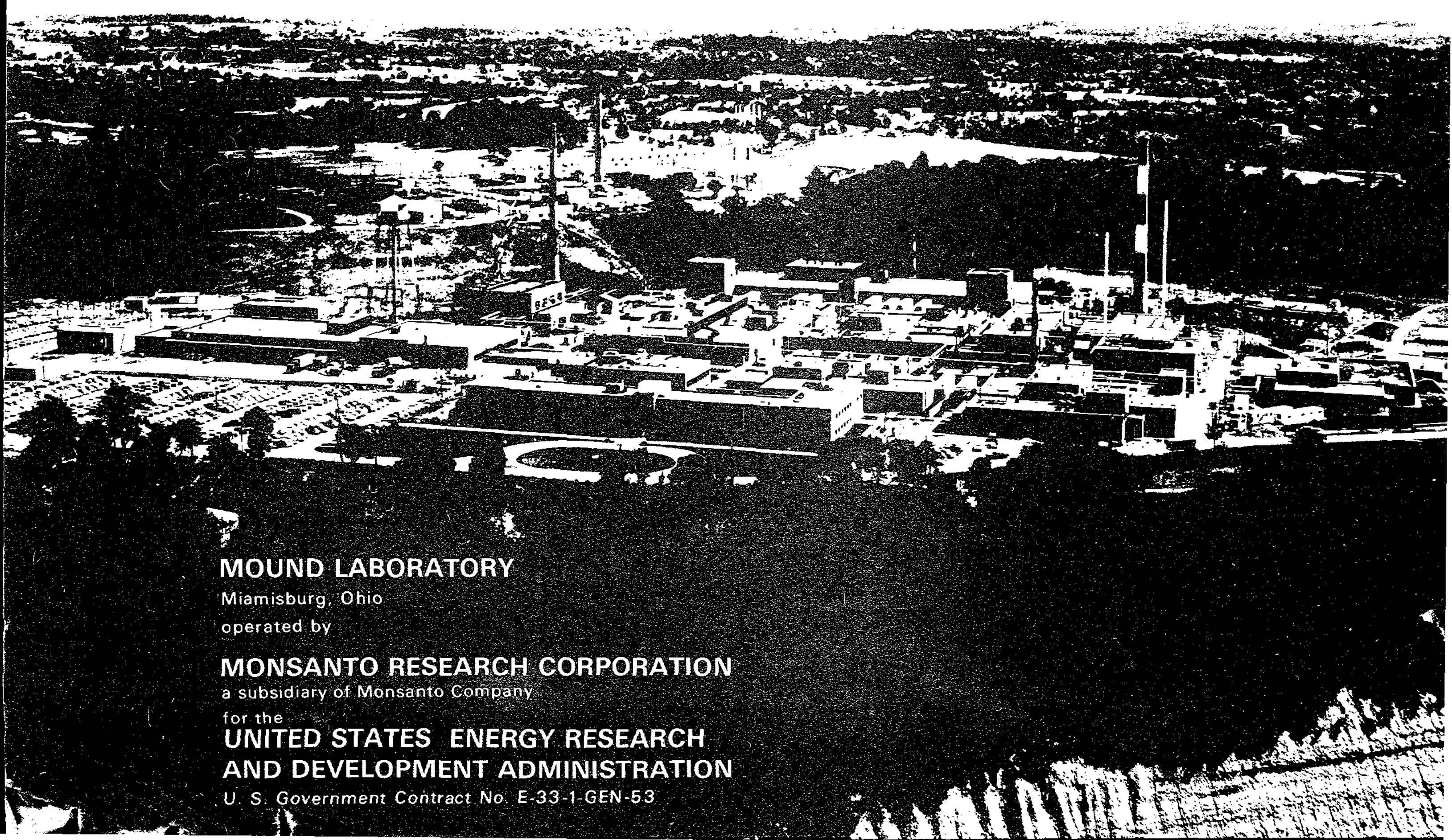
MLM-MU-75-71-0001

ANNUAL
ENVIRONMENTAL MONITORING SUMMARY

JULY 1974 - JUNE 1975



MOUND LABORATORY
Miamisburg, Ohio
operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company
for the
UNITED STATES ENERGY RESEARCH
AND DEVELOPMENT ADMINISTRATION
U. S. Government Contract No. E-33-1-GEN-53

Annual Environmental Monitoring Summary
July 1974 - June 1975

Issued: December 1975

MONSANTO RESEARCH CORPORATION

A Subsidiary of Monsanto Company

MOUND LABORATORY

Miamisburg, Ohio 45342

operated for

UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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

HIGHLIGHTS
July 1974 - June 1975

- A new Sanitary Waste Treatment Plant was placed in operation during this period. The plant will treat all sanitary waste generated on-site. The plant is designed to remove 90% of biological oxygen demanding material and 90% of suspended material from the sanitary waste stream prior to discharging in the Great Miami River. Allowance has been made to provide an additional stage of treatment at a later date.

- Mound Laboratory has been issued a discharge permit under the National Pollutant Discharge Elimination System which establishes permissible levels of pollutants which can be discharged to the Great Miami River. Mound effluents presently meet these discharge limitations.

- Summary results of sampling for tritium in water have been expanded to include community drinking waters and private wells adjacent to the plant site. These results indicate continuation of the downward trend reported last year. The concentration of tritium present is above background, but well within standards.

- Mound Laboratory has had an effective Effluent Reduction Program since 1969 as demonstrated on the effluent graphs on p. 7-10. Most of this reduction has resulted from the self imposed goals that Mound Laboratory originated and which are now more restrictive than those imposed by ERDA.

- A small amount of plutonium-238 has accumulated in the bottom sediments of the old Miami-Erie Canal and ponds adjacent to it in Miamisburg. An extensive program was undertaken to evaluate the situation. The program identified the extent of contamination, the cause, and mechanisms of the release. The health and safety aspects of this material were evaluated under prevailing and future conditions. It was found to present no hazard to the public under existing conditions nor under credible worst-case future conditions.

I. INTRODUCTION

Monsanto Research Corporation operates Mound Laboratory, a government-owned facility of the U. S. Energy Research and Development Administration, at Miamisburg, Ohio. Mound Laboratory is an integrated research, development, and production facility performing work in support of ERDA weapon and non-weapon programs with emphasis on explosive and nuclear technology.

Mound Laboratory originated as a technical organization in 1943 when Monsanto Chemical Company was requested to accept responsibility for determining the chemical and metallurgical properties of polonium as a project of the Manhattan Engineering District. Work was carried on at Monsanto's Central Research Department and several satellite units in the Dayton, Ohio area. Late in 1945, the Manhattan Engineering District determined that the research, development and production organization established by Monsanto at Dayton should become a permanent facility. A search for a suitable location in early 1946 led to the selection of a 180-acre tract adjacent to Miamisburg, about ten miles (16 km) south of Dayton.

Construction of Mound Laboratory, which was named after the Miamisburg Indian Mound adjacent to the site, began in February 1947 and was completed in 1948. The new laboratory was the first permanent facility of the Atomic Energy Commission which had succeeded the Manhattan Engineering District.

All early programs were concerned with polonium-210 and its applications. Additional assignments soon led to a wide variety of technical activities, and during the last 26 years many diversified capabilities for highly specialized research, development, and production operations have been developed.

