
11	1	3.1 ±0.2	0.31
12	1	<0.3 ±0.1	<0.03
13	1	0.8 ±0.1	0.08
14	1	1.5 ±0.1	0.15
15	1	0.6 ±0.1	0.06
16	1	0.4 ±0.1	0.04
17	1	2.1 ±0.2	0.21

[a] Minimum Detection Limit (MDL) for tritium in water is 0.3×10^{-6} μCi/ml. The MDL is 0.03% of the RCG.

[b] Radioactivity Concentration Guide (RCG) for tritium oxide in water = 1000×10^{-6} μCi/ml for the general population and soluble form of tritium.

[c] Error limits are counting statistics only at 95% C.L.

The average concentration of tritium oxide was $<1.4 \times 10^{-6}$ μCi/ml which is <0.14% of the RCG for the general population. The results of the community drinking water sampling program are summarized in Table 12.

Several private wells in the vicinity of Mound Laboratory were also sampled and analyzed monthly for tritium oxide. The average concentration of tritium oxide in these wells was 50.0×10^{-6} μCi/ml which is 5.0% of the RCG for the general population. The well results are summarized in Table 13. These wells apparently have been minutely influenced by Mound Laboratory tritium effluent releases in water. As shown by the data, concentrations in these wells are higher than in other wells in the area, but much less than the RCG. This situation has apparently developed from years of releasing quantities of water effluents at a small fraction of the RCG. Part of this water effluent has migrated into the aquifer at short distances from Mound Laboratory.

Two private wells and Miamisburg city water were sampled and analyzed monthly for plutonium-238. These samples also were large volume water samples averaging 40 liters. The average plutonium-238 concentration of these samples was 0.06×10^{-10} μCi/ml which is 0.0003% of the RCG for the general population. These results are shown in Table 14.

Table 12

SUMMARY OF TRITIUM OXIDE LEVELS
IN COMMUNITY DRINKING WATER IN 1975

Location	Number of Samples	Range (10^{-6} μCi/ml)	Average[a,c] (10^{-6} μCi/ml)	Percent of RCG[b]
Bellbrook	2	<0.5 - 1.1	<0.8 ±0.14	<0.08
Centerville	2	<0.5 - 1.7	<1.1 ±0.16	<0.11
Dayton	2	<0.5 - 0.9	<0.7 ±0.13	<0.07
Franklin	2	<0.5 - 1.4	<1.0 ±0.15	<0.10
Germantown	2	1.0 - 1.3	1.2 ±0.17	0.12
Kettering	2	<0.5 - 1.2	<0.9 ±0.15	<0.09
Miamisburg	11	5.5 - 8.9	7.1 ±0.45	0.71
Middletown	2	<0.5 - 0.7	<0.6 ±0.12	<0.06
Moraine	2	<0.5 - 1.2	<0.9 ±0.15	<0.09
South Lebanon	2	<0.5 - 0.7	<0.6 ±0.12	<0.06
Springboro	2	<0.5 - 1.4	<1.0 ±0.15	<0.10
Waynesville	2	<0.5 - <0.5	<0.5 ±0.11	<0.05
West Carrollton	2	1.6 - 1.7	1.7 ±0.20	0.17

[a]Minimum Detection Limit (MDL) for tritium oxide is 0.5 x 10^{-6} μCi/ml. The MDL is 0.05% of the RCG.

[b]Radioactivity Concentration Guide (RCG) for tritium oxide in water = 1000 x 10^{-6} μCi/ml for the general population and soluble form of tritium.

[c]Error limits are counting statistics only at 95% C.L.

Table 13

TRITIUM-OXIDE IN PRIVATE WELLS
IN 1975

Location	Number of Samples	Range (10^{-6} μCi/ml)	Average[a,c] (10^{-6} μCi/ml)	Percent of RCG[b]
B-1	11	65.3 - 89.9	74.9 ±1.5	7.5
B-2	11	32.7 - 40.0	35.7 ±1.0	3.6
B-3	11	34.6 - 42.9	37.7 ±1.0	3.8
J-1	11	44.0 - 63.5	51.5 ±1.2	5.2

[a]Minimum Detection Limit (MDL) for tritium oxide is 0.6 x 10^{-6} μCi/ml. The MDL is 0.06% of the RCG.

