HEALTH CONSULTATION

DOE MOUND PLANT

MIAMI-ERIE CANALS AND MIAMISBURG COMMUNITY PARK

MIAMISBURG, OHIO

FEDERAL PROGRAMS BRANCH

DIVISION OF HEALTH ASSESSMENT AND CONSULTATION

AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

September 29, 1993

ANNOUNCING

DOCUMENTS AVAILABLE FOR PUBLIC REVIEW
ON

MOUND PLANT

The Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the U.S. Public Health Service, is announcing the release of two documents which they have produced concerning the property immediately surrounding the Mound Plant in Miamisburg, Ohio.

ATSDR is releasing its health consultation on the soils and surface waters in the Miami-Erie Canals and Community Park in Miamisburg. Also, ATSDR is planning on collecting samples of surface soil, water, air, and some plants in the vicinity of the Mound Plant, to help in its mission to conduct a public health assessment of the Mound Plant. Both the health consultation and the sampling plan will be discussed as part of the Department of Energy (DOE) Mound Plant Quarterly Public CERCLA Meeting, to be held in the Carnegie Center in Miamisburg on the evening of October 20, 1993. Prior to that meeting the documents will be made available in the DOE repository in the Miamisburg Branch Library of the Dayton & Montgomery County Public Library System.

Written comments on either document may be submitted to:

ATSDR/Records & Information Branch
ATTN: Dontanette Cohill
1600 Clifton Rd. NE (E56)
Atlanta, Georgia 30333

Copies of the health consultation may be obtained through a written request or by calling Ms. Cohill at (404) 639-6070.

TO ALL INTERESTED PARTIES:

The Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the U.S. Public Health Service, announces the availability of a Health Consultation, "DOE MOUND PLANT Miami-Erie Canals and Community Park." This document addresses contamination in the soils and surface waters in the Miami-Erie Canals and Community Park in Miamisburg, Ohio.

ATSDR also announces the availability of a "Work Plan for Environmental Studies in the Vicinity of the Mound Plant." This document describes the environmental sampling and analysis ATSDR will conduct in the environs of the Mound Plant. This environmental sampling and analysis will be performed by the U.S. Environmental Protection Agency's National Air and Radiation Environmental Laboratory under an interagency agreement with ATSDR.

Both the Health Consultation and the Work Plan are being made available in the Mound Plant public repository at the Miamisburg Branch Library of the Dayton & Montgomery County Public Library. Copies of the Health Consultation may be requested from:

Ms. Dontanette L. Cohill
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
1600 Clifton Road, N.E.
Mail Stop E-56
Atlanta, Georgia 30333

Comments may be made in writing to:

Chief, Records and Information Management Branch
Agency for Toxic Substances and Disease Registry
Attention: Federal Programs
1600 Clifton Rd., NE
Mail Stop E-56
Atlanta, GA 30333

If you have any questions, you may contact William H. Taylor, Ph.D. at (404) 639-6068 between 7:00 a.m. and 3:30 p.m. (Eastern Time).

Health Consultation

DOE MOUND PLANT

Miami-Erie Canals and Miamisburg Community Park
Miamisburg, Ohio

Federal Programs Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

September 29, 1993

BACKGROUND AND STATEMENT OF ISSUES

The U.S. Department of Energy (DOE) asked the Agency for Toxic Substances and Disease Registry (ATSDR) to comment on the potential threat to human health posed by the presence of contamination in surface water and soils in the Miami-Erie Canals and Community Park immediately west and northwest of the Mound Plant [1].

The Mound Plant is an active DOE facility within the city limits of Miamisburg, Ohio. Mound's primary mission is the manufacture of both nuclear and nonnuclear components for weapons. The Monsanto Research Corporation operated the plant at its current location from 1948 to October 1988. During that time, the plant was called the Mound Laboratory. In October 1988, EG&G Mound Applied Technologies Inc. took over primary operation of the facility. The current name, Mound Plant, was adopted at that time. The site was added to the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) on November 21, 1989 (CERCLIS No. OH6890008984).

Most of the 306-acre site, which includes more than 100 on-site buildings, is on a ridge overlooking the city of Miamisburg. Mound Plant is characterized by two elevated areas, known as the Main Hill on the northwest and the SM/PP Hill on the east. The Main Hill is the location of the majority of the site buildings. The hills are separated by a valley sloping toward the southwest. The southernmost 124 acres were purchased in 1981 and remain undeveloped [2].

Miamisburg is a community of 18,000 people 10 miles southwest of Dayton, Ohio. Many city and township residences, five schools, Miamisburg's downtown area, and six of the city's 17 parks and playgrounds are within 1 mile of the plant. The 1990 U.S. census indicated that more than 887,000 people live within a 20-mile radius of the plant [3]. Mound Road, on the eastern side of the plant, is lined by residences and provides access to the plant's main gate. The entire site is fenced; access to the plant is strictly controlled 24 hours

a day. People entering the site are admitted through a guardhouse at the front gate. Along the plant's western border is a Consolidated Rail Corporation (Conrail) freight line, and beyond the tracks is an abandoned part of the old Miami-Erie Canal bed. Main Street is on the western side of the canal bed; further west of Main Street is the Great Miami River, which is approximately a half mile from Mound Plant (see map, Attachment 1).

In 1969, a pipe conducting a nitrate waste solution containing plutonium-238 and other radionuclides[1] broke on site; the waste solution was released to soils on site. During removal of the contaminated soils, heavy rains washed the soils off site into surface waters and soils adjacent to site boundaries. Mound Plant officials indicate that the incident is a primary reason why elevated levels of plutonium are found in the canals and surrounding area. Other reasons given for the contamination in the canals area are effluent discharges from SM and WD Building operations, and contaminated soil erosion [5].

Mound officials have reported other on-site spills that may have contaminated off-site soils, both before and after 1969. Those events included releases to the environment of plutonium-238, tritium (a radioactive form of hydrogen), inorganic and organic chemicals (nonradioactive), and unspecified radioactive substances [6]. In 1972, another pipeline break resulted in the release of "very high" levels (amount unknown) of plutonium-238 to the plant drainage ditch. That was the only ground release at Mound Plant that resulted in a board investigation (DOE Order 5484.1)[2].

Plutonium and tritium in off-site soils continue to be a source of community concern. On December 5, 1991, 33 residents of Miamisburg and surrounding communities within Montgomery County filed a lawsuit (class action complaint and jury demand) in the District Court in Dayton, Ohio, against the current and former primary contractors for the Mound Plant (EG&G Mound Applied Technologies Inc. and Monsanto Research Corporation, respectively.) The suit claims that the defendants failed to contain the radioactive or hazardous materials on site and that the "plaintiffs and the class members have been damaged in an amount to be determined at trial" [7].