Separation of the stable isotopes of noble gases began as an expansion of research beginning in 1954 on thermal diffusion columns. Today, Mound Laboratory is recognized as a world leader in thermal diffusion research, and stable isotope separation processes which provide a large number of nonradioactive isotopes for distribution throughout the free world.

In 1954 the thermoelectric generator fueled with polonium-210 was invented at Mound Laboratory. This invention utilized heat from the radioactive decay of polonium-210. The first SNAP generator, SNAP-3, fueled with polonium-210, was demonstrated at the White House in 1959. Since that time a large number of heat sources fueled with plutonium-238 have been developed and fabricated for use in thermoelectric generators and heat sources for lunar experiments, weather satellites, navigational satellites, and spacecraft. Figure 1 shows an astronaut on the moon removing a Mound-built plutonium-238 heat source from the spacecraft in preparation for placing it in a thermoelectric generator. A photograph of the Viking spacecraft which will land on Mars and explore its surface is shown in Figure 2. Electric power for this Mars mission will be provided by thermoelectric generators fueled with plutonium heat sources fabricated at Mound Laboratory. Additional Mound fueled power sources will be used in the Mariner-Jupiter-Saturn mission scheduled for the late 1970's. Other heat sources have been developed for use in life-support systems, swimsuit heaters, artificial hearts and cardiac pacemakers. Figure 3 shows a nuclear powered pacemaker.

Environmental protection has always been a prime concern at the Laboratory. A formal Environmental Control and Monitoring Program was adopted in 1949, the year in which the Laboratory began operations. The scope and effectiveness of this program, which was adopted and implemented long before the concerns of today's environment-sensitive society, demonstrates Mound's concern for the well-being of its employes and the communities surrounding the Laboratory.

In the early 1970's, as national concerns about the environment and the conservation of resources mounted, Mound expanded its comprehensive programs in environmental control, waste management, and energy conservation. One of the key aspects of Mound's Environmental Control Program deals with the safe handling of radioactive materials. The major elements which comprise that portion of our program are: (a) effective systems for the containment of radioactive material; (b)

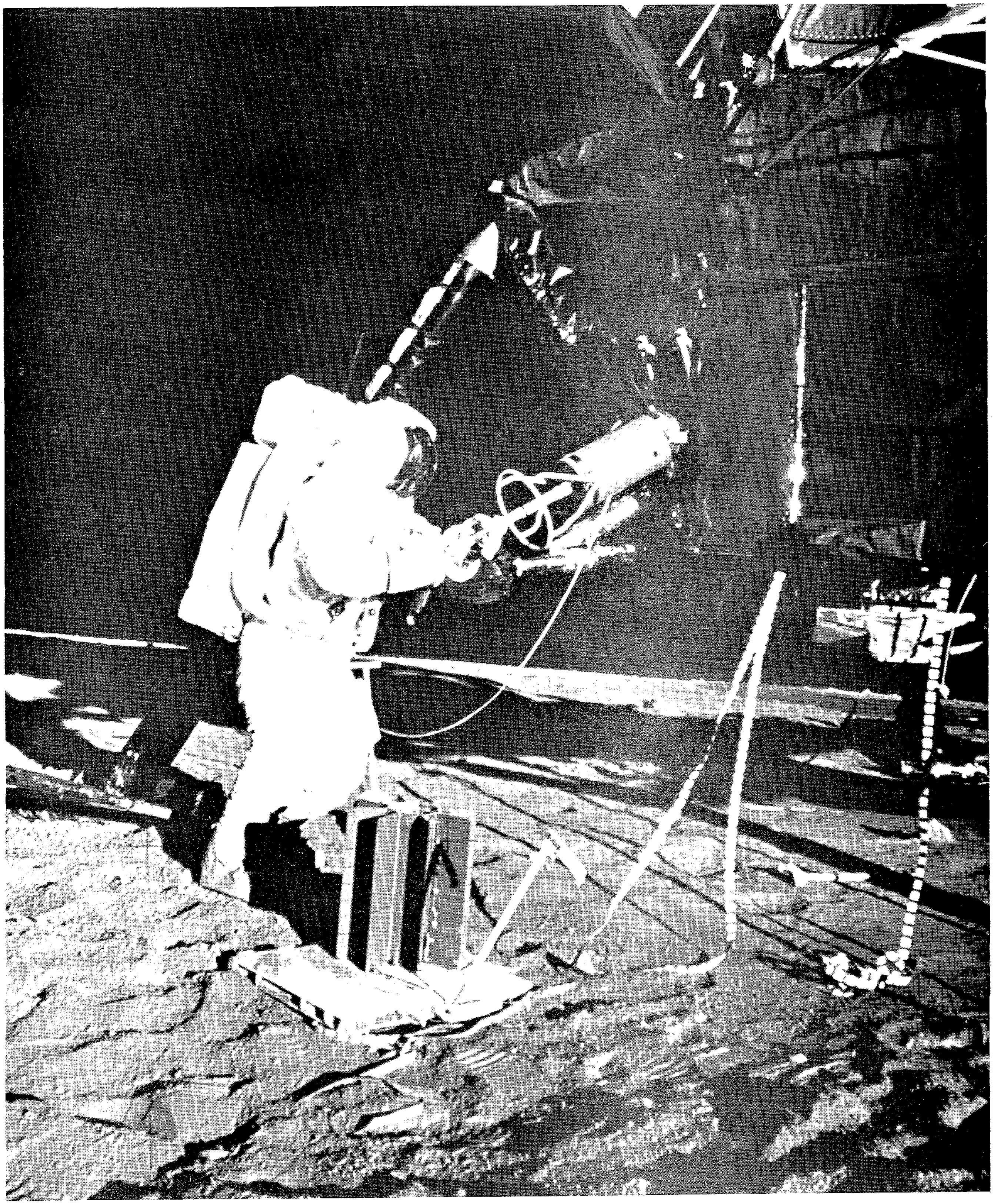


FIGURE 1 - Astronaut removing heat source from craft for placement into generator.

FIGURE 2 - Viking spacecraft Mars lander.