[b]Radioactivity Concentration Guide (RCG) for tritium oxide in water = 1000 x 10^{-6} μCi/ml for general population and soluble form of tritium.

[c]Error limits are counting statistics only at 95% C.L.

Table 14

PLUTONIUM-238 IN PRIVATE WELLS AND
MIAMISBURG MUNICIPAL DRINKING WATER IN 1975

Location	Number of Samples	Range (10^{-10} μCi/ml)	Average[a,c] (10^{-10} μCi/ml)	Percent of RCG[b]
Miamisburg	11	0.07 - 0.80	0.43 ±0.03	0.002
J	11	0.08 - 0.33	0.20 ±0.02	0.001
B	11	0.04 - 0.08	0.06 ±0.01	0.0003

[a] Minimum Detection Limit (MDL) for ^{238}Pu is 0.006 x 10^{-10} μCi/ml. The MDL is 0.00003% of the RCG.

[b] Radioactivity Concentration Guide (RCG) for ^{238}Pu in water = 20,000 x 10^{-10} μCi/ml for the general population and soluble form of plutonium-238.

[c] Error limits are counting statistics only at 95% C.L.

WATER - NONRADIOACTIVE

Mound Laboratory was issued a discharge permit under the National Pollutant Discharge Elimination System (NPDES). The permit was issued by Region V of the USEPA effective July 1, 1975. Each of the two effluent streams from Mound which discharge to the Great Miami River has limitations specified by the discharge permit. The discharge from outfall number 001 includes the discharge from the sanitary waste treatment plant, radioactive waste disposal facility, single-pass cooling water, zeolite softener backwash, and some storm water runoff. The discharge from outfall number 002 consists of single-pass cooling water, cooling-tower blowdown, boiler-plant blowdown, zeolite softener backwash, and most of the storm water runoff. A 24-hr composite sample of each effluent stream is automatically collected daily. The volume of samples collected is proportional to the flow in the stream. The composite effluent water samples are analyzed for the water quality parameters listed in Tables 10 and 11 according to standard methods.[10] The results of effluent stream analyses for 1975 are summarized in Tables 15 and 16. All results are within permit limitations with the exception of oil and grease. The limitation was exceeded once for outfall 001 and twice for outfall 002. A contaminated sample or an analytical error is suspected since no discharge of oil, either intentional or accidental, was reported or observed. However, since the flow of the Great Miami River, even under low-flow conditions, was approximately 400 times the maximum flow discharge from Mound during 1975[11], these limitation exceptions had no significant effect on the River and certainly did not cause the Ohio Stream Standards to be exceeded.

Table 15

1975 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT DATA FOR STATION 001

Parameter		No. Samples	Minimum	Maximum	Average
Flow	Reported	Cont.	0.12 MGD	0.33 MGD	0.19 MGD
	Permit			0.92	0.53
BOD_5	Reported	52	3.2	23.6	8.9
	Permit			45.0	30.0
Fecal Coliform	Reported	26	ND	15.0	5.4
	Permit			400.0	200.0
Suspended Solids	Reported	52	ND	44.0	16.9
	Permit			45.0	30.0
Dissolved Oxygen	Reported	182	5.4	9.6	7.4
	Permit				5.0
Residual Chlorine	Reported	52	0.25	0.8	0.61
	Permit			0.8	
Oil and Grease	Reported	26	ND	22.3	2.7
	Permit			10.0	
pH	Reported	182	6.2	8.3	
	Permit		6.0	9.0	
Carbon	Reported	52	53.0	110.0	85.0
	Permit		-	-	-
Ammonia	Reported	26	0.1	0.1	0.1
	Permit		-	-	-

NOTES:

ND - none detectable.

MGD - million gallons per day.

Values for fecal coliform are number of coliform per 100 ml of water.

All other values are in milligrams per liter.