Adjacent the Conrail railroad right-of-way, at the foot of the Mound Plant Main Hill, is the Miamisburg Community Park (see map, Attachment 2). The Community Park was the site of a coal-burning municipal power plant that operated until the early 1970s. The property also served as a storage area for city road-clearing equipment and rock salt used on icy streets during the winter. In the park are the South Pond and the North Pond. The ponds were originally cooling ponds for the power plant, which was dismantled in 1974 [8].

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[1] Plutonium-238 makes up approximately 80.0% by weight of the isotopic mixture [4].

[2] DOE Order 5484.1 describes requirements and procedures for reporting significant information about environmental protection, safety, or health protection during DOE operations.

Between the Conrail right-of-way and the northwest boundary of the Mound Plant are five off-site seeps. The Mound seeps are surface waters originating through cracks in the shale and limestone bedrock underlying Mound's Main Hill. Tritium and volatile organic compounds have been identified in the seeps. The seeps are addressed as an operable unit (OU-2) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) program, separate from the plutonium in the canals, which is addressed in OU-4.

Runoff water leaving Mound Plant property to the west typically is channeled into the nearby Great Miami River by one of two routes. One is through a near-surface pipe to the National Pollutant Discharge Elimination System (NPDES) Outfall 001 directly into the Great Miami River. The other is via an open drainage ditch on the site property to NPDES Outfall 002 into the south part of the Miami-Erie Canal (the South Canal). The South Canal empties into an overflow creek near its southern end (approximately one-half mile from Outfall 002) and then into the Great Miami River.

Before 1976, effluent from the plant drainage ditch flowed into both the northern and southern parts of the Miami-Erie Canal (the North and South Canals). The North Canal ends approximately one-half mile north of the drainage ditch, at the western edge of the Miamisburg Community Park. The North Canal is connected to the South Pond by an underground pipe, and the South Pond is connected underground to the North Pond. Before 1977, excess water from the North Pond emptied from a standpipe drain to the municipal storm sewer, which emptied into the Great Miami River.

In May 1976, Mound Laboratory diverted the drainage ditch water leaving the site into the South Canal and allowed the North Canal to dry [9]. A one-way flapper valve was installed that allows flow from the North Canal to the South Canal during periods of extensive runoff. In November 1976, the City of Miamisburg acquired the canals property from the state of Ohio, and, in 1977, the City renovated and developed the Community Park. Trees and brush were cleared from the northern two-thirds of the North Canal. The park was graded and landscaped; a sanitary sewer pipe was installed between the park restrooms and the sanitary sewer under the North Canal. The North Pond in the Community Park was deepened by 10 feet and converted to a solar heating pond (heat exchanger) to heat the park's swimming pool. The South Pond also was deepened and converted to a fishing pond for children (ages 15 and under). Soils from the ponds were moved to level the grounds under the tennis courts and to create a berm between the tennis courts and the Conrail right-of-way. No soils were removed from the park area [10]. In 1984, soils previously moved from the ponds were moved again to another area in the park during the water slide construction. In 1988, soils in the park were disturbed again when a water line to the swimming pool was repaired.

The solar pond (North Pond) ceased operation and was disassembled in 1988. Today, the North Pond is a deep, empty pit, entirely enclosed by a fence; the city is filling it with dirt. When the filling is complete, the city plans to build a volleyball court on top of the filled pit.

The South Pond remains a fishing pond, although it is regularly overgrown with cattails during summer months. That overgrowth has compromised the attractiveness of the pond for its intended use. Bluegills in the South Pond were reported to be "highly stressed" in the summer of 1992 because of the overgrowth and the pond's subsequent lowered oxygen content [11]. The frequency with which people fish at the pond is reported to be variable[3]; it is not believed to be high. The North Canal is a grass-covered, dry bed approximately 6 feet deep and 15 feet across. After precipitation, the North Canal holds some standing water until soil saturation subsides. City parks personnel mow the grass in the North Canal.

Average rainfall for the Miamisburg area is 36 inches; rainfall in 1991 was 31 inches. Rainfall is fairly evenly distributed throughout the year. The canals and Community Park are in a floodplain of the Great Miami River; low-lying areas between the river and the site boundary receive surface runoff from the Mound Plant property.

Environmental data describing contamination in the canals and Community Park are included in Appendix A. The most important of these data come from the Rogers study of plutonium-238 in the canals and Community Park conducted in 1974, and data reported by Mound in their annual environmental monitoring reports. The Rogers report describes the most comprehensive evaluation to date of plutonium-238 in the canals and city park. Additional soil data collected in the late 1980s and early 1990s are consistent with those reported in the Rogers study, although the latter data are too few to characterize the extent of contamination (plutonium-238 and other materials) in the area. The annual environmental monitoring data reported by Mound officials are of interest, primarily for the air monitoring data collected in the canals and park. These data provide the most direct measure of airborne material to which people may be exposed in the area. ATSDR has used the data described in Appendix A to make exposure assessments (dose calculations) which are presented in the Discussion that follows.

DISCUSSION

People may be exposed to plutonium-238 in the canals and Community Park at levels greater than those that occur naturally in the environment. The pathways of exposure of greatest public health concern are inhalation of airborne particulate plutonium-238 (or airborne particulate plutonium-238-contaminated soil), and incidental ingestion of soil. The ingestion of water from the canals and in Community Park is not expected to pose a public health hazard because plutonium-238 concentrations are much lower in the surface water than in the soil and because surface waters in the area are not used for drinking water. There is no evidence that anyone eats vegetation from the canals and park; therefore, ingestion of vegetation in the area is not expected to be a completed exposure pathway.

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[3] Mound officials, city officials, and private citizens were questioned about use of the fishing pond.

In the discussion that follows, the biologic effects of plutonium are presented, followed by radiation dose estimates to people in the Community Park who would come in contact with the air and soil, and incidently ingest small quantities of soil contaminated with plutonium-238. Understanding the movement of plutonium in the human body is necessary to estimate the radiation dose a person may receive from exposure to plutonium. The discussion that follows provides an overview of the uncertainties involved in dose estimations. The health effects of radiation are then considered, and the estimated radiation doses to people in the Miamisburg canals and Community Park are compared to radiation doses known to cause adverse health effects.