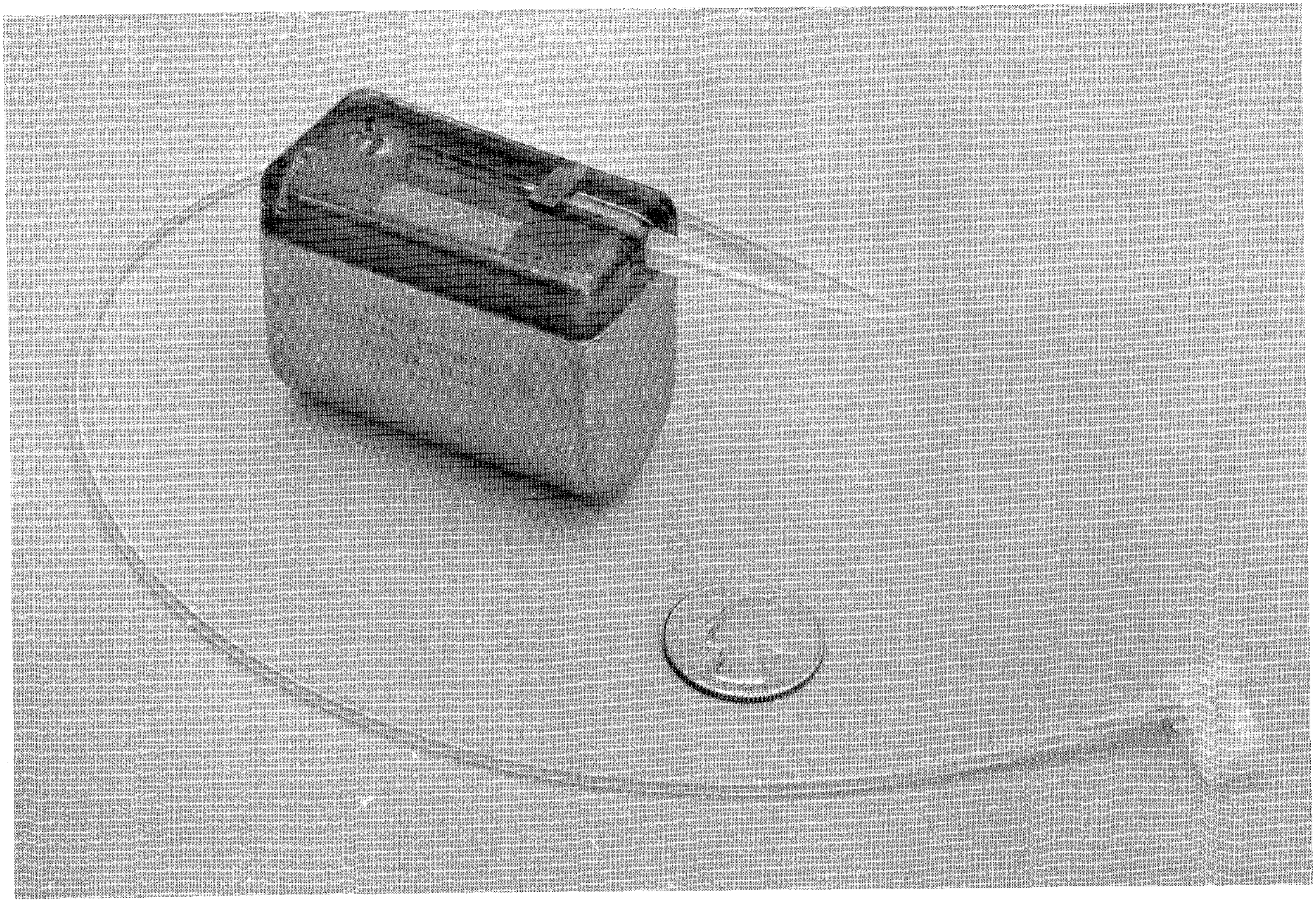


FIGURE 3 - Nuclear powered pacemaker.

devices and systems which ensure the quality of air and water effluents; and (c) on-site and off-site monitoring programs which verify the integrity of the control systems. This report describes the program for monitoring these materials and provides information concerning the results of our monitoring activities.

Mound has exerted a positive effort in reducing effluents to the environment since 1969. This reduction for the most part resulted from self-imposed goals which are now more restrictive than those imposed by ERDA. The reductions achieved are illustrated by Figures 4 through 7 which show the annual quantities of tritium and plutonium released to water and air.

II. THE MONITORING PROGRAM

Background In its mission assignment for ERDA, Mound Laboratory performs research, development, and production of explosive and nuclear materials. Air, water, foodstuff, and soil samples are collected off-site to ensure the integrity of our on-site environmental controls. The monitoring survey is conducted by a staff of professionally-trained personnel. A detailed technical report documenting the survey results has been issued on a regular basis since 1959 to the Atomic Energy Commission and to local, state, and federal agencies, such as the Miami Conservancy District, the

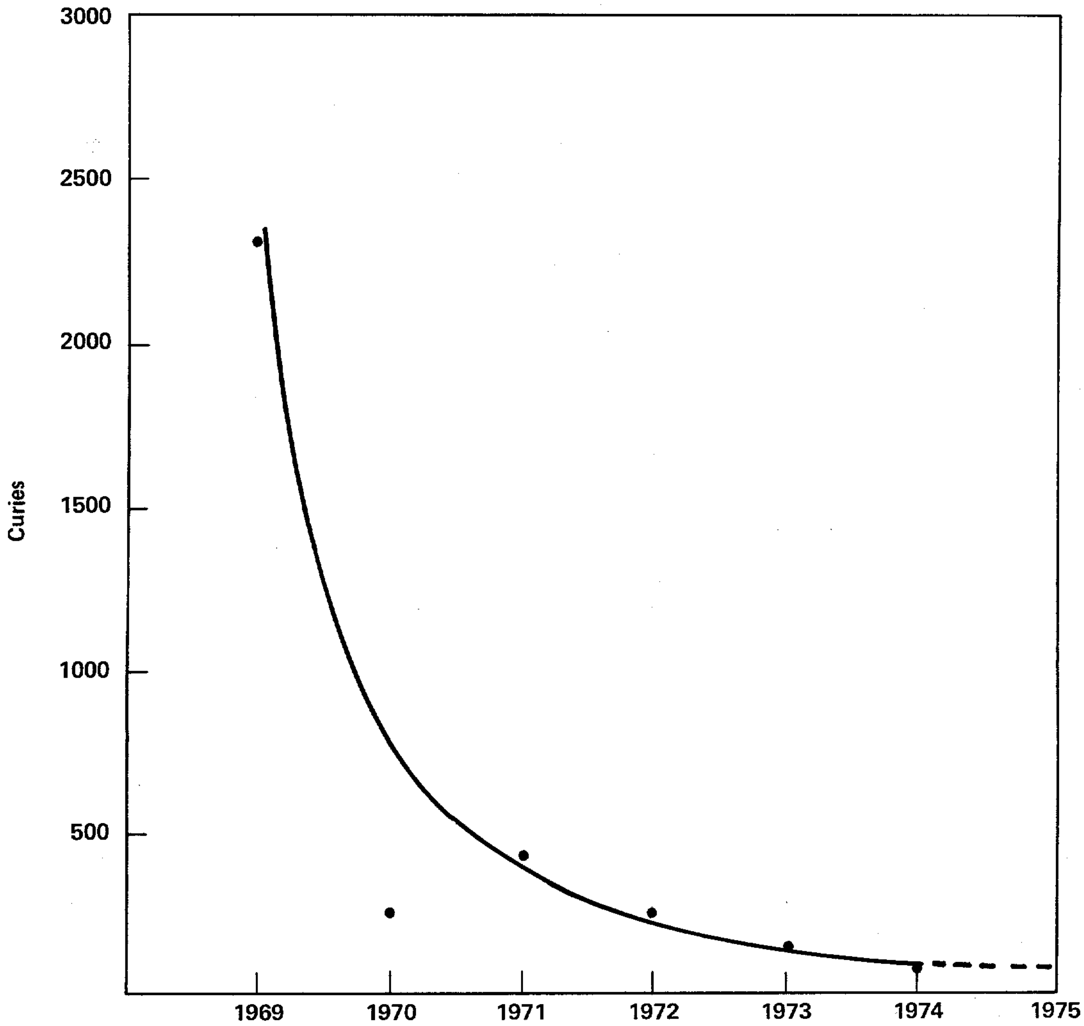


FIGURE 4 - Annual quantities of tritium released in liquid effluent streams.

Montgomery County Health Department, the State of Ohio Department of Health and to the Ohio Environmental Protection Agency (established in late 1972) and the Federal Environmental Protection Agency. This report summarizes our environmental monitoring activities for the period July 1974 - June 1975. Detailed environmental monitoring data is submitted to these agencies in technical report form on an annual basis. A copy of the technical report is available at year end upon request.

