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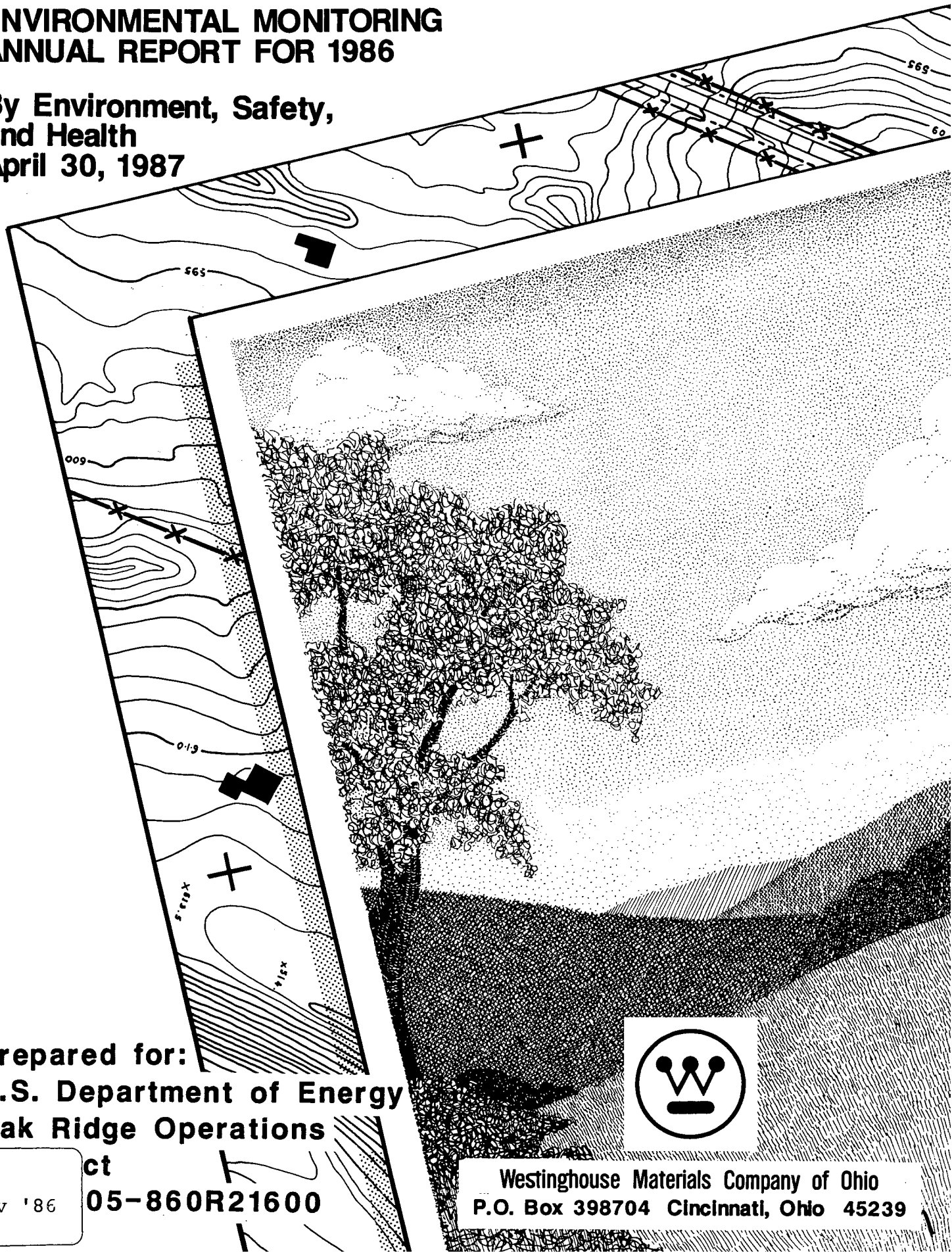
FEED MATERIALS PRODUCTION CENTER

ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1986

By Environment, Safety, and Health
April 30, 1987



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Westinghouse Materials Company of Ohio
P.O. Box 398704 Cincinnati, Ohio 45239

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Feed Materials Production Center

Environmental Monitoring Annual Report for 1986

by

Environment, Safety, and Health

Westinghouse Materials Company of Ohio

P.O. Box 398704

Cincinnati, Ohio 45239

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Prepared for:

U. S. Department of Energy
Oak Ridge Operations

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Approved:

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Feed Materials Production Center

Environmental Monitoring Annual Report for 1986

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Acronyms

ALARA	As Low as Reasonably Achievable
BOD_5	Five Day Biochemical Oxygen Demand
BTU	British Thermal Units
CFR	Code of Federal Regulations
CL	Confidence Limit
DOE	Department of Energy
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ICRP	Internal Commission on Radiological Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
ORNL	Oak Ridge National Laboratory
RCRA	Resource Conservation and Recovery Act
SSOD	Storm-sewer Outfall Ditch
TDS	Total Disolved Solids
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TSS	Total Suspended Solids
WMCO	Westinghouse Materials Company of Ohio

Executive Summary

Routine environmental monitoring is conducted at the Feed Materials Production Center (FMPC) and its environs to make sure that radiation protection standards and Federal and state standards regulating the discharge of radioactive and nonradioactive pollutants are met. In addition, releases of radioactive, toxic, and hazardous materials are maintained as low as reasonably achievable.

Environmental Standards

Environmental radiation protection standards, pollution emission control requirements, and toxic and hazardous material regulations are promulgated by the USEPA, or in their absence, by DOE consistent with EPA guidelines. Where EPA has not issued or is in the process of issuing radiation protection standards, DOE issues standards consistent with the recommendations of national consensus standard setting organizations and national and international radiation protection organizations. USEPA and state standards must be complied with for nonradioactive pollution.

Reporting

The results of environmental monitoring each year are published in an environmental report distributed to state and federal regulatory agencies, other interested organizations, and members of the public. During 1986, improvements were made in the areas of plant operations, the range and scope of regular monitoring, sampling and surveillance equipment, data handling capability, and special studies. These actions allow for a more comprehensive and detailed report than was previously possible. Radiation exposures, plant effluent discharges, and the maximum results for all but five out of hundreds of individual environmental sampling locations in 1986 were well below the DOE radiological standards, which have been established to aid in assuring compliance with DOE and EPA standards.

Radioactive Monitoring

The largest potential source of radiation exposure to the public from the operation of the FMPC is via the airborne pathway. Total uranium emissions to the atmosphere in 1986 (29 kg) were 61% lower than 1985 emissions, even though production of uranium metal products was 30% greater than in 1985. Average uranium concentrations measured at boundary air monitoring stations ranged from 11 to 41% lower than average values for 1985.

Another potential source of radiation to the public from the FMPC is via the surface water pathway. In 1986, the total amount of uranium discharged into the Great Miami River at the plant effluent discharge line (0.31 Curies or 1.2×10^{10} Becquerels) was 24% lower than 1985 discharges. The concentrations of other radionuclides decreased here as well. The total amount of uranium discharged into Paddy's Run from stormwater runoff to the storm-sewer outfall ditch (0.011 Curies or 4.1×10^{8} Becquerels) was 58% lower than in 1985. This is partly due to the stormwater retention basin, which became operational in October 1986. It successfully contained runoff before it could reach the storm-sewer outfall ditch. Average uranium concentrations and gross alpha and beta activities increased slightly at some surface water sampling sites. Possible causes of these increases will be examined closely over the next year.

A third potential source of radiation to the public from the FMPC is via the groundwater pathway. Results for on-site groundwater

sampling showed no significant differences in uranium concentration and alpha and beta activity from 1985 averages. Many on-site and all but three off-site wells had uranium concentrations considered within the range of natural background for this area. The uranium concentrations in, and radiation exposure from the water in these three off-site wells (none are currently used as a source of drinking water) were considerably below DOE guidelines. EPA has not yet established a drinking water standard for uranium. Two quarterly rounds of groundwater data are included in this report from sampling for 95 pollutants during the Resource Conservation Recovery Act (RCRA) groundwater monitoring program. Forty-one wells on- and off-site were sampled for this effort. A final discussion of the significance of RCRA sampling will be made in 1987. Initially, no unusual data has been observed. USEPA Region 5 is also reviewing this data.

Additional sources of radiation to the public from the FMPC can be via sediment, soil, vegetation, farm produce, milk and wildlife pathways. Average uranium and other radionuclide concentrations in the Great Miami River sediments were not significantly different upstream or downstream from FMPC effluent discharge points and were therefore considered to be at natural levels for the area. Average concentrations of uranium and other radionuclides in sediments from the storm-sewer outfall ditch and in Paddy's Run sediments below the storm-sewer outfall ditch were higher than what is considered natural for the area, but do not represent a significant source of potential radiation exposure to the public. Average uranium concentrations (both on- and off-site) in routinely collected soils for 1986 were slightly higher than average values at the same locations and depths in 1985. Concentrations in soils found off-site were within the range considered natural for the area and do not represent a significant source of potential radiation exposure. These increased values are most likely the result of normal variations in measurements rather than actual measurable increases in uranium in these soils.

Vegetation, farm produce, milk and fish were also sampled in 1986. Uranium and fluoride concentrations in vegetation samples measured in 1986 were approximately the same as concentrations measured in 1985. Average uranium and thorium concentrations in vegetables were low and appear to represent natural levels. No detectable concentrations of uranium were measured in any of the samples of milk collected in 1986, and other radionuclides were low and represent natural levels. The overall average uranium concentration in fish from the Great Miami River was lower than for fish collected in 1985. An ecological baseline study begun in 1986 noted apparently healthy populations of most organisms on the FMPC site. Some populations at the FMPC appeared similarly stressed to other populations stressed by construction and farming. Drought conditions that were present during the study may have been an additional source of stress. More ecological studies are planned.

Radiation Dose

To ensure that radiation protection standards for the general public are met, an estimation of the radiation doses via air, water, soil, sediment, plant and animal pathways was made and compared to DOE and EPA standards. The estimate of the maximum radiation dose the closest resident would receive to the lung was 2.9 mrem or 0.029 milliSieverts (mSv), which is 4% of the EPA standard for airborne radionuclide emissions. The effective dose equivalent (the weighted average for all body organs) that same individual would receive was 0.37 mrem or 0.0037 mSv, which is 0.37% of the DOE standard. This individual's estimated external whole body dose received was 0.00022 mrem (2.2×10^{-6} mSv), which is 0.088% of the EPA standard.

An estimate was made of the dose from external radiation to the nearest resident if he were to remain for an entire year outside his home. If this individual remained there 100% of the time throughout the year, his annual dose would be 18 mrem or 0.0018 mSv, which is 18% of the DOE whole body standard. Most of this would be due to external radiation from the K-65 Silos. Elevated external radiation levels from these silos is limited to a small off-site area which is occupied infrequently.

An assessment was made of radiation dose from drinking Great Miami River water and water

from the off-site well with the highest uranium concentration. The estimate of the radiation dose an individual would receive if that individual drank only from the Great Miami River at the point where the FMPC discharges (allowing for dilution) was 0.09 mrem or 0.0009 mSv to the bone, and the effective (weighted average) dose was 0.006 mrem or 6×10^{-5} mSv (0.0018 and 0.006% of the DOE standards for the whole body and bone, respectively). The bone and effective (weighted average) doses an individual would receive if that individual drank only from the off-site well with the highest uranium concentration were 520 mrem (5.2 mSv) and 35 mrem (0.35 mSv), which are 10 and 35% of the DOE standards, respectively.

An assessment was made of the incremental increase in radiation dose above background in the town of Ross, Ohio which is 4 km (2.5 mi) away in line with the predominant wind direction from the FMPC. An assessment was also made of the total dose to the entire population living within an 80 km (48 mi) radius of the FMPC. For a resident of Ross, the effective (weighted average) dose was 0.28 mrem or 0.0028 mSv, the lung dose was 2.1 mrem or 0.021 mSv, and the bone dose was 0.54 mrem or 0.0054 mSv, which are (1, 2.8, and 0.7% of the DOE standards, respectively). The estimated effective (weighted average) dose to the population within 80 km (48 mi) of the FMPC was 9.6 person-rem (0.096 person-Sievert). This 9.6 person-rem can be compared with approximately 275,000 person-rem effective dose to the same population from natural background excluding radon (100 mrem/person x population within 80 km radius).

Radon measurements made in 1986 indicated that, within the standard deviation of the measurements, there was no significant difference in radon concentration between background locations and AMS 6, the air monitoring station closest to the K-65 Silos. In addition, the Ohio Department of Health (ODH) measured indoor radon concentrations at several locations near the FMPC. The FMPC Health and Environmental Advisory Committee examined the data and issued a press release indicating that the FMPC is not the source of elevated indoor radon found by ODH.

Nonradioactive Monitoring

Radionuclides are not the only concern in effluent discharges. Nonradiological constituents must be monitored as well. From a total of 1723 measurements in 1986, the FMPC exceeded the National Pollutant Discharge Elimination System limits for fourteen different nonradiological parameters a total of fifteen times. This is better than 99% compliance, and is directly related to enhancements in administrative controls. At the same time, new projects are being planned and brought on-line to further eliminate sources and exceedances.

Incidents

A release of uranium hexafluoride (UF_6) gas occurred in January. Analysis of the incident showed the maximum amount of UF_6 that could have been released was 9.8 kg (21.6 lb). Calculations of the effective dose equivalent to the nearest resident at the time of the incident was 40 thousandths mrem, and the effective dose equivalent to the entire downwind population within 80 km was 80 millionths person-rem. This is 2500 times less than the average annual natural background radiation dose for this area.

Conclusions

In summary, there appears to be no deleterious effects to the public and the environment from FMPC operations in 1986. Estimated doses to the public were well below standard values, total emissions in air and water were lower than in 1985 despite higher production of uranium products, and all but a few areas that were sampled showed radionuclide concentrations that are considered natural. In addition to continuing present studies in the environs surrounding the FMPC, new studies and additional control measures will enable the FMPC to further characterize the environment and to continue to reduce emissions and exposures.

Chapter One — Introduction

The Feed Materials Production Center (FMPC) conducts routine environmental monitoring to make sure that radiation exposure and plant effluent discharges are below the standards set by DOE. The results of that program for 1986 are described in this report, the Environmental Monitoring Report (EMR). The EMR is the responsibility of the Environment, Safety, and Health Department of the Westinghouse Materials Company of Ohio (WMCO). WMCO has operated the FMPC since January 1, 1986 for the Department of Energy (DOE), which owns the facility.

The FMPC produces uranium metal products (fuel elements and target cores) for use at other DOE sites around the country. The average content of uranium-235 in the final products is close to what is found in nature — about 0.71%. However, some final products may be depleted (less than 0.71% uranium-235) or slightly enriched (greater than 0.71% uranium-235). No thorium was processed at the FMPC in 1986, as has been the case since 1979.

Production operations cover approximately 55 hectares (136 acres) in the center of a 425 hectare (1,050 acre) site. Several rural communities lie within a 1-5 km (0.6-3 mi) radius of the plant (Figure 1).

The production of uranium metal products generally begins with uranium compounds known as green salt and orange oxide for their color, or with other uranium compounds. If recycled uranium is used, the material may first be dissolved in nitric acid to extract uranium from the impurities. This forms a uranium solution which is converted to uranium trioxide (orange oxide) powder. The orange oxide powder is converted to uranium dioxide, and subsequently reacted with anhydrous hydrogen fluoride to produce uranium tetrafluoride (green salt). In 1986, uranium hexafluoride was converted to green salt in the pilot plant. Green salt is then reacted with magnesium metal to produce metallic uranium. This metallic uranium is combined with scrap uranium metal and remelted to yield a purified uranium ingot. Ingots are then extruded to form rods or tubes and machined to the dimensions specified by other DOE sites.

To meet its commitment to quality, plant operations were improved, along with the range and scope of regular monitoring and sampling and surveillance equipment. Data handling capability was enhanced, and the scope of special studies was extended.

The environmental monitoring program is only one aspect of these improvements and was carefully designed to obtain data representative of the state of the environment. These actions allow for a more comprehensive and detailed report than was previously possible.

Following a description of the area surrounding the FMPC in Chapter 2, the FMPC's quality assurance program is discussed in Chapter 3, and Chapter 4 describes how the various maximum rates of exposure are determined. The methods of data collection and analysis, along with the results of the monitoring and sampling, are discussed in Chapter 5, and Chapter 6 describes other environmental studies that were conducted at the FMPC during 1986.

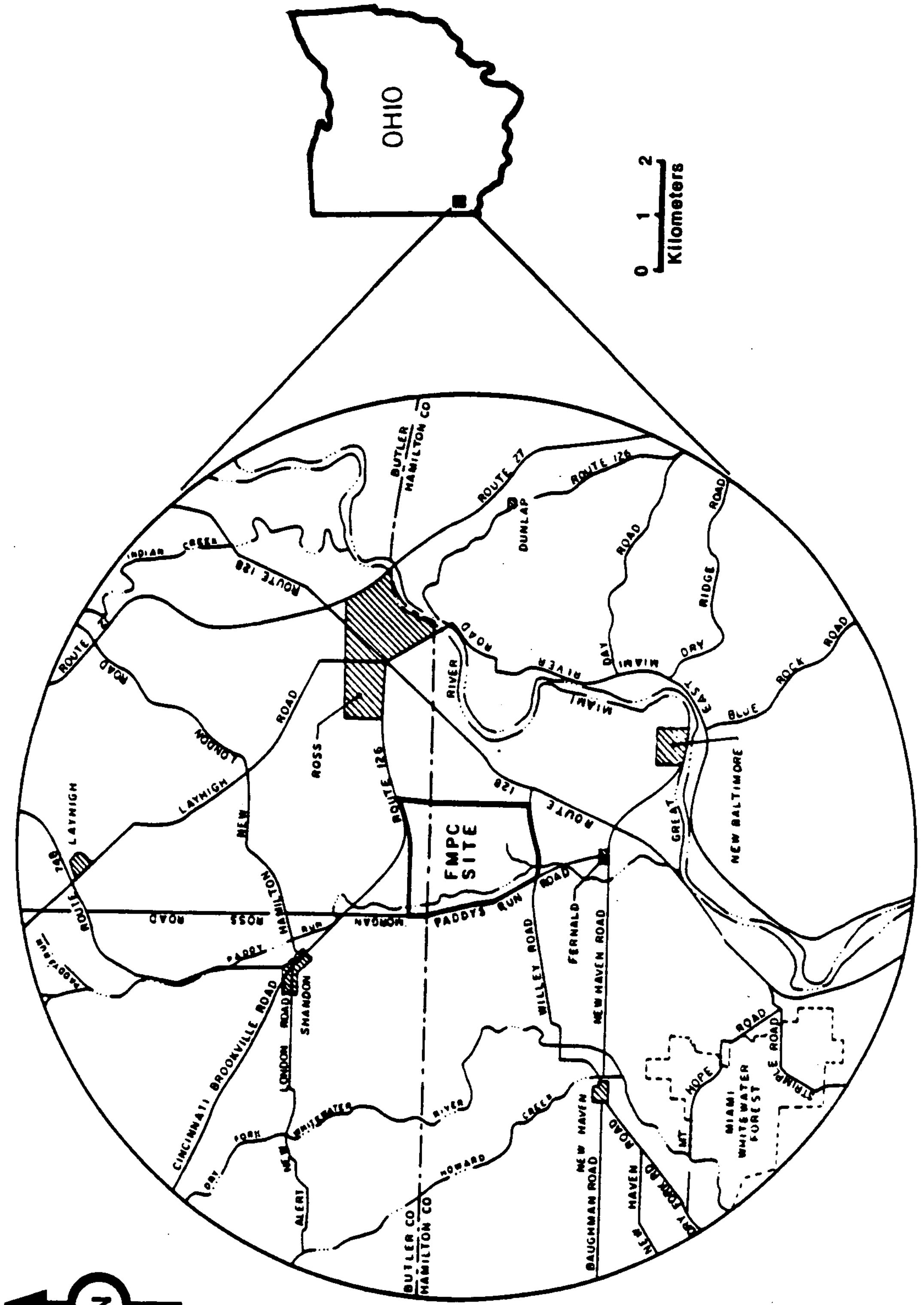

FIGURE 1: *FMPC Area Map*

Chapter Two — Local Area Features

In order to better understand the organization of the FMPC's environmental monitoring program, it is helpful to have some knowledge of the area surrounding the site and the populations that could be affected by its operations. This chapter of the EMR briefly describes some of the physical characteristics and leading economic activities of the area.

Physical Characteristics

The FMPC, located approximately 32 km (20 mi) northwest of downtown Cincinnati, Ohio, is situated on a relatively level plain, about 177 m (580 ft) above sea level. The land rises to 213 m (698 ft) at the northern boundary and slopes downward to 168 m (551 ft) at Paddy's Run on the western boundary.

At the FMPC, nearly 15 m (49 ft) of clay-rich till, generally characterized as silt loam, overlies sand and gravel deposits left by a retreating glacier. The deposits are approximately 5 km (3.1 mi) wide and 46 m (151 ft) deep and fill the remains of an ancient river valley that was cut into the bedrock. The Great Miami River, which runs in a southerly direction about 1 km (0.6 mi) east of the FMPC, presently cuts through these deposits. Sand and gravel deposits often hold water, and in fact, the area under the FMPC and vicinity is part of a large aquifer system in southwestern Ohio (Figure 2). More than 60 m (200 ft) below the surface of the FMPC lies bedrock consisting of alternating layers of limestone and shale.

The vegetation at the FMPC is typical for this region. Areas north and west of the production area are moderately wooded with a variety of deciduous hardwoods. Similar wooded areas are also found along natural watersheds on the west side of the site. Several acres immediately north of the production area were planted in pine as part of an environmental improvement project in 1973. Most of the remainder of the site is leased to local dairy producers whose cattle graze on a variety of pasture grasses. For additional information, see the section in Chapter 6, "FMPC Ecological Study."

The total rainfall for 1986 was 88.3 cm (34.8 in), slightly below this area's average of 95.8 cm (37.7 in). During 1986, September had the highest amount of precipitation at 15 cm (5.9 in), while January had the least precipitation at 2.3 cm (0.9 in).

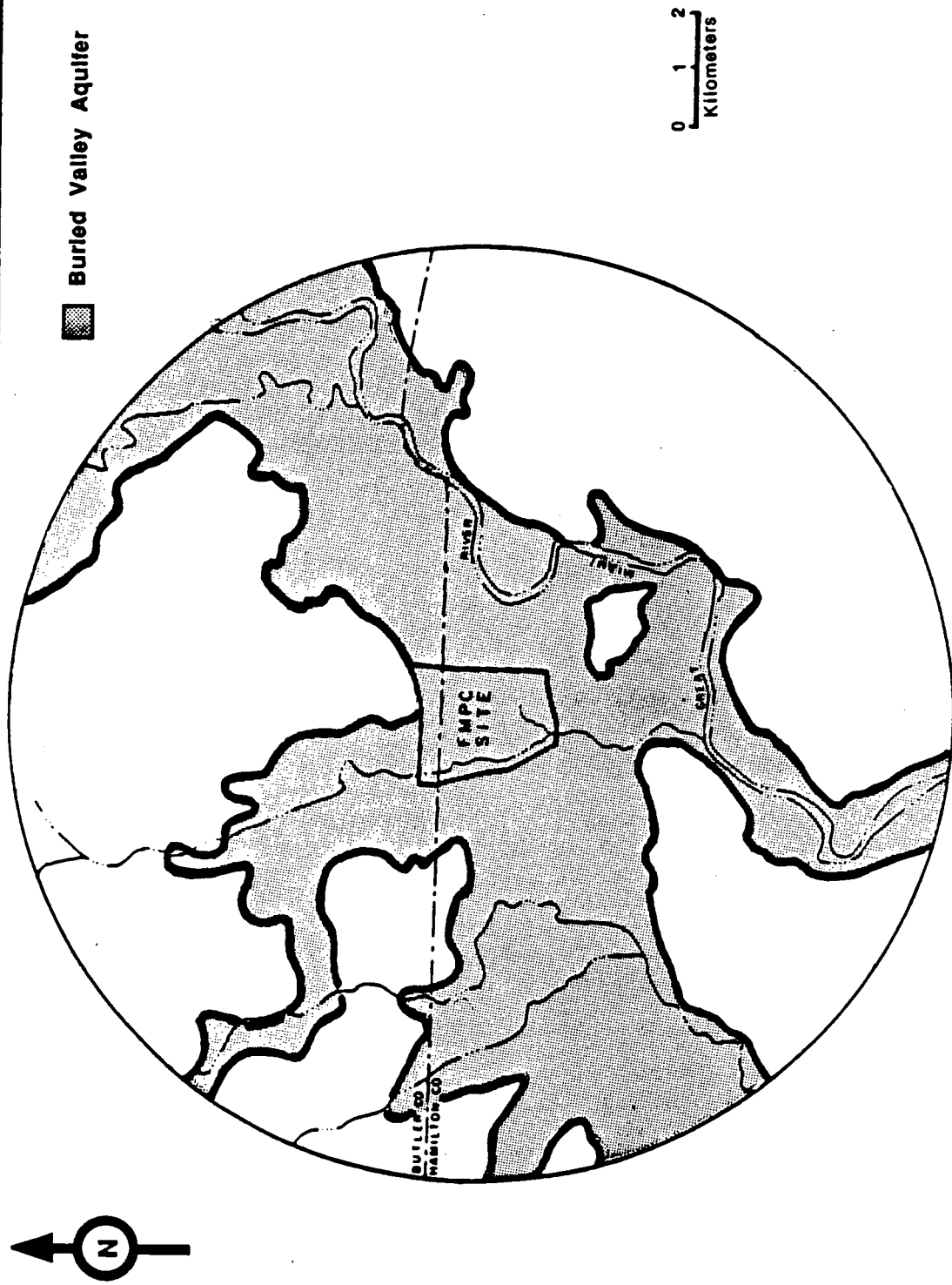

FIGURE 2: *Buried Valley Aquifer Underlying the FMPC Site and Vicinity*

Leading Economic Activities

The major economic activities in the area are farming and raising dairy and beef cattle. Major crops include sweet corn, field corn, soybeans, and wheat. Several nearby farms also sell garden produce locally or in nearby urban markets. The FMPC is a major employer and source of income for the local area as well.

