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Annual Environmental Monitoring Report: Calendar Year 1976

Billy M. Farmer, Bob Robinson,

and Daniel G. Carfagno

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operated for

UNITED STATES ENERGY RESEARCH
AND DEVELOPMENT ADMINISTRATION

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Foreword

This report was prepared by the Environmental Assessment and Planning Section of the Safety and Environmental Technology Function in the Administrative Services Department at Mound Laboratory. Sample analyses and data reduction were performed by the Environmental Evaluation and Environmental Laboratory groups of the Environmental Assessment and Planning Section. Particulate samples offsite 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 area for the Ohio Environmental Protection Agency.

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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 predominantly 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 weapon programs; research, development, and production of explosive components; separation, purification, and sale of stable isotopes of the noble gases; the fabrication of radioisotopic heat sources fueled with plutonium-238 for space, terrestrial, and military applications. The radionuclides of primary concern currently being handled include plutonium-238 and tritium.

Radionuclides in particulate form are removed from process 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 bank 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 offsite for burial at 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.

An onsite sanitary waste treatment 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 onsite 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 offsite for burial at an 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.

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 offsite by a commercial industrial-waste-disposal firm.

Conformance to regulations prescribed by ERDA pertaining to the safety of employees and the public has been demonstrated during the history of Mound Laboratory. The fundamental objective 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 function, effluents are monitored and controlled at each operating step resulting in only low-level releases of airborne or liquid wastes to the environment. Because of early detection, control techniques can be taken thus ensuring that concentrations are well within existing standards.

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.

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

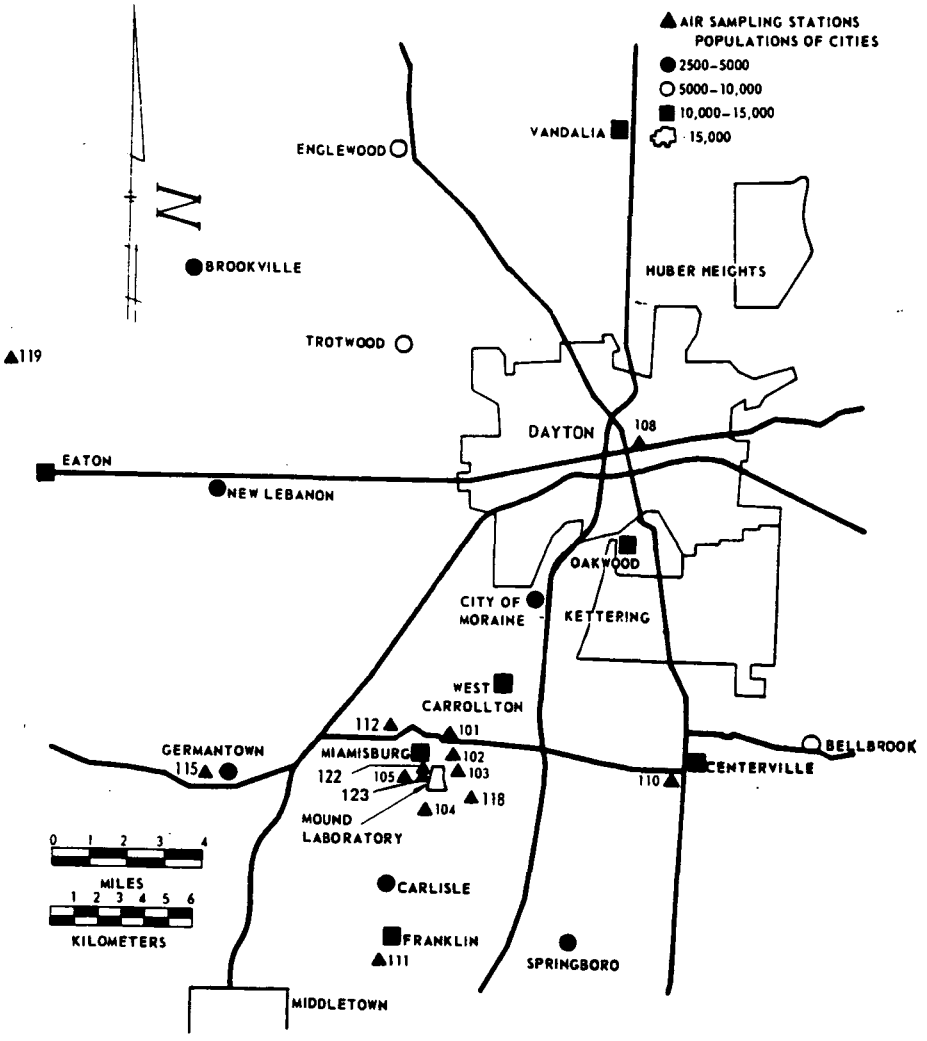

FIGURE 1 - Offsite air sampling locations

samples. The blank values have been consistently small in comparison with sample values indicating good control during analytical procedures. The duplicate results for 1976 were in the range expected. Chemical recoveries were greater than 50%. The external portion of the program consists of sending duplicate samples to an independent laboratory. These results for 1976 were also satisfactory. In addition, counting times or sampling volumes were increased during the second half of the year to provide lower detection limits. Mound Laboratory also, very successfully, participated in the International Atomic Energy Agency (IAEA) Laboratory Intercomparison for plutonium analyses in air and plutonium and tritium analyses in water.

The results of the environmental analyses for calendar year 1976 are provided in this report. Error limits, when given, reflect standard deviations in the data from 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 1976. The environmental parameters analyzed included air, water, foodstuffs, and silt. The average concentrations of plutonium-238 and tritium were within the stringent standards for radioactive species 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 oxide measured at all locations in air during CY-1976 were $<2.3 \times 10^{-17}$ and $<1.0 \times 10^{-11}$ μCi/ml, respectively. These correspond to <0.12% and <0.014% of their respective Radioactivity Concentration Guides (RCG). Details of the applicable standards are given in the Appendix.

The average concentrations of plutonium-238 and tritium measured at all locations in the Great Miami River during CY-1976 were $<0.09 \times 10^{-10}$ and $<1.0 \times 10^{-6}$ μCi/ml, respectively. These correspond to <0.0005% and <0.10% of the respective RCG.

The average concentrations of plutonium-238 and tritium found during CY-1976 in surface water, community drinking water, and private wells were also a small fraction of each respective RCG.

Although there are no specific standards (RCG) for plutonium-238 and tritium in foodstuffs, the concentrations found, if compared to the water standard, are also a small fraction of the RCG. In addition, there is no evidence of other than minimal reentrainment of radioactive species from silt.

Mound Laboratory has undertaken a comprehensive program to bring water supplies into compliance with new U. S. EPA drinking water standards which will be effective June 24, 1977.

Mound Laboratory has been granted a National Pollutant Discharge Elimination System permit. Analyses during 1976 indicate compliance with permit conditions. All results indicated 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 compliance with various current regulatory agency standards and that the operation of Mound Laboratory has a negligible effect on the environment.