To assist the reader the following is a brief review of some basic radiation facts. The most common types of radiation are alpha and beta particles, gamma rays, x-rays and neutrons. The alpha and beta particles are charged particles, alpha being positively charged and the beta negatively charged. Gamma and x-rays are not particles but are electromagnetic radiations similar to ordinary radiowaves and visible light waves except their frequencies are higher and they are not visible to the human eye. Neutrons are neutrally charged particles. Of these types of radiation neutrons and gamma rays have the greatest range and penetrating ability, easily penetrating several inches of steel although several inches of lead will stop gamma rays. Beta particles, although less penetrating than gamma, still have enough penetrating ability

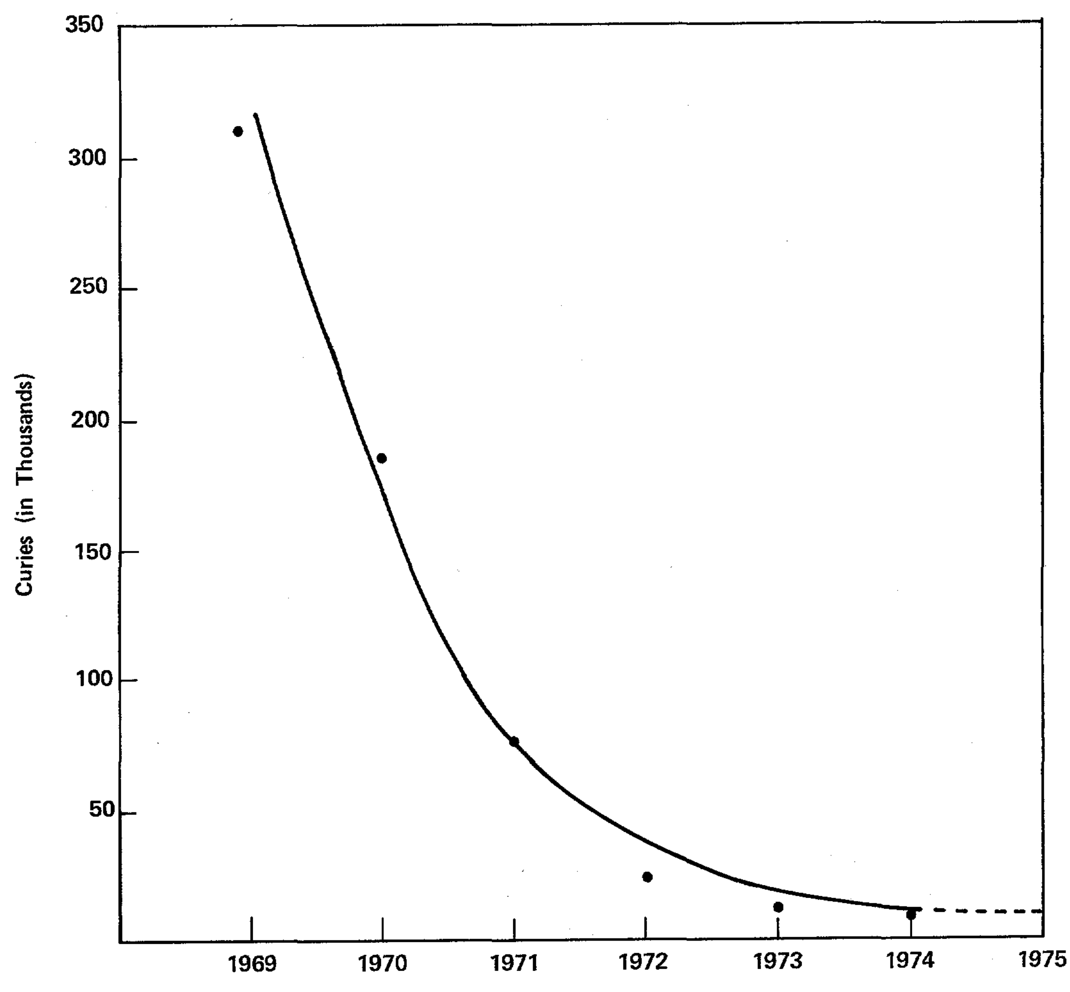


FIGURE 5 - Annual quantities of tritium in airborne emissions.

to penetrate human skin. Alpha particles have the least penetrating power. In fact, alpha particles are unable to penetrate an ordinary sheet of paper or the relatively thick human skin. These relative penetrating powers are illustrated in Figure 8. Plutonium-238 and tritium are the two radionuclides which are monitored in the environment and reported by Mound Laboratory. Plutonium-238 is primarily an alpha emitter and tritium is a beta emitter.

The concentration of liquid and airborne radioactivity in the environment surrounding the Laboratory has consistently been well within the levels established by the U. S. Energy Research and Development Administration. The technical reports which have been made since 1959 bear out this fact.

Water Monitoring All water discharged into the Great Miami River is first carefully treated to ensure that it is well within quality standards. Mound Laboratory collects water samples along a seven-mile stretch of the Great Miami River, extending from mid-town Miamisburg south to Franklin, from nearby ponds and streams, from drinking waters of various communities, and a few nearby private wells. The samples are analyzed for radioactive and nonradioactive materials as is detailed in Section IV of this summary. Additionally, two river monitoring stations, one above the Laboratory site and one below, now continuously monitor for six nonradioactive parameters; pH (acidity/alkalinity), temperature, turbidity, chlorides, dissolved oxygen and conductivity.