Other important commercial products from the area include sand, gravel, and water from the aquifer. Many gravel-pit operations exist along the Great Miami River and in the flood-plain some distance inland. In addition, a water company located 2 km (1.25 mi) upstream of the FMPC outfall (this is where the liquid effluent from the FMPC is discharged into the river) began operating just prior to the construction of the FMPC. Presently, this company pumps nearly 20 million gallons of water per day, which it sells chiefly to industries in Greater Cincinnati.

Upstream of the FMPC on the Great Miami River lie the communities of Fairfield, Hamilton, Middletown, and Dayton. Downstream areas are sparsely populated and have a few small and scattered industries. The Great Miami River flows into the Ohio River approximately 29 km (18 mi) south of the FMPC.

Using this information to supplement other facts about the surrounding area, data collection programs were developed to monitor the environment. These programs are described in Chapter 5, "Collecting and Analyzing Data." The FMPC maintains a quality assurance program to guide its collection and analysis of data, and is described in the next chapter.

Chapter Three — Verifying the Data

The integrity of the environmental monitoring program and this report depends on the accuracy of the collection and analyses of the data collected throughout the year. To ensure the integrity of the environmental data, the FMPC maintains a comprehensive quality assurance (QA) program. This QA program is consistent with DOE Order 5700.6A "Quality Assurance"; ANSI/ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities"; and other applicable DOE Orders and federal and state regulations.

Sampling Procedures

Careful planning went into the design of the sampling procedures to make sure the samples are representative. Quality assurance in sampling is critical. To ensure that sampling procedures are comprehensive enough so that one is certain the sample collected is representative of the media being investigated, procedures must address the following:

- Selecting proper sampling sites
- Preparing proper collection techniques
- Preparing the maps, diagrams, and forms used in sampling
- Emphasizing cautions that must be exercised in sampling (to prevent contamination)
- Preserving samples
- Considering shipping requirements
- Keeping accurate records.

Developing Analytical Procedures

Quality Assurance is as important in the laboratory as in the field. QA in the laboratory addresses the following:

- Maintaining good laboratory practices
- Maintaining a QA program that includes liberal use of the analyses of blanks, calibration checks, method validation, interlaboratory comparisons, and audits.

The FMPC uses both commercial laboratories and in-house analytical facilities. Commercial labs are screened by careful review of that laboratory's QA plans, along with the above listed practices. All labs maintain instrument logs and follow EPA or other standard and approved methods.

Comparing Results

In addition to the QA procedures described above, the FMPC also participates in a QA program administered by the DOE Environmental Measurements Laboratory (EML) in New York, and the NPDES Laboratory Performance Evaluation Program, in cooperation with the USEPA.

In making the interlaboratory comparison with EML, a ratio is computed between results obtained at EML and at the FMPC for the same air, water, and soil samples. If the results compare exactly, the ratio is one. The value of the ratio in 1986 was 1.04, and indicates less than 4% variance between the results from the two laboratories. In all instances, whether the samples are analyzed at the FMPC or at an off-site laboratory, the results are checked against known standards.

Data Validation, Reduction and Reporting

Data from the laboratories are further scrutinized to make sure sampling and analyses that were planned were actually performed, that a review of decisions regarding data reduction and reporting occurs, and that the data provided are accurate.

Data reduction for meaningful and accurate interpretation requires precise and accurate data. Once that is ensured, the data are then evaluated for the following:

- Central tendency and dispersion using arithmetic mean, geometric mean, range, and standard deviation
- Precision within and between laboratories
- Tests for significance (t-test, F-test, Chi-square test)
- Confidence limits.

While data from the samples will vary, most will cluster around a "most probable" value. Statisticians would say that these samples have a normal distribution. However, all samples may not be distributed normally and adjustments are made in the analyses to correct for results that indicate other than a normal distribution. All tests are designed to be 95% certain that the reported confidence limits for each respective parameter capture the most probable value.

The data are reduced to a more meaningful and easy-to-comprehend form which can be tabularized or charted. Tabular data includes ranges, averages, and confidence limits. Comparisons between years are often made to give a better indication of long-term trends. This information is evaluated and an interpretation is made where possible. Plant operation, remediation, pollution control, or any incident during the year may be considered in the interpretation of the data, if necessary.

Summary

The verification of data for environmental monitoring is a comprehensive program. It requires that appropriate sampling procedures be in place and followed, proper analytical procedures be practiced, that data be verified and validated, that data are reduced into a more meaningful form, and that results are properly reported. The next chapter describes how some of this data is used to estimate effects of radiation exposures to individuals and population groups.

Chapter 4 — Estimating Radiation Exposure

Estimating radiation exposure evaluates whether the public in the area around the FMPC has incurred any measurable effect from existing operations, and it also identifies areas that may need improvement. Radiation exposure estimates are based on large amounts of information collected throughout the year to support the FMPC environmental monitoring program.

This chapter describes how some of this information is entered into the AIRDOS computer program at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. AIRDOS computes the dispersion of airborne radionuclides, and then calculates several radiation exposure doses, including the maximum potential radiation dose to an individual and the total dose to the human population within 80 km (48 mi) of the FMPC. A more complete explanation of the AIRDOS program is found later in this chapter.

Included in this chapter are definitions of some terms that are used to describe the effects of radiation exposure. In addition, general information about radon is also included, along with a discussion of the potential radon contribution to the dose for the maximally exposed individual.

What is Radiation?

Radiation originates naturally from many sources -- cosmic rays, building materials, and even from the earth. In fact, radioactive elements are commonly found in nature. In this report, the radiological levels measured at the FMPC and the surrounding environment are compared to the background radiation levels considered natural in this area. This way, the impact of FMPC operations can be assessed.

Uranium is the heaviest naturally occurring element in the earth's crust. It is radioactive as well, and naturally decays in a long chain-like series to lead, which is a stable element. Many radionuclides are present at any one time in soil, since each radionuclide decays at a different rate. Radon is one of these elements found in soil from the decay of naturally occurring uranium. It has an atomic number of 86 and behaves chemically like other inert gases such as helium or neon. There are two distinct isotopes (isotopes are atoms which have the same number of protons but different numbers of neutrons) of radon that are of concern. They are radon-222 with an atomic mass of 222, and radon-220 with an atomic mass of 220. Radon–222 is a member of the uranium-238 decay chain and is commonly called radon, while radon-220 is a member of the thorium-232 decay chain and is called thoron.

Neither of the isotopes of radon are found in significant quantities in the materials processed at the FMPC. Before delivery to the site, the recycled feed materials are chemically processed which removes the aged uranium which contains the long-lived precursors of radon and thoron.

However, the FMPC does store materials that contain radon and thoron. Radium-226, the immediate precursor of radon, is a component of the material stored in the K-65 Silos. (See the section in Chapter 6, "Investigating the K-65 Silos.") Thorium-228, a precursor of thoron, is a component of the material stored in the thorium silos and the thorium storage facility. Radon has a half-life (the amount of time required for one-half of the material to decay) of 3.8 days and has a greater potential for off-

site exposure than thoron, which has a half-life of less than one minute.

These and other radioactive materials are controlled as closely as possible so they do not harm the public or the environment. By monitoring radiation levels in the environment and calculating radiation exposure to public, the FMPC can determine if present controls are adequate.

Defining Some Terms

To better understand the significance of the data and the conclusions drawn from the analyses, some of the general terms used in the discussion are defined in the following paragraphs.

Dose is the quantity of radiation absorbed by the body.

Whole body radiation dose results from a uniform irradiation of the whole body. For the most significant radionuclides emitted from the FMPC, a whole body dose is due to radionuclides external to the body (as opposed to radionuclides entering the body through ingestion and inhalation). The whole body refers to all human organs or tissue excluding the skin and cornea. These doses are reported for comparison with the NESHAP guideline.

Effective dose equivalent represents a weighted average of exposures to specific organs as defined by International Commission on Radiological Protection (ICRP).[1] The effective dose equivalent incorporates exposures from inhalation and ingestion as well as external exposure. It is equivalent to the risk of incurring health effects when exposed to uniform whole body irradiation. The weighting factor is the ratio of the random risk of any health effect arising from exposure of a specific tissue to the total risk of possible health effects when the whole body is irradiated uniformly.

Organ doses are also reported to verify compliance with NESHAP, which sets exposure limits from airborne emissions of 25 mrem (0.25 mSv) whole body dose, and 75 mrem (0.75 mSv) to specific organs. The organ of interest is the particular organ or tissue that is likely to be of greatest importance when more than one organ is exposed. Several factors influence the selection of this organ, including the amount of dose received, the chemistry of the radionuclide, the sensitivity of that organ to the particular form of radiation, and the importance to the overall health of the person due to damage to that organ. Organs of potential interest for the radionuclides found in FMPC discharges and processes are the lung, kidneys, and bone surfaces.

Activity (or radioactivity) is the number of spontaneous nuclear transformations in a given quantity of material per unit time. Activity varies with each type of radioactive decay and with each radionuclide.

Curie (Ci) and *Becquerel (Bq)* are units of radioactivity that measure spontaneous, energy-emitting atomic transformations in the nuclei of atoms. One Curie equals 37 billion transformations per second. One Becquerel equals one transformation per second. One Curie (37 billion Bq) of natural uranium equates to about 1,500 kilograms (3,300 lb).

Roentgen (R) and *coulombs per kilogram (C/kg)* are units of exposure to radioactivity. One R equals 2.6×10^{-4} C/kg.

Roentgen Equivalent Man (rem) and *Sievert (Sv)* are units of dose which account for the relative biological damage due to the type of radiation involved. One rem equals 0.01 Sv.

Environmental Standards

Several sets of standards established by DOE, the United States Environmental Protection Agency (USEPA), and the Ohio Environmental Protection Agency (OEPA) apply to the environmental sampling performed at the FMPC.

Radiation exposures to the public resulting from effluent discharges of air and water from the FMPC are required to meet the federal standards defined in "Radiation Standards for the Protection of the Public in the Vicinity of DOE Facilities."[2] The standards for prolonged radi-

ation exposure to the maximally exposed individual is 100 mrem (one mSv) effective dose equivalent, but no individual organ can receive more than 5 rem (0.05 Sv) per year.

The National Emission Standards for Hazardous Air Pollutants (NESHAP), which became effective in February 1985, are also applicable to air emissions from the FMPC.[3] The standards for radionuclides are 25 mrem (0.25 mSv) annual whole body dose to an individual, and 75 mrem (0.75 mSv) to any organ of that individual. The dose contribution of radon and its daughter products are not included in the NESHAP standard.

Using AIRDOS to Estimate Radiation Exposure

The calculations involved in estimating radiation exposure are very complex. A number of computer programs aid in these calculations, and the FMPC used the program known as AIRDOS, which ORNL developed for the EPA. Much of the data collected for the environmental monitoring program is entered into AIRDOS, as well as the following parameters used in the calculations:

- Particle size
- Stack discharge height
- Meteorological data
- Population distribution data
- Uranium particle solubility.

AIRDOS computes the committed dose equivalents due to airborne releases of uranium through all inhalation, ingestion, and direct radiation pathways, and estimates the radiation dose an individual is committed to over the next 50 years due to operations during 1986 at the FMPC. Calculations follow the standards established by ICRP Reports 26 and 30, with some modifications recommended by EPA.[1]

Estimating Maximum Exposure to an Individual Member of the Public

The maximum radiation exposure to an individual is based on radionuclides at the point of maximum exposure to the nearest resident (1,128 meters or 0.7 mi north of the FMPC). Calculations were made, based on the maximum exposure in 1986, to determine the dose an individual would receive over a 50-year period to pulmonary tissue, to the bone surface, the committed effective dose equivalent, and the estimated external whole body dose from the operation of the FMPC during 1986. The results are:

- 2.9 mrem (0.029 mSv) for pulmonary tissue
- 0.39 mrem (0.0039 mSv) to the bone surface
- 0.37 mrem (0.0037 mSv) committed effective dose equivalent
- 0.00022 mrem (2.2×10^{-6} mSv) external whole body dose (Table 1).

These calculated values are well within the NESHAP standards of 25 mrem (0.25 mSv) for whole body and 75 mrem (0.75 mSv) for the critical organ. In addition, new administrative controls implemented in 1985 and the installation of new emission-control equipment helped ensure that the FMPC remained in full compliance with NESHAP in 1986.

Besides using the AIRDOS program to calculate maximum exposure levels resulting from the airborne emissions pathway, maximum exposures from other potential pathways of exposure were also calculated. Exposure assessments were made for external radiation by using a pressurized ionization chamber and thermoluminescent dosimeters (TLDs). Internal ingestion exposures were assessed by analyzing water from the Great Miami River and local wells, and by analyzing produce grown in the vicinity of the FMPC.

At each high-volume air monitoring station (AMS), TLDs measure ambient beta-gamma

radiation levels (Table 2). The maximum annual exposure was measured at AMS 6, the closest station to the waste materials stored in the K-65 Silos on the west side of the site. To assess external exposures to individuals living near the site, a pressurized ionization chamber was used to collect data at various locations around the FMPC. The data indicate that the annual dose to the nearest resident (in the unlikely scenario of that resident remaining at home 100% of the time) was conservatively calculated at 18 mrem (0.18 mSv) in 1986. This is 18% of the DOE standard. It should be noted that the background dose from natural sources measured at several locations surrounding the FMPC was 79 mrem (0.79 mSv) per year.

Although the Great Miami River is not designated as a public water supply by the OEPA, calculations were made to estimate the radiation dose to an individual over 50 years if, during the year 1986, that person drank only the water from the river at the FMPC effluent discharge point. A daily intake of 2.0 liters (2.1 quarts) would result in a dose of 0.09 mrem (0.0009 mSv) to the bone surface, and a weighted average dose of 0.006 mrem (6×10^{-5} mSv).[4] The maximum effective dose equivalent from drinking river water would be less than 0.006% of the DOE standard for radiation protection of the public in the vicinity of the FMPC.

Since off-site well 15 had the highest above-background uranium concentration in 1986, the potential radiation dose an individual could receive over a 50-year period from drinking only the water from that well was calculated (Table 1). The effective dose equivalent is 35 mrem (0.35 mSv), which is 35% of the standard, and 520 mrem (5.2 mSv) to the bone surface, which is 10.4% of the DOE standard.

Fish from the Great Miami River were analyzed for total uranium, and locally grown produce was analyzed for total uranium and isotopic thorium. There was no statistical difference in the average uranium concentrations between the fish collected upstream and those collected downstream of the FMPC. It was assumed all fish collected exhibited natural background uranium levels and any dose received by eating fish would be insignificant.

Calculations were also made to determine the estimated effective dose equivalent an individual would receive over 50 years from eating locally grown vegetables. The calculation considers the dose from ingesting uranium and thorium in the vegetables; the result was 6.6×10^{-8} mrem (6.6×10^{-10} mSv) and was considered insignificant. The calculations were based on an annual consumption of 84 pounds of potatoes (potatoes were chosen since they were the largest source of radiation dose from the produce collected). Therefore, it is apparent an individual would not receive a significant radiation dose from eating fish from the Great Miami River and locally grown vegetables.

Estimating Potential Exposure to a Population Group

The community of Ross, Ohio (population 3000) is located 4 km (2.5 mi) northeast of the FMPC (Figure 1). Because of the prevailing westerly wind direction, the FMPC has placed an air monitoring station at a school in Ross. Airborne particulates moving toward Ross from the vicinity of the FMPC are measured there.

Since AMS 3, located on the FMPC site, had the highest measured uranium concentrations of all stations and is in the prevailing wind direction toward Ross, the data collected here were used to calculate the hypothetical maximum radiation exposure to a population group. The details of these complicated dose calculations can be found in DOE/TIC-11468.[4] Dose conversion factors for specific isotopes and organs used in the program are obtained from ICRP Report 26.[1]

The annual averages for radionuclides at AMS 3 were used to calculate the average emission rates from the FMPC and, subsequently, the average concentration of radionuclides at the center of Ross. Assuming an individual remained in Ross 100% of the time, that individual's 50-year radiation dose commitment is 0.54 mrem (0.0054 mSv) to the bone surface, 2.1 mrem (0.021 mSv) pulmonary, and 0.28 mrem (0.0028 mSv) effective dose equivalent.

Estimating the 80 km (48 mi) Population Exposure

AIRDOS was also used to calculate the weighted average estimate of radiation dose to the human population within 80 km (48 mi) of the FMPC over 50 years (Table 3). This dose due to 1986 airborne emissions is 9.6 person-rem (0.096 person-Sv) (Table 1). The total external whole body dose for the 80 km (48 mi) population is 0.0066 person-rem (6.6×10^{-5} person-Sv) due to 1986 airborne emissions. As a comparison, the annual external whole body dose due to natural radiation for the same population group is 275,000 person-rem (2,750 person-Sv).

Radon Exposure Considerations

Determining the dose due to radon emission from the FMPC is an important consideration for the public in the vicinity of the plant. Calculation of dose due to radon emission is not one of the requirements for NESHAP compliance. DOE standards, however, specify that emissions of Rn-222 to uncontrolled areas must be less than 3.0 pCi/l.

During 1986, background radon measurements at locations that are 6.4 and 10.5 km from the FMPC (OS 1 and OS 2 respectively) averaged 0.58 pCi/l (Table 6). AMS 6, which is in the same direction and closer to the K-65 Silos than the nearest residence, recorded an average radon concentration of 0.65 pCi/l. All radon measurements include an error term of about ± 20%. Therefore, there are no significant differences in radon concentration between background locations and AMS 6 in 1986. A dose calculation based on this data does not yield significant results.

In addition to FMPC measurements of outdoor radon concentrations, the Ohio Department of Health (ODH) monitored indoor radon concentrations at nine locations around the FMPC between July 1985 and July 1986. These concentrations ranged from 1.1 pCi/l to 12.8 pCi/l with no apparent correlation between average concentration and proximity to the K-65 Silos. The FMPC Health and Environmental Advisory Committee examined this data and issued a press release indicating that the FMPC is not the source of elevated radon levels found in this study.[21]

Chapter Five — Collecting and Analyzing Samples

In order to accurately determine the level of radiation exposure and plant effluent discharges from operations at the FMPC, significant amounts of data from all potential sources and pathways must be collected and analyzed. The discussion of the collection and analyses of data is organized into two major sections, radiological parameters and nonradiological parameters.

Radiological Parameters

This section describes the various elements that were sampled and analyzed for radiological parameters, including uranium content and other trace radionuclides. These sampling media, listed below, are discussed in the following paragraphs:

- Air
- Groundwater
- Surface Water
- Sediments
- Soil
- Vegetation
- Garden Produce
- Milk
- Fish.

Sampling the Air

The conversion of impure uranium compounds to reactor-grade feed materials can generate airborne radioactive particulates. Ventilation and air-cleaning systems reduce employe exposure to these particles and reduce their release into the environment. As part of the reclamation program at the FMPC, materials containing uranium are returned to the production process when economically feasible.

Emissions to the air are filtered or scrubbed before release to the atmosphere. A total of 29 kg (65 lbs) or 0.02 Ci (7.4×10^8 Bq) of uranium was emitted into the atmosphere during 1986. This is a 61% reduction from the 75 kg (165 lbs) of uranium emitted in 1985, even though production of uranium metal products increased 30% over 1985 levels.

In addition to the seven high-volume air monitoring stations located along the FMPC site boundary, two stations (AMS 8 and AMS 9) were added in the third quarter of 1986 to continuously collect samples of airborne particulates (Figure 3). Samples were collected and analyzed at weekly intervals. At each sampler, air is drawn through a 20 cm by 25 cm (about 8 in by 10 in) filter at a rate of approximately 1 m^3/min (about 35 ft^3/min); any changes in flow rate over the sampling period are accounted for. Filters are accurately weighed before installation and after collection to obtain the weight of the collected particulates. The filter is then dissolved in acid and the solutions are analyzed for uranium content and beta activity. A portion of each of these solutions is retained to provide a yearly composite, which is then used to detect the presence of trace radionuclides such as isotopes of neptunium, plutonium, and thorium.

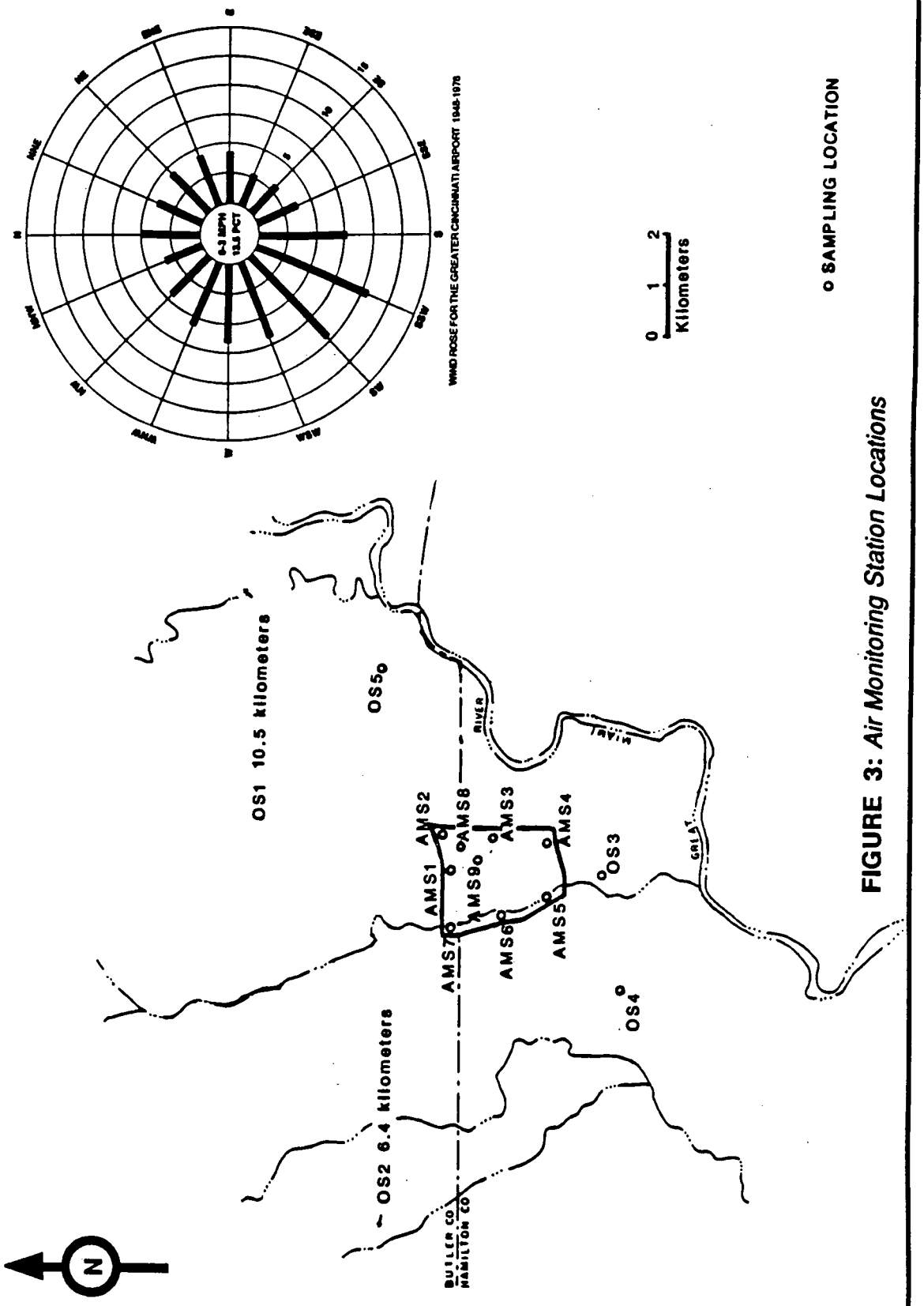

FIGURE 3: *Air Monitoring Station Locations*

Table 4 presents the results of the air sampling in 1986 for average particulate and uranium concentrations and beta activity in various radionuclides. Comparisons were made using the data from the 1984 through 1986 Environmental Monitoring Reports. The concentration of uranium measured at the air monitoring stations in 1986 was 11 to 41% lower than the concentrations measured in 1985 (Figure 4). Beta concentrations were reported 23 to 40% higher at all air monitoring stations in 1986 than in 1985 (Figure 5). These higher values were anticipated (these values are still within the range of what is expected) because in 1986, the FMPC radiochemistry lab adopted a more accurate geometry factor for use in gross beta analyses. The FMPC began using a Sr-90 beta solution that is traceable to the National Bureau of Standards as a calibration source for gross beta measurements. Concentrations of the airborne trace radionuclides at all stations where previous measurements were made were substantially lower than those measured in 1985 (Figures 6 to 10; Table 5).