Environmental Surveillance

AIR - RADIOACTIVE

An offsite air sampling network consisting of 12 continuously operating air-sampling stations which are used for sampling both tritium oxide and plutonium and a thirteenth sampler used for sampling plutonium only were used for the first six months of CY-1976. One additional sampler was added during the second half of the year in the abandoned Miami-Erie canal area to provide additional monitoring capabilities. During the first half of the year, seven sampling stations were located within a 1.6-km (1-mi) radius of the Laboratory (eight during the last half), and four samplers were located in or near population centers. 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 locations of the sampling stations 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/day, 7 days/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 which represents a sample of approximately 13,000 m^3 of air. Plutonium-238 analyses were performed on a monthly composite during the first half of the year and quarterly during the last half.

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 offsite plutonium-238 air concentration for all locations was $<2.3 \times 10^{-17}$ µCi/ml which is <0.12% 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 analytical 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.

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 associted with sample collection [4]. Any tritium (oxide) in the air is collected in the solution. Tritium oxide rather than elemental tritium is sampled and analyzed because the RCG for the oxide is 200 times more restrictive than it is for elemental tritium [5]. 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-1976 for all locations was $<1.0 \times 10^{-11}$ µCi/ml which is <0.014% of RCG. The RCG used for comparison is the most restrictive RCG for tritium for the general population. The results are summarized in Table 2. Table 3 shows background values for plutonium-238 and tritium in air and water.

An onsite perimeter network consisting of five continuous, high-volume air samplers is used to further assess the effectiveness of control systems. The onsite sampling locations are shown in Figure 2. Particulate samples are collected by the onsite samplers at approximately the same flow rate as the offsite 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 offsite samplers.

The average plutonium-238 concentration measured for all locations onsite was 10×10^{-17} µCi/ml which is 0.14% of the RCG. The results are summarized in Table 4.

The average onsite tritium oxide concentration for all locations was $<2.2 \times 10^{-11}$ µCi/ml which is <0.01% of the RCG. The results are summarized in Table 5.

The RCGs used for onsite comparisons are those applicable for incidently exposed individuals in the population. The total amounts of plutonium-238 and tritium discharged to the atmosphere were 0.015 mCi and 6206 Ci respectively. Comparison of these quantities to the RCG is not valid.

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 <1% sulfur content is burned. Natural gas was burned during most of 1976 until late November when natural gas supply to Mound was halted. Fuel oil was burned for the remainder of the year, and the use of fuel oil is forecast for all of 1977. The average sulfur content of the fuel oil burned was approximately 0.4%. Approximately 340,000 gal of No. 2 fuel oil were burned during 1976. Additional sources of airborne emissions are as follows. A waterwash, paint spray booth is operated intermittently in the Mound paint shop. Wastes from operations involving explosives are disposed of by open burning. A shipping container fire test facility for testing shipping containers for radioactive wastes is used on the average of once per month. A maintenance grinding operation and a carpenter shop are also operated on an intermittent basis. Firefighter training excercises are held at an open outdoor facility.

Table 1

CONCENTRATIONS OF PLUTONIUM IN
AIR AT OFFSITE SAMPLING LOCATIONS IN 1976

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	0.26 - 14.4	3.9 ±0.18	0.20	0.67 ±0.10	5.8
102	52	0.76 - 7.4	2.6 ±0.17	0.13	0.52 ±0.09	5.0
103	52	0.59 - 7.5	2.9 ±0.19	0.15	0.85 ±0.11	3.4
104	52	<0.077 - 1.9	<0.79 ±0.10	<0.04	0.52 ±0.09	<1.5
105	52	<0.077 - 0.47	<0.21 ±0.07	<0.01	0.48 ±0.09	<0.44
108	44	0.08 - 0.71	0.39 ±0.08	0.02	0.44 ±0.09	0.89
110	52	<0.077 - 0.42	<0.17 ±0.06	<0.01	0.46 ±0.09	<0.40
111	52	0.16 - 1.0	0.41 ±0.08	0.02	0.59 ±0.10	0.69
112	51	0.12 - 0.43	0.26 ±0.07	0.01	0.51 ±0.09	0.51
115	52	0.04 - 1.4	0.21 ±0.07	0.01	0.55 ±0.09	0.38
118	51	0.35 - 1.7	0.65 ±0.10	0.03	0.56 ±0.09	1.2
119	52	<0.027 - 0.06	<0.05 ±0.03	<0.01	0.38 ±0.06	<0.13
122	51	0.55 - 10.7	3.8 ±0.20	0.19	0.60 ±0.10	6.3
123	25	3.1 - 29.4	16.0 ±0.35	0.80	0.51 ±0.06	31.4

[a] Minimum Detection Limit (MDL) for ^{238}Pu in air is 0.077×10^{-17} µCi/ml for the first half of the year and 0.027×10^{-17} µCi/ml for the second half of the year. This is 0.004% and 0.001%, respectively, of the RCG.

[b] Radioactivity Concentration Guide (RCG) = 2000×10^{-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 0.043×10^{-17} µCi/ml for the first half of the year and 0.015×10^{-17} µCi/ml for the second half of the year.

[d] Error limits are counting statistics only at 95% confidence level.

Table 2

CONCENTRATIONS OF TRITIUM OXIDE IN AIR
AT OFFSITE SAMPLING LOCATIONS IN 1976

Location	Number of Samples	Tritium Oxide Range (10^{-11} µCi/ml)	Tritium Oxide Average[a,c] (10^{-11} µCi-ml)	Percent of RCG[b]
101	51	<0.45 - 13.6	<1.3 ±0.72	<0.02
102	51	<0.45 - 19.2	<1.5 ±0.85	<0.02
103	51	<0.45 - 7.5	<1.1 ±0.72	<0.02
104	49	<0.45 - 3.8	<0.94 ±0.70	<0.01
105	51	<0.45 - 5.3	<0.89 ±0.70	<0.01
108	50	<0.45 - 4.1	<0.89 ±0.70	<0.01
110	51	<0.45 - 5.4	<0.90 ±0.70	<0.01
111	51	<0.45 - 1.8	<0.81 ±0.70	<0.01
112	51	<0.45 - 3.1	<0.92 ±0.70	<0.01
115	51	<0.45 - 3.5	<0.85 ±0.70	<0.01
118	50	<0.45 - 1.9	<0.90 ±0.70	<0.01
119	51	<0.45 - 3.5	<0.88 ±0.70	<0.01
123	25	<0.45 - 3.1	<1.1 ±0.44	<0.02

[a] Minimum Detection Limit (MDL) for tritium oxide in air during the first half of the year was 0.99 x 10^{-11} µCi/ml and 0.45 x 10^{-11} µCi/ml for the second half. This is 0.014% and 0.006%, respectively, of the RCG.

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

[c] Error limits are counting statistics only at 95% confidence level.