FOODSTUFFS AND VEGETATION - RADIOACTIVE

Various locally grown foodstuffs and vegetation samples are collected from the surrounding area. The intent of this portion of the Environmental Monitoring Program is to determine whether there is any uptake and concentration of radionuclides by plant or animal life. Where possible, sampling sites are chosen at maximum deposition locations predicted on the basis of the diffusion model developed for Mound Laboratory. Field crops, fruit, and vegetables are collected on the

Table 16

1975 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT DATA FOR STATION 002

Parameter		No. Samples	Minimum	Maximum	Average
Flow	Reported	Cont.	0.33 MGD	0.85 MGD	0.51 MGD
	Permit				0.53
Suspended Solids	Reported	52	ND	23.0	10.6
	Permit			25.0	20.0
Dissolved Oxygen	Reported	182	5.2	9.6	7.3
	Permit				5.0
Residual Chlorine	Reported	26	0.05	0.05	0.05
	Permit			0.10	
Oil and Grease	Reported	26	ND	11.5	3.5
	Permit			10.0	
pH	Reported	182	6.5	8.3	
	Permit		6.0	9.0	
Dissolved Solids	Reported	52	93.0	2295.0	1008.0
	Permit			3000.0	2000.0

NOTES:

ND - none detectable.

MGD - million gallons per day.

All values are in milligrams per liter.

basis of this diffusion model. Milk is collected from individual farms closest to the Laboratory. Aquatic life is trapped from the Miami River generally downstream of Miamisburg and from adjacent waterways, dependent upon availability of fish. Grass samples are collected in the vicinity of the surface water locations listed in Tables 17 and 18. The plutonium-238 content of the foodstuff and vegetation samples is determined by slowly evaporating the samples to dryness and then proceeding with the same techniques used for plutonium-238 analyses of air samples (see section on Air - Radioactive). Milk samples are analyzed for tritium oxide by distilling the water fraction from an aliquot. The distillate is then analyzed for tritium by liquid scintillation spectrometry in the same manner as the water samples previously discussed in this report (see section on Water - Radioactive). The remaining foodstuff samples are analyzed for tritium by oxidizing the samples in a controlled air stream and collecting the combustion products. The tritium content of the combustion products is then determined by liquid scintillation spectrometry as discussed above. This technique allows analysis for total tritium in the samples rather than tritium oxide

only. The results of the foodstuff and vegetation analyses are summarized in Table 17 and 18. The concentration is given in terms of the sample weight (wet weight) before evaporation to dryness. The vegetables and fruits analyzed included potatoes and tomatoes. The field crops analyzed were the edible portions of corn and soybeans. The sample of aquatic life analyzed included only the edible fleshy portions of the fish. No evidence has been found that there is any significant uptake and concentration by plant or animal life of the radionuclides handled at Mound Laboratory.

Table 17

PLUTONIUM-238 IN FOODSTUFFS
AND VEGETATION IN 1975

Type of Sample	Number of Samples	Range (10^{-8} μCi/g)	Average[a-c] (10^{-8} μCi/g)
Milk	6	<0.013 - 0.028	0.024 ±0.01
Fruits & Vegetables	3	<0.022 - 0.086	<0.064 ±0.02
Grass	8	0.50 - 2.18	1.01 ±0.15
Field Crops	1	(0.11)	0.11 ±0.03
Aquatic Life	3	<0.022 - 0.03	<0.026 ±0.01

[a]Minimum Detection Limit (MDL) for ^{238}Pu in milk, fruits and vegetables, field crops, and aquatic life is 0.022 x 10^{-8} μCi/g.

[b]Minimum Detection Limit (MDL) for ^{238}Pu in grass is 0.09 x 10^{-8} μCi/g.

[c]Error limits are counting statistics only at 95% C.L.

SOIL AND SILT - RADIOACTIVE

During CY-1975 emphasis was placed on the evaluation of previously collected soil monitoring data, specifically soil core samples. The program is twofold, evaluation of plutonium-238 deposition from releases via water and evaluation of plutonium-238 deposition from releases via stack.

Preliminary soil and silt samples collected from off-site sediment in the Miami-Erie canal area near Mound Laboratory indicated that plutonium-238 concentrations were substantially above baseline levels. As a result, an extensive sampling and analysis program was performed during 1974 to determine plutonium-238 concentrations as a function of depth and location in the drainage ditch, the canal, two ponds, a runoff hollow, a canal overflow creek, and the Great Miami River. The study

Table 18

TRITIUM IN FOODSTUFFS
AND VEGETATION IN 1975

Type of Sample	Number of Samples	Average[a,b] (10^{-6} μCi/g)
Milk	3	<10.5 ±6.9
Fruits & Vegetables	1	< 4.4 ±2.9
Grass	8	< 4.4 ±2.9
Field Crops	1	< 4.9 ±3.3
Aquatic Life	3	< 4.4 ±2.9

[a]All samples less than Minimum Detection Limit (MDL). MDL for tritium in fruits and vegetables, grass, and aquatic life = 4.4 x 10^{-6} μCi/g. MDL for tritium in field crops = 4.9 x 10^{-6} μCi/g. MDL for tritium in milk = 10.5 x 10^{-6} μCi/g.