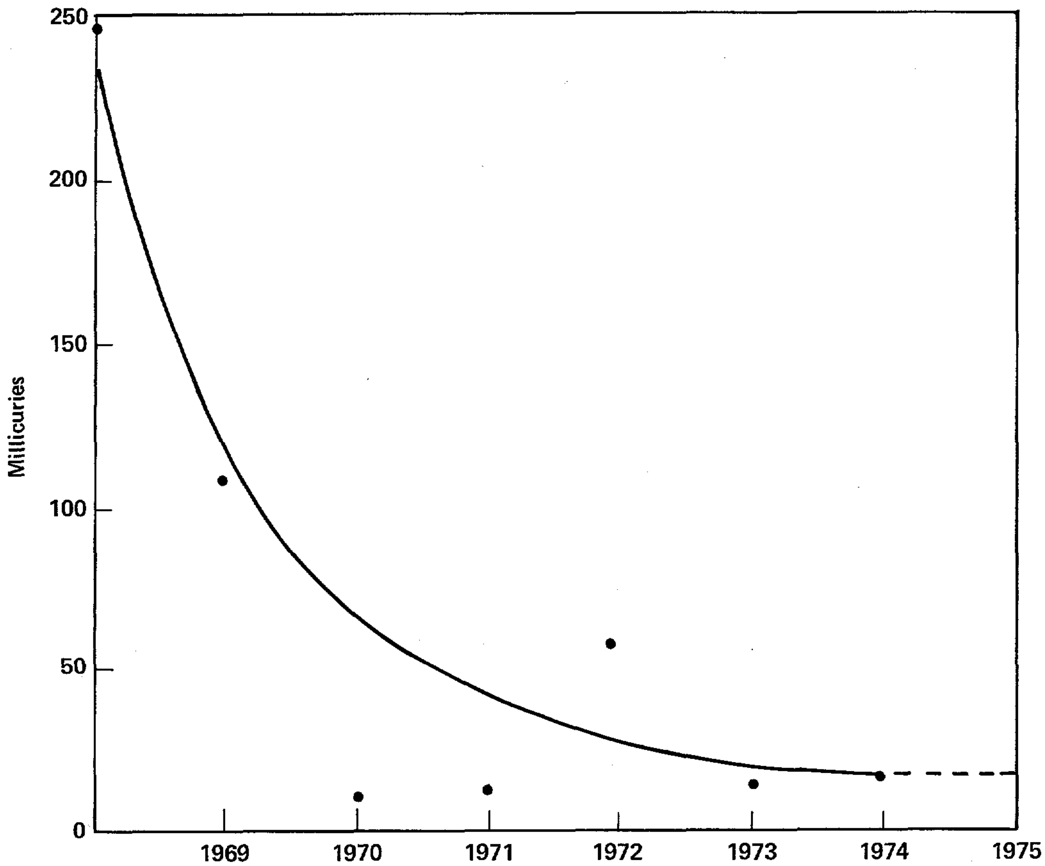


FIGURE 6 - Annual quantities of plutonium-238 released in liquid effluent streams.

Air Monitoring Air samples are collected primarily by a system of 21 off-site continuous air sampling stations, and additional samples are obtained from the mobile laboratory. Samples are analyzed for plutonium-238, tritium, and nonradioactive materials.

Soil and Silt Sampling Soil and silt sampling provides Mound and the Energy Research and Development Administration with supplemental data on long-lived radioactive elements that may be deposited on the ground and in silt. Sampling and analytical techniques employed at Mound represent the state-of-the art of this area of environmental monitoring. Samples are collected and analyzed on a scheduled basis and the results are published in the annual technical report.

Foodstuffs/Vegation This section represents an area of environmental monitoring initiated in late 1970. Locally grown foodstuff and vegetation samples are collected and analyzed to determine if there is any absorption and concentration of radioactive elements by plant or animal life. Representative samples are analyzed for concentrations of plutonium-238 and tritium. The results of these analyses are also published in the annual technical report.

III. APPLICABLE STANDARDS

Radioactivity Concentration Guide ERDA regulations on radiation protection are based principally on the Radioactivity Concentration Guide

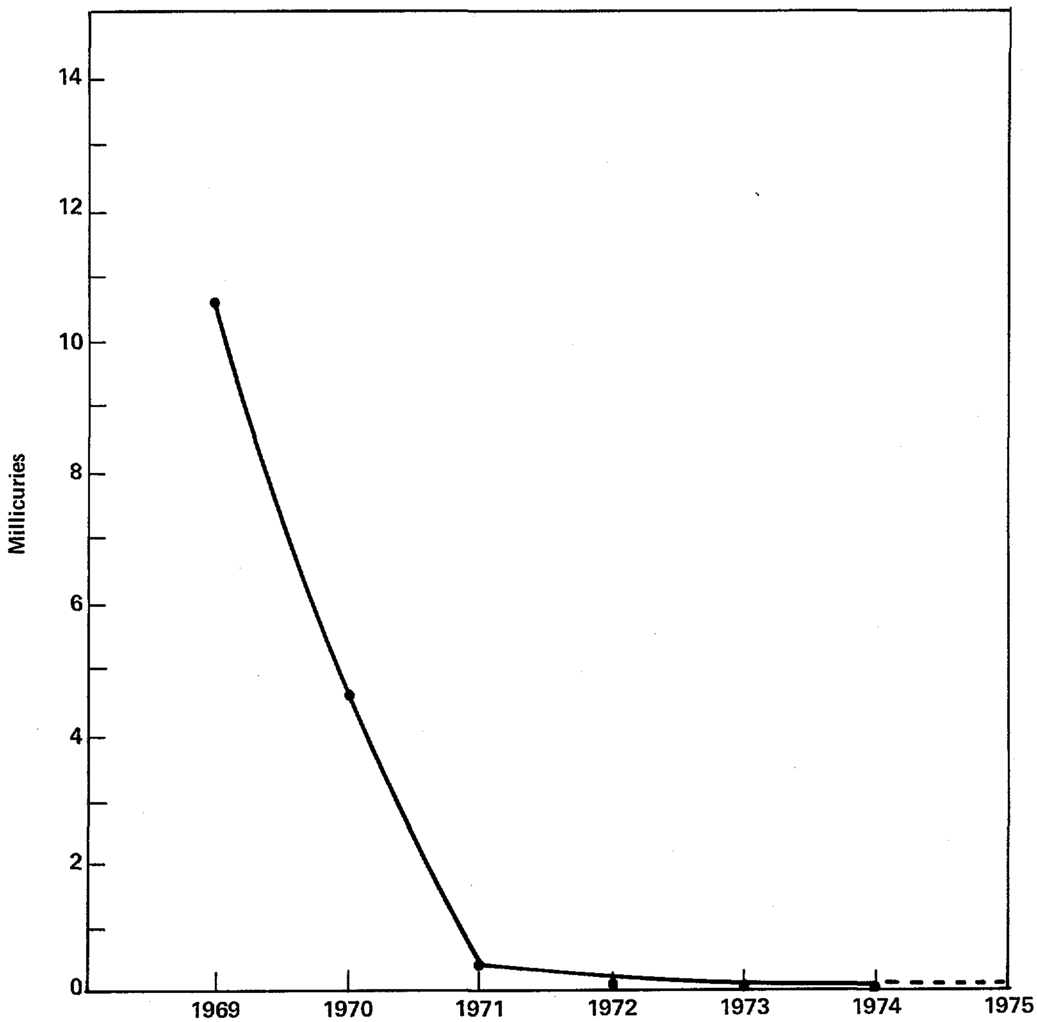


FIGURE 7 - Annual quantities of plutonium-238 in airborne emissions.

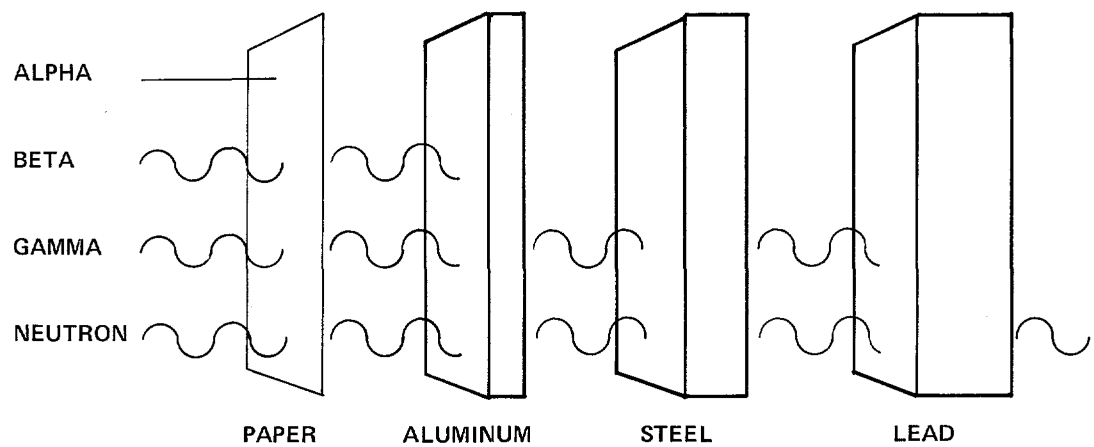


FIGURE 8 - Relative penetration powers of alpha and beta particles, gamma rays, and neutrons through paper, aluminum, steel, and lead.