Table 3

CONCENTRATIONS OF BACKGROUND LEVELS
OF TRITIUM AND PLUTONIUM-238

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

[a] References 6, 7
[b] Reference 8
[c] Reference 9
[d] Reference 10

Table 4

CONCENTRATION OF ^{238}Pu IN
AIR AT ONSITE SAMPLING LOCATIONS IN 1976

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)
211	52	0.26 - 37.3	8.7 ±0.36	0.1	0.59 ±0.10
212	52	1.4 - 11.0	3.5 ±0.23	0.05	0.54 ±0.09
213	52	7.2 - 77.6	26.7 ±0.59	0.4	1.3 ±0.14
214	47	1.7 - 37.9	9.1 ±0.36	0.1	0.81 ±0.11
215	50	0.75 - 6.8	3.3 ±0.21	0.05	0.60 ±0.10

[a] Minimum Detection Limit (MDL) for ^{238}Pu in air is 0.081×10^{-17} µCi/ml during the first half of the year and 0.027×10^{-17} µCi/ml for the second half. This is 0.0012% and 0.0004%, respectively, of the RCG.

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

[c] Minimum Detection Limit (MDL) for ^{239}Pu is 0.045×10^{-17} µCi/ml during the first half of the year and 0.015×10^{-17} µCi/ml for the second half of the year.

[d] Error limits are counting statistics only at 95% confidence level.

Table 5

CONCENTRATION OF TRITIUM OXIDE IN
AIR AT ONSITE SAMPLING LOCATIONS IN 1976

Location	Number of Samples	Tritium Oxide Range (10^{-11} µCi/ml)	Tritium Oxide Average[a,c] (10^{-11} µCi/ml)	Percent of RCG[b]
211	49	<0.74 - 8.6	<1.8 ±1.2	<0.01
212	48	<0.74 - 5.2	<2.0 ±1.2	<0.01
213	51	<0.74 - 20.0	<2.8 ±1.2	<0.01
214	50	<0.74 - 10.2	<2.2 ±1.2	<0.01
215	50	<0.74 - 33.9	<2.4 ±1.2	<0.01

[a] Minimum Detection Limit (MDL) for tritium oxide in air was 1.65×10^{-11} µCi/ml during the first half of the year and 0.74×10^{-11} µCi/ml during the last half. This is 0.008% and 0.004%, respectively, 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% confidence level.

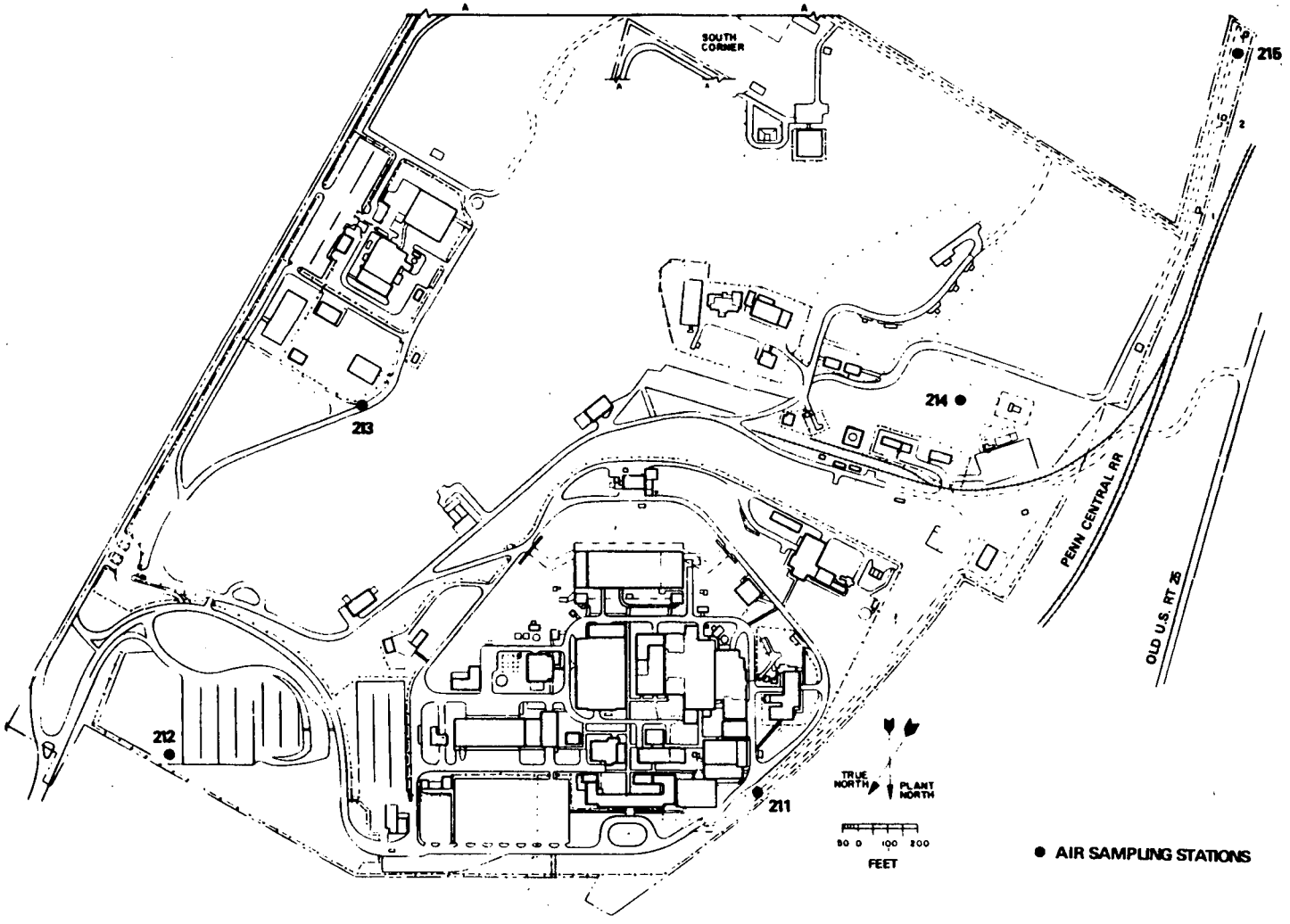

FIGURE 2 - Onsite air sampling locations

Emissions from sources registered with the Regional Air Pollution Control Agency (RAPCA) and the Ohio EPA which have applicable emission standards are summarized in Table 6. The emissions were estimated from emission factors established by the USEPA or from material balances [11]. The emission from the shipping container fire test facility is controlled with a forced air supply and water spray nozzles at the fuel-flame interface to an average opacity of <20%. The particulates from the grinding and carpenter shop operations are captured by cyclone air cleaners rated at 95% efficiency. No fire fighter training exercises were held during 1976. Non-radioactive airborne emissions at Mound Laboratory were all within applicable standards and had minimal impact on ambient air quality.

WATER - RADIOACTIVE

Water sampling locations along the bank of the Great Miami River were selected according to guidelines recommended by the U. S. EPA [2]. 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 normally collected at these locations five days per week and are subjected to specific analyses for plutonium-238 and tritium.