[b]Error limits are counting statistics only at 95% C.L.

found that in January, 1969, plutonium-238 had been released when an underground pipeline carrying plutonium-238 waste solution from the Plutonium Processing (PP) Building to the Waste Disposal (WD) Facility ruptured. Acidic waste solution containing plutonium-238 was released to the soil adjacent to the pipe. The plutonium was quickly and strongly sorbed by the soil where it was immobilized. During excavation and repair operations in 1969 when the contaminated soil was most susceptible to erosion, the weather warmed and there was intense rainfall for two days. This heavy rain eroded the exposed surface of the contaminated soil causing the soil particles to be carried off-site. These erosion products, suspended in the moving water, settled according to normal sedimentation processes in the waterways adjacent to Mound Laboratory. From 1974 sampling and analysis data, it was determined that about 5.2 Ci of plutonium-238 were deposited on sediment in these waterways, approximately 1-1/2 miles long, mostly buried under up to 3 ft of sediment.[5]

Soil core sample values around and within the Laboratory site boundary were used to arrive at a preliminary estimate of deposition of airborne plutonium-238 from Laboratory operations. It should be pointed out that this is <u>not</u> a <u>final</u> estimate of the inventory value. More core samples should be taken in order to obtain a statistically valid inventory value. A minimum of 80 additional sampling locations is planned.

The preliminary soil inventory was established within the 1 mCi/km^2 boundary of plutonium-238 concentrations. Additional data, to be collected during 1976, will be required to assess the inventory beyond the 1 mCi/km^2 boundary.

The concentrations were determined by using a planimeter on an enlarged map of the area (see Figure 4). Iso-millicurie lines were determined from soil samples taken in and around the Laboratory vicinity. The area between each isopleth was measured by the planimeter. The millicurie concentration between each contour line was calculated by taking the product of the area and the average value of the two boundary contour lines.

Equations were developed for each of 16 directions from Mound Laboratory of the form: $y = ax^b$

where y = concentration
a = constant
x = distance
b = exponent

These equations were used to plot additional isopleths to fill gaps in the data where no soil core samples had been taken. These additional contours were then used to determine a revised estimate of the total millicurie value in the vicinity of Mound Laboratory.

The estimate of deposited plutonium-238 is 464 mCi outside Mound Laboratory within the 1 mCi/km^2 boundary. It should be pointed out again that this estimate is only a preliminary estimate. More core sampling data are needed to arrive at a final estimate.

In summary, a preliminary evaluation indicates that airborne releases of plutonium-238 have contributed roughly 0.5 Ci to the off-site environment as deposition on soil. Water releases of plutonium-238 are responsible for an additional 5.2 Ci deposited in the off-site adjacent waterways.