When particulates are breathed into the lungs, some are breathed back out and some are deposited in the respiratory system (nasal passage, trachea/bronchial tree, and pulmonary parenchyma). Clearance of the deposited plutonium from the respiratory system happens when mechanical actions carry larger particles up to the esophageal passages, where they are swallowed, or when plutonium is transported to the lung-associated lymph nodes or absorbed into the bloodstream. Once plutonium is in the bloodstream, it is distributed to other internal organs. The distribution of plutonium to other organs varies widely, depending on the amounts of plutonium and the chemical species[4] of plutonium in the body. Studies in 1945 and 1946 in which plutonium was injected directly into the bloodstream of 18 terminally ill persons, provided information about the initial, internal distribution of plutonium. The data indicate that plutonium principally partitions between liver and skeleton[5] and that accumulation within specific organs (especially skeleton) is highly inhomogeneous [12]. Other studies suggest much redistribution of plutonium subsequent to the initial exposure and early distribution. Currently, the model endorsed by the International Commission on Radiological Protection (ICRP) includes absorption fractions for the uptake of plutonium from the lung to the blood of between 10^{-3} and 10^{-5}, depending upon the chemical species of plutonium, as well as deposition parameters (partition fractions) for plutonium to the liver and skeleton of 45% each, and retention parameters (biologic half-lives) of 100 years in the skeleton and 40 years in the liver. That model is still undergoing scrutiny. More recent data suggest that actual retention times may be half those currently used in the model [12, 13].

People also may be exposed by ingestion of contaminated soil to plutonium-238 in the canals and park. When plutonium is ingested, an estimated absorption fraction is used to calculate the portion of the ingested material that is transferred to the blood through the

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[4] Chemical species here refers to which isotope is involved (e.g., plutonium-238 or 239), whether the plutonium is a citrate, nitrate, or oxide; whether it is complexed with americium, uranium, or sodium salts; whether it is a small particle (<1 nm) or large; whether it is spherical or oddly shaped; whether it is bound to protein (such as transferrin or albumin) or to chelating substances; and whether it is polymerized or monomeric.

[5] Approximately 10% of plutonium absorbed to the blood is distributed to tissues other than liver and skeleton; these include mainly muscle, but also gonads and other tissues.

gastrointestinal mucosa. Absorption is affected by the presence or absence of food in the gastrointestinal tract; by the presence or absence of fasting and/or dietary deficiencies; by the chemical form of the ingested plutonium; and particularly, by the total mass of plutonium ingested -- quantities less than a milligram are more efficiently absorbed across the gut than larger quantities. In the absence of known chemical and physiologic information describing specific circumstances of plutonium ingestion, the ICRP recommends an absorption fraction of 10^{-3}. That value is considered cautious and provides an adequate margin of safety for purposes of protecting people from radiation. Unabsorbed plutonium is eliminated in the feces. Plutonium transferred to the blood is transported mainly to the skeleton and the liver as described previously for inhalation [12].

Tissue damage from radiation exposure is a function of the energy type (alpha, beta, photon, etc.), the energy intensity, and the duration of exposure to the radiation. Radiation may cause molecular changes that can lead to changes in cell function, or in cell death. Most tissues and organs of the body are unaffected by the loss of even substantial numbers of cells, but if the number lost is large enough, there will be noticeable harm (e.g., tissue damage and loss of tissue function) [14]. Biologic effects resulting from cell death are called deterministic effects and are not believed to occur below a threshold level of absorbed radiation. The threshold for deterministic effects is from 10,000 to more than 100,000 millirem (mrem), depending on the tissue involved [14]. None of the radiation exposures in the environment around the Mound Plant are expected to result in doses above the threshold levels for deterministic effects; therefore, deterministic effects will not be discussed further.

Below the threshold for deterministic effects, at lower energies absorbed, radiation damage that affects cell function (but doesn't kill the cell) may lead to cancer or to hereditary effects through chromosomal damage or some other mechanism. Those radiation effects are called stochastic effects. Many millions of ionization events take place in the body every year from natural sources of radiation [14]. We are all exposed to radiation in the air we breathe, the water we drink, and the food we eat. Our bodies contain radioactive elements, and we receive radiation from one another. Yet this constant exposure to low levels of radiation does not often result in stochastic effects because the homeostasis and defense mechanisms of the body ensure that damaged and altered cells seldom survive. Less than 1% of the United States population will be diagnosed with cancer in 1993 [15]. The number of babies born in the U.S. who are born with birth defects is approximately 2-5%, depending on how the defects are counted [16]. Since stochastic effects may result from multiple causes (in addition to radiation), radiation is expected to be responsible for only a small fraction of cancers and birth defects [14, 15].

Human epidemiologic data are not sufficiently precise to define a threshold level for stochastic effects (level of radiation at which stochastic effects begin to occur) [14]. This is true in part for the following reasons: a) Radioactive substances are naturally present throughout the body, and radiation doses from industrial processes are always additions to the natural background radiation dose; b) stochastic effects are expressed a relatively long time after exposure (latency); c) mechanisms for the cause of all stochastic effects are not

well understood; d) there are large uncertainties associated with the reporting of cancer incidence rather than cancer mortality; and e) many agents in the environment, other than radiation, are believed to cause cancer.

The ICRP has evaluated accumulated data describing radiation damage at low doses, in part to recommend dose limits for occupational and general public exposures to radiation. The dose limits are subjective because they assume a level of acceptable risk from exposure to radiation. Because there may be no threshold dose of radiation below which no cell damage occurs, the potential for adverse health effects from very low radiation doses is estimated by extrapolating the data for known stochastic effects at higher doses down to doses at which adverse health effects are less likely to occur. The ICRP considered several factors when formulating recommendations for dose limits: known levels of naturally occurring radiation, risks associated with lethal cancers and curable cancers, and hereditary harm. For members of the general public, the ICRP recommends a dose limit of 100 mrem (1 mSv) per year from radiation sources other than medical and those occurring naturally in the environment. Higher doses are considered acceptable for short-term (whole body) exposures, and separate dose limits are recommended for acute (one-time) exposures to the skin and lens of the eye [14].

To put the 100 mrem dose limit in perspective, the Committee on the Biological Effects of Ionizing Radiations (BEIR V, 1990) estimates that people in the United States receive a total average radiation dose of approximately 300 mrem/year from naturally occurring sources. These sources include radioactive materials in soil and rocks in the United States that contribute about 30 mrem/year to our exposure. Those materials decay and produce radon and radon decay products that may contribute an additional 200 mrem/year to our exposure. An additional radiation dose of 60 mrem/year is contributed from consumer products and medical uses of radiation [17]. To put such radiation doses in perspective, an excess numbers of malignancies (statistically significant at the 95% level) has been found only at doses exceeding 20,000 mrem (20 rem or 200 mSv) [14]. Furthermore, no increase in the frequency of cancer has been documented in populations residing in areas of high natural background radiation (600-800 mrem/year) [17]. The National Council on Radiation Protection and Measurements (NCRP) estimated (1987) that a dose of 100 mrem per year above background would impose an lifetime risk to the public (all ages, both sexes) for cancer and severe genetic effects (over two generations) in excess of one person in 100,000 population (10^{-5}). Risk estimates are undergoing re-evaluation as a result of new information, particularly arising from ongoing studies of Japanese survivors of the atomic bombs [18].