The plutonium-238 river water analyses have been upgraded from a procedure developed at Mound Laboratory 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 concentration of plutonium-238 measured for all locations in the Great Miami River was $<0.09 \times 10^{-10}$ µCi/ml which is <0.0005% of the RCG for the general population and the most restrictive standard for plutonium-238. These results are summarized in Table 7.

Tritium analyses are performed on a weekly composite of daily samples. The average concentration of tritium measured at all locations in the Great Miami River was $<1.0 \times 10^{-6}$ µCi/ml which is <0.1% of the RCG for the general population and the most restrictive standard for tritium. These results are summarized in Table 8.

Results of plutonium-238 and tritium analyses for three offsite sampling locations on the abandoned Miami-Erie Canal and adjacent ponds shown in Figure 4 are reported in Tables 9 and 10, respectively. These values represent levels from the site drainage ditch which discharges into the offsite 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 3 mCi, 46 Ci, and 2.5 mCi, respectively. The concentrations were 0.7%, 1.8% and 0.01% of the most restrictive RCG for individuals in the population. From the uranium-233 concentrations found in the effluent streams, estimated concentrations offsite from Mound operations would be undistinguishable from any background. This can be readily seen by comparing plutonium-238 quantities found in the effluent streams with concentrations found offsite.

Eight additional surface water locations such as ponds in all quadrants surrounding Mound Laboratory are sampled annually. These samples, used for plutonium-238 determination, are large volume water samples of approximately 25 liters each. The large volume of sample increases the sensitivity of the analysis. A smaller aliquot (10 ml) was taken for the tritium analysis. The average concentrations of plutonium-238 and tritium for all locations were 0.08×10^{-10} and $<0.63 \times 10^{-6}$ µCi/ml, respectively, which are 0.0004% and 0.06% of the respective RCG for the general population. The results of the surface water samples are summarized in Tables 11 and 12. Background levels of plutonium-238 and tritium for the surface water are shown in Table 3.

Drinking water from communities in the surrounding area is sampled and analyzed annually for tritium with the exception of drinking water from Miamisburg which is sampled and analyzed quarterly for tritium. These communities and their relative locations are shown in Figure 1. The average concentration of tritium for all locations was $<0.9 \times 10^{-6}$ µCi/ml which is <0.09% of the RCG for the general population. The results of the analyses of the community drinking water samples are summarized in Table 13.

Several private wells in the vicinity of Mound Laboratory were also sampled and analyzed monthly for tritium. The average concentration of tritium in these wells was 43.5×10^{-6} µCi/ml which is 4.4% of the RCG for the general population. The private well analyses results

Table 6

NONRADIOACTIVE AIRBORNE EMISSIONS

1976

Emission Source	Pollutant	Emission	Emission Standard[a]	% of Standard
Power House	Particulates	0.03 lb/10^6 Btu Input	0.25 lb/10^6 Btu Input	12
Power House	Sulfur Oxides	0.066 lb/10^6 Btu Input	1.6 lb/10^6 Btu Input	4
Paint Shop	Organics	0.22 lb/day	40 lb/day	0.6
Explosives Burning Area	Particulates	∿3 lb/yr	NA	NA

[a] Ohio EPA Air Pollution Regulations AP-3-01 through AP-3-14 and AP-5-01 through AP-5-08

NA - not applicable

Table 7

CONCENTRATION OF ^{238}Pu IN THE GREAT MIAMI RIVER IN 1976

Location	Number of Samples[a]	^{238}Pu Average[b,d] (10^{-11} μCi/ml)	Percent of RCG[c]
1	105	0.06 ±0.02	0.0003
2	105	0.19 ±0.03	0.0010
3	105	<0.04 ±0.02	<0.0002
4	105	0.10 ±0.02	0.0005
5	105	0.05 ±0.02	0.0003

[a] One composite large volume water sample for each location from water collected during a six-month period.

[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 the general population and the soluble form of plutonium-238.

[d] Error limits are counting statistics only at 95% confidence level.