(Text continues on page 21)

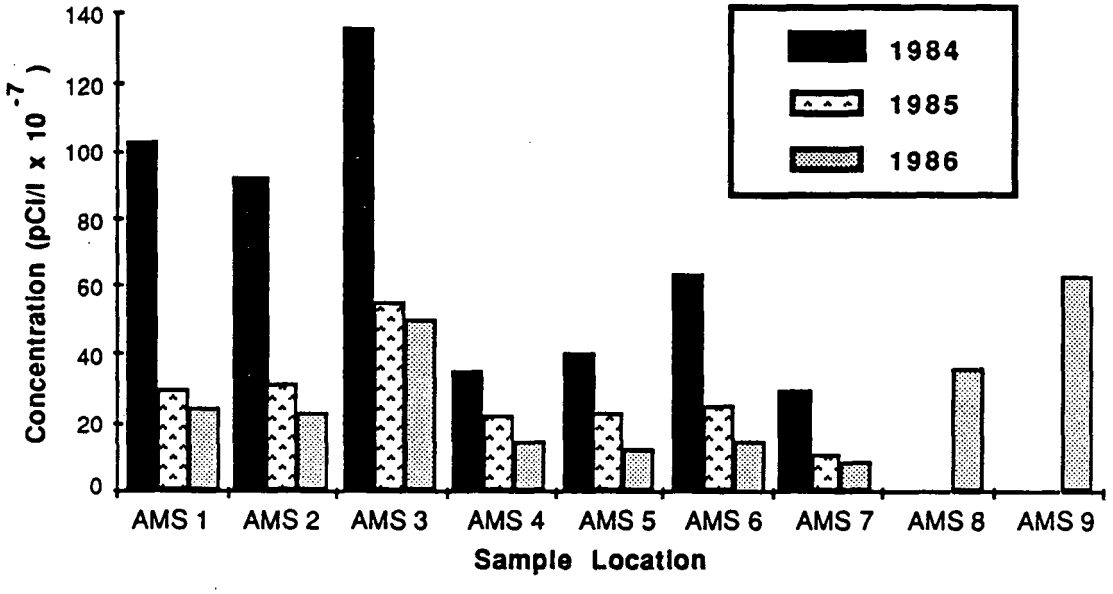

FIGURE 4: *Average Uranium Concentrations in Air, 1984 to 1986*

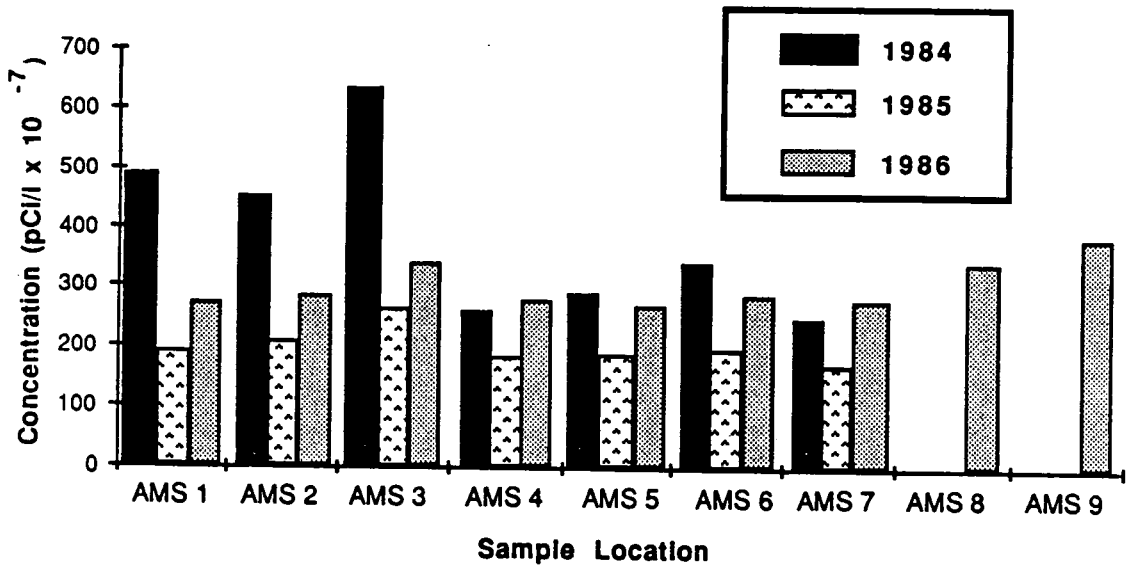

FIGURE 5: *Gross Beta Concentrations in Air, 1984 to 1986*

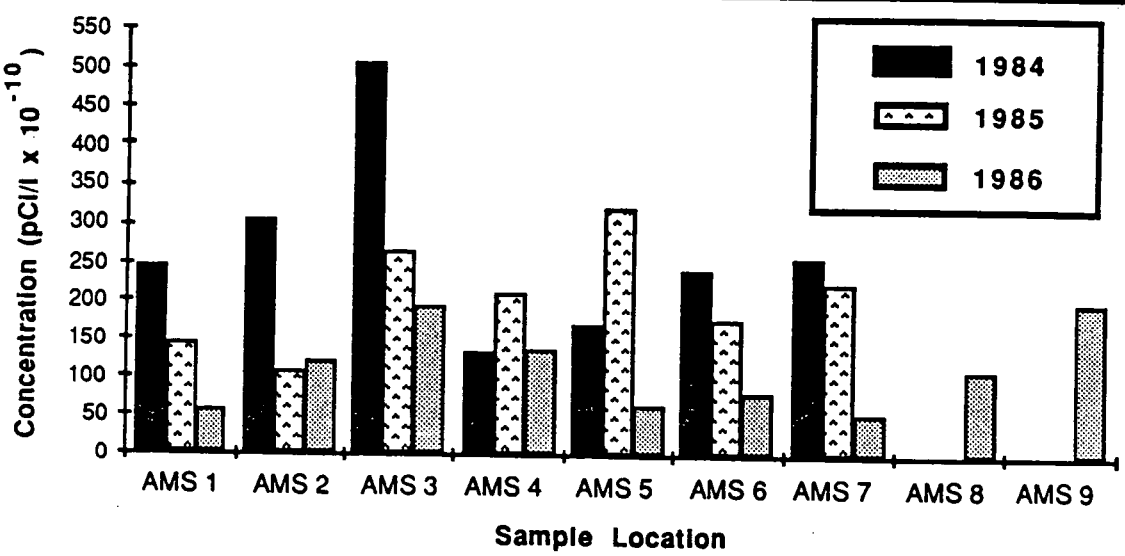

FIGURE 6: *Average Thorium–228 Concentrations in Air, 1984 to 1986*

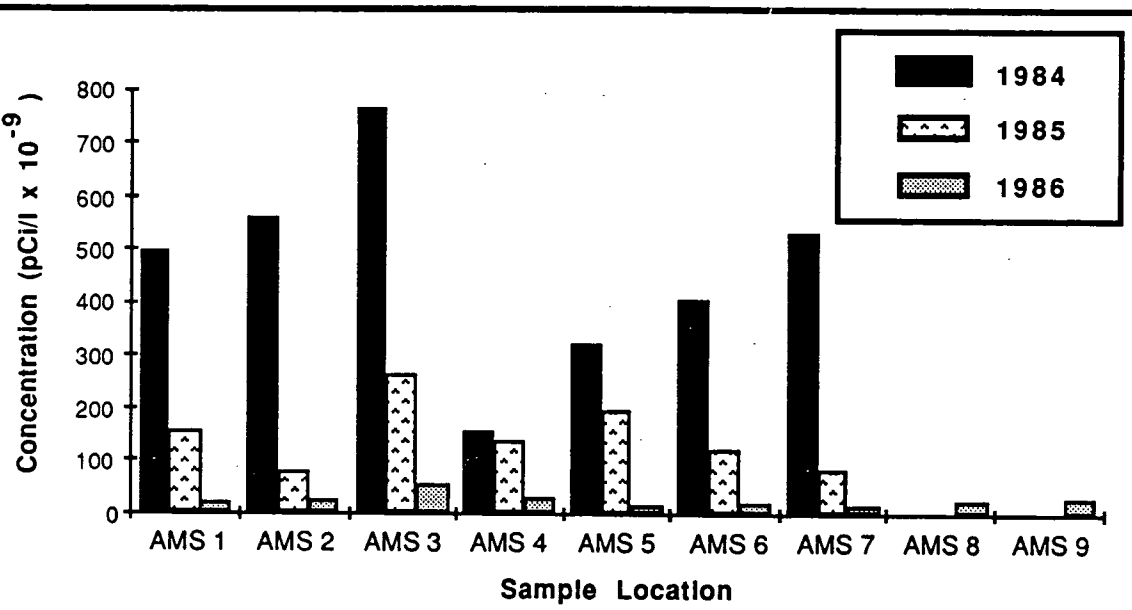

FIGURE 7: *Average Thorium–230 Concentrations in Air, 1984 to 1986*

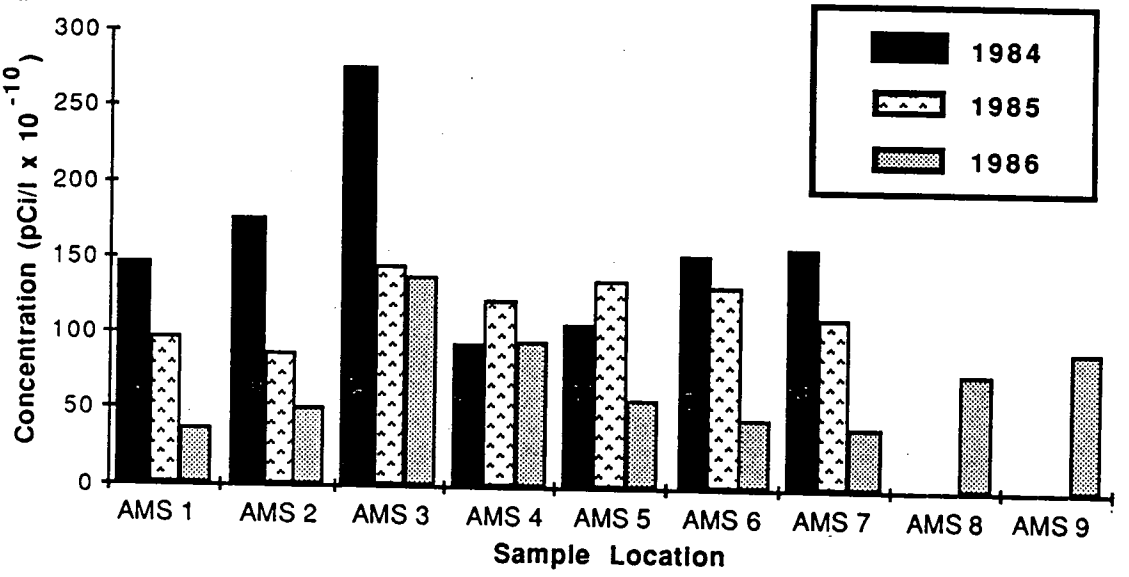

FIGURE 8: *Average Thorium-232 Concentrations in Air, 1984 to 1986*

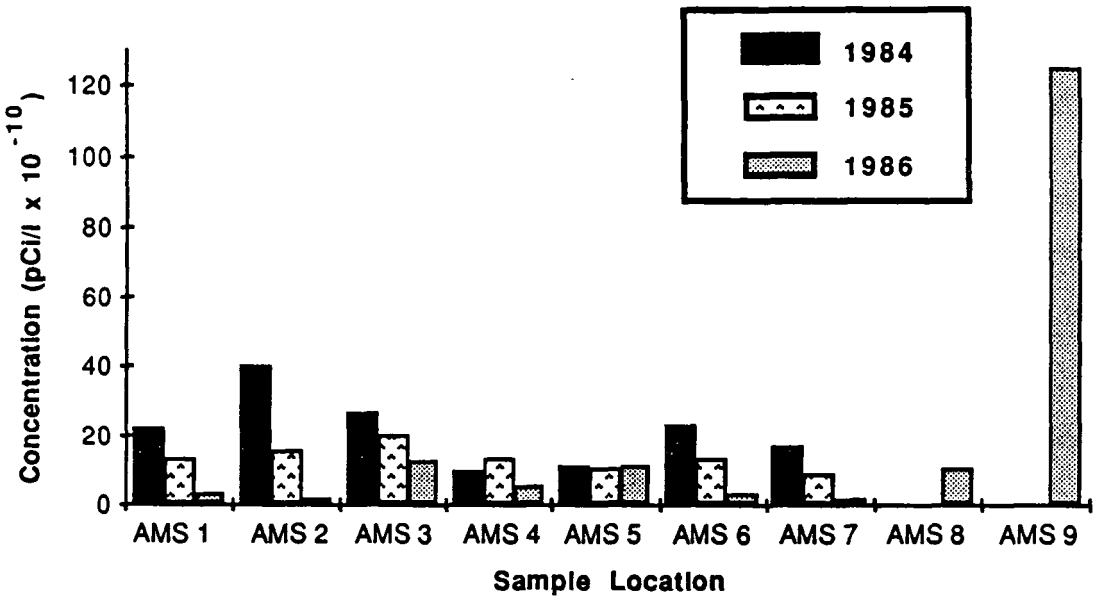

FIGURE 9: *Average Plutonium–238 Concentration in Air, 1984 to 1986*

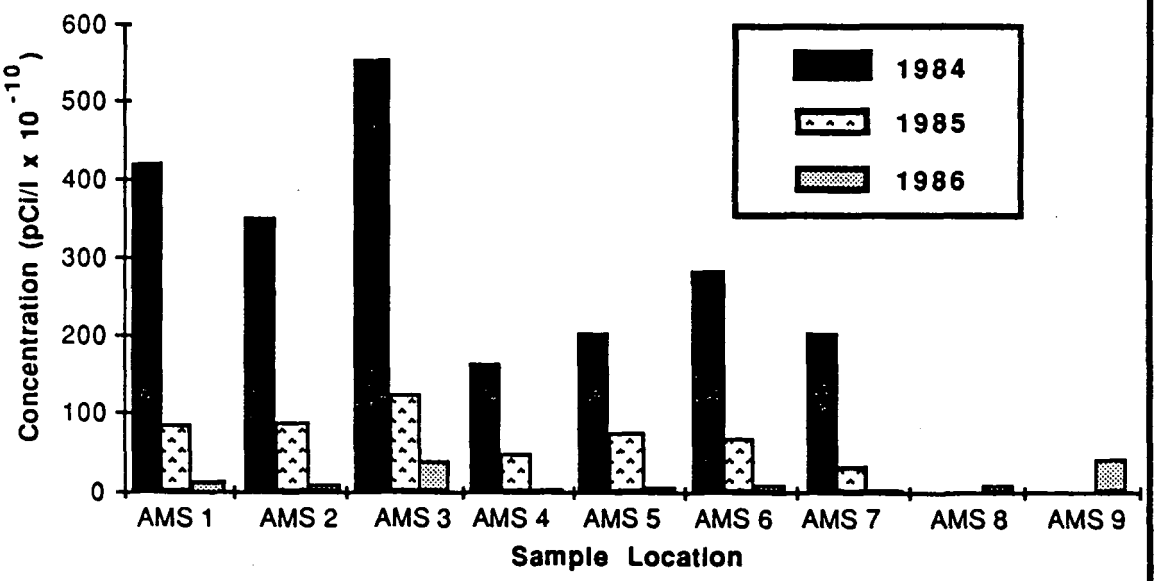

FIGURE 10: *Average Plutonium – 239/240 Concentration in Air, 1984 to 1986*

Since particulates of uranium are relatively heavy (uranium is a heavy metal), they tend not to disperse as far or as uniformly as lighter particulates might under similar conditions. Therefore, it is expected that the further an air monitoring station is from the FMPC process area, the lower the concentrations of uranium isotopes in the air. This statement is supported by the data collected at air monitoring stations 9, 8, and 2 (these stations are in line sequentially outward from the process area along the prevailing wind direction). A reduction of all isotopes in the air is apparent as distance from the process area increases.

Concentrations of radon-222 were monitored at 9 on-site and 5 off-site monitoring stations using commercially available instruments (Figure 3). The 1986 average concentrations of radon-222 vary slightly from station to station but were not significantly different from one another nor from the 1985 data. The results also indicate that no distinct trends for radon exist in the prevailing wind direction (Table 6).

Concentrations of radon-222 are also measured at two residences 6.4 and 10.5 km (4 and 6.6 mi) from the FMPC and also at two nearby elementary schools. In 1986, the average concentration of radon-222 measured at these locations ranged from 0.6 to 0.9 pCi (0.02 to 0.03 Bq) per liter of air, which does not differ significantly from the 1985 averages.

Concentrations of thoron (radon-220) were also measured at the on- and off-site stations in the third and fourth quarters of 1986 (Table 7). Average concentrations ranged from less than the minimum detectable to 0.30 pCi/l (0.011 Bq/l). It would be difficult to draw any conclusions due to the variable nature of the data.

Sampling Groundwater

A total of 35 on-site wells and 26 off-site wells are sampled as part of the environmental monitoring program (Figure 11). There are 22 different on-site well locations; however, 12 of these locations are cluster wells. A cluster well is a grouping of two or more wells of different depths at the same location from which water samples may be taken. The notation "s" on a well cluster identification means shallow, "d" means deep sand and gravel aquifer, and TP means test pit or till well. The s, d, and TP notations are purely relative in nature and do not indicate precise depth ranges.

The FMPC wells are sampled as part of several monitoring programs. Twenty-six off-site wells belonging to individuals and companies in the vicinity of the FMPC are sampled monthly for radiological parameters. On-site monitoring wells T1, T3, T4, T5, T8, T9, T10, T11, and production wells P1, P2, and P3 are all sampled monthly and quarterly, but for separate programs including both radiological and nonradiological parameters. All the on-site wells and off-site wells 8, 12, 15, 17 and 26 were sampled quarterly in 1986 as part of the FMPC/RCRA (Resource Conservation and Recovery Act) monitoring program. These wells will be sampled on a semiannual basis in 1987 for RCRA purposes which include radiological and nonradiological parameters.[7 8] This sampling was performed according to guidelines set forth by the USEPA in RCRA. Forty-one wells on- and off-site were sampled for 95 parameters (15 of which are radiological) and the data for the second and third quarters of sampling are listed in Appendix B. The first quarter RCRA data was reported in the 1985 Environmental Monitoring Annual Report for the FMPC.

During 1986, water samples were collected and analyzed monthly for uranium concentration from 13 on-site wells and 26 off-site wells (Figure 11). The results of the monthly samples from the off-site wells are presented in Table 8. Quarterly samples from the on-site wells were analyzed for uranium concentrations and gross alpha and beta concentrations (Tables 9, 10, and 11).

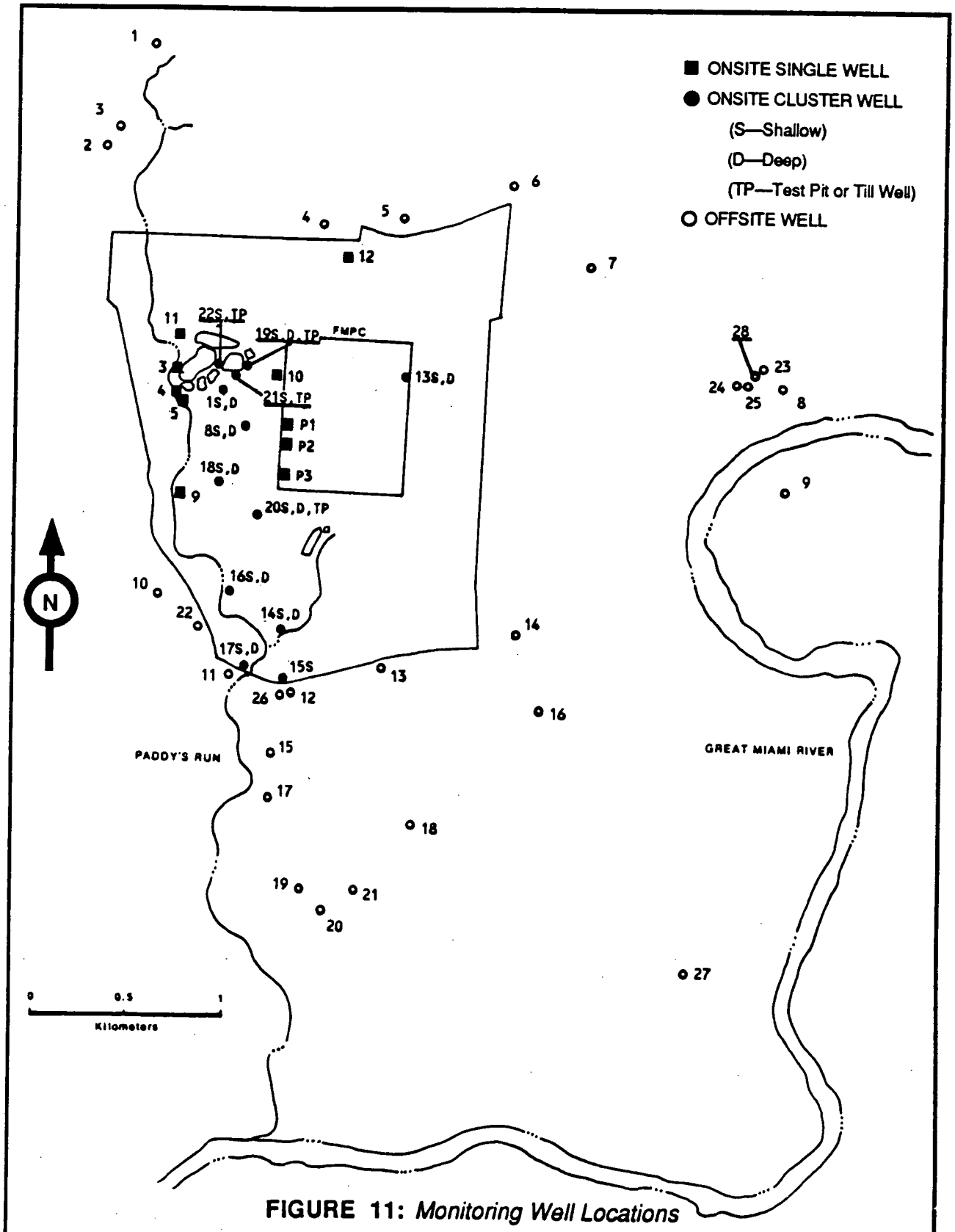

FIGURE 11: *Monitoring Well Locations*

Figure 12 shows average uranium concentrations from 1984 to 1986 for the on- site wells. Wells T1s and T4 showed increases in average uranium concentration in 1986 from 1985. Wells near the waste storage area (T10, T1s and T4) had the highest average uranium concentrations in 1986 (12.84, 7.77 and 6.08 pCi/l or 0.48, 0.29 and 0.22 Bq/l, respectively).

Figure 13 shows the average gross alpha concentrations in on-site wells from 1984 to 1986. Well T1s showed a very slight increase in alpha activity in 1986 over previous years. Slight decreases were observed in wells T10 and T8d. Gross alpha concentrations were highest in 1986 in wells T10 and T1s (14 and 12 pCi/l or 0.50 and 0.45 Bq/l, respectively), which are located east and south of the waste storage area respectively.

Figure 14 shows the average gross beta concentrations in on-site wells from 1984 to 1986. Wells T10 and T1s showed slight decreases in gross beta activities in 1986 from 1984; other wells showed no clear trends. Wells T10 and T1s had the highest levels of gross beta concentrations in 1986 (23 and 10 pCi/l or 0.83 and 0.38 Bq/l, respectively).

As in past years, the average uranium concentrations in samples collected from all off-site wells, except wells 12, 15, and 17 (147, 193 and 31 pCi/l or 5.44, 7.15 and 1.27 Bq/l, respectively), were within the range considered natural background for uranium content in groundwater. Figures 15, 16, and 17 show average uranium concentrations in off-site wells for 1984-1986. No clear-cut trends are evident in the majority of the off-site wells, and the variation shown may be natural. Natural background levels for uranium in groundwater in most areas in the U. S. range from 0.68 to 6.8 pCi/l or 0.002 to 0.25 Bq/l.[6]

Contaminated surface water seeping into the aquifer from the storm-sewer outfall ditch and Paddy's Run was identified as the source of above-background concentrations of uranium in wells 12, 15 and 17.[5] The stormwater retention basin, which began operations in 1986, should reduce discharges of contaminated stormwater to the storm-sewer outfall ditch and Paddy's Run.

Two areas of above-background uranium concentration in groundwater exist in the vicinity of the FMPC (Figure 18). One is on-site, extending eastward from the waste pit area. The other is near the confluence of Paddy's Run and the storm-sewer outfall ditch.