ATSDR has estimated radiation doses resulting from exposures to plutonium-238 using the maximum concentrations of plutonium-238 reported for the canals and Community Park area and models recommended by the ICRP. Each dose estimate is calculated using an arbitrary "scenario" that assumes a person is in the area and breathes the air for a period of time or ingests some quantity of the soil. Most of the plutonium in the area is expected to be bound to the soil. However, the soil may contain different chemical forms of plutonium, which are

absorbed into the bloodstream at different rates. Because the chemical forms of plutonium in the soil are not known, the most soluble form of plutonium is assumed for the dose estimates.

1. For the inhalation pathway, concentrations of plutonium-238 in the air are measured by air filter sampling. Air filter samples are collected by Mound officials from the canals and Community Park using two stationary air monitors. Stationary air monitors are directional; winds carrying resuspended surface soils and Mound stack releases may elude the monitors. Therefore, air samples may or may not be representative of the air that people breathe in the canals and park areas. The air monitoring data have been questioned by inspectors at the Mound Plant for technical reasons; however, they are the best currently available approximations of the plutonium concentrations in the air at the canals and Community Park.

   The maximum monthly air concentration of plutonium-238 reported by Mound at the monitors (54.4×10^{-11} pCi/mL) was measured in 1976 at monitor #123 near the juncture of the North and South canals. Assuming a person could be exposed to this air concentration 24 hours per day for 365 days, the estimated annual (whole body) dose to that person over his or her lifetime would be less than 2 millirems per year.

2. Although both children and adults may inadvertently ingest soil from the canals or park, this exposure pathway is not expected to affect many people because it is not an intentional activity. The likelihood of anyone ingesting very much soil is diminished by the fairly heavy ground cover (grasses and other vegetation), and by the moderate level of precipitation in the area. Surface soil contamination levels are poorly characterized; however, from the available data, there are apparently some areas where plutonium-238 concentrations in the soil are greater than 300 pCi/g.

   The maximum surface soil concentration of plutonium-238 was measured at 752 pCi/g in 1974. Assuming a child played in this area at least part of the day every day of the year, the estimated dose to the child from ingestion of soil (50 mg/day) would be less than 34 mrem per year. A far more conservative (and less likely) scenario might be that a child would ingest 5 grams of soil at the maximum level of plutonium-238 measured in the soils in the canals and park area (4,560 pCi/g, from a 1-foot core composite below the surface). The estimated (whole body) dose to that child would be less than 60 mrem per year.

3. People in the canals and park area are more likely to be exposed to radiation from simple physical contact (skin contact) to contaminated soils than actual ingestion of the soils. ATSDR has considered dermal absorption of plutonium-238 from soils and surface water. However, the rate of absorption through the skin for the most soluble forms of plutonium is less than one-tenth the absorption rate from ingestion. Because the plutonium probably has adhered to soil particles, very little, if any, plutonium will

be absorbed through the skin into the blood [12]. Therefore, dermal exposure is not considered a public health hazard.

4. Finally, ATSDR has considered radiation doses that people might receive at a distance from soils containing plutonium-238. Plutonium-238 decays by emitting alpha particles. Approximately 12% of the time, plutonium-238 also will emit low-energy x-rays with the alpha particles; approximately 37% of the time, plutonium-238 also will emit low-energy electrons. Because of the low penetrating ability of these emissions and the self-shielding qualities of the soil, external exposure from the soil is determined by the radioactive contamination in the uppermost surface soils only. Using the maximum concentration of plutonium-238 in the surface soils (0 to 2 inches), the whole body external exposure would be less than 2 mrem per year. Therefore, external exposure to radiation from plutonium-238 in the environment is not expected to pose a public health hazard.

In summary, ATSDR has estimated radiation doses using measured concentrations of plutonium-238 in the Miami-Erie Canals and the Miamisburg Community Park. These doses were calculated using conservative scenarios that consider exposures to the maximum reported environmental levels of plutonium-238. The resulting total radiation dose to a person from all pathways considered is less than 100 mrem per year. The dose estimates are necessarily limited by the uncertainties in both the environmental data and the dose models and do not consider radiation contributions from other radiologic contaminants in the environment.

Because exposures to intentional activities are more easily prevented than inadvertent exposures, ATSDR has chosen to consider separately the fish in the South Pond. People who eat the fish from that pond may be exposed to contamination in the pond environment. Fish samples were analyzed in 1974 for plutonium-238; however, no more recent analyses of the South Pond fish have been performed to characterize their safety as a food. The possibility that people may experience adverse health effects related to eating fish from the Community Park fishing pond cannot be dismissed until the fish are sampled and analyzed for contaminants.

Data collected in 1990 suggest that the South Pond water may have low levels of osmium contamination. The toxicity of osmium, a heavy metal, is not known[6], nor is it known whether fish bioaccumulate osmium. Therefore, the health effects of eating fish potentially contaminated with osmium are not known.

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[6] The only osmium compound known to produce toxic effects is osmium tetroxide. Osmium tetroxide is a strong eye irritant [19,20]. However, osmium tetroxide is expected to be reduced to osmium metal in the pond environment.

CONCLUSIONS

1. ATSDR used environmental data collected for the Rogers study in 1974 and for the Mound Plant environmental monitoring program to estimate potential health threats from plutonium-238 in the canals and Community Park. The results of that examination showed that the total radiation dose a person might receive from all pathways considered is likely to be less than 100 mrem per year and would indicate that there is no public health hazard.

2. Environmental samples collected in the Miami-Erie Canals and Community Park do not indicate that a public health hazard exists. However, the data are limited and insufficient to fully assess whether or not a public health hazard exists in this area.

3. Because of a lack of data, ingestion of contaminants by people who eat fish from the South Pond cannot be eliminated as an exposure pathway of concern.

RECOMMENDATIONS

1. Analyze surface soil samples (less than or equal to 3 inches of soil) and surface waters to better define the extent and concentration of contamination in and around the canals and Community Park area. Collect samples throughout the Community Park, and sample in low-lying areas between the Mound Plant property and the Dayton-Cincinnati Pike and from the Dayton-Cincinnati Pike westward onto the properties south of the plant drainage ditch. Samples should be analyzed for plutonium-238 and -239, tritium, thorium, uranium, americium, and for nonradioactive contaminants (volatile organic compounds, semivolatile organic compounds, heavy metals, pesticides).