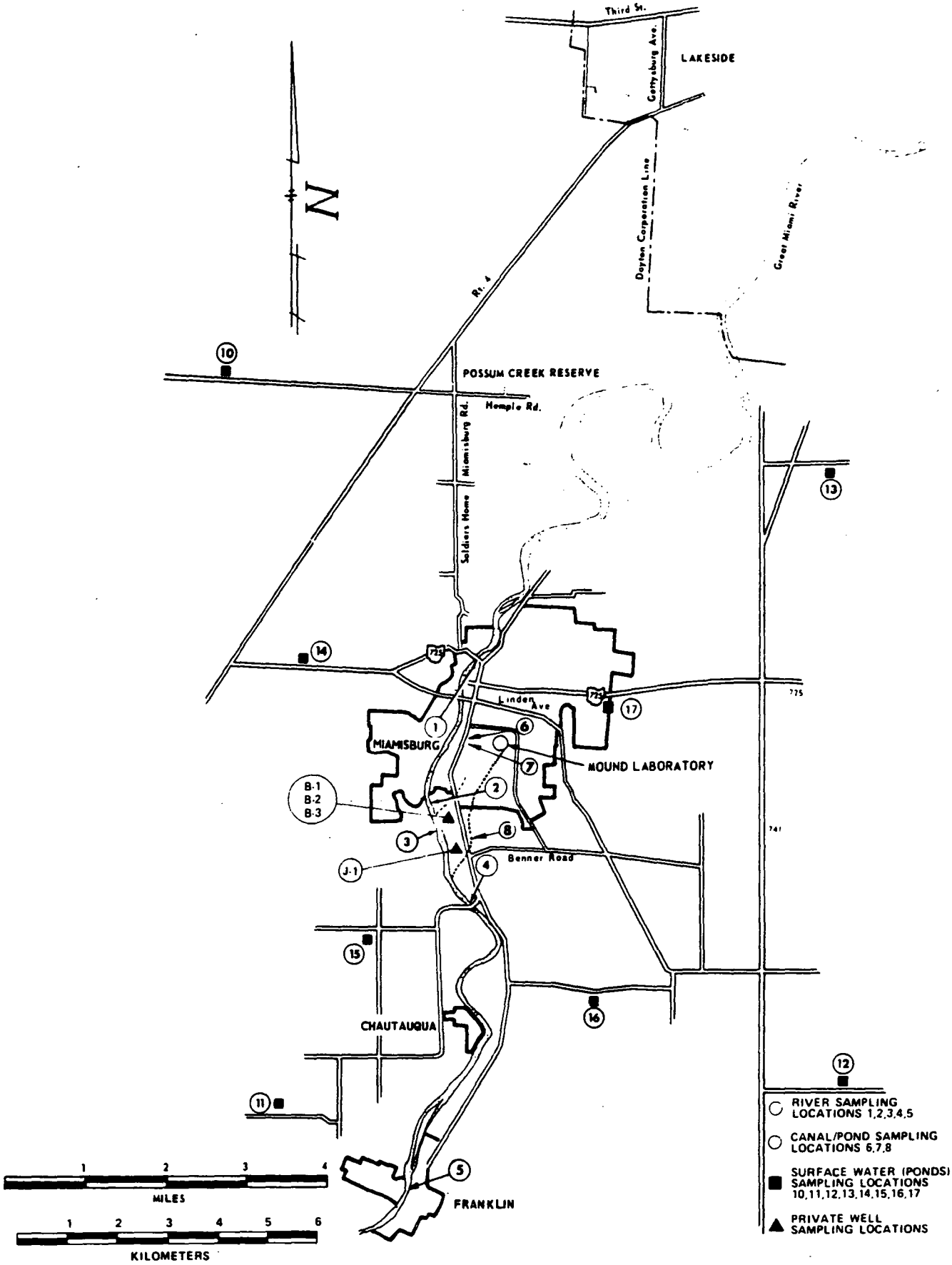

FIGURE 3 - Offsite water sampling locations

Table 8

CONCENTRATION OF TRITIUM IN
THE GREAT MIAMI RIVER IN 1976

Location	Number of Samples	Tritium Range (10^{-6} μCi/ml)	Tritium Average[a,c] (10^{-6} μCi/ml)	Percent of RCG[b]
1	210	<0.34 - 2.1	<0.89 ±0.42	<0.09
2	210	<0.51 - 3.7	<1.30 ±0.43	<0.13
3	210	<0.34 - 1.9	<0.93 ±0.42	<0.09
4	210	<0.34 - 2.4	<0.90 ±0.42	<0.09
5	210	<0.34 - 2.6	<0.90 ±0.43	<0.09

[a] Minimum Detection Limit (MDL) for tritium in water is 0.51 x 10^{-6} μCi/ml for the first half of the year and 0.34 x 10^{-6} μCi/ml for the second half. This is 0.051% and 0.034%, respectively, of the RCG.

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

[c] Error limits are counting statistics only at 95% confidence level.

Table 9

CONCENTRATION OF ^{238}Pu IN
CANAL/POND AREA IN 1976

Location[a]	Number of Samples[b]	^{238}Pu Average[c,e] (10^{-10} μCi/ml)	Percent of RCG[d]
6 (North Pond)	105	0.35 ±0.03	0.002
7 (North Canal)	105	0.96 ±0.06	0.005
8 (South Canal)	105	32.2 ±0.30	0.16

[a] Locations are shown in Figure 3.

[b] One composite large volume water sample for each location from water collected during a six-month period.

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

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

[e] Error limits are counting statistics only at 95% confidence level.

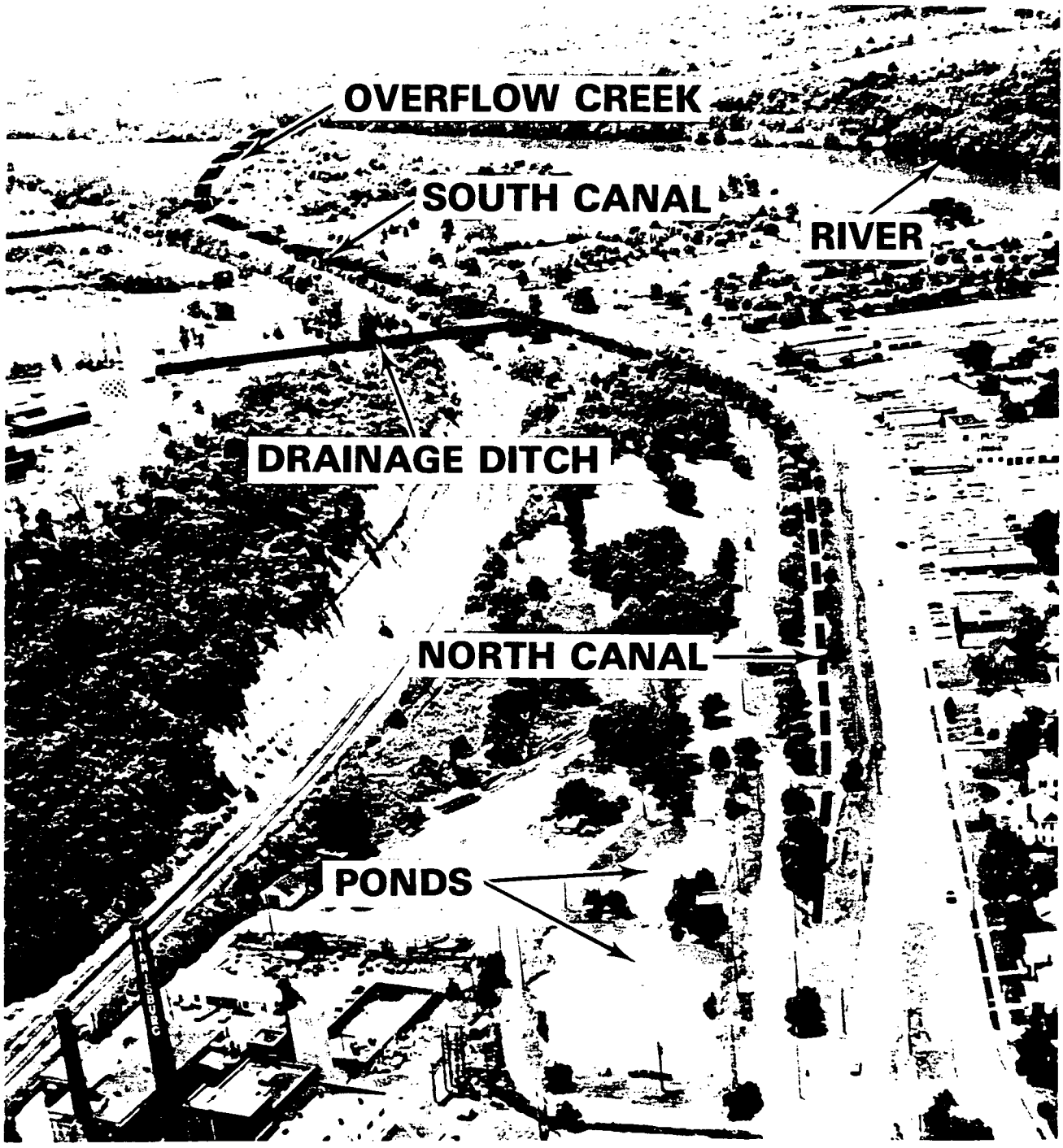

FIGURE 4 - Aerial view (from the north) of offsite abandoned canal and pond system.

Table 10

CONCENTRATION OF TRITIUM IN
CANAL/POND AREA IN 1976

Location[a]	Number of Samples	Tritium Range (10^{-6} µCi/ml)	Tritium Average[b,d] (10^{-6} µCi/ml)	Percent of RCG[c]
6 (North Pond)	210	13 - 37	24 ±0.8	2.4
7 (North Canal)	210	17 - 41	30 ±0.9	3.0
8 (South Canal)	210	19 - 59	41 ±0.9	4.1

[a] Locations are shown in Figure 3.