Sampling Surface Water

Surface water is sampled for radiological parameters at 10 locations: 5 on-site and 5 off-site. This sampling enables the FMPC to monitor the effect of its operations on Paddy's Run and the Great Miami River (Figure 19).

There are several areas at the FMPC where wastewater is collected and treated before it is sent to the general sump. Uranium-bearing wastewater is collected at each of the seven major plants for recycling. Figure 20 details the flow scheme of the liquid-waste streams, the major points of treatment, and the sampling locations used to check the effluent.

Rain which falls in the production area and overflows at the storm-sewer lift station flows into the stormwater retention basin. An emergency spill containment basin, located within the stormwater retention basin, captures spills of hazardous liquids.

Depending on the sampling location, the frequency of collection of surface water varies along with the parameters that are analyzed. The following paragraphs detail these variations.

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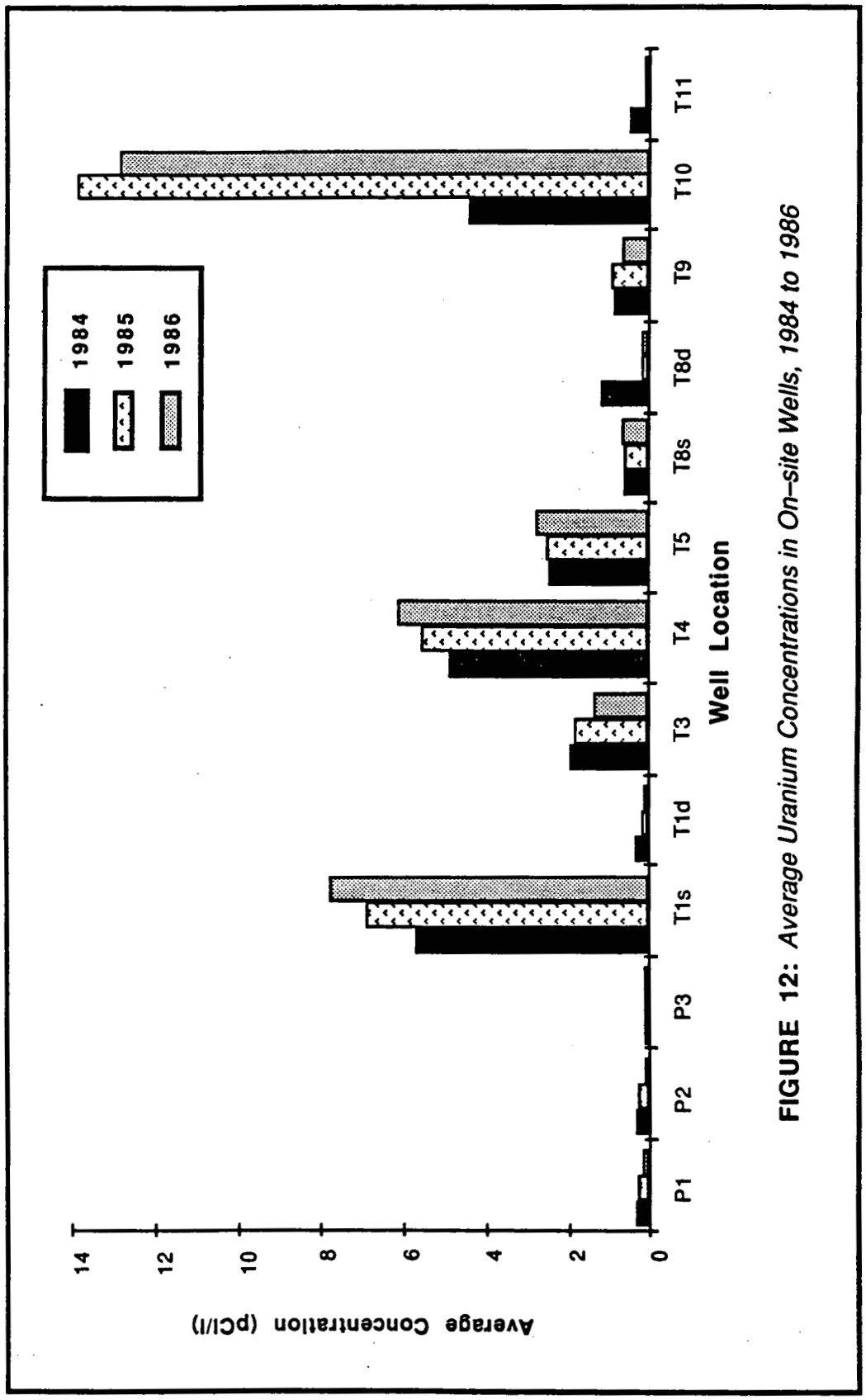

FIGURE 12: *Average Uranium Concentrations in On-site Wells, 1984 to 1986*

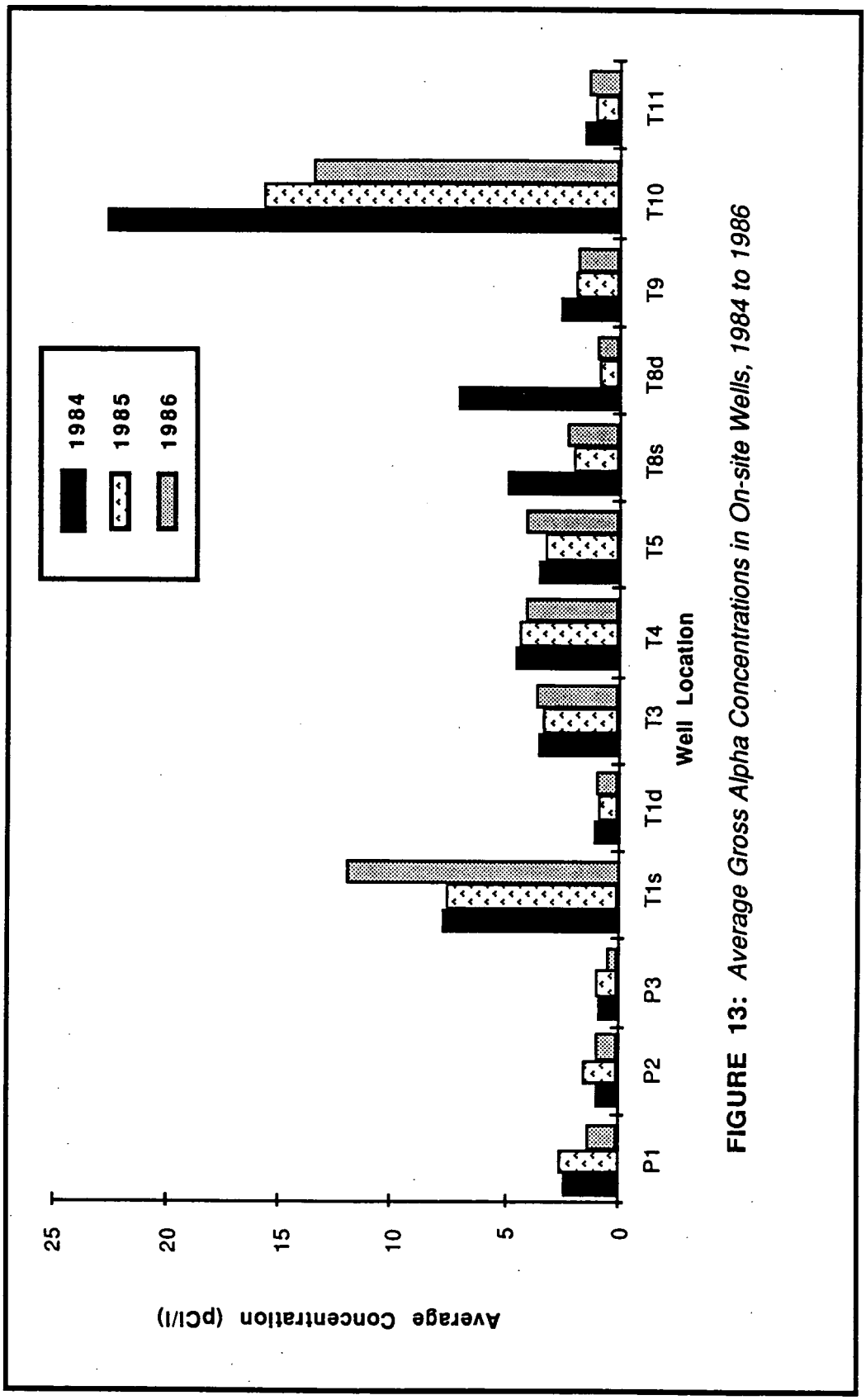

FIGURE 13: *Average Gross Alpha Concentrations in On-site Wells, 1984 to 1986*

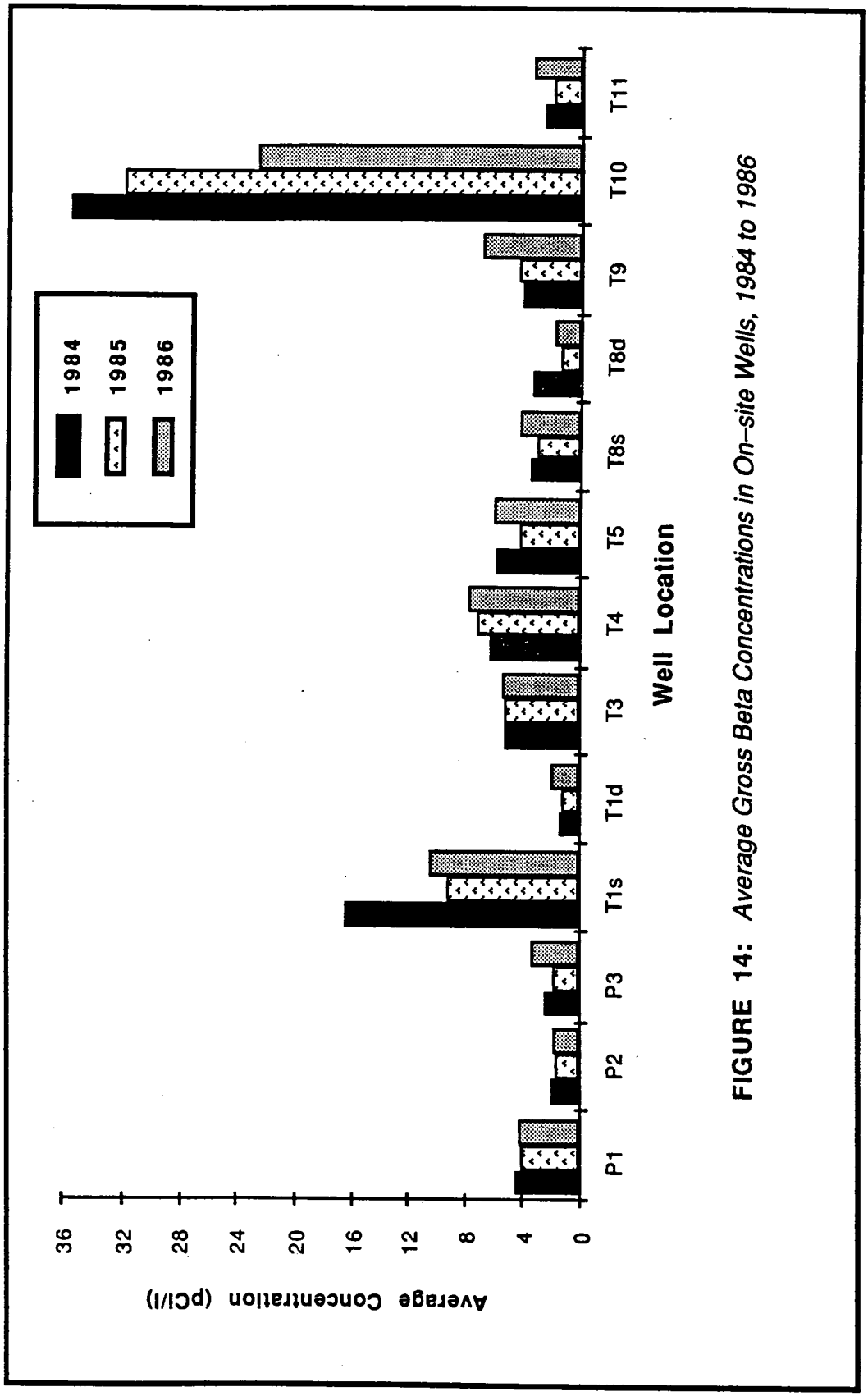

FIGURE 14: *Average Gross Beta Concentrations in On-site Wells, 1984 to 1986*

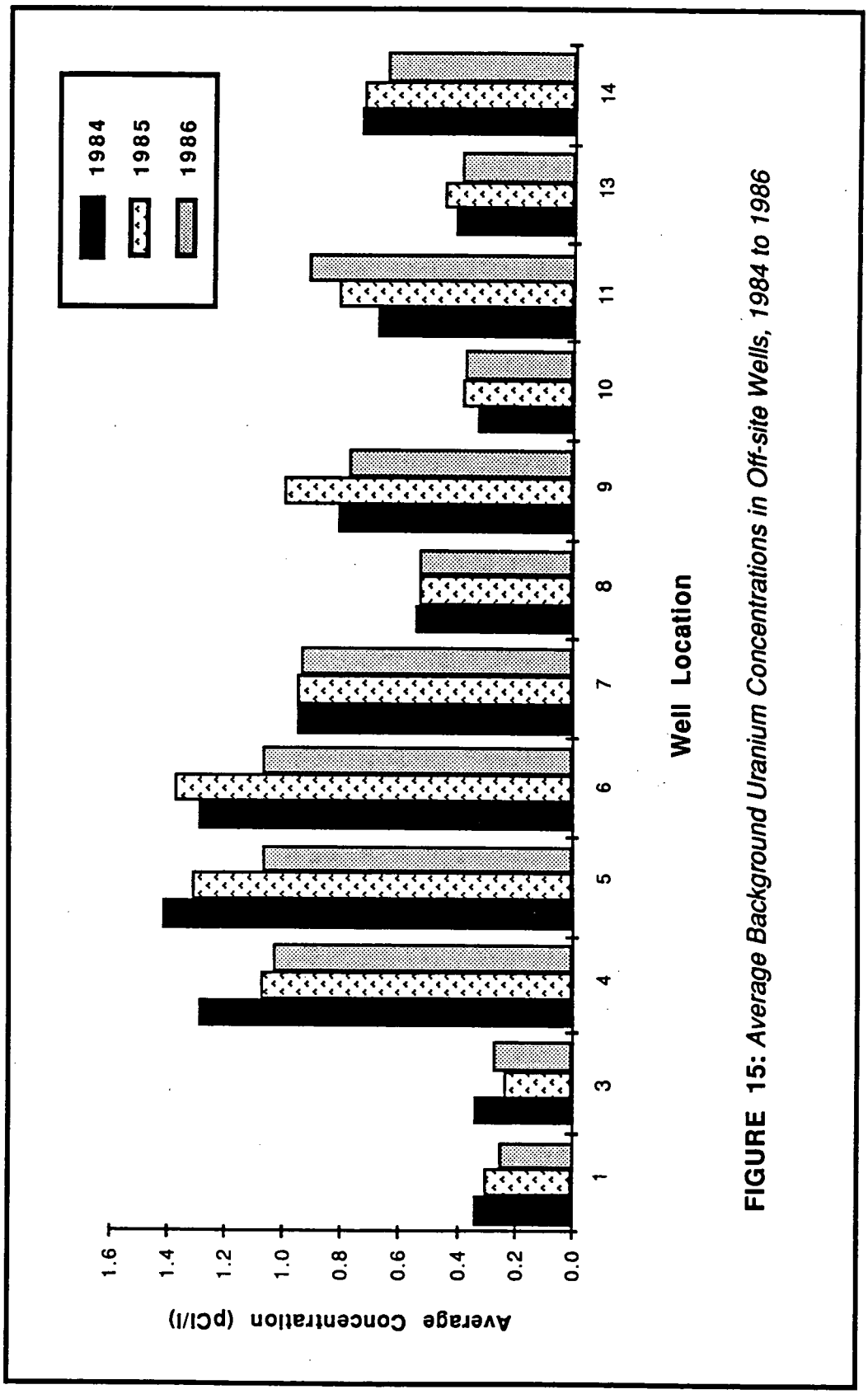

FIGURE 15: *Average Background Uranium Concentrations in Off-site Wells, 1984 to 1986*

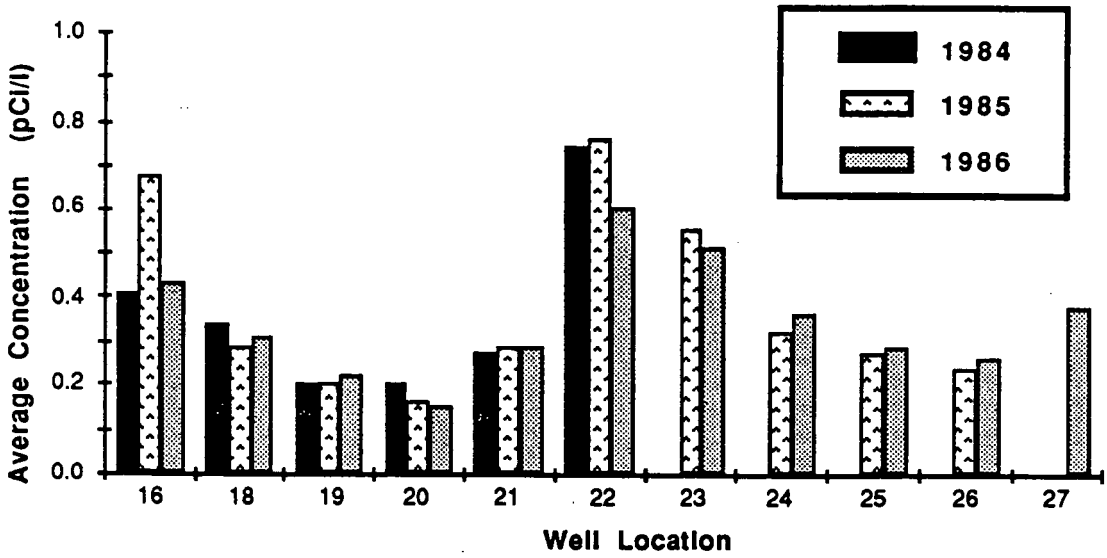

FIGURE 16: *Average Background Uranium Concentrations in Off-site Wells, 1984 to 1986*

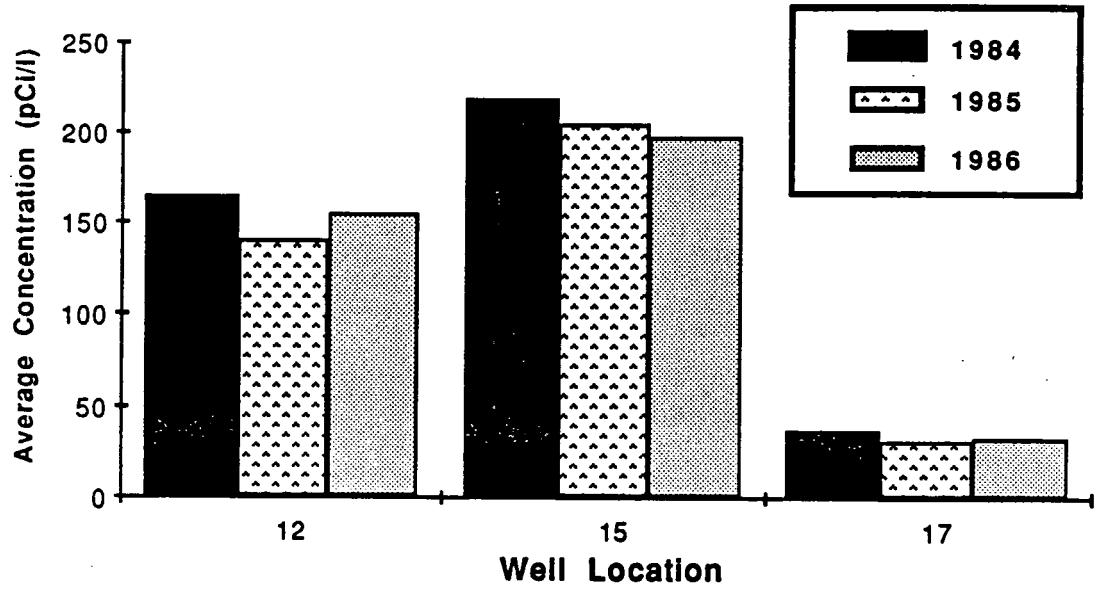

FIGURE 17: *Average Above-Background Uranium Concentrations in Off-site Wells, 1984 to 1986*

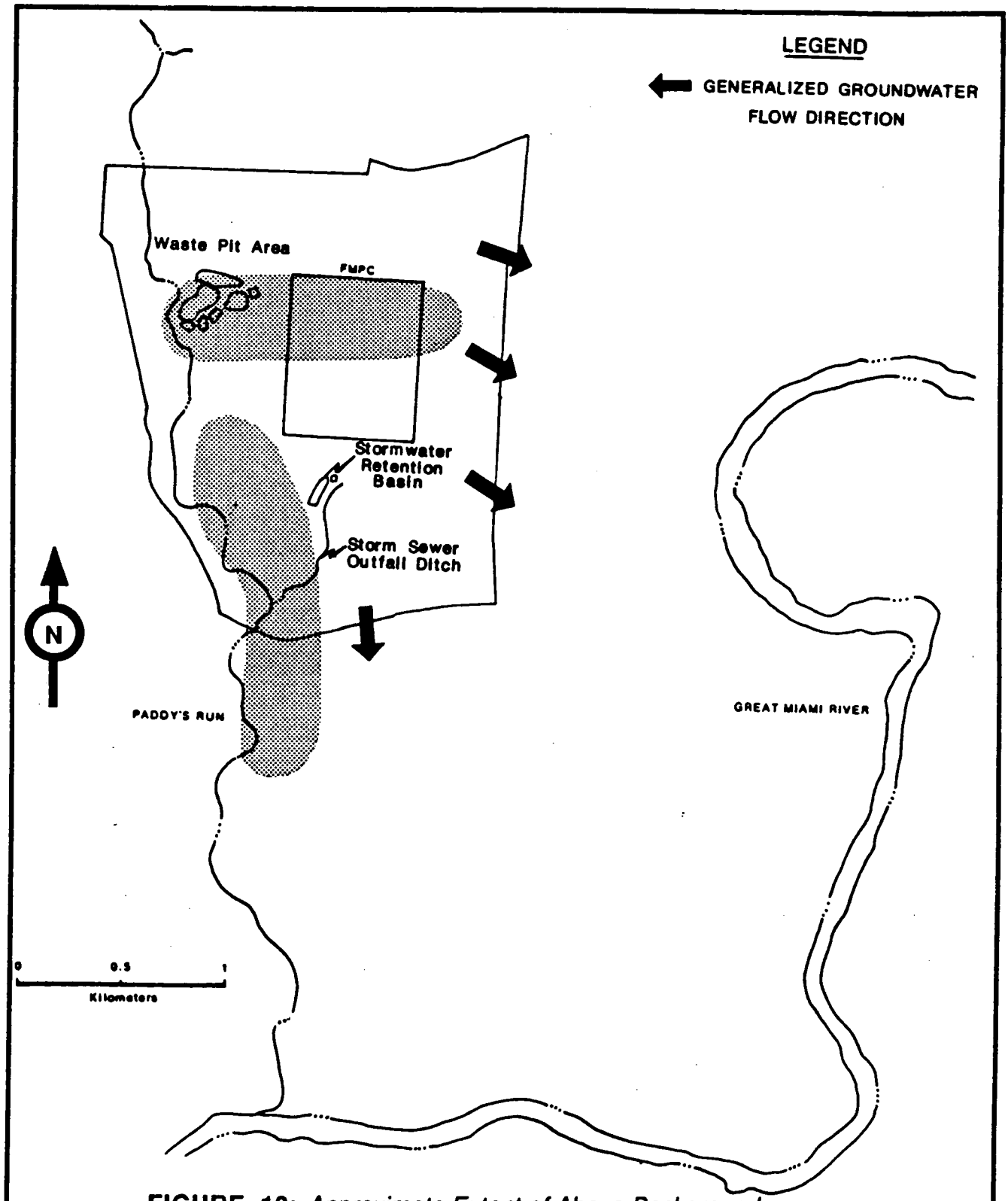

FIGURE 18: *Approximate Extent of Above-Background Uranium Concentrations in Groundwater Samples*

Note: Uranium concentrations in non-shaded areas are at or below background level of 1.35 pCi/l.