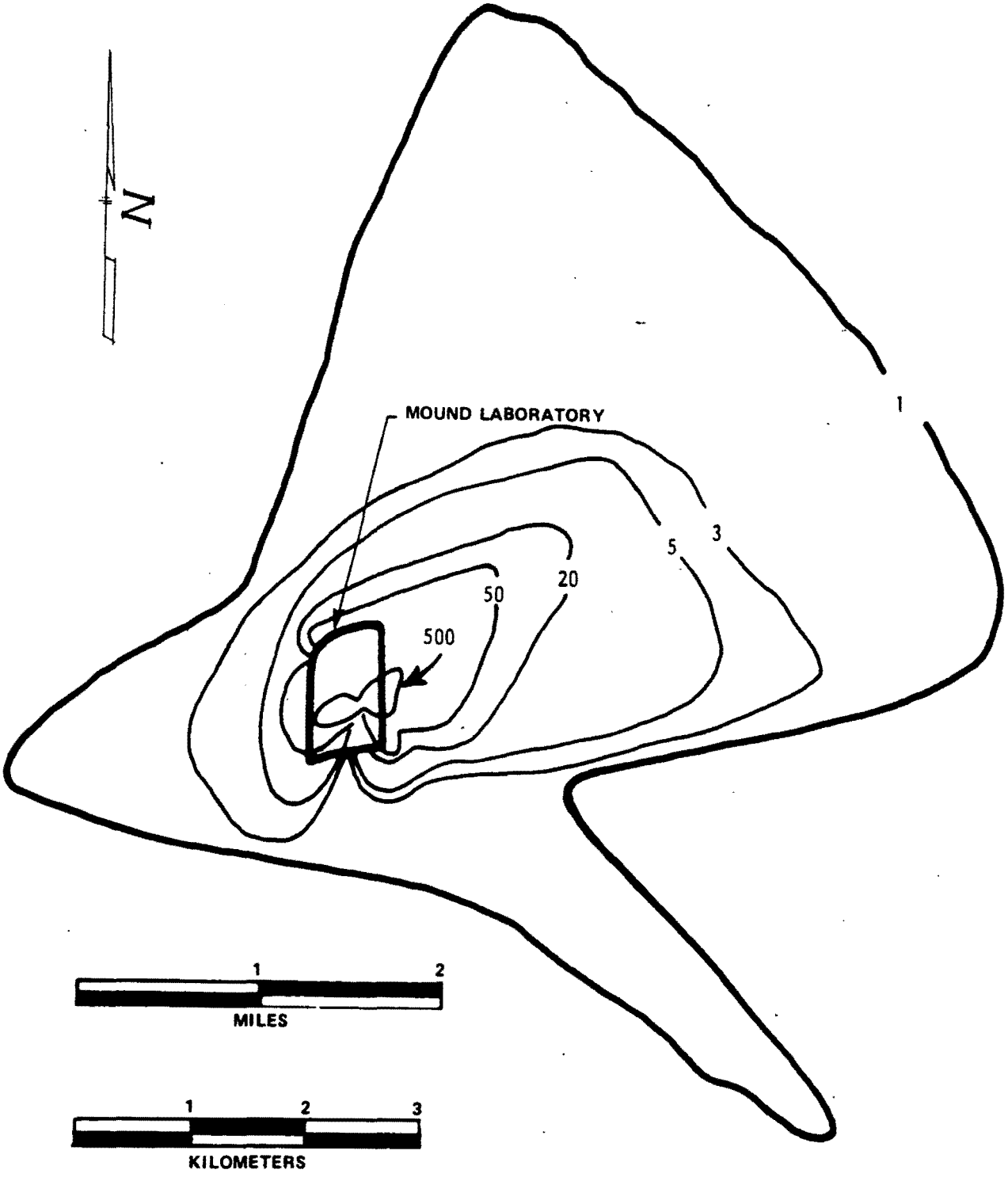

FIGURE 4 - Millicurie per square kilometer isopleths

Evaluation of Potential Dose to the Public

A dose assessment was performed for each radionuclide measureable in the environment from Mound Laboratory operations. These radionuclides are plutonium-238 and tritium. Tritium (oxide) is the only radionuclide at Mound Laboratory for which the critical organ is the whole body. The critical organs for plutonium-238 are assumed to be the lung for insoluble material and the bone for soluble material since the solubility in the receptor is unknown. In order to resolve the uncertainty of the solubility of plutonium, each dose evaluation for the lung or the bone included 100% of the concentration found in the environment, which gives a very conservative estimate.

PLUTONIUM-238

Assumptions and Methodology The dose estimates for plutonium-238 were based on environmental monitoring data for CY-1975. The estimates for maximum dose to the lung at the site boundary and maximum dose to the lung in individuals were based on the maximum on-site average concentration of plutonium-238 in air from our on-site samplers since the samplers are in close proximity to the site boundary. The maximum dose to the lung in population group(s) was based on the maximum off-site average concentration of plutonium-238 in air.

The estimates for maximum dose to the bone at the site boundary and in individuals were also based on the maximum on-site average concentration of plutonium-238 in air and the maximum off-site average concentration of plutonium-238 in drinking water. The maximum dose to the bone for population group(s) was based on the maximum off-site average concentration of plutonium-238 in air and water. The total dose equivalent for bone was obtained by the addition of the dose equivalent of plutonium in air and the dose equivalent of plutonium in water.