[b] Minimum Detection Limit (MDL) for tritium in water is 0.52 x 10^{-6} µCi/ml for the first half of the year and 0.35 x 10^{-6} µCi/ml for the second half. This is 0.052% and 0.035%, respectively, 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% confidence level.

Table 11

SUMMARY OF SURFACE WATER MONITORING
FOR PLUTONIUM-238 IN 1976

Location	Number of Samples[a]	^{238}Pu Range (10^{-10} µCi/ml)	^{238}Pu Average[b,d] (10^{-10} µCi/ml)	Percent of RCG[c]
10	2	0.06 - 0.15	0.10 ± 0.02	0.0005
11	2	0.07 - 0.20	0.12 ± 0.02	0.0006
12	2	0.03 - 0.15	0.07 ± 0.02	0.0004
13	2	0.03 - 0.10	0.06 ± 0.01	0.0003
14	2	0.08 - 0.14	0.11 ± 0.02	0.0006
15	2	0.04 - 0.08	0.05 ± 0.01	0.0003
16	2	0.06 - 0.09	0.08 ± 0.02	0.0004
17	2	0.03 - 0.06	0.04 ± 0.01	0.0002

[a] Two composite large volume water samples were used for each location.

[b] Minimum Detection Limit (MDL) for ^{238}Pu in water for the first half of the year was 0.007 x 10^{-10} µCi/ml and 0.012 x 10^{-10} µCi/ml for the second half. This is 0.000035% and 0.00006%, respectively, of the RCG.

[c] 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.

[d] Error limits are counting statistics only at 95% confidence level.

Table 12

SUMMARY OF SURFACE WATER MONITORING
FOR TRITIUM IN 1976

Location	Number of Samples	Tritium Average[a,c] (10^{-6} μCi/ml)	Percent of RCG[b]
10	1	0.59 ± 0.3	0.059
11	1	<0.34 ± 0.3	<0.034
12	1	<0.34 ± 0.3	<0.034
13	1	0.38 ± 0.3	0.038
14	1	0.48 ± 0.3	0.048
15	1	0.63 ± 0.3	0.063
16	1	<0.34 ± 0.3	<0.034
17	1	1.9 ± 0.4	0.19

[a] Minimum Detection Limit (MDL) for tritium in water is 0.34 x 10^{-6} μCi/ml. The MDL is 0.034% 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% confidence level.

Table 13

SUMMARY OF TRITIUM LEVELS
IN COMMUNITY DRINKING WATER IN 1976

Location	Number of Samples	Tritium Range (10^{-6} μCi/ml)	Tritium Average[a,c] (10^{-6} μCi/ml)	Percent of RCG[b]
Bellbrook	1		<0.54 ±0.5	<0.05
Centerville	1		<0.54 ±0.5	<0.05
Franklin	1		<0.54 ±0.5	<0.05
Germantown	1		<0.54 ±0.5	<0.05
Kettering	1		<0.54 ±0.5	<0.05
Miamisburg	4	1.6 - 6.0	3.7 ±0.6	0.37
Middletown	1		<0.54 ±0.5	<0.05
Moraine	1		<0.54 ±0.5	<0.05
Springboro	1		<0.54 ±0.5	<0.05
Waynesville	1		<0.54 ±0.5	<0.05
West Carrollton	1		1.3 ±0.6	0.13

[a] Minimum Detection Limit (MDL) for tritium oxide is 0.54 x 10^{-6} μCi/ml. The MDL is 0.054% 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% confidence level.

are summarized in Table 14. The concentrations of tritium in these wells have been minutely influenced by past Mound Laboratory tritium effluent releases. As shown by the data, concentrations in these wells are higher than in other wells in the area, but are much less than the RCG and show a steady decrease over the past 7 yr. This situation has developed primarily 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 adjacent to Mound Laboratory. Changes in operating procedures have reduced Mound Laboratory tritium releases by a factor of 50 since 1969. As mentioned earlier, these levels are well within the ERDA standard; however, the U.S. EPA has formulated new drinking water standards for radiological, biological, and chemical elements in water, which will be effective in June 1977. Although they are not based on new toxicological or epidemiological information, these standards will reduce the current federal standard by a factor of approximately 50.

There is no health problem associated with the very low levels of tritium in local water supplies; in fact, the EPA's very conservative regulations do not condemn water supplies that exceed the new standards as being unsafe to drink. However, as a result of Mound's influence upon local water supplies, a comprehensive program has been undertaken to bring the affected water supplies into compliance. This program has been approved by the Ohio EPA.

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 for these locations was 0.03 x 10^{-10} μCi/ml which is 0.00015% of the RCG for the general population. These results are shown in Table 15.

WATER - NONRADIOACTIVE

Mound Laboratory has been granted a discharge permit under the National Pollutant Discharge Elimination System (NPDES) by Region V of the U. S. EPA. The permit specifies limitations for the pollutants for the two effluent streams from Mound that discharge to the Great Miami River. 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 water quality parameters according to standard methods [13]. The results of effluent stream analyses for 1976 are summarized in Tables 16 and 17. All discharges for 1976 are within permit limitations and these waterborne effluents had no significant effect on the River since the river flow, even under low flow conditions, was approximately 350 times the maximum flow discharge from Mound during 1976. These data show that the Mound releases to the Miami River did not cause the Ohio Stream Standards to be exceeded.

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 [14]. Field crops and vegetables are collected on the 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, depending upon availability of fish. Grass samples are collected in the vicinity of the surface water locations shown in Figure 3. The plutonium-238 content of the foodstuff and vegetation samples is determined by ashing the samples 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 (see section on Water - Radioactive). The field crop 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. This technique allows analysis for total tritium in the samples rather than for tritium oxide only. The results of the foodstuff and vegetation analyses are summarized

Table 14

TRITIUM IN PRIVATE WELLS
IN 1976

Location	Number of Samples	Tritium Range (10^{-6} µCi/ml)	Tritium Average[a,c] (10^{-6} µCi/ml)	Percent of RCG[b]
B-1	28	43.3 - 69.5	59.8 ±1.2	6.0
B-2	28	20.3 - 37.8	31.0 ±0.8	3.1
B-3	26	31.8 - 49.7	42.3 ±0.9	4.2
J-1	25	32.3 - 47.6	40.8 ±0.9	4.1

[a] Minimum Detection Limit (MDL) for tritium oxide is 0.54 x 10^{-6} µCi/ml. The MDL is 0.54% 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% confidence level.