2. Conduct additional air monitoring (breathing zone) in the canals and Community Park to characterize the quality of the air data currently being collected in the area.

3. Prohibit fishing at the South Pond until evidence from fish samples indicates that eating the fish is not likely to pose a health threat. Soft tissues should be analyzed for the same contaminant list described previously for surface soils.

4. All digging, excavating, remediation, and removal activities in the canals and Community Park area should be conducted with strict adherence to applicable National Institute for Occupational Safety and Health (NIOSH) recommendations and the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) regulations cited in Title 29 Code of Federal Regulations (CFR), Parts 1910, Standards for General Industry, and 1910.120, Hazardous Waste Operations and Emergency Response. In certain instances, 29 CFR 1926, Standards for Construction

Industry, may apply. Appropriate dust control measures should be taken to minimize potential exposures of workers and the public.

ATSDR will re-evaluate pertinent environmental data when it becomes available.

APPENDIX A

1974 Plutonium Study

Mound Laboratory officials in 1974 conducted a study to characterize the extent and concentration of plutonium-238 contamination in the canals and park area [21]. Plutonium-238 was measured above background levels in the sediment, soils, and surface water in the South Canal, the North Canal, and the South and North ponds. Plutonium-238-contaminated soils also were detected outside of usual water channels -- off site in the area called the runoff hollow, which is between the western site boundary (north of the site drainage ditch) and the Conrail right-of-way. Mound officials estimated that a total of 5.2 curies (Ci) of plutonium-238 (approximately 0.3 gram) had been deposited in the canals and ponds area [22]. The report Mound officials published in 1975 concluded that the concentrations of plutonium in the soils, surface waters, and sediment do not pose a health hazard to people [4]. The U.S. Environmental Protection Agency, the Ohio Department of Health, and the Ohio Environmental Protection Agency concurred with that conclusion [23, 24].

LFE Environmental Analysis Laboratory (Richmond, CA) analyzed surface water samples collected from the canals and ponds as a part of the 1974 study. Between four and seven water samples were collected by Mound Laboratory personnel from each of the sampled areas: the drainage ditch, the runoff hollow, the South and North canals, the South and North ponds, and the overflow creek to the Great Miami River. All water samples were filtered before analysis. Most of the plutonium-238 concentrations detected in water north of the plant drainage ditch (runoff hollow, North Canal, South Pond, North Pond) were below 1 pCi/L. One sample from the North Pond showed an anomalous concentration of 18,829 pCi/L; the concentration for a nearby water sample (also obtained from the North Pond during this study) was reported to be 0.4 pCi/L. The value of the silt portion (filtrate) of the anomalous water sample was consistent with other silt values, possibly indicating that the anomalous water value resulted from field or laboratory error. The original report offered no discussion of the data. Levels of plutonium-238 were slightly greater in the water in the drainage ditch and south of the drainage ditch than in the surface water north of the drainage ditch. The greatest concentration of plutonium-238 in surface water (besides the anomalous value in the North Pond) was 13.5 pCi/L; it was measured in the South Canal. DOE reported in 1990 that the background level of plutonium-238 in pond water in the area is approximately 0.003 pCi/L, which is typical of background pond water measurements made throughout the 1980s [25].

EPA obtained seven samples from area surface waters; all values except one were reported to be below 1 pCi/L. EPA reported a plutonium-238 concentration of 2 pCi/L for one sample taken from the South Canal.

Silt, sediment, and soil samples were collected and dried by Mound Laboratory personnel, Bowser Morner Testing Laboratory, and EPA. The samples were analyzed by Mound

Laboratory; the U.S. Atomic Energy Commission Health and Safety Laboratory (HASL), New York, NY; the Ohio Environmental Protection Agency (OEPA); the EPA Eastern Environmental Radiation Facility, Montgomery, AL; and the LFE Environmental Analysis Laboratory, Richmond, CA (LFE). DOE reported in 1992 that background levels of plutonium-238 in pond and river silt in the area are approximately 0.0009 pCi/g [26].

Measurements of plutonium-238 in silt filtered from water samples were all below 300 pCi/g, except in the drainage ditch, the South Canal, and in the runoff hollow (which had one value of 19,820 pCi/g, believed to be anomalous). Other values reported for runoff hollow silt were below 30 pCi/g. Drainage ditch and South Canal silt values were in the 100-500 pCi/g and 300-400 pCi/g ranges, respectively. Table 1 shows the mean and range of the plutonium-238 concentrations in silt measured in the 1974 study.

Table 1. Silt [Pu-238], pCi/g.

Location	n@	Mean	Range
N Pond	6	18.9	12-22
S Pond	6	75.6	37-208
N Canal	6	67.8	6-267
S Canal	4	353	328-395
O Creek	4	188	122-270
D Ditch	6	273	106-450
R Hollow*	6	25	23-29

@ n is number of values reported.
* Anomalous value (19,820 pCi/g) not included.

Samples of sediment and soil were collected from borings, usually 5 feet deep, and composited in 1-foot increments. Table 2 includes the maximum soil and sediment plutonium-238 concentrations measured in sample composites from the North and South canals and in the drainage ditch (from the Mound Plant to the canals). Those three areas contained the highest plutonium levels measured during the study.

Table 2. Maximum Soil and Sediment [Pu-238], pCi/g.

Depth (feet)	North Canal	Drainage Ditch	South Canal
1	1,140	749	3,800
2	3,330	287	3,370
3	4,560*	152	576
4	3,580	42	230
5	3,070	50	28
n**	63	18	62***

* The maximum plutonium-238 concentration measured in the study (4,560 pCi/g) was found in one 1-foot soil composite, below the surface, just north of where the plant drainage ditch runoff entered the North Canal.

** n is the number of separate borings.

*** South Canal includes 15 core borings south of the overflow creek.

The North and South canals contained more than 90% of the plutonium-238 measured during the study; nearly twice as much plutonium-238 was found in the South Canal as in the North Canal. Samples from the centers of the canals contained higher plutonium-238 concentrations than samples from the canal banks. North and south distribution of plutonium-238 in the top two-foot composites through the canals is fairly even; below two feet there is more variation in the concentrations. There is less dispersion east and west in the North Canal than in the South Canal. That finding may be due in part to the greater flooding experienced in the South Canal area. Plutonium levels measured in samples of sediment and soil collected from the overflow creek (South Canal to the Great Miami River) and from the North and South Ponds were all below 100 pCi/g.