Calculational Methods The dose equivalent to the lung resulting from continuous inhalation of airborne plutonium-238 was calculated by:

$$D(t) = \frac{51.1\ C\ I_a\ t\ f_a\ f_r\ \Sigma EF(RBE)_x}{\lambda m} \left(1 - \frac{1 - e^{-\lambda t}}{\lambda t}\right)$$

where D(t) = dose equivalent delivered to the lung in 365 days of continuous exposure to plutonium-238 in air, rem/yr

C = average airborne concentration, μCi/ml

I_a = average air intake = 2×10^7 ml/day (Ref. 17)

t = time exposed, 365 days

f_a = fraction of inhaled material reaching organ of interest = 0.7 (max.) for the pulmonary region (Ref. 22)

f_r = fraction of pulmonary deposition undergoing long-term retention = 0.6 for actinide (class Y) (Ref. 22)

$\Sigma EF(RBE)_\alpha$ = effective energy deposition per disintegration = 57

λ = effective decay rate, 0.0014 day^{-1} for actinides (class Y) from the pulmonary region (Ref. 23)

m = lung mass, 1000 g (Ref. 17)

The dose equivalent to bone resulting from continuous inhalation of airborne plutonium-238 was calculated by:

$$D(t) = \frac{51.1\ C\ I_a\ f_a\ t\ \Sigma EF(RBE)_\alpha}{\lambda m} \left(1 - \frac{1 - e^{-\lambda t}}{\lambda t}\right)$$

where f_a = 0.2 (Ref. 17)

$\Sigma EF(RBE)_\alpha$ = 284 (Ref. 17)

$m = 7 \times 10^3$ g (Ref. 17)

$\lambda = 3 \times 10^{-5}\ day^{-1}$ (Ref. 17)

The dose equivalent to bone resulting from continuous ingestion of plutonium-238 in water was calculated by:

$$D(t) = \frac{51.1\ C\ I_w\ f_a\ t\ \Sigma EF(RBE)_\alpha}{\lambda m} \left(1 - \frac{1 - e^{-\lambda t}}{\lambda t}\right)$$

where I_w = average quantity of water intake, 2200 cm^3 (Ref. 17)

$f_a = 2.4 \times 10^{-5}$ (Ref. 17)

The results of the calculations are:

Maximum dose to the lung at the site boundary -	1.43	mrem/yr
Maximum dose to the lung in individuals -	1.43	mrem/yr
Maximum dose to the lung in population group(s) -	0.028	mrem/yr
Maximum dose to the bone at the site boundary -	0.572	mrem/yr
Maximum dose to the bone in individuals -	0.572	mrem/yr
Maximum dose to the bone in population group(s) -	0.011	mrem/yr

TRITIUM (OXIDE)

Assumptions and Methodology The dose estimates for tritium (oxide) were also based on environmental monitoring data for CY-1975. The concentrations used for dose estimates for tritium (oxide) were produced by the same method as that used for plutonium. The total dose equivalent for the whole body was obtained by addition of the dose equivalent of tritium (oxide) in air and the dose equivalent of tritium (oxide) in air and the dose equivalent of tritium (oxide) in water.

Calculational Methods The dose equivalent to the whole body resulting from continuous exposure to tritium (oxide) in air was calculated by:

$$D(t)_a = \frac{\overline{C}_a}{R_a} \times S$$

where $D(t)_a$ = dose equivalent, mrem/yr

$\overline{C}_a$ = average concentration of tritium (oxide) in air

R_a = RCG for tritium (oxide) in air (Ref. 8)

S = Radiation protection standard in mrem/yr (Ref. 8)

The dose equivalent to the whole body resulting from continuous uptake of tritium (oxide) in water was calculated by:

$$D(t)_w = \frac{\overline{C}_w}{R_w} \times S$$

where $D(t)_w$ = dose equivalent in mrem/yr

$\overline{C}_w$ = average concentration

R_w = RCG for tritium (oxide) in water (Ref. 8)

S = radiation protection standard in mrem/yr (Ref. 8)

These dose equivalent values were divided by 1.7 in order to reflect the quality factor of one as recommended by the International Commission on Radiological Protection[18] and the National Council on Radiation Protection and Measurements.[19]

The results of the calculations are:

Maximum dose at the site boundary -	4.84 mrem/yr
Maximum dose to an individual -	4.84 mrem/yr
Maximum dose to population group(s) -	4.81 mrem/yr

The 50-mi (80-km) person-rem (whole body) dose estimates were based on average tritium (oxide) data from environmental air sampling stations, average tritium (oxide) data in community drinking water, and atmospheric dispersion estimates.