Table 15

PLUTONIUM-238 IN PRIVATE WELLS AND MIAMISBURG
MUNICIPAL DRINKING WATER IN 1976

Location	Number of Samples[a]	^{238}Pu Average[b,d] (10^{-10} µCi/ml)	Percent of RCG[c]
Miamisburg	6	0.033 ±0.008	0.00017
B#1	6	0.038 ±0.009	0.00019
B#2	6	0.033 ±0.008	0.00017
B#3	6	0.022 ±0.008	0.00011
J	6	0.036 ±0.009	0.00018

[a] One composite large volume water. Sample was analyzed for each location from water collected during a six-month period.

[b] Minimum Detection Limit (MDL) for ^{238}Pu is 0.005 x 10^{-10} µCi/ml. The MDL is 0.00003% of the RCG.

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

[d] Error limits are counting statistics only at 95% confidence level.

Table 16

1976 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT DATA FOR STATION 001[a]

Parameter		No. Samples	Minimum	Maximum	Average
Flow	Reported	Cont.	0.09 MGD	0.44 MGD	0.18 MGD
	Permit			0.92	0.53
BOD_5	Reported	104	0.2	12	4.1
	Permit			45.0	30.0
Fecal Coliform	Reported	64	ND	52	13
	Permit			400.0	200.0
Suspended Solids	Reported	104	ND	45	16.0
				45.0	30.0
Dissolved Oxygen	Reported	260	5.0	10.2	7.8
	Permit				5.0
Residual Chlorine	Reported	64	ND	0.8	0.3
	Permit			0.8	
Oil and Grease	Reported	52	ND	6.5	1.0
	Permit			10.0	
pH	Reported	260	6.2	8.9	
	Permit		6.0	9.0	
Carbon	Reported	104	74	134	88
Ammonia	Reported	52	0.1	0.1	0.1

[a] 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.

Table 17

1976 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT DATA FOR STATION 002[a]

Parameter		No. Samples	Minimum	Maximum	Average
Flow	Reported	Cont.	0.20 MGD	0.90 MGD	0.43 MGD
	Permit				0.53
Suspended Solids	Reported	104	ND	24	14.1
	Permit			25.0	20.0
Dissolved Oxygen	Reported	154	6.7	11.8	8.7
	Permit				5.0
Residual Chlorine	Reported	52	<0.05	0.05	<0.05
	Permit			0.10	
Oil and Grease	Reported	52	ND	7.0	0.6
	Permit			10.0	
pH	Reported	260	6.7	8.6	
	Permit		6.0	9.0	
Dissolved Solids	Reported	104	160	2179	967
	Permit			3000.0	2000.0

[a] ND - none detectable

MGD - million gallons per day

All values are in milligrams per liter.

in Tables 18 and 19. The concentration is given in terms of the sample weight (wet weight) before ashing. The vegetables analyzed were turnips and the field crop analyzed was the edible portions of corn. 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.

SOIL AND SILT - RADIOACTIVE

During CY-1976, emphasis was placed on the relocation of soil sampling, and soil samples were collected throughout the year to provide better inventory data. However, because of the time involved in the collection of the samples and the time involved in other critical projects, no CY-1976 data were obtained. Therefore, there will be no soil data reported for CY-1976.

Silt samples from the Great Miami River (See Figure 3) and from the surface water monitoring locations (ponds) were analyzed, however. These samples were obtained by filtration of sediment (silt) from the water that was collected from these locations for that water analyses shown in Tables 7 and 11. The results of the silt sample analyses are found in Tables 20 and 21.

Evaluation of Potential Dose Equivalent to the Public

A dose assessment was performed for radionuclides 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 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 and the bone included the concentration found in the environment, which gives a very conservative estimate of dose equivalence.

PLUTONIUM-238

Assumptions and Methodology The dose equivalent estimates for plutonium-238 were based on environmental monitoring data for CY-1976. The estimates for maximum dose equivalent to the lung at the site boundary and maximum dose equivalent to the lung in individuals were based on the maximum onsite average concentration of plutonium-238 in air from onsite samplers since the samplers are in close proximity to the site boundary. The maximum dose equivalent to the lung in population group(s) were based on the maximum offsite average concentration of plutonium-238 in air.

The estimates for maximum dose equivalent to the bone at the site boundary and in individuals were also based on the maximum onsite average concentration of plutonium-238 in air and the maximum offsite average concentration of plutonium-238 in drinking water. The maximum dose equivalent to the bone for population group(s) was based on the maximum offsite average concentrations 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:

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

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. 15)

t = time exposed, 365 days

f_a = fraction of inhaled material reaching organ of interest = 0.7 (max.) for the pulmonary region (Ref. 16)

f_r = fraction of pulmonary deposition undergoing long-term retention = 0.6 for actinide (class Y) (Ref. 16)

$\Sigma EF(RBE)_x$ = effective energy deposition per disintegration = 57 (Ref. 15)

λ = effective decay rate, 0.0014 day^{-1} for actinides (class

Table 18

PLUTONIUM-238 IN FOODSTUFFS AND VEGETATION IN 1976

Type of Sample	Number of Samples	^{238}Pu Range (10^{-8} µCi/g)	Average[a,b,c,d] (10^{-8} µCi/g)
Milk	2	-	<0.009 ±0.01
Vegetables	2	<0.022 - 0.036	<0.029 ±0.02
Grass	9	<0.052 - 6.32	<2.03 ±0.17
Field crop	2	<0.022 - 0.028	<0.024 ±0.02
Aquatic Life	2	0.024 - 0.047	0.036 ±0.03

[a] Minimum Detection Limit (MDL) for ^{238}Pu in 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 milk is 0.009 x 10^{-8} µCi/g.

[c] Minimum Detection Limit (MDL) for ^{238}Pu in grass is 0.052 x 10^{-8} µCi/g.

[d] Error limits are counting statistics only at 95% confidence level.

Table 19

TRITIUM IN FOODSTUFFS AND VEGETATION IN 1976

Type Sample	Number of Samples	Tritium Range (10^{-6} µCi/g)	Average[a,b] (10^{-6} µCi/g)
Milk	2	0.72 - 0.75	0.73 ±0.29
Field crops	2	-	< 3.0 ±3.0

[a] MDL for tritium in milk = 0.29 x 10^{-6} µCi/g. MDL for tritium in field crops = 3.0 x 10^{-6} µCi/g. MDL for tritium in aquatic life = 1.8 x 10^{-6} µCi/g.

[b] Error limits are counting statistics only at 95% confidence level.

Table 20

^{238}Pu IN SILT FROM RIVER MONITORING LOCATIONS IN 1976

Location	Number of Samples	^{238}Pu Average[b,c] (10^{-6} μCi/g)
1	1	1.19 ±0.11
2	1	15.22 ±0.36
3[a]	-	-
4	1	5.12 ±0.44
5	1	0.47 ±0.04

[a] No data reported

[b] Minimum Detection Limit (MDL) for Pu^{238} is 0.018 x 10^{-6} μCi/g.

[c] Error Limits are counting statistics at 95% confidence level.