A smaller number of soil samples (26 values reported) were collected by Mound Laboratory and EPA in which only the top one or two inches of soil were composited and analyzed. The maximum value reported (752 pCi/g) was from a sample obtained just north of where

the railroad crosses the eastern side of the South Canal. All other surface sample values were below 300 pCi/g.

The primary limitations of the 1974 data for assessing public health are that the data are more than 18 years old and that the samples collected were analyzed only for plutonium-238. In addition, apparently, no soil samples were collected from across the highway (Dayton-Cincinnati Pike), where flooding might have also dispersed contaminated soils.

In 1975, the DOE Albuquerque Field Office commissioned an ad hoc committee of six government and nongovernment professionals to examine the results of the Mound Laboratory study; to review the health and safety analysis conducted by Mound; and to determine whether the plutonium deposited off site is a hazard to the general population "now or in the future." The committee, which published its report in early 1976, concluded that the plutonium released to the environment was not a health hazard to people living in the vicinity of Mound Laboratory [27]. They noted, however, that "physical modifications to the sites of plutonium deposition in the canal and pond areas could alter the amounts of plutonium available for contamination of the local human population." In other words, people could be exposed to the plutonium below the surface soils if the soils are disturbed. Committee members reported that they believed that inhalation of airborne plutonium is the major potential route of exposure for people living near the Mound Laboratory.

Additional Environmental Data

Mound officials estimate that background levels of plutonium-238 in their part of the state are 0.0002 pCi/g (0.1 mCi/km^2), primarily as a result of fallout from worldwide nuclear weapons testing and the burnup of a SNAP 9-A heat source[7]. Most surface soil on the Mound Plant site, however, has a baseline plutonium-238 level of approximately 0.01 pCi/g, primarily as a consequence of 30 years of operations involving the substance [29, 30]. Plutonium-238 has been measured above background levels in soil (0.0002 pCi/g) at least 30 miles from the Mound Plant and tapers fairly evenly in all directions [31, 32]. Ongoing environmental surveillance at the Mound Plant does not include monitoring soils or sediment or surface water in the canals and park area.

Plutonium is released from Mound Plant stacks to the air, and through waste effluent to the plant drainage ditch, where it disperses into the environment. Since 1974, Mound has

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[7] The "SNAP" (Satellite Nuclear Auxiliary Power) 9-A is a type of satellite with a plutonium-238 heat source. Heat from the SNAP unit is converted to electricity to provide power for the satellite equipment. In 1964, one SNAP 9-A satellite failed to reach its intended orbit and burned up during reentry into earth's atmosphere; 95% of the plutonium-238 (17,000 curies) was estimated to have been deposited worldwide by the end of 1970 [28].

reported plutonium-238 releases into the surface waters off site and into the air through the plant stacks.

No comprehensive sampling of the soils or water in the canals and park area has been undertaken since 1974, although there was limited sampling in the area for specific projects. Soils or sediment from the canals or park area were sampled in 1984 [33], 1987 [34], 1988 [35], 1989 [36], 1990 [37], 1991 [38, 39], and 1992 [40]. In general, those projects involved few sampling locations. The maximum environmental levels of plutonium-238 reported for the projects were in soil samples taken from the middle of the North Canal (1987, 0- to 12-inch composite sample, 1,600 pCi/g) and from east of the South Canal at the foot of the Conrail bridge during the shoring of the bridge support (1991, 1,223 pCi/g) [34, 39]. During the Conrail bridge project, DOE contractors removed contaminated soils from the area [39]. None of the maximum plutonium-238 soil concentrations reported from the other projects exceeded the DOE clean-up level of 100 pCi/g [41, 42].

Mound has monitored airborne plutonium-238 in the canals area since 1974. The ad hoc committee report in 1975 recommended increased air monitoring near the canals and pond area, and, that same year, Mound officials installed a permanent high-volume continuous air sampler between the ponds in the Community Park (sampler #122) [43]. In 1976, a similar air sampler was installed near the juncture of the North and South canals (sampler #123).

When the flapper valve was installed in the canals (1976), and the North and South ponds were modified (1977), Mound officials used monitoring stations #122 and #123 to conduct air studies to investigate the correlation of airborne plutonium with wind direction, precipitation, and "particulate loading" (amount of soil in the air). Plutonium-238 concentrations measured before and during construction were slightly elevated during periods of low rainfall, and when particulate loading was elevated. A correlation between plutonium-238 concentration and wind direction implicated the North Canal and the park area, or both, as the source of airborne plutonium-238. No correlation was seen between plutonium-238 measured at samplers #122 or #123 and Mound Plant stacks emissions [44].

Additional (portable) air samplers were used in the park to collect samples during the construction in that area. Data showed increased airborne plutonium-238 concentrations during periods of construction in the canals and in the park. The average plutonium-238 concentration at sampler #122 (24-hour collection, weekly composite analysis), collected for 80 weeks during the park construction activities, was 2.13×10^{-11} pCi/mL. The five portable samplers, which operated only during construction (8 hours per day, 56 days), showed average concentrations approximately 14 times higher (29.21×10^{-11} pCi/mL) [45].

The highest monthly plutonium-238 concentration reported in air, 54.4×10^{-11} pCi/mL, was measured at air sampler #123 in September 1976. In 1990, Mound officials calculated an airborne plutonium-238 concentration in the canals of 16×10^{-11} pCi/mL, representing the 95th percentile of all the airborne concentrations measured over the period 1974-1988 at the

six air monitoring locations[8] "most likely to be impacted by resuspension from the canal area" [46]. In 1991, the maximum monthly plutonium-238 concentrations measured at air monitors #122 and #123 were 0.30 x 10^{-11} pCi/mL and 0.63 x 10^{-11} pCi/mL, respectively [26].

In 1989, DOE headquarters personnel, their contractors, and personnel from the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) conducted an inspection of the Mound Plant to assess the status of environmental, safety, and health programs. Among their observations was that on-site and off-site air samplers varied in terms of air monitor placement (height and proximity to sample interference) specified in DOE orders. Inspectors noted that air monitors #122 and #123 were both deficient in the following ways: inadequate sampling station housekeeping, incorrect sampling inlet height, and proximity to wind flow obstructions. The report stated, "The Mound Plant air effluent and air sampling measurements are substantially below U.S. Environmental Protection Agency (EPA) and DOE radionuclide health criteria. Therefore, the observed variances . . . challenge the credibility of the measured air concentrations but not the conclusion that the Mound Plant is in compliance with applicable health criteria for the air pathway [47]."