(RCG) levels recommended by the former Federal Radiation Council and approved by the President for guidance of all Federal agencies.

The recommended levels are developed with the assistance of appropriate Federal agencies, the National Academy of Sciences, the National Committee on Radiation Protection and Measurements, and the International Commission on Radiological Protection. In addition to their own expertise, the members of these groups seek the advice of other highly qualified scientists and researchers with specialized knowledge of the many factors that determine the effects of radioactivity on man. The results of the extensive experimental programs on the behavior and effect of radioactive material in the environment and in living tissue are also carefully considered in developing the RCG levels. These levels are reviewed as new research information becomes available or as new problems arise to determine whether changes in these standards are needed.

The RCG which has been established for each specific type of radioactive material is the concentration of radioactivity in the environment which should not be exceeded without careful consideration. The radiation dose received from radioactive materials at the RCG level is less than the radiation dose received routinely by the general population from such sources as cosmic rays, naturally-occurring radioactive materials and medical x-rays. These and other examples are illustrated in Figure 9. The levels of radioactive materials documented in this report are small fractions of the RCG.

Nonradioactive Standards The Federal and Ohio Environmental Protection Agencies have established standards for ambient levels of pollutants in the environment. The more restrictive of the standards serve as the criteria for this report. In addition, the Federal EPA has issued a discharge permit for each of Mound's effluent streams effective June 30, 1975. The permit specifies concentration limits for various pollutants.

IV. WATER MONITORING

A. Radioactive Water sampling locations along the Great Miami River were revised during the first half of 1972 to provide more representative samples of river water. The selection of these sampling sites was based on guidelines adopted by the Federal Environmental Protection Agency (see Figure 10).

Water samples are collected each work day from each of these five locations and are analyzed using equipment capable of detecting traces of radioactivity less than 1/10 of 1% of the RCG

Table 1 shows the percentage of RCG, based on the average

TYPICAL WHOLE BODY EQUIVALENT DOSES

FIGURE 9

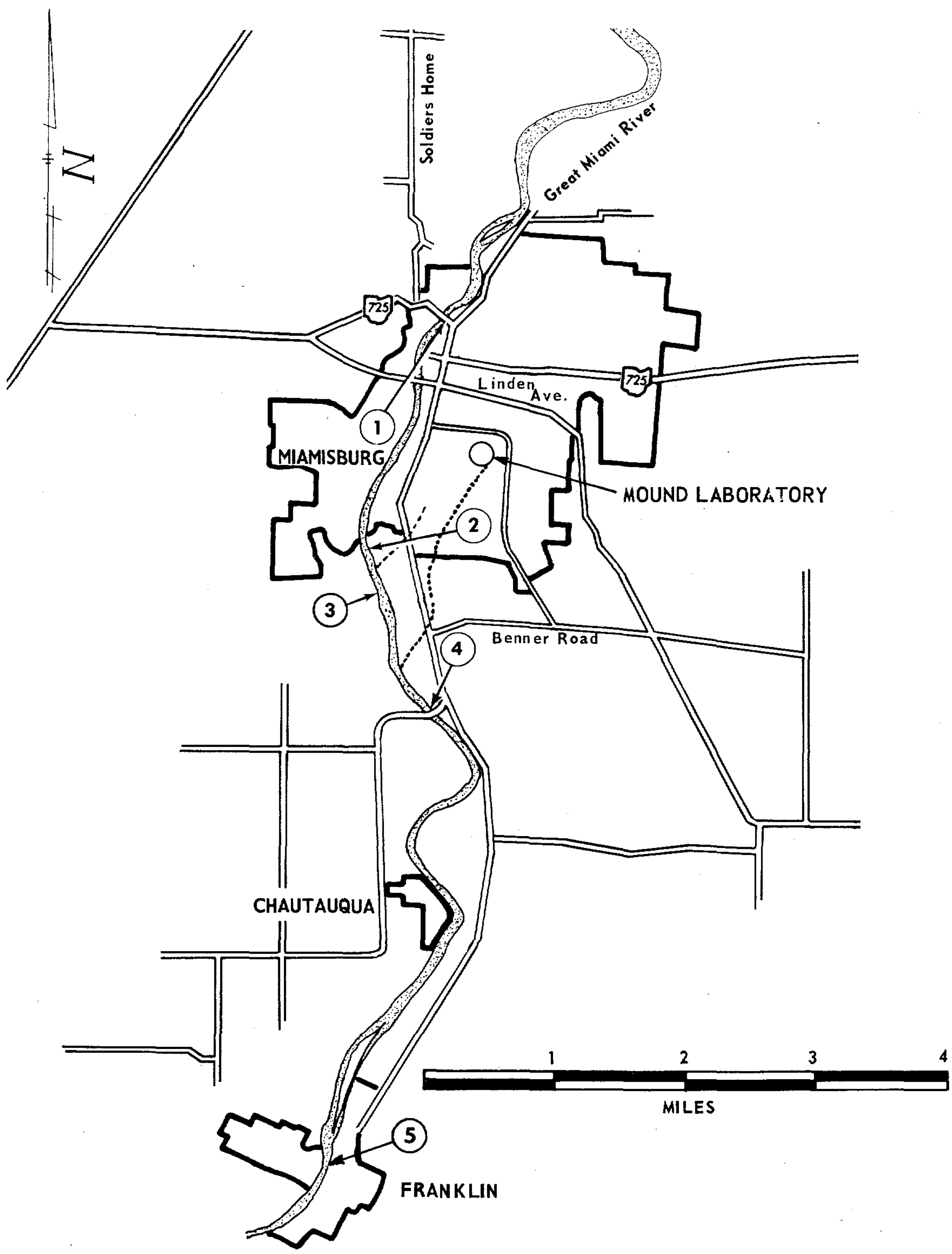


FIGURE 10 - Water sampling locations.

concentration detected in the waterways during the first half of fiscal year 1975 for plutonium-238 and for all of fiscal 1975 for tritium. In this table, a concentration equal to the RCG (maximum recommended concentration) would be shown as 100.0%. The figure 0.5%, therefore, means that the concentration was 1/2 of 1% of the RCG.

Table 1

RADIONUCLIDE CONCENTRATION
(% RCG)

Location	Plutonium	Tritium
#1	0.05	0.10
#2	0.08	0.20
#3	0.03	0.20
#4	0.03	0.10
#5	0.04	0.10

The results of these figures can be summarized as follows:

Plutonium

Plutonium-238 concentration measured at each location is well within the standard, i.e., significantly less than 1% of the RCG with the maximum being 8/100 of 1% of the RCG.

Tritium

The average concentration at each sampling location was significantly less than 1% of the RCG with the maximum being 2/10 of 1% of the RCG at Location #2. This data demonstrates that the average concentration in each sampling location was well within the RCG.

In addition to daily samples from the Miami River, drinking water samples have been collected regularly from various communities and a few nearby private wells and analyzed for tritium content. During 1975, the data ranged from less than 1% of the RCG for all community drinking water samples up to 8% of the RCG for water in wells adjacent to the plant site.

The levels of tritium continue to subside as the source, Mound effluents, continues to diminish as it has for the last few years. This reduction is the result of a planned program to minimize tritium discharges.