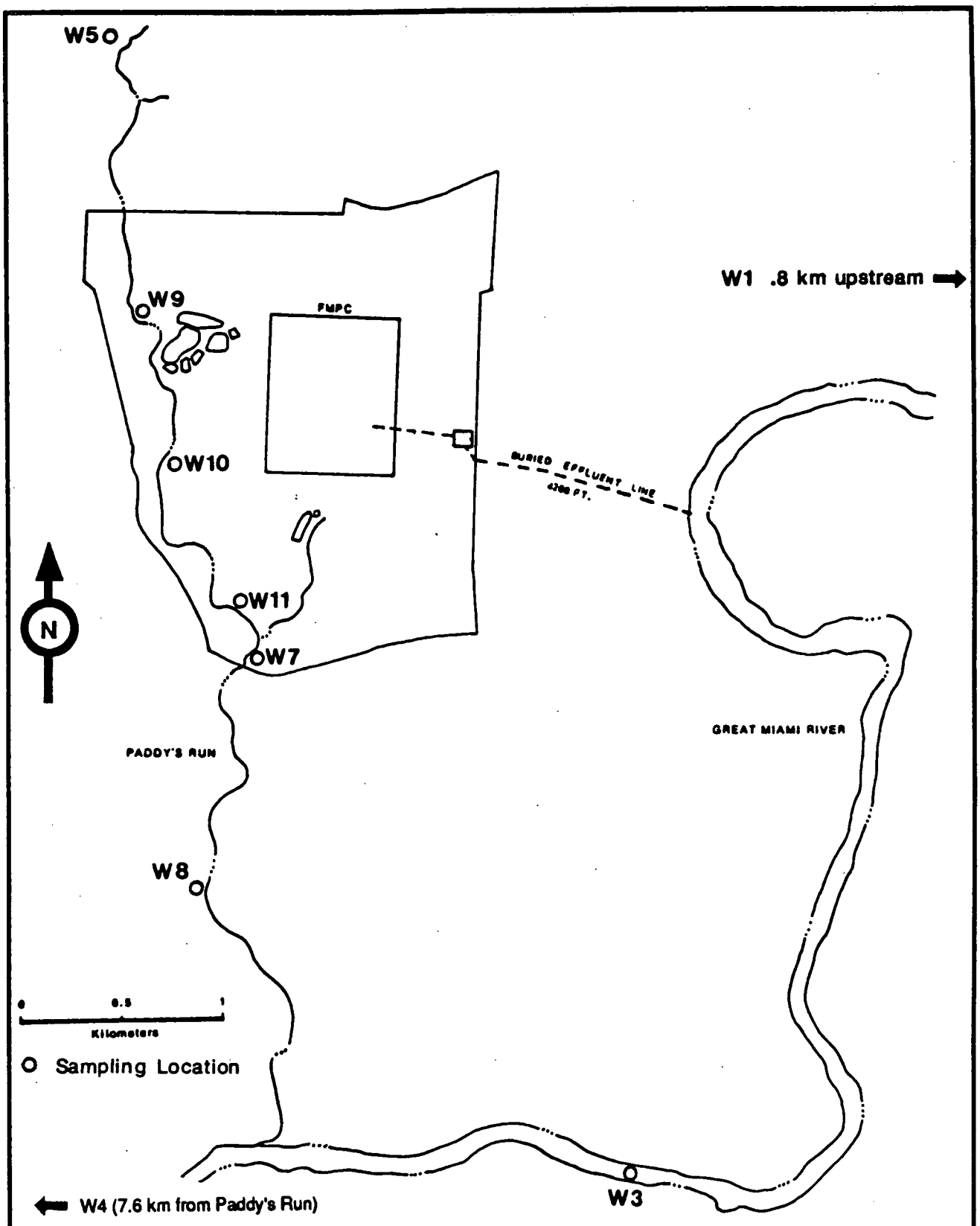

FIGURE 19: *Surface Water Sampling Locations*

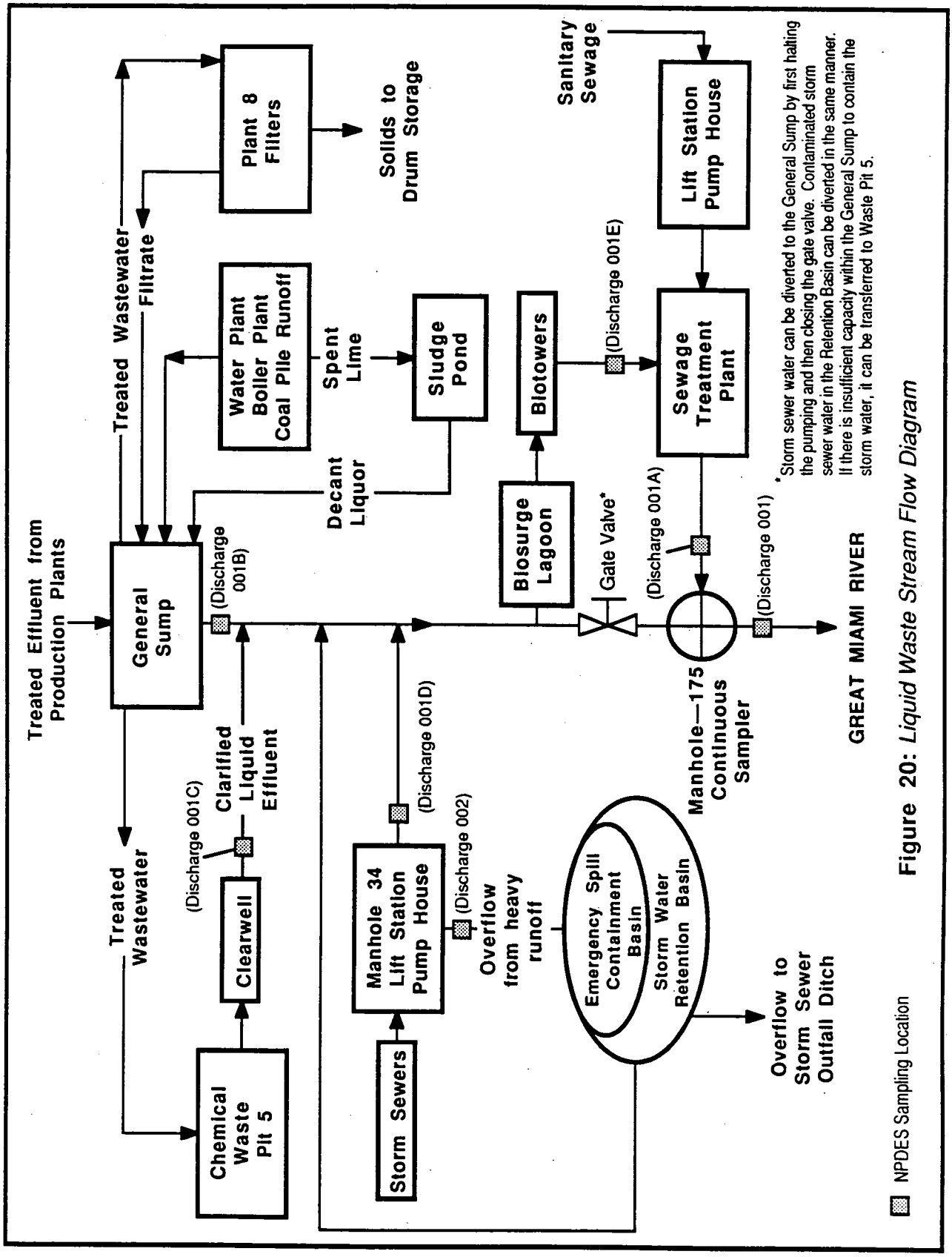

Figure 20: *Liquid Waste Stream Flow Diagram*

Samples are collected continuously by an automatic sampler in proportion to the total flow at the final access point (Discharge 001) in the FMPC effluent discharge line into the Great Miami River. Twenty-four-hour composite samples at Discharge 001 are collected daily and analyzed for uranium content and alpha and beta radioactivity. One-month composites of the daily samples are analyzed for radium-226, radium-228, ruthenium-106, and thorium-232. Two semi-annual composite samples are analyzed for other radionuclides.

Each week, surface-water grab samples are collected at sampling stations W1, W3 and W4 on the Great Miami River. These samples are analyzed for radionuclides, ions and pH. Grab samples are collected and analyzed monthly for the same parameters at locations W5, W7, W8, W9, W10 and W11 on Paddy's Run. During heavy rains, grab samples are collected at the overflow of the stormwater retention basin. The samples are analyzed for total uranium, gross alpha and beta, and total suspended solids.

The total amount of uranium present in the liquid effluent (0.31 Ci or 1.2×10^{10} Bq) discharged into the Great Miami River at Discharge 001 in 1986 was 24% less than in 1985. The total amount of uranium present in stormwater runoff (0.011 Ci or 4.1×10^{8} Bq) that flows into Paddy's Run via the storm- sewer outfall ditch was 58% lower in 1986 than 1985. These data are based on grab samples since a continuous monitor is not in place, and may be subject to some analytical error since the rate of liquid effluent discharge and uranium concentrations at Discharge 001 varies.

Table 12 and Figures 21 and 22 compare the radionuclides measured at Discharge 001 during 1986 to values from 1984 and 1985. Uranium-236 discharges increased when compared with discharges during 1985, but decreased when compared with 1984. Cesium-137, ruthenium-106, radium-226 and 228, plutonium-238 and -239/240, and neptunium-237, if present at all, were at concentrations less than the minimum detectable by the sensitive analytical procedures used. Strontium-90 decreased significantly in 1986. All radionuclide discharges in 1986 were below DOE standards. Further study and attention will be given to this in the future.

Table 13 describes radionuclides measured in surface-water monitoring locations. Radioisotope concentrations in surface water in the Great Miami River and Paddy's Run measured in 1986 did not differ significantly from 1985 concentrations. In 1986, radium-226 and -228, strontium-90 and uranium-234, -235, -236 and -238 concentrations were unchanged or lower in Paddy's Run and the Great Miami River.

Technetium-99 concentrations rose slightly in 1986 at sampling locations W1 and W3 in the Great Miami River. However, the 1986 values were below the 1984 values. The total discharge of technetium-99 from the FMPC via the liquid effluent line to the Great Miami River decreased from 8.3 Ci (3.1×10^{11} Bq) in 1985 to 1.5 Ci (5.7×10^{10} Bq) in 1986. Therefore, it is unlikely that the FMPC liquid discharge caused the slight increase in technetium-99 concentrations in the Great Miami River in 1986. The reasons for these increases are not known, and further study and attention will be given to this in the future.

Figure 23 shows plots of the average concentrations of total uranium at the surface-water sampling points for 1984, 1985 and 1986. Average concentration of total uranium increased at locations W7 and W11, and decreased at locations W9 and W10 in 1986. No clearcut trends were shown at other sampling points. The highest uranium concentrations measured in 1986 occurred at locations W7 (49 pCi/l or 1.8 Bq/l) and W11 (29 pCi/l or 1.1 Bq/l). Figure 24 shows the approximate extent of above-background uranium concentrations (>1.4 pCi/l or >0.05 Bq/l) in surface water in the vicinity of the FMPC. All sampling locations had uranium concentrations below the DOE standard of 550 pCi/l or 20.4 Bq/l (which is a standard relative to off-site discharges).

Gross alpha and beta are screening techniques used to identify areas where analysis of specific isotopes is indicated, allowing a concentration of effort to be placed where needed most. Figure 25 shows a plot of the

average gross alpha concentrations at surface-water sampling locations during 1984, 1985 and 1986. Gross alpha concentrations increased at locations W7, W8, W10 and W11 in 1986, but decreased at W9. The highest average gross alpha concentrations were found at locations W7 (39 pCi/l or 1.4 Bq/l) and W11 (23 pCi/l or 0.83 Bq/l). Only the average alpha concentration at on-site W7 was above the DOE standard of 30 pCi/l or 1.11 Bq/l (which is a standard relative to off-site discharges). Further study and attention will be given to this in the future.

Figure 26 shows a plot of the average gross beta concentrations at surface water sampling locations during 1984, 1985 and 1986. Gross beta concentrations increased at locations W7 and W8 in 1986, but decreased at W3, W4, W9 and W11. No clear trends were observed at W1, W5 and W10. The highest average gross beta concentrations were found at W7 (27 pCi/l or 1.0 Bq/l), W8 (26 pCi/l or 1.0 Bq/l), and W11 (13 pCi/l or 0.50 Bq/l). All sampling locations showed gross beta concentrations that were below the DOE standard of 30 pCi/l or 1.11 Bq/l (which is a standard relative to off-site discharges).

Total uranium concentration at location W7 on Paddy's Run was 11% higher in 1986 than in 1985, gross alpha concentration increased 15%, and the average gross beta concentration increased 37%. Since the total amount of uranium (0.011 Ci or 4.1×10^8 Bq) discharged via the storm-sewer outfall ditch to Paddy's Run in 1986 was less than in 1985 (0.026 Ci or 9.6×10^8 Bq), an additional source contributing to these higher concentrations at location W7 is implied. The reasons for these increases are not known, and further study and attention will be given to this in the future.

A portion of stormwater runoff from the waste storage area is discharged directly into Paddy's Run at points approximately 0.9 to 1.5 km (0.56 to 0.93 mi) above where the storm-sewer outfall ditch flows into Paddy's Run. The runoff contains above-background uranium concentrations, and may contribute to higher uranium concentrations in Paddy's Run.[5] Beginning in August 1986, runoff from Pit 4 was collected by means of berms and sumps and then discharged into the plant effluent via Pit 6, Pit 5, and the clearwell. (See the Waste Pit Area in Figure 20.) This system should help control the flow of runoff from the waste pit area into Paddy's Run.

Average uranium concentrations measured during 1986 at locations W9, W10 and W11 in Paddy's Run (upstream of the confluence of the storm sewer outfall ditch and Paddy's Run) were lower in total uranium than at location W7 (at the confluence). However, the 1985 averages, which are variable and based on fewer samples, indicate that the average uranium concentration was higher at location W10 than at location W7. Above-background levels of uranium were found at locations W10 (11 pCi/l or 0.42 Bq/l) and W11 (29 pCi/l or 1.1 Bq/l) in 1986, which may reflect a contribution of uranium in surface and shallow groundwater discharge from the waste storage area. During periods of increased erosion from heavy runoff, resuspension of uranium-bearing sediments may also have contributed to the higher uranium content in surface water at location W7.

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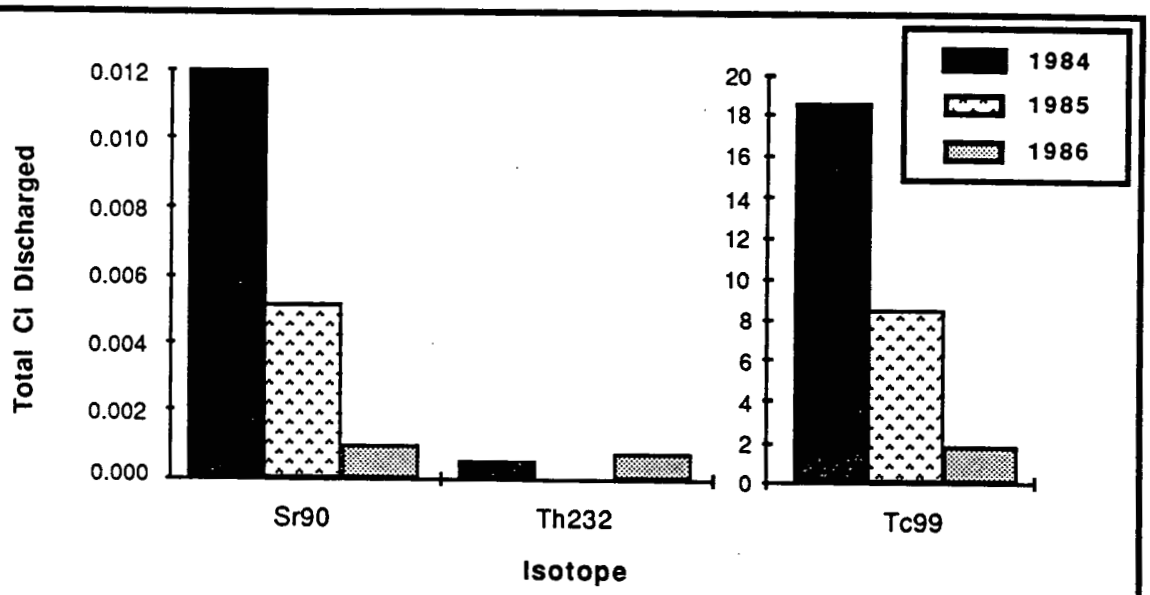

Figure 21: *Radionuclides Discharged at NPDES Sampling Point 001, 1984 to 1986*

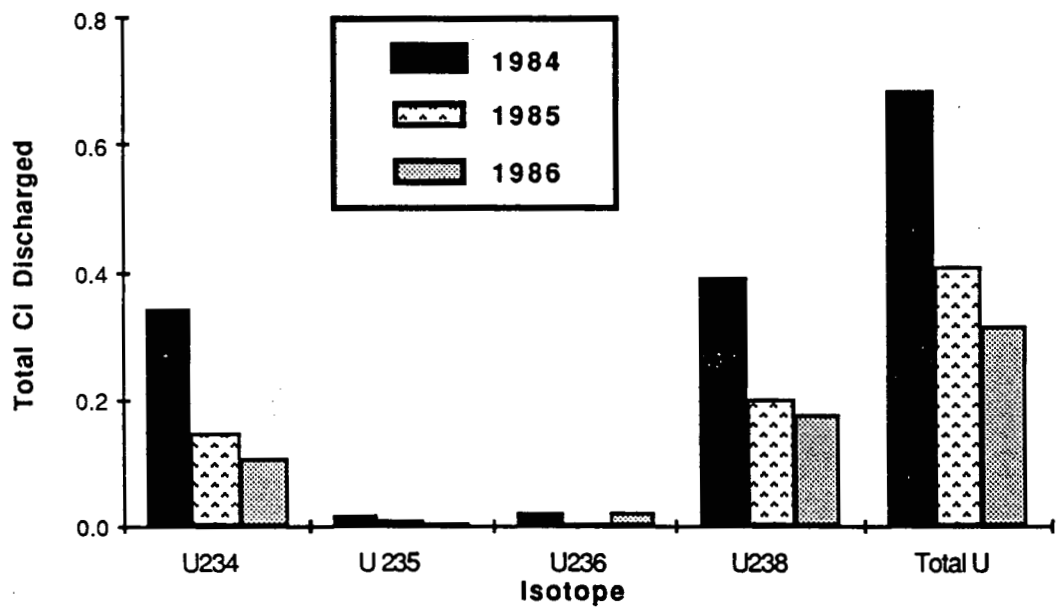

Figure 22: *Radionuclides Discharged at NPDES Sampling Point 001, 1984 to 1986*

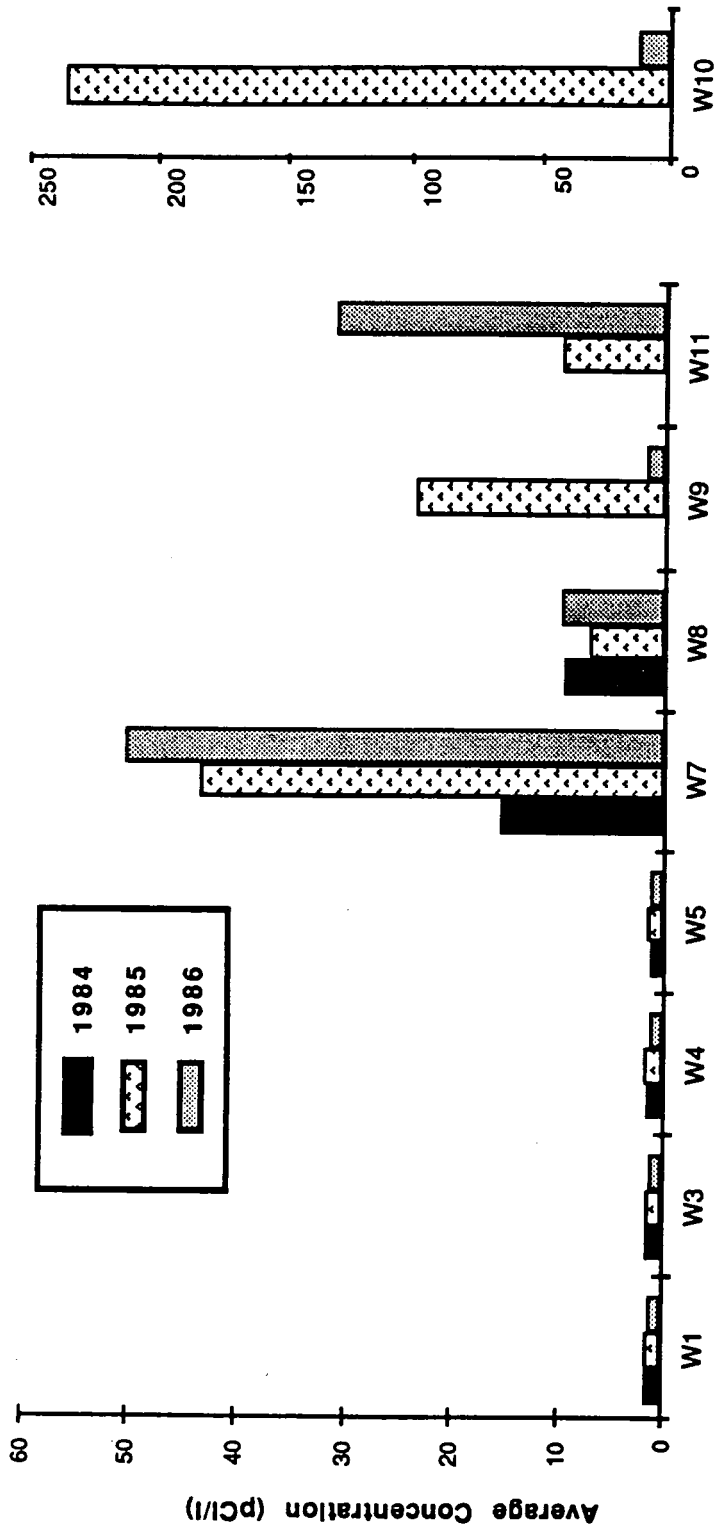

FIGURE 23: *Average Uranium Concentrations in Surface Water, 1984 to 1986*

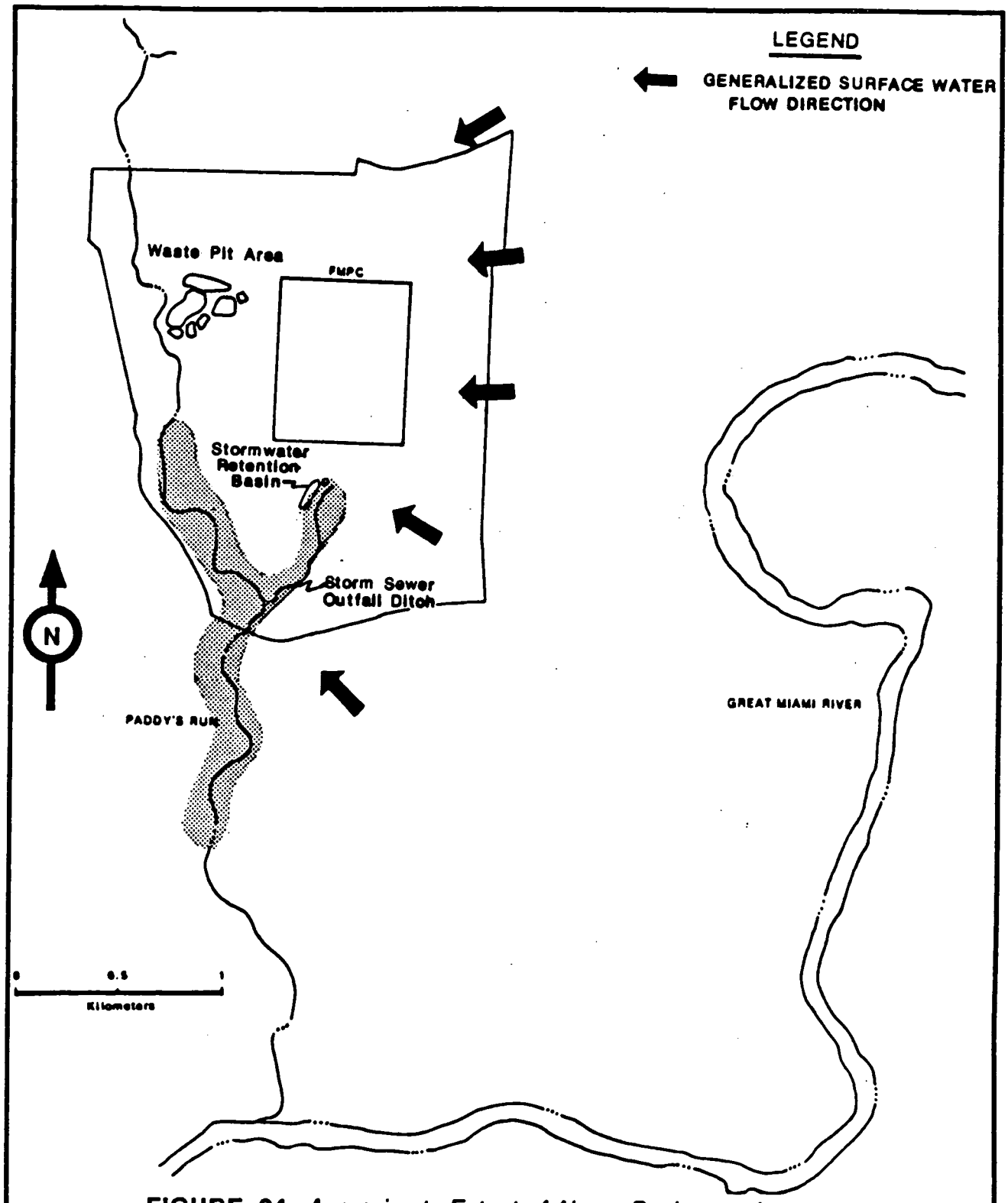

FIGURE 24: *Approximate Extent of Above-Background Uranium Concentrations in Surface Water Samples*

Note: Uranium concentrations in non-shaded areas are at or below background level of 1.35 pCi/l.