In addition to concentrations of plutonium-238, Mound officials publish in their annual environmental reports, concentrations of plutonium-239 and -240, and tritium in air collected at permanent air monitors. In 1977 and 1978, during the 80-week period of construction in the Community Park, curies of plutonium-239 in the air collected at sampler #122 were equal to curies of plutonium-238 collected [48]. That finding implies a chemical concentration of 275 times more plutonium-239 than plutonium-238. However, Mound has not published any soil concentration values for plutonium-239 or -240. In Mound's 1992 annual environmental report (data for 1991), the plutonium-239 and -240 concentrations (average, 12 monthly samples) at air monitors #122 and #123, were below the lowest detectable limit (3 x 10^{-13} pCi/mL) for these isotopes [26]. These data imply that plutonium-239 and -240 do not exist in the surface soils; or, if surface soils are contaminated with these isotopes, they are not being resuspended. Therefore, plutonium-239 and -240 would not contribute to radiation exposures except under conditions where park soils are excavated.

Since 1974, Mound has reported releasing plutonium-239 and -240 into surface waters and into the air through the plant stacks. In 1991, the total of these isotopes released was 9.7 x 10^{-6} Ci to the Great Miami River and 5.5 x 10^{-8} Ci to the air from stack emissions. Air releases in 1991 of these isotopes were more than 200 times smaller than releases of plutonium-238.

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[8] Air monitoring stations 104, 122, 123, 211, 214, and 215.

Radioactive metals other than plutonium were detected in on-site soils during a site survey project (1982-1985)[9]. From that study, the authors concluded that evidence indicates that there is runoff from contaminated site soils [49]. However, radiologic data from the same study did not show surficial contamination from areas within the site boundaries being blown by the wind to areas outside the boundaries [50]. Discharges from the Mound Plant drainage ditch to NPDES Outfall 002 (to the South Canal) are routinely analyzed for tritium, plutonium, and uranium isotopes, but not for other radioisotopes. Concentrations of radioactive metals other than plutonium-238 were reported for some of the soil samples collected from the canals and Community Park since 1987. However, none of the concentrations reported for the radioactive metals were at levels of health concern.

Levels of tritium in the canals were measured in 1976 as part of a study of tritium in groundwater. Tritium concentrations of nearly 200,000 pCi/mL were measured in soil distillate from the canals. Next to the ponds in the Community Park, tritium levels of more than 12,000 pCi/mL were measured near the surface. Total tritium in the North and South canals in 1976 was estimated to be 300 Ci and 30 Ci, respectively; 200 of the curies were estimated to have been bound in the subsurface soils; the half-life for release from the soils to the aquifer was estimated to be 3 years[10] [51, 52]. Since 1976, there has been no further characterization of tritium in canals or park soils. Tritium is monitored at the air monitoring stations on site and off site; in air releases from the Mound Plant stacks; in water releases through plant effluent; and in the Mound seeps. However, because of the highly mobile nature of tritium in the environment, it is not possible to adequately estimate current tritium levels in the canals and Community Park surface waters and soils.

Preliminary sampling of soils in the canals area in 1992 was conducted to determine a) whether the plutonium measured in the canals in 1974 is in the same place and in the same (expected) concentrations; b) whether there is significant radioactive material in addition to the plutonium-238; and c) whether the soils contain mixed waste. Mixed waste, as defined by the Atomic Energy Act (AEA) and the Resource Conservation and Recovery Act (RCRA), is contamination containing both radioactive and hazardous (nonradioactive) components. Identifying mixed waste is a necessary step in planning remedial actions in the canals and park area. Mound officials expect to find nonradioactive chemical contamination because of the proximity of the railroad that runs through the canals area and because a highway (U.S. Route 25/Dayton-Cincinnati Pike/South Main Street) runs immediately alongside the contaminated parts of the canals [53]. Nonradioactive contamination (principally trichloroethene) has been measured in the ground seeps east of the Community

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[9] Thorium (all isotopes), cobalt-60, cesium-137, radium-226, actinium-227, americium-241, bismuth-207, bismuth-210m.

[10] Approximately 2 Ci of tritium would still be left in the soils in 1992 if 200 Ci of tritium was bound to the soils in 1976, assuming a soils-release half-life of 3 years and a radiation half-life of 12.3 years.

Park and in on- and off-site well water [54]. In addition, Mound releases low levels of nonradioactive wastes through the South Canal (NPDES Outfall 002) to the Great Miami River. Although there is no evidence that nonradioactive contaminants in the seeps or groundwater, or from the plant effluent, are in the surface soils in the canals area, the proximity of those geologic formations suggests that it is possible.

The soils in the park and canals area have not been sampled for nonradioactive contaminants, with the exception of samples taken from the South Pond in 1990 and the previously described preliminary sampling of the canals area in 1992. Data for the 1992 sampling have not been made available[11]. During the 1990 sampling, samples from the South Pond were analyzed for many nonradioactive contaminants. One sediment sample contained high levels of osmium (53 parts per million [ppm]) compared with naturally occurring background levels; the sample was reanalyzed by another laboratory and found to contain less than 4 ppm [55]. Until this conflict is resolved through additional sampling, osmium must still be considered a contaminant of concern.

Data on fish contamination in the South Pond are limited to very few fish samples that were analyzed for plutonium-238 only, in 1974. These data are insufficient for evaluating the potential for adverse health effects from eating fish.

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[11] The Special Canal Sampling Report, Miami-Erie Canal (Environmental Restoration Program, Operable Unit 4, Final, July 1993) prepared for EG&G Applied Technologies and the U.S. Department of Energy by Science Applications International Corporation (SAIC), was received by ATSDR on August 30, 1993, and is not considered in this document.