B. Nonradioactive

Mound's program includes monitoring for nonradioactive materials in water. Samples are collected from Mound's two effluent streams and are analyzed for 32 different water quality parameters listed by the Federal Environmental Protection Agency. Analyses of the data indicate that Mound's water effluents are so minimal that they have no significant effect on the Miami River into which they are discharged. Mound's effluent concentrations are also well within Mound's discharge permit limitations.

V. AIR MONITORING

A. Radioactive

Mound completed the installation of ten off-site continuous air sampling stations in early 1972 (see Figure 11, Locations 101-110). During the first quarter of 1973, eleven additional sampling stations became operational (see Figure 11, Locations 111-121), completing the air monitoring system. Seven of the samplers are located within a one-mile radius of Mound Laboratory. The others are located up to 20 miles from the Laboratory.

Air samples are collected continuously at each sampling station. Analysis of these samples is made on a regular basis with equipment capable of detecting traces of radioactivity less than 1/10 of 1% of the RCG. As you know, the RCG is the concentration of radioactivity in the environment which cannot be exceeded without careful consideration. Table 2 shows the percentage of RCG, based upon average concentration, for each of the radioactive materials handled at Mound Laboratory during fiscal year 1975. The table lists the data compiled at each of the off-site sampling stations in the completed air monitoring network. As in Table 1, a concentration equal to the RCG would be shown as 100.0%. The figure 0.10%, therefore, means that the concentration was 1/10 of 1% of the RCG.

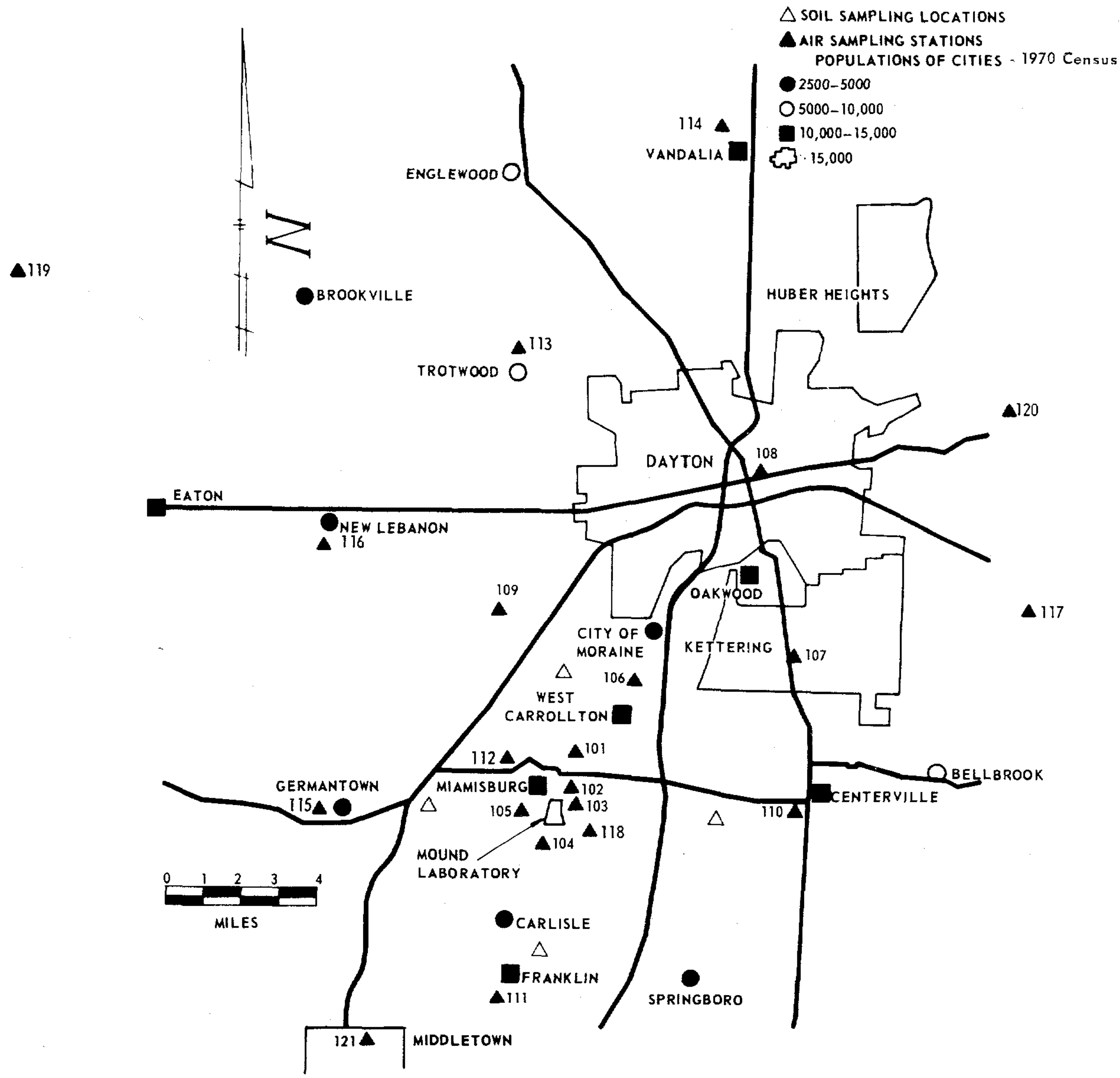


FIGURE 11 - Off-site air sampling stations.

Table 2

OFF-SITE RADIONUCLIDE CONCENTRATION
(% RCG)

Location	Plutonium	Tritium
#101	0.40	0.09
#102	0.20	0.10
#103	0.30	0.07
#104	0.08	0.05
#105	0.08	0.06
#106	0.02	0.04
#107	0.06	0.02
#108	0.10	0.02
#109	0.03	0.02
#110	0.04	0.01
#111	0.04	0.01
#112	0.10	0.05
#113	0.03	0.01
#114	0.03	0.01
#115	0.05	0.01
#116	0.04	0.01
#117	0.05	0.01
#118	0.05	0.02
#119	0.01	0.01
#120	0.02	0.01
#121	0.03	0.01

The results of the above figures can be summarized as follows:

Plutonium

The average concentration measured at each location was no more than 4/10 of 1% of the RCG, which is well within the recommended RCG for plutonium-238.

Tritium

The highest average concentration was less than 1/10 of 1% of the RCG, and the remainder were lower. This data demonstrates that the average concentration at each sampling location was well within the RCG.

B. Nonradioactive

Since Mound normally uses natural gas rather than oil for its power supply system, sulfur dioxide emissions have been eliminated. Mound's contract with the supplier of natural gas, however, provides for the interruption of natural gas service during unusually cold weather. During such interruptions, fuel oil with less than 1% of sulfur content is burned to power plant operations. Sulfur dioxide emissions from the use of this oil are within standards governing the use of fuel oil. Furthermore, the emissions of carbon monoxides, photochemical oxidants, hydrocarbons, and other nonradioactive gases from other parts of the operation are quite low and have virtually no effect on the environment. While operations at Mound result in only small amounts of nonradioactive particles being released to the atmosphere, a sampling has been made to establish the background level of particulate concentrations at the Laboratory site. This sampling indicates Laboratory operations do not at this time have measurable effect on the ambient particulate level of the region.