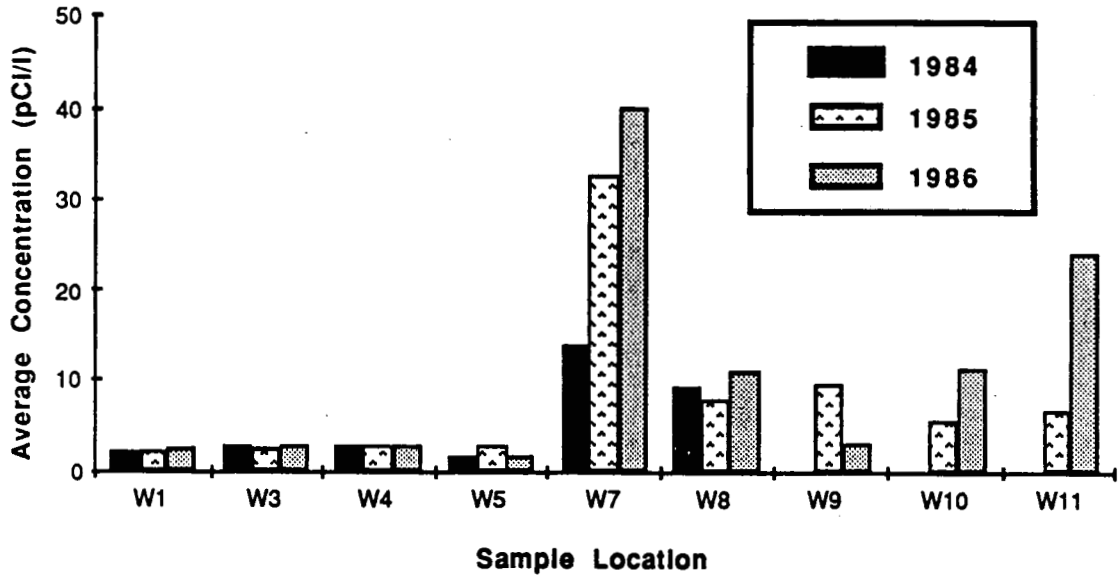

FIGURE 25: *Average Gross Alpha Concentrations In Surface Water, 1984 to 1986*

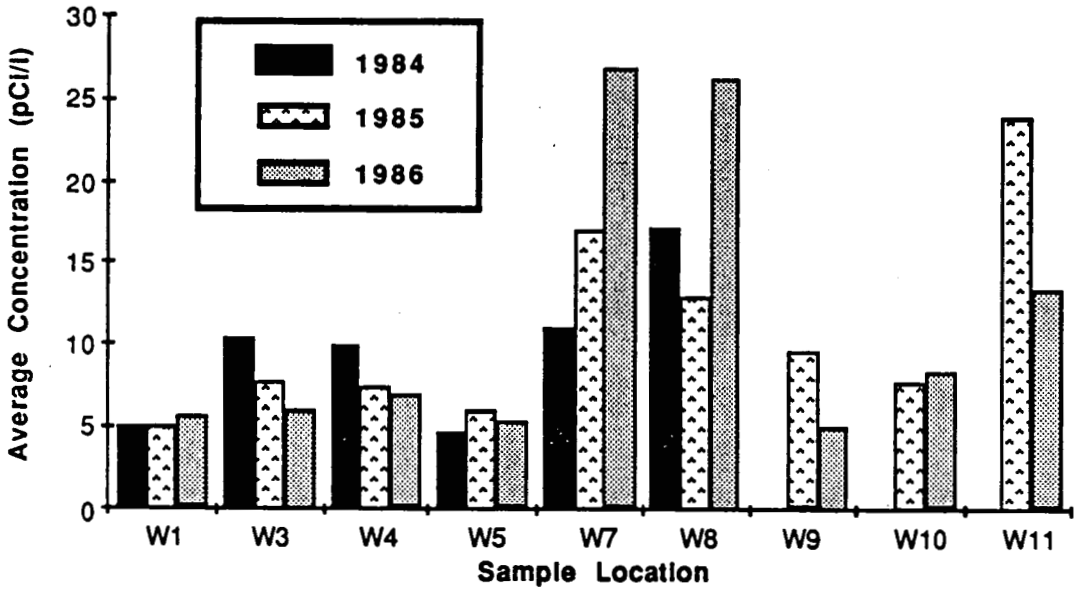

FIGURE 26: *Average Gross Beta Concentrations in Surface Water, 1984 to 1986*

Sampling Sediments

Sediment samples were collected and analyzed for radiological parameters from nine locations along the Great Miami River, and from 40 locations along Paddy's Run and the storm-sewer outfall ditch (Figure 27). These locations are combined into three regions of interest: Paddy's Run from the northern boundary of the FMPC to its confluence with the storm sewer-outfall ditch; Paddy's Run from the storm-sewer outfall ditch to the Great Miami River; and the entire storm-sewer outfall ditch. Each location in Paddy's Run and the storm-sewer outfall ditch consisted of three separate samples, one from each bank and one from the center of the stream bed. All sediments were analyzed for isotopic uranium, isotopic thorium, isotopic radium, isotopic plutonium, and technetium-99.

Uranium concentrations in sediment samples collected along the Great Miami River above the FMPC outfall to the river are at background levels that would commonly be found in the area (Table 14). There was no significant difference between the average concentrations found in the samples from locations upstream or downstream of the FMPC effluent line to the Great Miami River or between riverbank and midstream sediments. Therefore, it appears that all locations sampled in the Great Miami River exhibited radionuclide concentrations that were natural background for the area.

Radionuclide concentrations in sediment samples collected from Paddy's Run and the storm-sewer outfall ditch varied from location to location (Table 14). Uranium concentrations in the sediments from Paddy's Run and the storm-sewer outfall ditch did not follow concentration trends for uranium in surface water from Paddy's Run. In 1986, the highest radionuclide concentrations in sediments (considered to be above background levels) were found within the storm-sewer outfall ditch near the stormwater retention basin, and in Paddy's Run near its confluence with the storm-sewer outfall ditch.

In general, concentrations of most radionuclides decreased from the origin of the storm-sewer outfall ditch to its confluence with Paddy's Run. Concentrations of most radioisotopes across the profile of Paddy's Run and the storm-sewer outfall ditch did not follow any cross-sectional trend, but slightly higher isotope concentrations were associated with bends, pools, areas where sediments tended to settle, or where infiltration may have occurred. Variations that exist between locations may also be due to sediment flushing during heavy storms.

Sampling Soil

As part of the soil monitoring program, samples were collected from each of the 15 annual routine on- and off-site locations (Figure 28), and at 13 farm/garden produce sampling sites which are both remote and close to the FMPC (Figure 29). The discussion on farm/garden soils is deferred to the section "Sampling Farm/Garden Produce." Each routine soil sample was made up of a composite of ten cores 2 cm (about 1 inch) in diameter and 5 cm (about 2 inches) deep. If possible, vegetation was not included in the sample. The cores were taken at two depths (0-5 cm (0-2 inches) and 5-10 cm (2-4 inches)) within the soil profile, and were obtained from each corner and the center of two 1 m^2 (about 11 ft^2) grids.

Soils sampled at the annual routine locations were analyzed for uranium, and concentrations from the first 5 cm (2 inches) depth were generally higher than 1985 results at the same depth (Table 15 and Figure 30). Different laboratories were used to analyze uranium in soil in 1985 and 1986, and may account for this difference. Uranium concentrations from the 0-5 cm (2 inches) depth did not differ significantly from concentrations at the 5-10 cm (2 to 4 inches) depth. Further study and attention will be given to this in the future.

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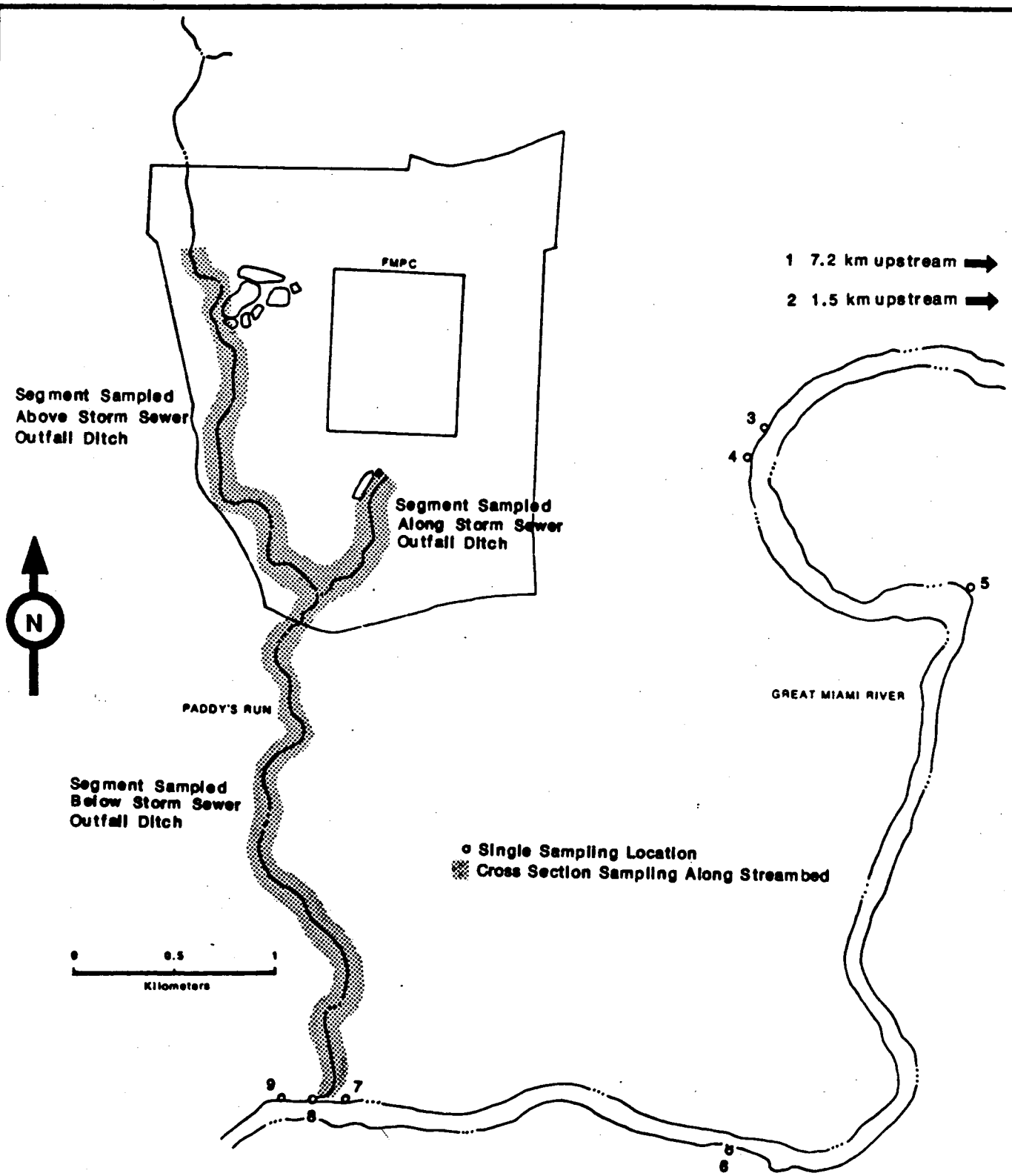

FIGURE 27: *Sediment Sampling Locations*

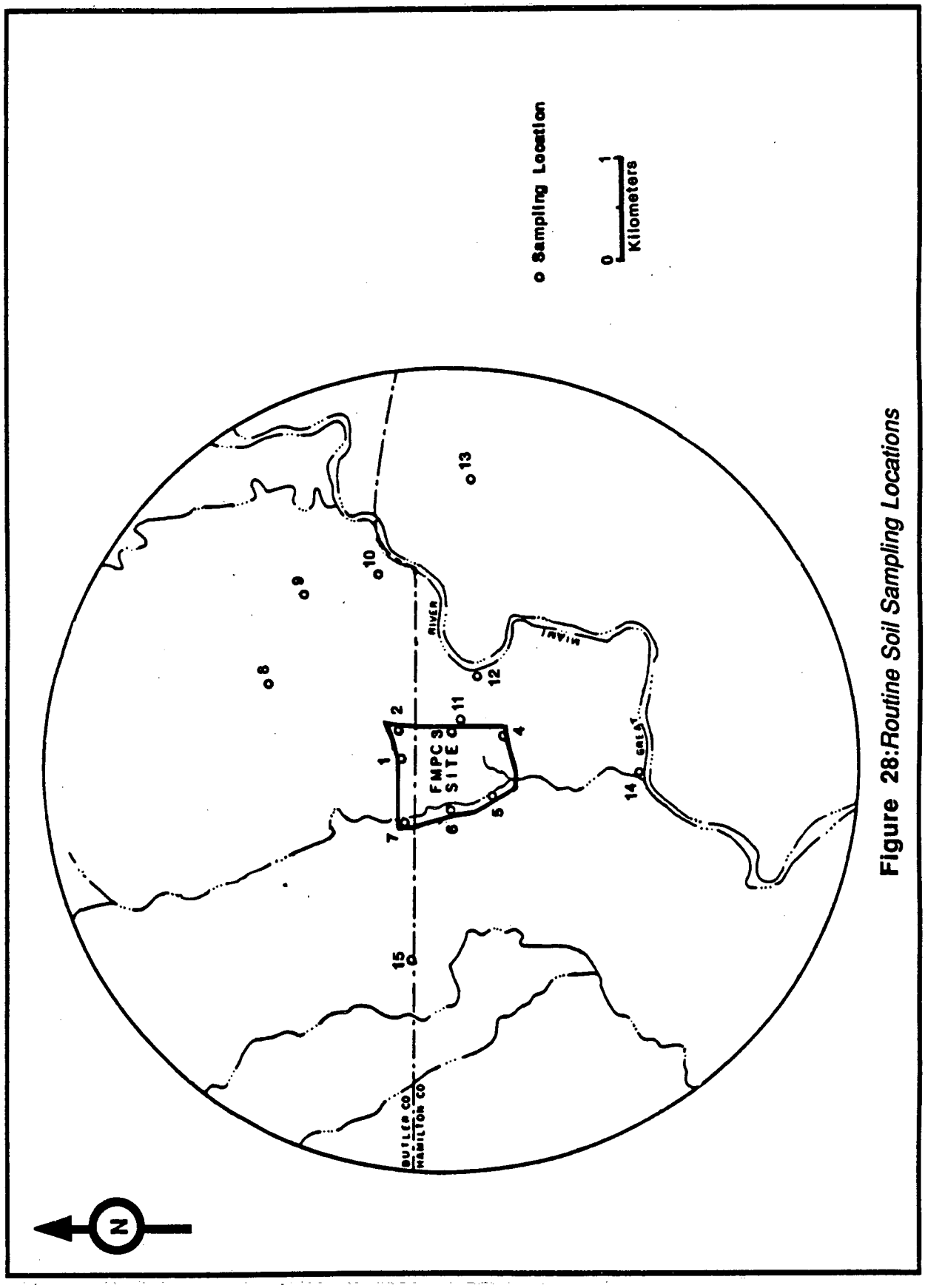

Figure 28: *Routine Soil Sampling Locations*

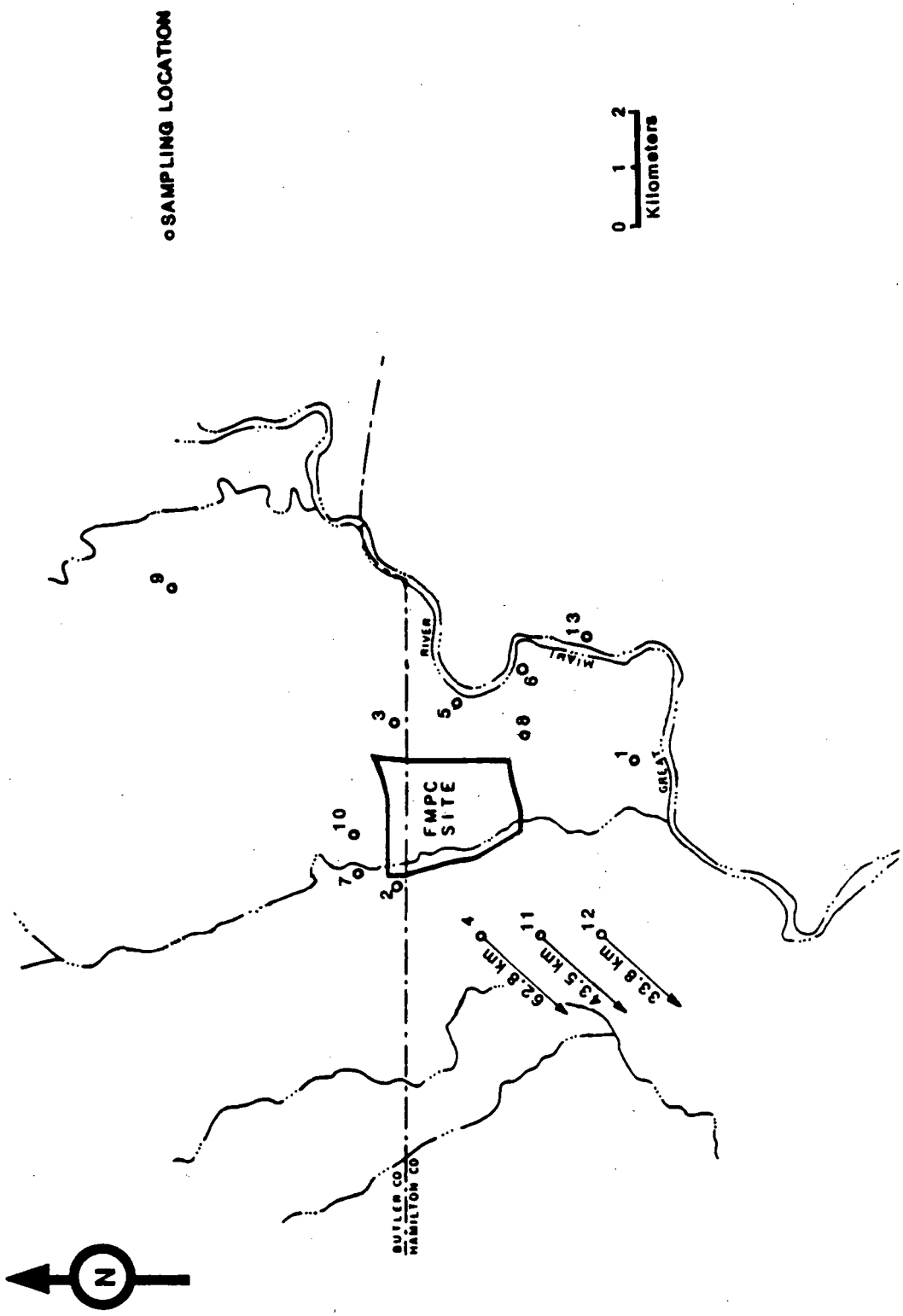

Figure 29: *Sampling Locations for Farm/Garden Produce*

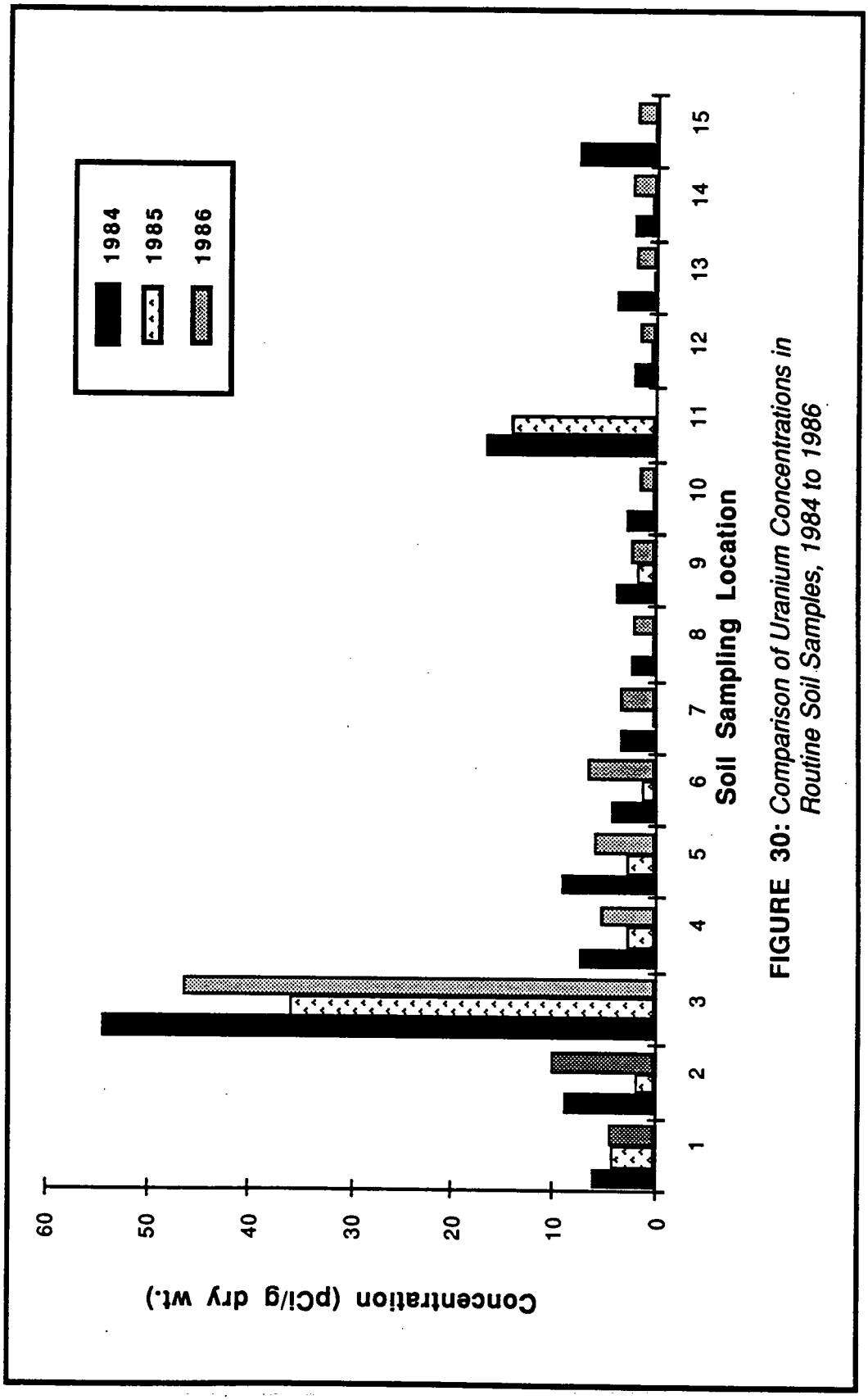

FIGURE 30: *Comparison of Uranium Concentrations in Routine Soil Samples, 1984 to 1986*

The highest uranium concentrations in the soil were measured near the eastern boundary of the FMPC and probably remain from the former operation of an incinerator adjacent to the sewage treatment plant. No DOE or EPA standards have been established for most soil radionuclide levels. A concentration of 35 pCi (1.3 Bq) of uranium per gram (≈50 ppm) of soils is the level generally used in the DOE's remedial action programs for acceptance of decontaminated areas, whereas naturally occurring uranium-238 concentrations in Ohio range from 0.6 pCi/g (0.02 Bq/g) to 2.2 pCi/g (0.08 Bq/g).[9 10] Total uranium is approximately twice this concentration since two major isotopes of uranium (U-238 and U-234) are considered to occur together naturally in equal activities in soil. In 1986, all locations showed slightly higher uranium concentrations than in 1985. All off-site locations showed soil uranium concentrations within the range considered background (values listed above) for southwestern Ohio.

Sampling Vegetation

Samples of grass and other vegetation were collected during 1986 (Figure 31). Each vegetation sample was a composite of a number of subsamples in order to provide approximately 500 g (wet weight) total. Each subsample consisted of all above-ground plant material (material was clipped near ground level) from a 0.5 m (about 1.5 feet) diameter circular quadrant (5 such subsamples = 1 m^2 (about 11 ft^2) of ground cover). After collecting the vegetation samples, each sample was air dried before analysis for uranium and fluoride.

Uranium concentrations in grass ranged from 0.06 pCi/g dry wt (0.002 Bq/g dry wt) to 5 pCi/g dry wt (0.2 Bq/g dry wt) (Table 16). There was no association between the uranium concentration in the vegetation at each sampling point and the distance from the FMPC; the concentrations of uranium were insignificant.

Sampling Farm/Garden Produce

Radionuclides that occur naturally or are deposited in the soil may be taken up by plants and animals and ultimately find their way into the human food chain. In order to monitor produce grown in areas surrounding the FMPC and at remote distances, samples of vegetables, soil, and fertilizer from area farms/gardens were examined (Figure 29). Soil and fertilizer were analyzed for uranium only, while vegetables were analyzed for isotopes of thorium as well as uranium.