Table 21

^{238}Pu IN SILT FROM SURFACE WATER MONITORING LOCATIONS IN 1976

Location	Number of Samples	^{238}Pu Range (10^{-6} μCi/g)	Average[a,b] (10^{-6} μCi/g)
10	2	0.03 - 0.05	0.04 ± 0.01
11	2	0.10 - 10	5.1 ± 0.28
12	2	0.07 - 0.39	0.23 ± 0.06
13	2	2.8 - 47	25.1 ±15.1
14	2	0.1 - 7.1	3.6 ± 0.33
15	2	0.01 - 0.23	0.12 ± 0.01
16	2	2.2 - 224	113 ± 8
17	2	0.4 - 2.4	1.4 ± 0.23

[a] Minimum Detection Limit (MDL) for ^{238}Pu is 0.003 x 10^{-6} μCi/g.

[b] Error Limits are counting statistics at 95% confidence level.

Y) from the pulmonary region (Ref. 17)

m = lung mass, 1000 g (Ref. 15)

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

$$D(t) = \frac{51.1CI_a f_a t\ EF(RBE)_x}{\lambda m} \quad 1 - \left(\frac{1 - e^{-\lambda t}}{\lambda t}\right)$$

where f_a = 0.2 (Ref. 15)

$\Sigma EF(RBE)_x$ = 284 (Ref. 15)

m = 7×10^3 g (Ref. 15)

$\lambda = 3 \times 10^{-5}\ day^{-1}$ (Ref. 15)

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

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

where I_w = average quantity of water intake, 2200 cm^3 (Ref. 15)

$f_a = 2.4 \times 10^{-5}$ (Ref. 15)

The results of the calculations are:

Maximum dose equivalent to the lung at the site boundary - 0.37 mrem/yr

Maximum dose equivalent to the lung in individuals - 0.37 mrem/yr

Maximum dose equivalent to the lung in population group(s) - 0.22 mrem/yr

Maximum dose equivalent to the bone at the site boundary - 0.15 mrem/yr

Maximum dose equivalent to the bone at the site boundary - 0.15 mrem/yr

Maximum dose equivalent to the bone in individuals - 0.15 mrem/yr

Maximum dose equivalent to the bone in population group(s) - 0.09 mrem/yr

TRITIUM (OXIDE)

Assumptions and Methodology The dose equivalent estimates for tritium (oxide) were also based on environmental monitoring data for CY-1976. The concentrations used for dose equivalent estimates for tritium (oxide) were calculated 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 water.

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

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

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

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

R_a = RCG for tritium (oxide) in air (Ref. 5)

S = Radiation protection standard in mrem/yr (Ref. 5)

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

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

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

$\bar{C}_w$ = average concentration

R_w = RCG for tritium (oxide) in water (Ref. 5)

S = radiation protection standard in mrem/yr (Ref. 5)

Those 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 equivalent at the site boundary - 4.43 mrem/yr

Maximum dose equivalent to an individual - 4.43 mrem/yr

Maximum dose equivalent to population group(s) - 0.37 mrem/yr

The 50-mi (80-km) person-rem (whole body) dose equivalent 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 equivalent estimates based on distance from Mound Laboratory,

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

The 0 to 3.2 km range dose estimate for airborne tritium oxide was obtained from the average concentration (less background) of eight offsite tritium (oxide) samplers within a 3.2 km 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:

$$\bar{D}(t)_{a\,0-2} = \frac{\bar{C}_a}{R_a} \times S$$

where $\bar{D}(t)_{a\,0-2}$ = dose equivalent from 0 to 3.2 km from tritium (oxide) in air

$\bar{C}_a$ = average tritium (oxide) concentration in air from 0 to 3.2 km

R_a = RCG for tritium (oxide) in air (Ref. 5)

S = radiation protection standard for tritium (oxide) in air in mrem/yr (Ref. 5)

$$\bar{D}(t)_{w\,0-2} = \frac{\bar{C}_w}{R_w} \times S$$

where $\bar{D}(t)_{w\,0-2}$ = dose equivalent from 0 to 3.2 km from tritium (oxide) in water

$\bar{C}_w$ = average tritium (oxide) concentration in water from 0 to 3.2 km

R_w = RCG for tritium (oxide) in water (Ref. 5)

S = radiation protection standard for tritium (oxide) in water, mrem/yr (Ref. 5)

The 3.2 to 80 km range dose estimate was obtained by finding the midpoint distance where the average tritium (oxide) concentration of the remaining offsite samplers would be located. This value is estimated at 6.3 km [20]. From this distance and average concentrations of tritium (oxide) at sampling locations from 3.2 to 32 km, it was determined that the maximum distance of influence from Mound Laboratory is ∿32 km. Beyond 32 km the levels are calculated to be background concentrations.

The dose equivalent for tritium (oxide) from 3.2 to 32 km 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:

$$\bar{D}(t)_{a\,2-0} = \frac{\bar{C}_a}{R_a} \times S$$

where $\bar{D}(t)_{a\,2-20}$ = dose equivalent from 3.2 to 32 km from tritium (oxide) in air

$\bar{C}_a$ = average tritium (oxide) concentrations in air from 3.2 to 32 km

R_a = RCG for tritium (oxide) in air (Ref. 5)

S = Radiation Protection Standard for tritium (oxide) in air, mrem/yr (Ref. 5)

$$\bar{D}(t)_{w\,2-20} = \frac{\bar{C}_w}{R_w} \times S$$

where $\bar{D}(t)_{w\,2-20}$ = dose equivalent from 3.2 to 32 km from tritium (oxide) in water

$\bar{C}_w$ = average tritium (oxide) concentration in water from 3.2 to 32 km

R_w = RCG for tritium (oxide) in water (Ref. 5)

S = Radiation Protection Standard for tritium (oxide) in water, mrem/yr (Ref. 5)

The total person-rem from 0 to 32 km is obtained by:

$$\sum_0^{20} R = \left(\bar{D}(t)_{a\,0-2} + \bar{D}(t)_{w\,0-2}\right) \sum_0^{2} P + \left(\bar{D}(t)_{a\,2-20} + \bar{D}(t)_{w\,2-20}\right) \sum_2^{22} P$$

where $\sum_0^{20} R$ = person-rem within 32 km

$\sum_0^{2} P$ = population from 0 to 3.2 km = 14,700

$\sum_2^{20} P$ = population from 3.2 to 32 km = 881,241

Note: The total person-rem from 0 to 3.2 km is equal to 25 person-rem in addition to background. Based on diffusion model calculations, the remaining population from 32 to 80 km is not receiving dose from tritium (oxide) releases from Mound Laboratory; therefore, the total person-rem from 0 to 80 km from tritium (oxide) releases from Mound Laboratory is equal to 25 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 to 80 km range [21]. The dose commitment due to natural background tritium alone is 80 person-rem for the 0 to 80 km range.

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Appendix

APPLICABLE STANDARDS

RADIOACTIVE STANDARDS

In conformance with ERDA Manual Chapter 0524, "Standards for Radiation Protection," offsite 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.

Onsite 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 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		
October-April (mg/l)	>8	-
May-September (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 excerpted 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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