Two ranges of dose estimates were considered to obtain the 50-mi (80-km) person-rem dose estimate. The first range was from 0 to 2 mi (3.2 km). The second range was from 2 to 50 mi. This distance breakdown was used because of the placement of samplers in the Mound diffusion model.

The 0 to 2 mi range dose estimate for airborne tritium oxide was obtained from the average concentration (less background) of seven off-site tritium (oxide) samplers within a 2-mi radius of Mound Laboratory. This distance range dose from tritium (oxide) in water was obtained from a weighted average of drinking water concentrations. These dose equivalents from tritium (oxide) in air and in water were summed.

The equations used for this calculation were:

$$\overline{D}(t)_{a_{0-2}} = \frac{\overline{C}_a}{R_a} \times S$$

where $\overline{D}(t)_{a_{0-2}}$ = dose equivalent from 0-2 mi from tritium (oxide) in air

$\overline{C}_a$ = average tritium (oxide) concentration in air from 0 to 2 mi

R_a = RCG for tritium (oxide) in air (Ref. 8)

S = radiation protection standard for tritium (oxide) in air in mrem/yr (Ref. 8)

$$\overline{D}(t)_{w_{0-2}} = \frac{\overline{C}_w}{R_w} \times S$$

where $\overline{D}(t)_{w_{0-2}}$ = dose equivalent from 0-2 mi from tritium (oxide) in water

$\overline{C}_w$ = average tritium (oxide) concentration in water from 0-2 mi

R_w = RCG for tritium (oxide) in water (Ref. 8)

S = radiation protection standard for tritium (oxide) in water, mrem/yr (Ref. 8)

The 2 to 50-mi range dose estimate was obtained by finding the midpoint distance where the average tritium (oxide) concentration of the remaining off-site samplers would be located. This value is estimated at

4.4 mi.[20] From this distance and average concentrations of tritium (oxide) at sampling locations from 2 to 20 mi, it was determined that the maximum distance of influence from Mound Laboratory is ~22 mi. Beyond 22 mi the levels are calculated to be background concentrations.

The dose equivalent for tritium (oxide) from 2 to 22 mi was based on the average of the remaining tritium (oxide) air sample concentrations and the average of the remaining community drinking water concentrations.

The equations for these calculations are:

$$\overline{D}(t)_{2-22_a} = \frac{\overline{C}_a}{R_a} \times S$$

where $\overline{D}(t)_{2-22_a}$ = dose equivalent from 2-22 mi from tritium (oxide) in air

$\overline{C}_a$ = average tritium (oxide) concentrations in air from 2 to 22 mi

R_a = RCG for tritium (oxide) in air (Ref. 17)

S = Radiation Protection Standard for tritium (oxide) in air, mrem/yr (Ref. 17)

$$\overline{D}(t)_{2-22_w} = \frac{\overline{C}_w}{R_w} \times S$$

where $\overline{D}(t)_{2-22_w}$ = dose equivalent from 2-22 mi from tritium (oxide) in water

$\overline{C}_w$ = average tritium (oxide) concentration in water from 2 to 22 mi

R_w = RCG for tritium (oxide) in water (Ref. 17)

S = Radiation Protection Standard for tritium (oxide) in water, mrem/yr (Ref. 17)

The total person-rem from 0-22 mi is obtained by:

$$\sum_0^{22} R = \left(\overline{D}(t)_{0-2_a} + \overline{D}(t)_{0-2_w}\right) \sum_0^{2} P + \left(\overline{D}(t)_{2-22_a} + \overline{D}(t)_{2-22_w}\right) \sum_2^{22} P$$

where $\sum_0^{22} R$ = person-rem within 22 mi

$\sum_0^{2} P$ = population from 0 to 2 mi = 14,700

$\sum_{2}^{22} P$ = population from 2 to 22 mi = 1,066,302

Note

The total person-rem from 0-22 mi is equal to 64 person-rem in addition to background. Based on diffusion model calculations, the remaining population from 22 to 50 mi is not receiving dose from tritium (oxide) releases from Mound Laboratory; therefore, the total person-rem from 0-50 mi (80 km) from tritium (oxide) releases from Mound Laboratory is equal to 64 person-rem.