Leafy vegetables, roots and stems, and fruits did not show significantly different concentrations of uranium and thorium. Uranium concentrations in vegetables were generally lower than those found in grass samples. A large percentage of vegetables analyzed exhibited concentrations of uranium and thorium that were less than detectable levels. There was no association between any radionuclide, distance from the FMPC (remote or otherwise), vegetable type, or farm from which they came (Tables 17, 18, 19, 20).

No relationship was found between soil or fertilizer and uranium concentrations in vegetables (Table 17). Uranium concentrations in fertilizer were generally higher than in soil found on the farms in which that fertilizer was used. Uranium concentrations were not associated with thorium concentrations in the same samples; therefore, the uptake of uranium and thorium may be independent.

Sampling Milk

On six occasions in 1986, the FMPC sampled the milk produced by cows grazing on the FMPC land adjacent to the site, and in Kentucky, about 30 km (19 mi) southeast of the FMPC (Table 21). The levels of uranium present in the samples from each of these locations were consistently less than 6.8 pCi/l (0.25 Bq/l) and did not vary between the two locations. One sample of milk was analyzed for alpha, beta, isotopic uranium, isotopic radium, isotopic thorium, strontium-90, and technetium-99. All concentrations were less than detectable except

for strontium-90, radium-226 and beta, which were at concentrations considered to be natural background. Beta activity in milk is probably due to naturally occurring potassium-40.

Sampling Fish

Fish were collected from three areas of the Great Miami River in September 1986, with the aid of a fisheries research team from the University of Cincinnati (Figure 32). Electroshocking techniques resulted in the collection of 334 fish representing 24 species: 74 from sampling location 1; 79 from location 2; and 181 from location 3. The fish from each location were initially placed in plastic bags and packed in ice, then later scaled and the heads and entrails removed. A fish was filleted if its total weight was greater than 800-900 g (about 2 lb). The fillets were then frozen, packed in dry ice, and shipped to an independent testing lab for analysis, along with the fish that were not filleted.

The University of Cincinnati determined that the fish populations in the Great Miami River have not changed appreciably since 1984. The same types of fish were collected in the same types of habitats in the river. Some river habitats changed from 1984 to 1986 due to gravel quarrying. University of Cincinnati scientists suggest that populations of fish throughout the river between 1984 and 1986 are healthy.

The overall average uranium concentration in fish collected in 1986 was statistically lower than the average for fish collected in 1985 and 1984. Average uranium concentrations in fish were lowest at the FMPC outfall to the Great Miami River and were the highest downstream (Table 22); however, the differences in uranium concentration between any of the locations or between species were not significant.

Nonradiological Parameters

In addition to monitoring radiological parameters, the FMPC monitors production processes for nonradiological pollutants including sulfur dioxide and nitrous oxide emissions into the air, and nitrate and dissolved solids into the water. Control of these and other nonradiological parameters improve the quality of the environment, and this section describes the procedures and techniques used to accomplish this.

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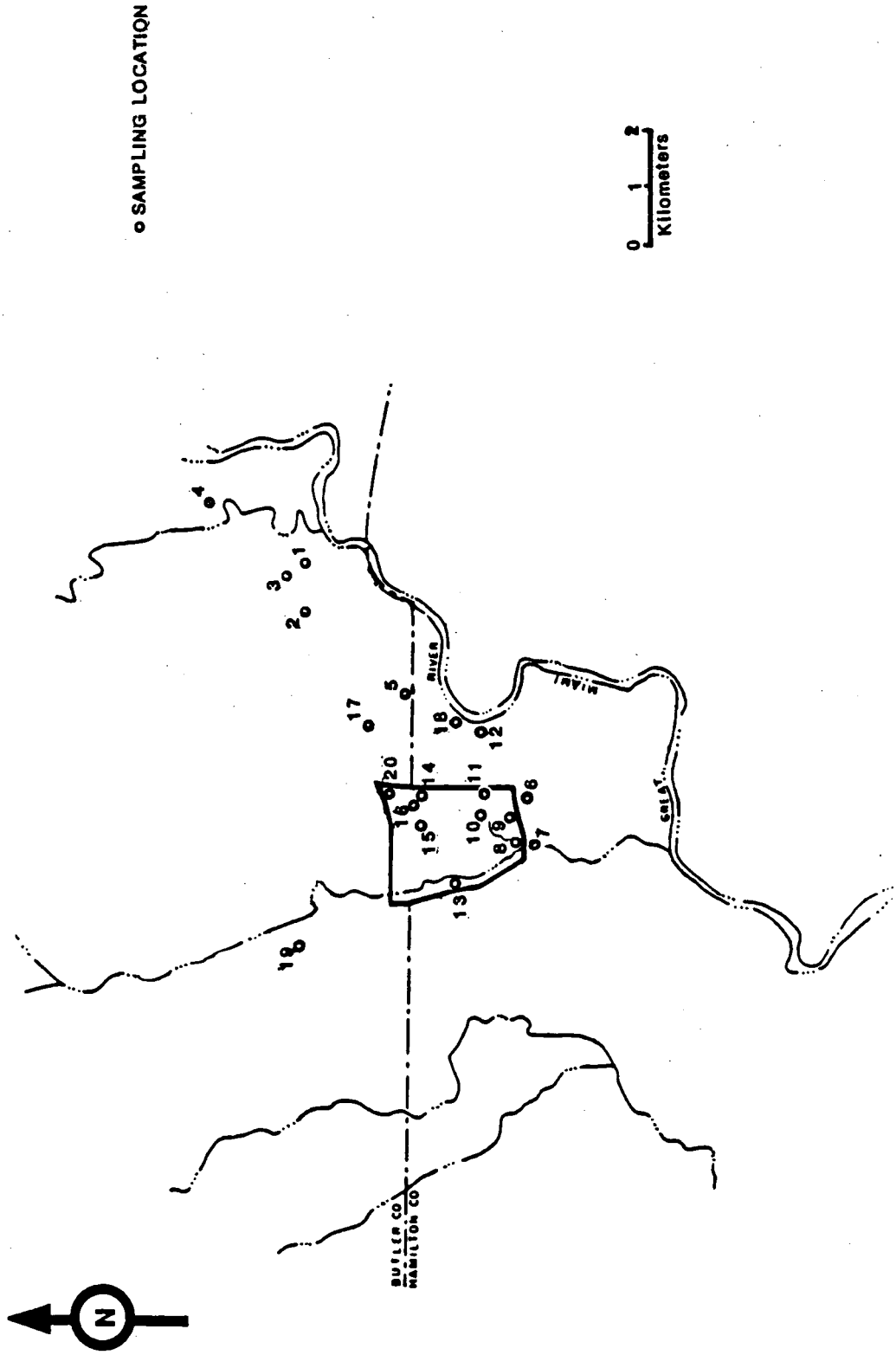

Figure 31: *Vegetation Sampling Locations*

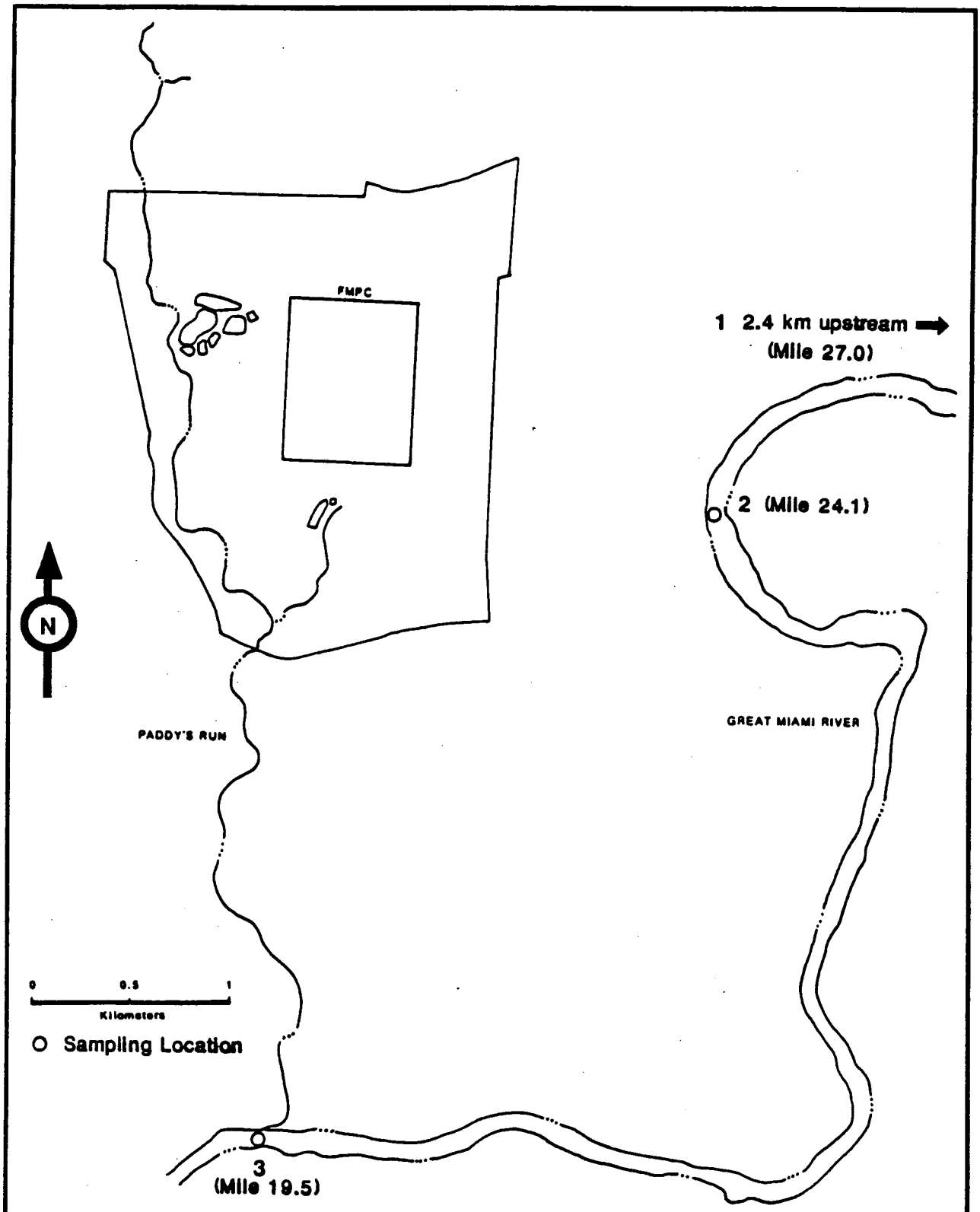

FIGURE 32: *Fish Sampling Locations*

Sampling the Air for Nonradiological Parameters

There are several types of nonradiological emissions at the FMPC, including particulates, sulfur dioxide (SO_2), and nitrous oxide (NOx). The FMPC carefully controls these emissions, keeping the levels as low as practicable.

Section 3745-17-11 of the Ohio Administrative Code establishes the maximum permissible levels of particulate emissions from industrial processes.[11] At the FMPC, particulate emissions from these processes are well within the established guidelines.

The 1986 results of the analysis of total suspended particulate concentrations from the FMPC site-boundary air-monitoring stations ranged from 32 to 39 $\mu g/m^3$, and were approximately the same as the 1984 and 1985 results (Table 4; Figure 33). As in 1984 and 1985, the highest average concentration of particles in 1986 was found at AMS 4 (formerly BS4), located at the southeast corner of the FMPC. This elevated concentration at AMS 4 may be due to its location near a large tract of flat farmland where wind-borne dust is more prevalent. The 1986 results indicate a slight reduction in particle concentrations at AMS 4, AMS 5, AMS 6, and AMS 7 from 1984 and 1985 results. Particle concentrations fluctuated at AMS 1, AMS 2, and AMS 3 between 1984 and 1986.

The OEPA establishes the limits for particulates emitted by the steam-generation plant at the FMPC. Electrostatic precipitators maintain these emissions at the FMPC below the limit of 0.09 kg (0.19 lb) per million British Thermal Units (BTU) input.

The OEPA also sets the limits for SO_2 emissions for stationary facilities. Under these rules, SO_2 emissions from the steam-generation plant are limited to 1 kg (2.2 lb) of SO_2 per million BTU input from each of the two boilers. This limit could be reached if the FMPC used coal containing 1.3% or greater sulfur. To ensure that the SO_2 emission limits are not exceeded at the FMPC steam-generation plant, coal containing less than 1% sulfur is used.

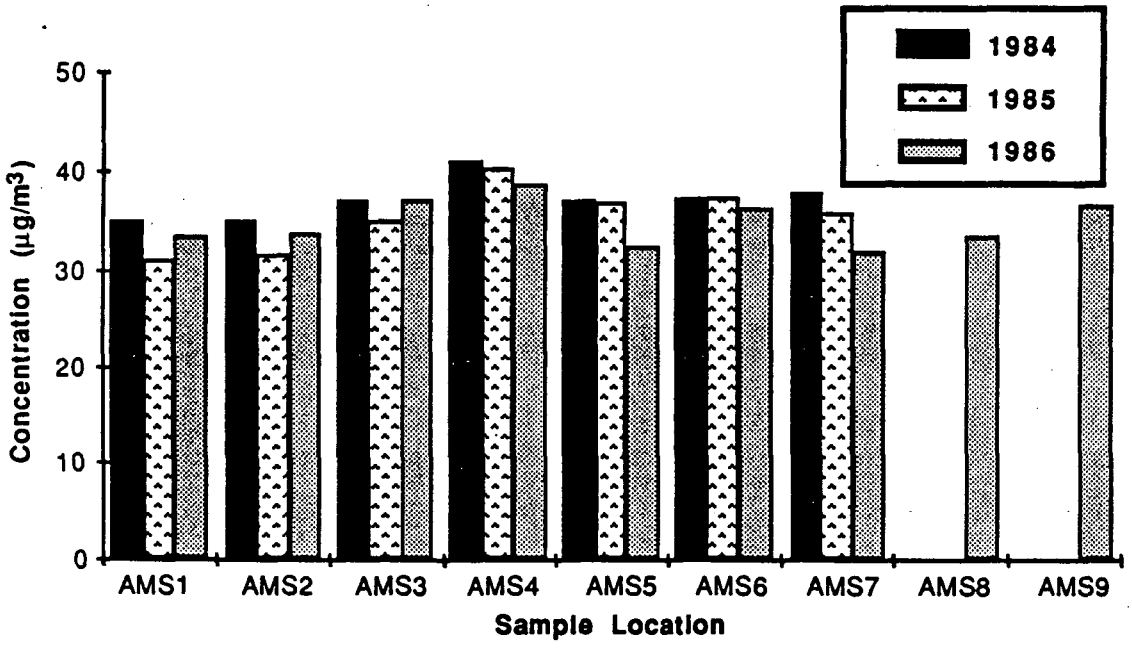

FIGURE 33: *Particulate Concentrations in Air, 1984 to 1986*

The State of Ohio has no established NOx emission limits for industrial process sources. Presently the FMPC maintains NOx emissions standards at 100 ppm NOx, which is below the visible range. This standard is maintained by ventilating potential sources of NOx to a bubblecap tower where they are scrubbed before they are released into the atmosphere. Smaller sources of potential NOx emissions exist at the FMPC which are not ventilated through a scrubber system. Efforts are continuing to develop systems to reduce emissions from these facilities.

Sampling Groundwater for Nonradiological Parameters

Results of groundwater sampling are compared to National Primary and Secondary Drinking Water Regulations as well as the Federal guidelines for radiation protection.

Analyses of 80 nonradiological parameters were performed as part of the quarterly RCRA groundwater monitoring program (also described in the radiological groundwater sampling section). These parameters were selected to assess general water quality, drinking water suitability, and the presence of metals, organics and other pollutants in the groundwater underlying the FMPC and vicinity. The results for RCRA quarterly samples 2 and 3 are found in Appendix B, but final analysis of the data has not been made since the results of the fourth quarter are not yet available.

However, the following general conclusions can be made from the results of the first three quarters of RCRA sampling:

- Groundwater contamination by organic chemicals is not a widespread problem at the FMPC
- Till wells near the waste pit area have above-background levels of some metals, radionuclides, and inorganic anions
- Some sand and gravel wells in the waste pit and plant area also have elevated levels of some metals, radionuclides and some inorganic anions.

RCRA data also show that nitrate, sulfate, chloride, calcium, manganese, sodium, potassium, total dissolved solids, and coliform bacteria are significantly higher in well T10 than they are in any other on-site monitoring well in the sand and gravel aquifer.

Studies by WMCO have shown that contaminated surface water from west of the Plant 1 storage pad is seeping into the casing of well T10 after periods of rainfall. WMCO plans to solve this problem in 1987 by regrading the land surface so it slopes away from the well and by resealing the cement well cap. The Remedial Investigation/Feasibility Studies (RI/FS) will investigate other possible sources of contamination of this well by drilling additional wells between T10 and the waste pit area and the FMPC sanitary landfill. RCRA data now available, however, show a significant difference in chemical constituents in well T10 and three wells immediately adjacent to waste pit 4 and well T1s just east of Pit 2.

Nitrate concentrations were also analyzed in the quarterly on-site groundwater monitoring program. The 1986 average results for nitrate concentrations in all on-site wells were less than 3 mg/l except for well T10, which averaged 154 mg/l (Table 23, Figure 34). Nitrate levels in wells T9 and P1 increased slightly in 1986 from 1985 levels, while levels in wells T4, T1s, and T10 decreased slightly. Wells T9 and T4 also have slightly elevated nitrate levels, which may be due to their proximity to Paddy's Run. Surface water, like Paddy's Run, generally has higher nitrate levels than groundwater due to agricultural runoff. All on-site wells had nitrate levels below the USEPA drinking water standards (10 mg/l) except well T10.

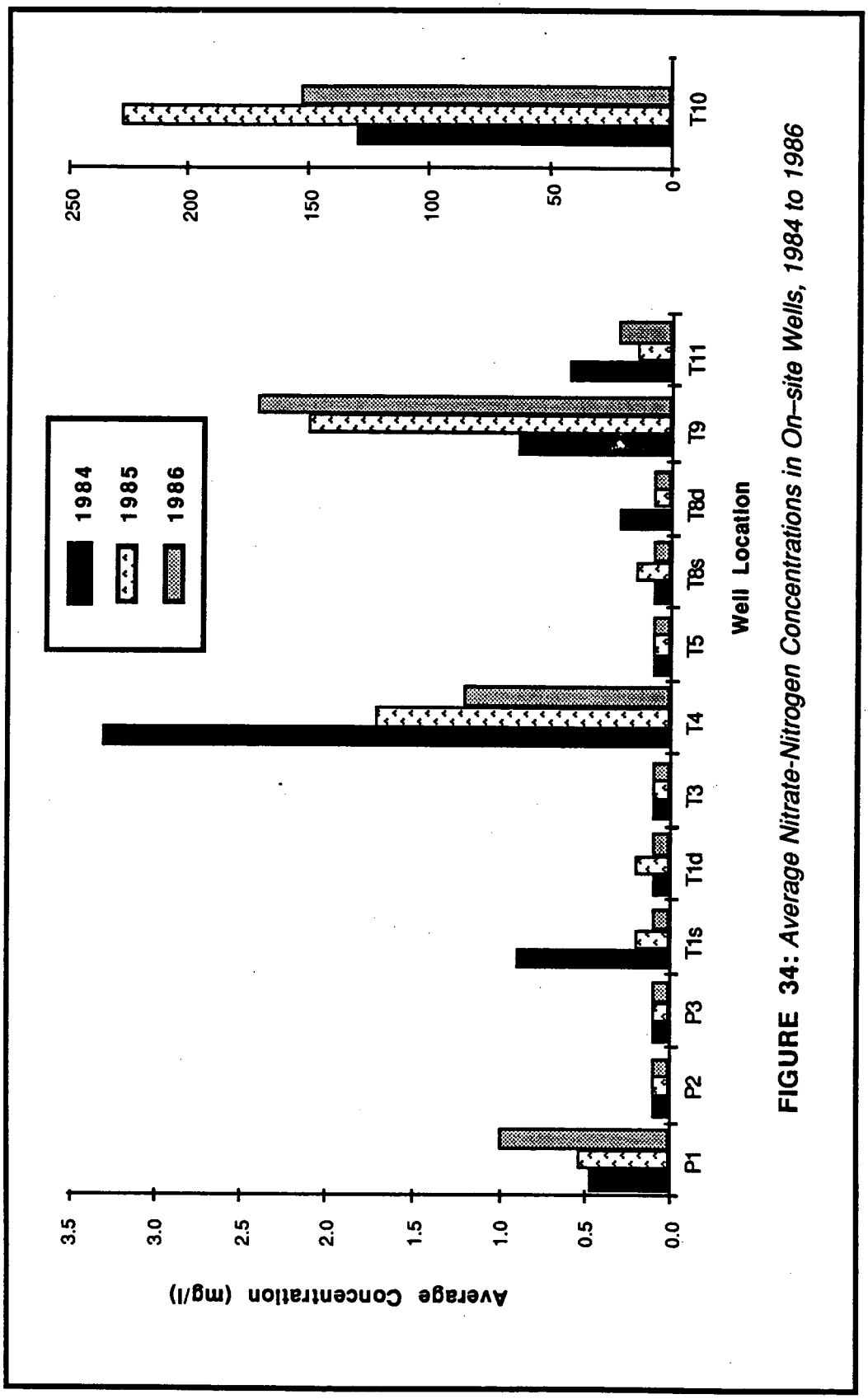

FIGURE 34: *Average Nitrate-Nitrogen Concentrations in On-site Wells, 1984 to 1986*

The quarterly on-site samples were also analyzed for sulfate, chloride, and pH (Tables 24, 25, and 26). Values for pH remained relatively constant in 1985 and 1986. The 1986 chloride and sulfate results correlate closely to those of 1985, with well T10 exhibiting the highest average concentrations for both of these parameters. The average chloride concentration in well T10 increased in 1986, but other wells did not exhibit clear-cut trends. Sulfate concentrations in FMPC on-site wells range from 10 mg/l in T8d to 672 mg/l in T10. Average sulfate concentrations in wells T1s and T8s were slightly higher in 1986, but were lower in T3, T5, T9 and T10. Average sulfate levels in individual wells vary considerably from year to year. All on-site wells had chloride levels below the USEPA drinking water standard of 250 mg/l. Only well T10 had sulfate levels above the USEPA standard of 250 mg/l for drinking water.

Additional special samples were collected from 24 off-site wells in March 1986, and analyzed for 16 metals. The wells are identified and the results provided in Table 27. Concentrations of calcium, iron, and manganese were high, but this is typical for groundwater in this area.[12] Concentrations of silver, arsenic, barium, cadmium, chromium, copper, lead, selenium, and zinc were well below USEPA drinking water guidelines.[13 14] These analyses show that the FMPC is probably not a source of metals, other than possibly uranium, in off-site groundwater.

Sampling Surface Water for Nonradiological Parameters

Criteria used for nonradioactive contaminants in water from the Great Miami River and Paddy's Run are taken from standards adopted by the OEPA.[15] Nonradiological liquid effluent discharged from the FMPC is regulated by the Ohio EPA as part of NPDES. In the State of Ohio, water quality standards for rivers and streams apply only beyond a specified zone permitted for mixing and dilution of industrial and municipal effluents. That means an area of water surrounding the FMPC outfall can have levels of contaminants higher than OEPA standards. But WMCO monitors the levels of contaminants directly at the FMPC outfall in order to better understand the effects of its operations on surface water.

To improve the quality of its liquid effluents, the FMPC has also designed a water pollution control project, consisting of four subprojects:

- Biodenitrification System
- Stormwater Retention Basin
- Coal Pile Runoff Collection System
- Ultraviolet Disinfection of Sewage Effluent.

The Biodenitrification Project (BDN), currently undergoing a demonstration run and testing, will lower the nitrate concentrations of discharges into the Great Miami River. Test runs in 1986 showed that the BDN project did lower nitrate levels in the process waste water. The stormwater retention basin, completed and brought into operation in October 1986, should lessen the potential for groundwater pollution from infiltration of contaminated runoff in the storm-sewer outfall ditch and Paddy's Run. The third subproject, the Coal Pile Runoff Collection System, collects and transports runoff from the coal-storage area for treatment. The Ultraviolet Disinfection of Sewage Effluent Project replaces chlorine as a disinfectant for the effluent at the Sewage Treatment Plant.

There are six locations on-site that require NPDES permits, which are issued by Region V of the EPA and administered by the Ohio EPA. The FMPC must characterize effluent streams by analyzing samples collected at these six specific locations (Figure 20). The permits specify sampling schedules, and the results are reported monthly to both the U.S. and Ohio EPA.

Over 1700 samples were collected at the six locations to support NPDES surveillance and monitoring. The results indicated that the facility met the NPDES daily maximum or monthly average permit limits more than 99% of the time in 1986 (Table 28). More than 50% of the noncompliances in 1986 involved the sanitary-sewage treatment plant. It exceeded the limit for five-day biochemical oxygen demand (BOD_5) four times, the limit for total suspended solids three times, and the limit for

fecal coliform bacteria one time. Approximately 25% of noncompliances in 1986 involved the storm-sewer outfall, which exceeded the limit for total suspended solids four times. Approximately 20% of the noncompliances involved the general sump and the clearwell. They exceeded the limit for hexavalent chromium three times in 1986. Immediate corrective actions have been taken; long-term solutions will be studied and implemented.