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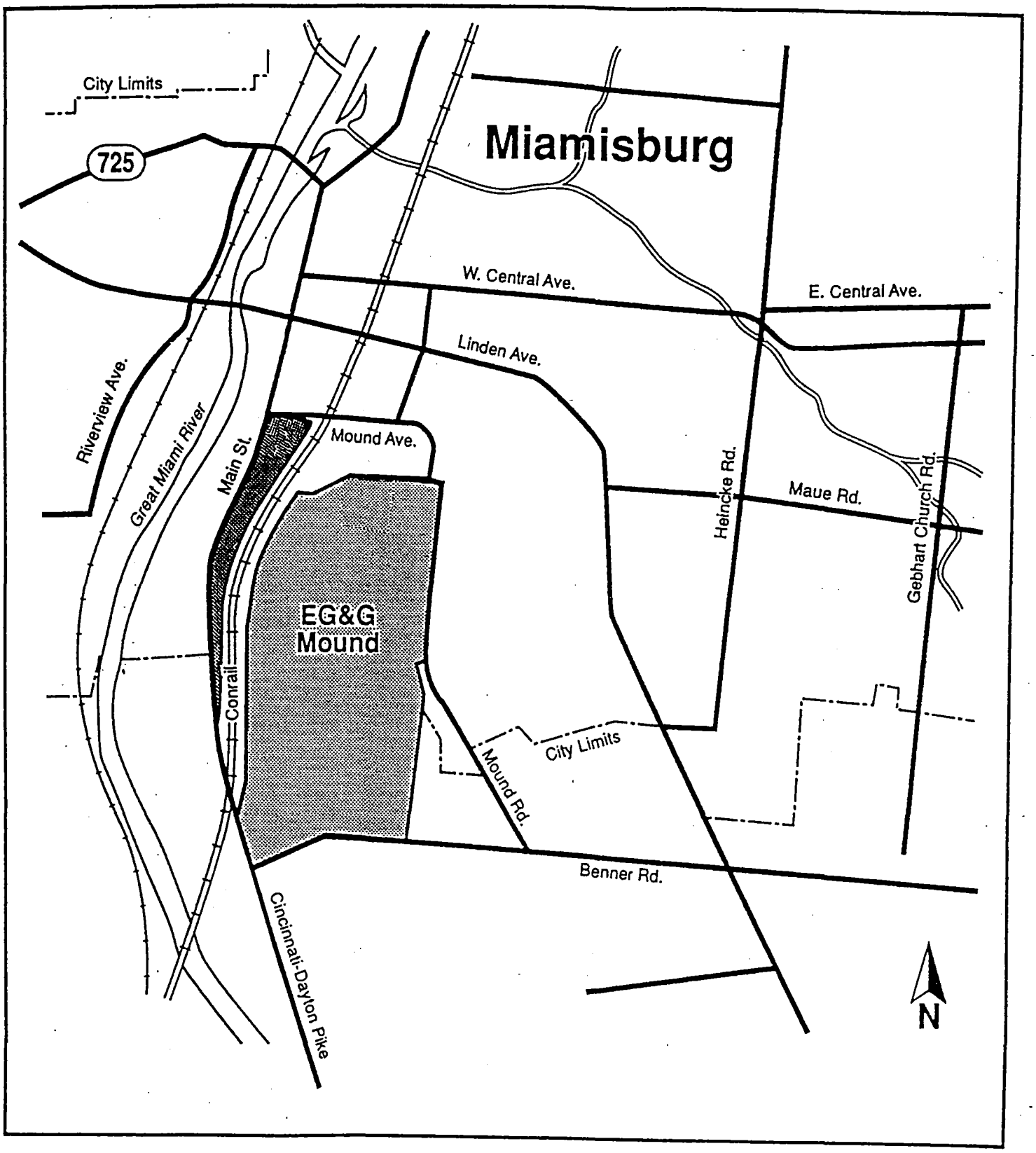
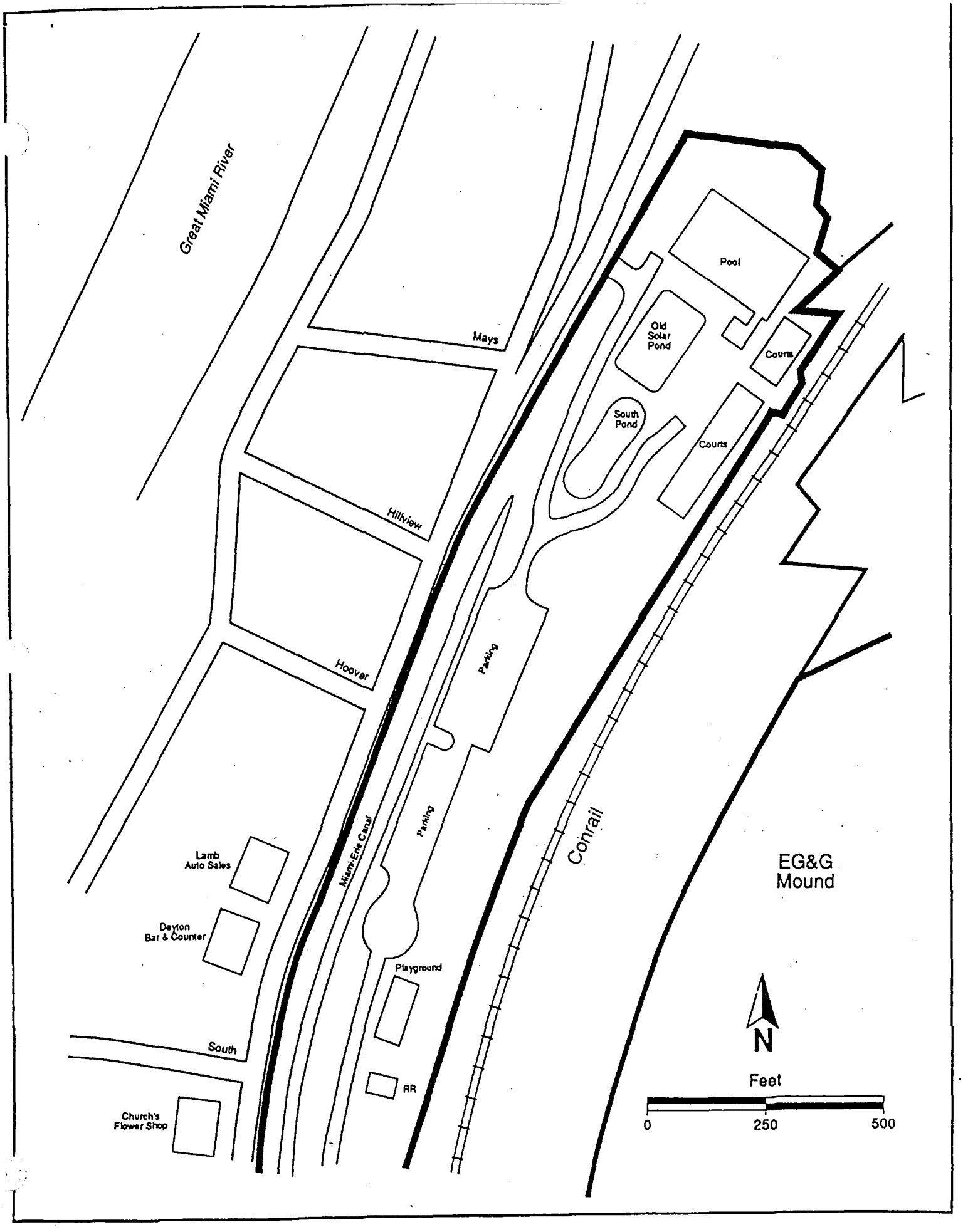


ATTACHMENT 1



ATTACHMENT 2