For comparison, the person-rem values from natural radiation, including cosmic rays and terrestrial radiation, would be approximately 320,000 person-rem for the 0-50 mi range.[21] The dose commitment due to natural background tritium is 82 person-rem for the 0-50 mi range.

Acknowledgement

The authors gratefully acknowledge the efforts of L. C. Hopkins in collecting the radiological data and R. Brown in collecting the non-radiological data contained in this report. The authors also gratefully acknowledge the efforts of J. S. Madachy in the preparation of the preliminary atmospheric deposition estimate of plutonium-238 included in this report.

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Appendix

APPLICABLE STANDARDS

RADIOACTIVE STANDARDS

In conformance with ERDA Manual Chapter 0524, "Standards for Radiation Protection," off-site sample results are compared with RCG's established for the general population. These RCG's are derived by dividing the RCG's for an uncontrolled area by 3.

On-site sample results are compared with the uncontrolled area RCG's which are applicable for individuals in the population.

The RCG values (in microcuries per milliliter - μCi/ml) used for comparison purposes for the various types of samples in this report are listed below. In all cases, these are the most restrictive RCG's.

Plutonium-238 (Soluble Form)

Air

General Population	2×10^{-14} μCi/ml
Uncontrolled Area (Individuals in the Population)	7×10^{-14} μCi/ml

Water

General Population	2×10^{-6} μCi/ml
Uncontrolled Area (Individuals in the Population)	5×10^{-6} μCi/ml

Tritium (Soluble Form)

Air

General Population	7×10^{-8} μCi/ml

Uncontrolled Area (Individuals in the Population)	2×10^{-7} μCi/ml

Water

General Population	1×10^{-3} μCi/ml
Uncontrolled Area (Individuals in the Population)	3×10^{-3} μCi/ml

Foodstuffs There are no RCG values specified for foodstuffs.

Soil There are no guidelines established for radioactive species in soil.

NONRADIOACTIVE STANDARDS

Water Region V of the USEPA has issued a discharge permit under NPDES regulations covering both of the Mound Laboratory liquid effluent streams. The discharge limitations for each effluent stream are as follows:

Outfall Number 001

	Daily Average	Daily Maximum
Flow (10^6 gal/day)	0.53	0.92
BOD-5 Day (mg/l)	30	45
Suspended Solids (mg/l)	30	45
Dissolved Oxygen (mg/l)	5	--
Residual Chlorine (mg/l)		0.8
Oil and Grease (mg/l)		10
Fecal Coliform (No./100 ml)	200	400
pH	6-9	

Outfall Number 002

Flow (10^6 gal/day)	0.53	--
Suspended Solids (mg/l)	20	25
Dissolved Oxygen		
Oct.-April (mg/l)	≥8	--
May-Sept. (mg/l)	≥5	--
Residual Chlorine (mg/l)		0.1
Dissolved Solids (mg/l)	2000	3000
Oil and Grease (mg/l)		10
pH	6-9	

The Ohio EPA has established Water Quality Standards (EP-1-EP-9). The standards listed below are exerpted from these regulations. These standards are stream standards and apply to a stream beyond a suitable mixing zone permitted for discharges. They should not be compared with effluent concentrations.

Constituent	Average Concentration (mg/l)
Dissolved Oxygen	5.0
pH	6-9
Fecal Coliform	200 per 100 ml
Dissolved Solids	1500
Ammonia	1.5
Arsenic	0.05
Barium	0.8
Cadmium	0.005
Chloride	250
Chromium (Hexavalent)	0.05
Cyanide (Free)	0.005
Fluoride	1.3
Foaming Agents (MBAS)	0.5
Iron	1
Lead	0.04
Manganese	1
Mercury	0.0005
Oil & Grease	5
Phenols	0.01
Selenium	0.005
Silver	0.001
Copper	0.005 - 0.075[a]
Zinc	0.075 - 0.5[a]

[a]Dependent on $CaCO_3$ hardness.

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