VI. SUMMARY

Mound Laboratory has continuously operated well within local, state, and federal air and water quality standards. The effectiveness of our environmental program, as documented in this report, attests to our concern for the well-being of Mound employes and the surrounding communities.

type of soliton known as a *skyrmion,* in which the nucleon and Δ are viewed as a soliton in the field of the pion, as described by a nonlinear sigma model. This realization has allowed us to calculate for the first time, from first principles, the leading-order width of the Δ (as mentioned above). Furthermore, the same set of corrections that I have elucidated in the instanton case can be analyzed order by order in the hadron case as well. Many of the technical theoretical questions (e.g., proving independence of the final answer from the choice of Faddeev-Popov constraints) admit parallel solutions in both cases. Furthermore, the loop or h-bar expansion in the instanton case, is tied to the $1/N_c$ expansion in the skyrmion case, as the fields in the nonlinear sigma model can be resealed in order to pull $1/N_c$ out in front of the action.

The Skyrme model can be viewed as *complementary* to the quark model, and as such is an *approximate* "bosonization" of QCD (in the language of 1+1 dimensional field theory). Whereas the quark picture is useful at high momentum transfer, skyrmion physics is typically much more predictive in the opposite kinematic regime.

2. Importance to LANL's Science and Technology Base and National R&D Needs

This work has furthered the Laboratory's commitment to forefront theoretical research. In particular, it has contributed directly to our understanding of the phenomenology of the Standard Model, and has direct observable experimental consequences. This work is directly relevant to the Lab's desire to play a major role in the design, planning and construction of any future high-energy accelerator and its major detectors. (For instance, Laboratory scientists have played a particularly visible role in the GEM detector collaboration.) A strong theoretical effort into the understanding of collider-related phenomena should be an important component of the mutually beneficial link between LANL and other national labs. In particular, should B violation b nd design of said collider would need to be seriously rethought. In addition, the work relates to many experimental programs involving hadron physics, in particular DOE's Colliding Electron Beam Accelerator Facility (CEBAF). Closer to home, this work has strengthened LANL's science and technology base. Specifically, the study of anomalous B and L violation has been one of the strengths of the Laboratory's theoretical effort in elementary particle physics.

3. Scientific Approach and Results

We have made significant progress on the following fronts:

High-energy B violation: is it even semiclassical?

If there is a hope of calculating the leading exponential behavior of the B-violating cross section σ, then semiclassical techniques are almost certainly required. Which is why Mueller's findings **[1]** that *loop* graphs in instanton backgrounds are surprisingly large was dismaying: loops, unlike trees, cannot be accommodated semiclassically. But recently, McLerran, Yaffe and Mattis have argued that Mueller's loops—looked at the right way—can be summed using tree graphs alone. Independent confirmation of the semiclassical nature of the initial state has come in recent preprints by Mueller and by Rubakov and Tinyakov.

What is the size and shape of the relevant distorted instanton?

It appears that the appropriate semiclassical objects mediating high-energy (rather than high-temperature) anomalous scattering are indeed instantons, and not, say, sphalerons. But the instantons are *distorted* due to the backreaction of the $O(1/\alpha)$ soft gauge and Higgs bosons typically produced in the final state. Dorey and Mattis have analyzed the space of distorted instantons, and looking for "bifurcations" in which, above some critical energy, the number of unstable modes increases by one. The existence of such a bifurcation would almost surely mean that σ can never grow observably large, but always remains exponentially suppressed. Recently, Grandy and Mattis have conclusively demonstrated the existence of such a bifurcation in a "toy" model of electroweak theory, the $2d$ $O(3)$ α model. In this model, σ only loses around 10 of its exponential suppression prior to the bifurcation. The parameter space we explored appears to correspond to the heavy-Higgs regime of electroweak theory, $M_{Higgs} > M_W$.

What is the role of multi-instantons?

Recently, Zakharov and independently Maggiore and Shifman (ZMS) have proposed that above a certain critical energy, the dilute instanton gas approximation breaks down, and the B-violating ground state becomes a dense multi-instanton "liquid" as in QCD, with the important caveat that anomalous electroweak processes (unlike QCD) are always suppressed at zero temperature **[2]**. This scenario has attracted much attention lately. Dorey and Mattis have looked critically at these proposals, and in the context of one toy model, have come to the opposite conclusions: multi-instanton effects are always down by many orders of magnitude.

However, in the context of another toy model (again the *O (3)* a model), Dorey, in a remarkable calculation, has confirmed the Zakharov-Maggiore-Shifman scenario **[3]**. Therefore, the importance of multi-instantons appears to be highly model-dependent, and remains an open question.

Can instanton technology be applied to solitons?

With the demise of the Superconducting Supercollider (SSC) project, our work turned to thinking about the strong, rather than the electroweak, interactions. The major concepts from the work on the semiclassical aspects of electroweak baryon number violation at the SSC find immediate, and important, application to strong interaction physics. To be more concrete: Dorey, Hughes, Silbar and Mattis have looked at the related topic of soliton dynamics ("skyrmions") in the strong interactions. Adapting many of the same collective coordinate techniques from instanton theory, we have been able to systematize the $1/N_c$ expansion in the Skyrme model (N_c being the number of colors). Interestingly, questions of constraint independence which Mattis explored in the instanton case in several recent publications turn out to be crucial to a correct calculation of $\Delta \rightarrow \pi N$ in the Skyrme model. Pleasingly, a first-principles calculation of the width of the Δ has yielded 114 MeV, compared with 115 +/- 5 MeV experimentally. This recent research direction is a natural outgrowth, and spinoff, from the earlier SSC work.

The various techniques of perturbation theory about the instanton have been successfully applied to the realm of skyrmion physics in other ways as well. Particular methodologies employed that exploit these parallels are: (1) the $1/N_c$ expansion, (2) the use of extended (semi)classical objects to construct quantum Green's functions, (3) the systematization of the study of corrections to the leading semiclassical results, (4) the order by order establishment of constraint independence, and (5) the reformulation of collective coordinate quantization. The expected results are a highly predictive phenomenology of low-energy hadron processes.

References

[1] A. Mueller, *Nucl. Phys.* **B348**, 310 (1991); *Nucl. Phys.* **B353**, 44 (1991).

[2] V. Zakharov, *Nucl. Phys.* **B353**, 683 (1991) and *Nucl. Phys.* **B377**, 501 (1992); M. Maggiore and M. Shifman, *Nucl. Phys.* **B371**, 177 (1992) and *Phys. Rev.* **D46**, 3550 (1992).

[3] N. Dorey, *Phys. Rev.* **D46**, 4668 (1992).

Publications

1. Mattis, Michael; Dorey, Nicholas; Huges, Jim; and Skidmore, D., "Chiral Divergent Properties of Hadrons in the Large Nc Limit," Los Alamos document LAUR-95-2991, submitted for publication in Physics Letters B (1995).

2. Mattis, Michael and Dorey, Nicholas, "The Large Nc Renormalization Group," Los Alamos document LAUR-95-1490 to be published in Proceedings of the International Workshop on Nuclear and Particle Physics, Seoul, Korea Feb. 6-10, 1995.

3. Mattis, Michael and Dorey, Nicholas, "The Rotationally Improved Skyrmion, or RISKY," Los Alamos document LAUR-95-1489 to be published in Proceedings of the International Workshop on Nuclear and Particle Physics, Seoul, Korea, Feb. 6-10, 1995.

4. Mattis, Michael and Dorey, Nicholas, "From Effective Lagrangians, to Chiral Bags, to Skyrmions with the Large Nc Renormalization Group," Physical Review **D52,** 2891 (1995).