As measured in 1986 at NPDES Discharge 001, the FMPC discharged an average of 0.022 m^3/sec (0.5 million gallons of water per day (MGD)) into the Great Miami River, a 10% increase over 1985 discharges. In 1986, an average of 568 m^3 (0.15 million gallons) of additional runoff water was discharged into Paddy's Run via the storm-sewer outfall ditch each time the stormwater retention system overflowed. Two overflow events were recorded during the time the basin was in operation in 1986.

The average nitrate concentrations in the plant effluent at Discharge 001 decreased to 78 mg/l in 1986 from 217 mg/l in 1985. This was probably due to a decrease in the operation of the Refinery, which is a major source of nitrates in FMPC effluents. During rainfalls, stormwater overflow at the storm-sewer outfall ditch decreased to an average of 0.0066 m^3/sec (0.15 MGD) in 1986 from 0.0079 m^3/sec (0.18 MGD) in 1985. This was due to a decrease in precipitation and the operation of the stormwater retention basin.

Weekly grab samples were also taken and analyzed for various nonradiological parameters at locations W1, W3 and W4 in the Great Miami River and at locations W5, W7, W8, W9, W10, and W11 along Paddy's Run (Figure 19). The results of this sampling are presented in Table 29.

Figure 35 shows the nitrate-nitrogen concentrations in surface water at W1, W3, W4, W7, W8, W9, W10 and W11 from 1984 to 1986. Nitrate concentrations have remained relatively constant from 1984 to 1986, although concentrations at sampling points W5 and W11 decreased during this period. In all cases, average nitrate concentrations are higher in the Great Miami River (W1, W3, W4) than in Paddy's Run. This may be caused by the discharge of municipal and industrial wastes, which are sources of nitrates, into the river upstream of the FMPC. The data also indicated that operations at the FMPC do not affect nitrate levels in Paddy's Run since there are no significant differences between upstream or downstream concentrations of nitrates in Paddy's Run. Nitrate levels in both Paddy's Run and the Great Miami River are below the USEPA drinking water standard of 10 mg/l.

Figure 36 shows the average fluoride concentrations in surface water at locations W1, W3, W4, W5, W7, W8, W9, W10 and W11 from 1984 to 1986. The average fluoride levels at locations W1, W3, W4 (the Great Miami River) are higher than those in Paddy's Run, except for location W7. Fluoride levels in 1986 were relatively low (0.5 mg/l or less), and these levels are below the USEPA drinking water standards of 1.4 to 2.4 mg/l. This standard is temperature dependent.

Sampling Other Media for Nonradiological Parameters

The overall average fluoride concentration of 5.3 µg/g (ppm) detected in vegetation in 1986 was about 7% of the Kentucky standard of 80 ppm (Table 16). A Kentucky standard was used for comparisons because Ohio does not have a standard. Fluoride concentrations in grass ranged from 3.8 ppm to 7.6 ppm. There was no association between the observed fluoride concentration at each sampling point and the distance from the FMPC.

The collection and analysis of data enable the FMPC to monitor the effects of its operations on the environment. The next chapter describes incidents and environmental studies performed at the FMPC by other organizations.

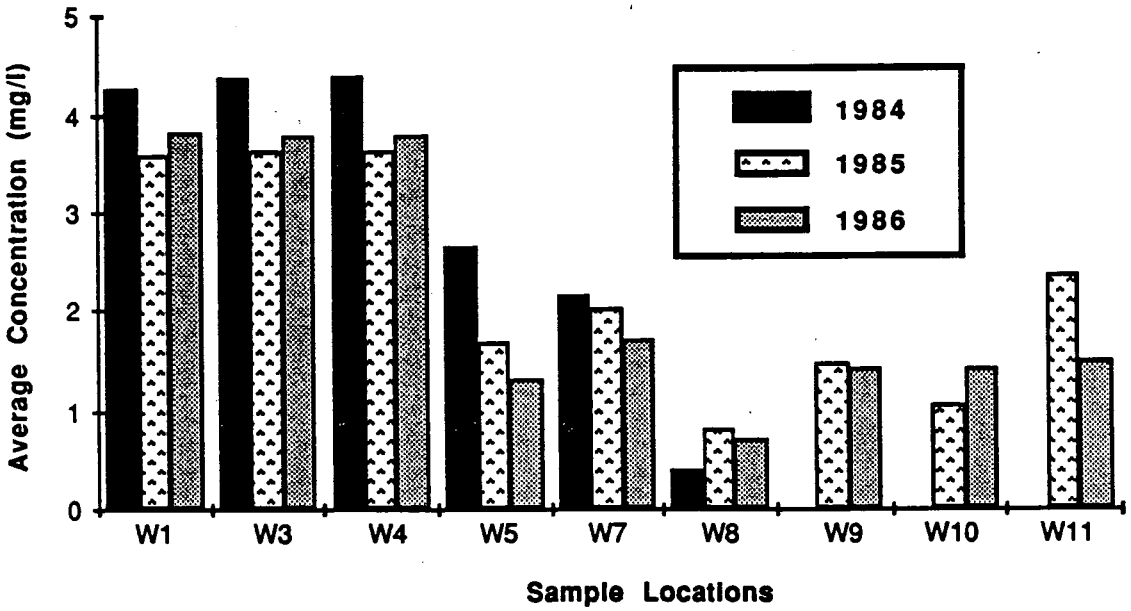

FIGURE 35: *Average Nitrate-Nitrogen Concentrations in Surface Water, 1984 to 1986*

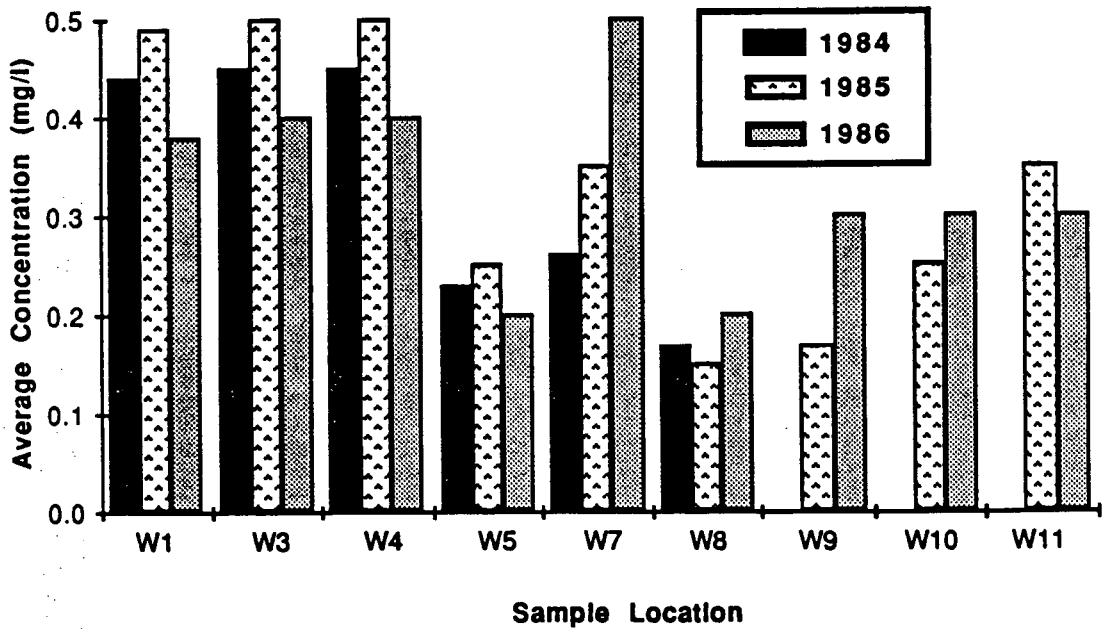

FIGURE 36: *Average Fluoride Concentrations in Surface Water, 1984 to 1986*

Chapter Six — Significant Events and Special Studies

In addition to the data collections and analysis performed by WMCO, several additional studies were completed by outside organizations. These were performed to support WMCO's work and to investigate a number of significant events that occurred at the FMPC during 1986. The studies discussed in this chapter include:

- The Pilot Plant release of uranium hexafluoride
- An aerial survey conducted by EG&G, Inc.
- Investigations of the K-65 Silos
- Water and soil studies by IT Corporation
- Historical discharges of uranium
- Plant 4 uranium trioxide spill
- Investigations of unusual gamma radiation in Paddy's Run by Dames & Moore
- An ecological study by Miami University
- FMPC-OEPA split sampling.

Pilot Plant Release of Uranium Hexafluoride

On January 19, 1986, reaction vessel #2 in the Pilot Plant facility cracked, releasing uranium hexafluoride (UF_6) gas to the atmosphere. The FMPC thoroughly investigated the accident, and estimated the maximum possible amount of UF_6 released (and the maximum amount of uranium). In addition, the FMPC also estimated the effect of this release on the people living near the site.

The analysis showed that the maximum amount of UF_6 that could have been released is 9.8 kg (21.6 lb). Therefore, the maximum amount of uranium in that amount is 6.6 kg (14.5 lb). Using site meteorological data and dose conversion factors published by the International Commission on Radiological Protection, the FMPC calculated the maximum possible effective dose equivalent to the nearest resident downwind at the time of the accident at 0.04 mrem (4×10^{-4} mSv). The estimated maximum possible dose to the nearest resident is approximately 2500 times less than the average annual background radiation dose each resident of this area receives. A similar calculation of the maximum possible effective dose equivalent received by the entire downwind population within 80 km (48 mi) as a result of this release was 0.08 person-rem (8×10^{-4} person-Sv).

EG&G Aerial Survey

In 1985, EG&G, Inc. conducted an aerial survey of the FMPC and surrounding areas for radiation due to gamma emission, both on-site and off-site.[16] Data was collected from a

height of 46 m (150 ft). The survey was similar to one performed in 1979 by EG&G, Inc.[17]

Data collected both by technicians using an ion chamber elevated 1 m (39 in) from the ground surface and by soil analysis support the data collected during the aerial survey. The average reading is 10.4 µR/hr (2.7×10^{-6} C/kg/hr). This value is representative of all off-site locations and may represent background or natural levels, except for an area directly west of the K-65 Silos.

According to EG&G, this area exhibited "shine" from the silos. Shine is a measured increase in background radiation, but is actually due to radiation from another location that has changed direction by scattering off intervening air molecules. This means shine appears to originate from a location other than the actual source; this was confirmed by data from soil samples taken in the shine area. The data indicated surface deposition and contamination were not responsible for the radiation levels detected in the ion chamber survey.

In 1985, EG&G conducted a soil-sampling program. Concentrations of uranium-238 at most off-site locations were fairly typical of values found throughout the United States. The EG&G survey identified two areas off-site that had higher concentrations of uranium than are considered natural background for the area. The study also found the maximum uranium deposition rate occurred in the past in the area of the retired incinerator on the eastern perimeter of the FMPC site.

On-site radiation levels varied from background levels to over 350 µR/hr (9.0×10^{-5} C/kg/hr) directly above the K-65 Silos and some storage facilities within the FMPC production area. Control measures are taken to limit exposures in these areas of the FMPC. The location where the public could potentially incur the maximum exposure rate is at the FMPC fenceline directly west of the K-65 Silos. That exposure rate was measured as 19 µR/hr (4.9×10^{-6} C/kg/hr) or approximately twice the natural background (Table 2). No areas of elevated activity were found outside the plant boundaries, and no hazards to the public are noted.

Investigating the K-65 Silos

Four waste-storage silos are located near the waste storage area along the northwest region of the site. Silos 1 and 2, both encased by an earthen embankment, contain refinery residues from the processing of pitchblende ores. These residues, or tailings, contain radium-226.

Silo 3 contains similar tailings, but they are from the processing of non-pitchblende ore concentrates and contain only low levels of radium. Silo 4 is empty. Several projects were undertaken in 1986 to improve the reliability and life-expectancy of the silos, and they are discussed in the following paragraphs.

K-65 Silos Remediation Project

Several projects were undertaken in 1986 to improve the life expectancy of the K-65 Silos. In January 1986, 20 ft diameter covers were placed over the deteriorating silo domes, and a subcontractor began applying a weatherproof coating to the domes. On April 25, 1986, one of the silos was vented to the atmosphere for several hours. A subsequent DOE investigation concluded that the venting caused no significant environmental impact, although slightly elevated levels of radon were detected off-site.[22] However, the weatherproofing application was suspended until additional engineering studies are completed.

Martin Marietta Energy Systems Review of K-65 Silo Data

In October 1986, members of the Radiological Survey Activities Group of ORNL visited the FMPC to review environmental radiological data and methodology relating to the K-65 Silos, and to perform gamma exposure rate

measurements at various locations around the facility.

Evaluation of past radon monitoring data at off-site locations near the K-65 Silos indicated average radon levels (including background) at the nearest locations of 0.8 pCi/l (0.03 Bq/l). This is well below the current standard of 3.0 pCi/l (0.1 Bq/l) above background specified by DOE for release to an uncontrolled area.

Martin Marietta judged that the radon monitoring methodology used until 1986 adequately addressed the effect of radon from the K-65 Silos on the surrounding environment. Since a significant part of this plan was being terminated in 1986 (see the following section "Mound Laboratory Radon Monitoring Study"), Martin Marietta also evaluated the radon monitoring plan proposed for 1987 by FMPC. The proposed plan (see "Expanded FMPC Radon Monitoring" in this chapter) was also judged adequate to quantify average radon concentrations. Martin Marietta made several suggestions to improve the quality of data obtained, all of which have been incorporated into the plan.

Initially, the results of the data review of direct gamma exposure rate measurement near the K-65 Silos indicated that WMCO may have been overestimating these levels by approximately 20 to 30%. This was later confirmed by direct measurements. Current measurement procedures have been modified to provide accurate results. All data presented in this report have had this correction factor incorporated.

Mound Laboratory Radon Monitoring Study

Between September 1984 and October 1986, another DOE site, Mound Laboratory of Miamisburg, Ohio, monitored radon concentrations at 20 locations on-site and off-site at the FMPC. Using passive environmental radon monitors (PERMs), Mound Laboratory took weekly or biweekly readings. An interim report of results has been issued; however, a preliminary review of the PERM data by Martin Marietta indicated that radon levels in the vicinity of the K-65 Silos were elevated above background, as expected. However, the maximum off-site levels were about one-sixth of the current DOE standard of 3.0 pCi/l (0.1 Bq/l) above background for release to uncontrolled areas.

Expanded FMPC Radon Monitoring

When the Mound Laboratory Radon Monitoring Program was discontinued in October 1986, all PERM detectors were replaced with track-etch cup radon detectors so that data collection would continue for the remainder of the calendar year. At the same time, an expanded radon monitoring program was developed for 1987. It incorporates both radon- and radon-plus-thoron-sensitive track-etch cups in each of 16 cardinal-compass directions centered around the K-65 Silos, at the FMPC site boundary, and at the fence surrounding the K-65 Silos.

Studies by the IT Corporation

The IT Corporation conducted an extensive sampling and analysis program in 1986. Data was obtained for use in litigation involving the former operating contractor, NLO. Some samples were taken on the FMPC site, but most were off-site within a 5-mile radius. Soil, surface water, groundwater, sediment, and vegetation samples were taken. Results were furnished to landowners.[18]

Sampling Surface and Groundwater

One part of IT Corporation's work was a study of surface and groundwater at the FMPC. IT Corporation reviewed historical data and installed six groundwater-monitoring wells. They sampled groundwater at these and existing wells, and also sampled surface water, plant effluent outfalls, and stream sediments. The IT Corporation identified off-site wells 8, 12, 13, 15, and 21 as having above-background concentrations of uranium, although only wells

12, 15, and 17 have been previously identified in this and past FMPC Environmental Monitoring Annual Reports as having above-background levels of uranium.[5]

IT Corporation's analytical results agree with the 1986 monthly average uranium concentrations for wells 12, 13, and 15. Even though the results for well 13 are within the natural background concentration range in all data sets, the values reported by IT Corporation show it as above background.

However, analytical data from IT Corporation and the FMPC environmental monitoring studies for wells 8 and 21 do not agree. IT Corporation reported the concentration in well 8 as 1.4 pCi/l (0.05 Bq/l) and in well 21 as 4.1 pCi/l (0.15 Bq/l). Monthly samples for the annual environmental monitoring program showed an average of 0.54 and 0.27 pCi/l (0.02 and 0.01 Bq/l) for the two wells, respectively. WMCO conducts monthly sampling to support routine environmental monitoring; however, IT Corporation's conclusions are based on one set of samples. Therefore, conclusions for these wells should be based only on careful consideration of all data available.

Sampling Soil

The IT Corporation extensively sampled soils within a 5-mile radius of the FMPC. The sampling program identified the median concentration of total uranium in the soil by quadrant and distance from the FMPC (Figure 37). The results appear to agree with WMCO's findings. Most concentrations of uranium found at off-site locations were fairly typical of concentrations found throughout the United States, although the northeast quadrants (out to 3 miles in radius) had concentrations slightly above these average values for the United States.[19]

Historical Discharges of Uranium

Information about FMPC radionuclide discharges was presented in a report covering the period from plant start-up in 1951 through 1984.[23] This information was compiled to permit the calculation of the radiation dose to the public resulting from FMPC operations. Dose calculations are now being developed and will be included in a future Environmental Monitoring Report.

In the radionuclide discharge report, both airborne and waterborne discharges were considered. The information includes the quantity of uranium discharged each year, enrichment data, discharge of thorium, radium and fission products, and the particle size distribution of particulates in dust collector material. This data show that the total uranium discharged to the air from 1951 to 1984 was estimated to be 136,000 kgU. A summary of uranium discharges is presented in Appendix C.

The radionuclide discharge report is a revision of a similar document published one year earlier.[24] Comments from the U.S. EPA, Ohio EPA, Centers for Disease Control, and the Department of Energy were considered in the revision. The principle comments from these reviewers centered on the need for estimated airborne discharges during the first years of operation when dust collector stack monitoring was intermittent. These comments were resolved in the revised report issued in 1986.

Plant 4 Uranium Trioxide Spill

On November 11, 1986, a release of approximately 230 pounds of uranium trioxide (UO_3) containing 26 parts per billion (ppb) plutonium occurred from the Plant 4, Bank 9 fluid bed reactor system used to convert UO_3 to uranium tetrafluoride (UF_4). The release incident was reported to DOE and the Ohio Disaster Services Agency (ODSA). An investigation was conducted and the results are summarized below.[25]

The release of material was confined within the established contamination control zone. Personnel radiation exposures were less than 1 % of the radiation protection standards. Cleanup of the released material returned the area contamination levels to pre-incident levels within twenty-four hours.

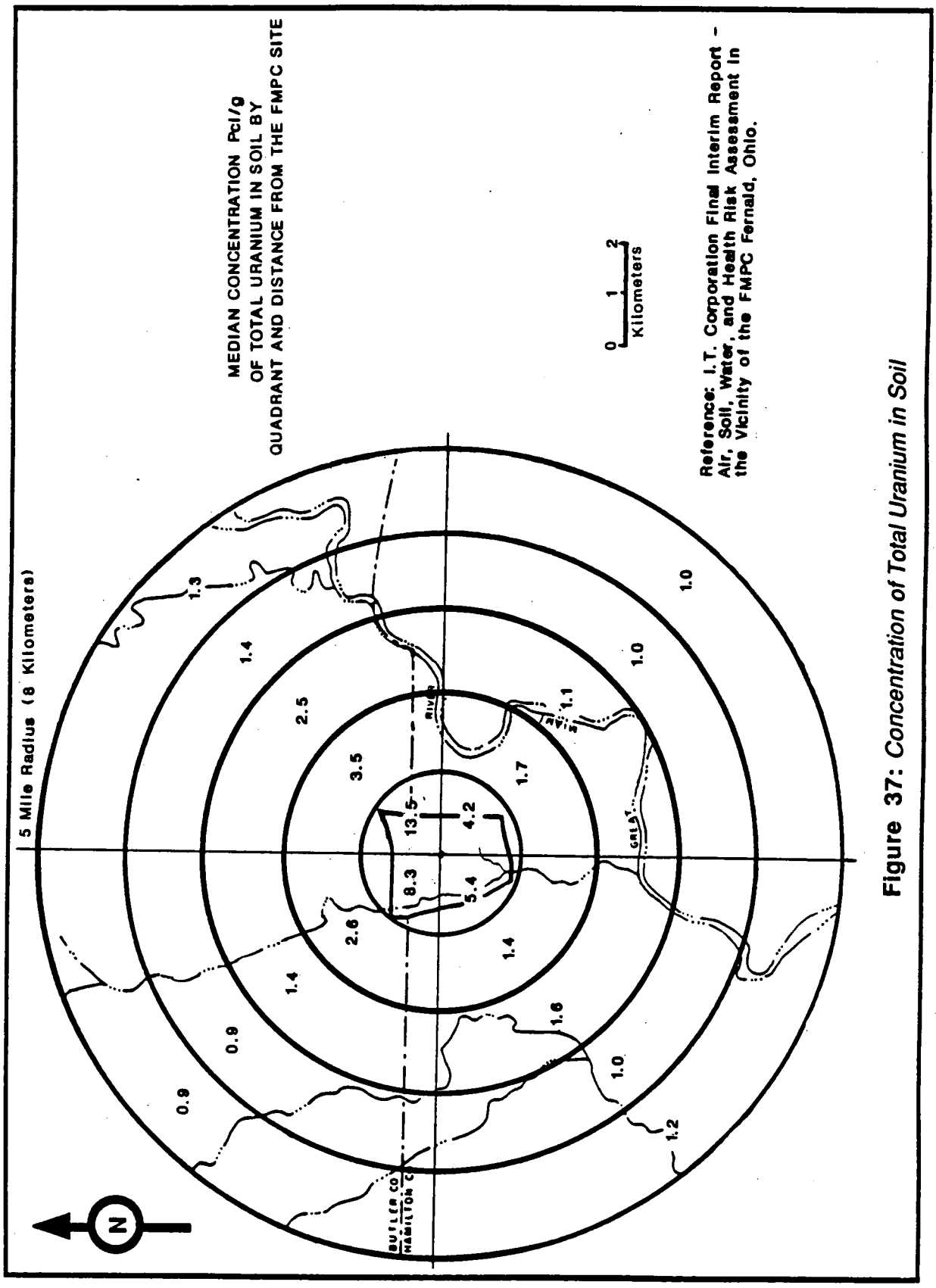

Figure 37: *Concentration of Total Uranium in Soil*

The primary cause of the incident was the stopping of the feed conveyor screw in a position that allowed for an open path for the UO_3 to flow through freely. The one missing and one loose bolt contributed to the severity of the incident. The above situations existed due to a lack of design engineering and were not identified due to a lack of systematic design change review and facility inspection.

Dames and Moore Study

In May 1986, a radiological survey and subsequent sampling program was conducted along Paddy's Run by Dames & Moore to verify the existence of areas of sediment containing elevated levels of uranium.[20] Such areas of uranium-contaminated sediment had previously been postulated as a potential source of the above-background uranium levels detected in three off-site wells.[5] Measurements of gamma radiation levels were made from the FMPC railroad bridge downstream in Paddy's Run Creek bed to its confluence with the Great Miami River. In addition, sediment samples were taken from both the east and west banks of Paddy's Run at approximately 25 ft intervals in the section of the creek closest to the K-65 Silos.

Although a final report on the survey and sampling program has not yet been received, preliminary data identified two areas of unusually high gamma radiation levels (50 μR/hr and 30 μR/hr, which are 5 and 3 times greater than background for the area, respectively). In November 1986, WMCO conducted its own radiological survey of the two areas. One very small area of above-background gamma activity was found. (An area of about one meter or three feet in diameter, reading approximately 25 μR/hr maximum was found on the ground surface.)

Before soil sampling could be accomplished, several heavy rains raised the water level in Paddy's Run Creek above the area identified. When the water subsided enough to allow sampling, the area in question was no longer significantly above background. However, one sample was obtained from that area and was analyzed. Concentrations of Ra-224, Ra-226, and Ra-228 were higher in this one sample than in Paddy's Run below the storm-sewer outfall ditch in 1986. Analysis of this sample indicates that concentrations of other radionuclides were similar to concentrations found for routine environmental samples in this area. No explanation for this is possible at this time, and further study and attention will be given to this in the future.

When Paddy's Run Creek dries sufficiently in the spring of 1987, WMCO will again survey the length of Paddy's Run Creek from the FMPC railroad bridge to its confluence with the Great Miami River to look for soils containing elevated levels of uranium or thorium.

FMPC Ecological Study

Miami University was contracted by WMCO to perform a comprehensive ecological study of the FMPC in the summer of 1986. The purpose of this study was to identify the organisms present on the FMPC site, and to study the flora and fauna included in the major habitats within the FMPC (excluding the production center, parking lots, construction sites, and waste storage area).

Six distinct habitats were identified at the FMPC, and permanent sampling locations were established there (Figure 38). Populations of the following groups of living organisms were counted:

- Herbaceous plants
- Woody plants
- Terrestrial insects, birds and small mammals
- Game animals
- Aquatic plants and animals from Paddy's Run.

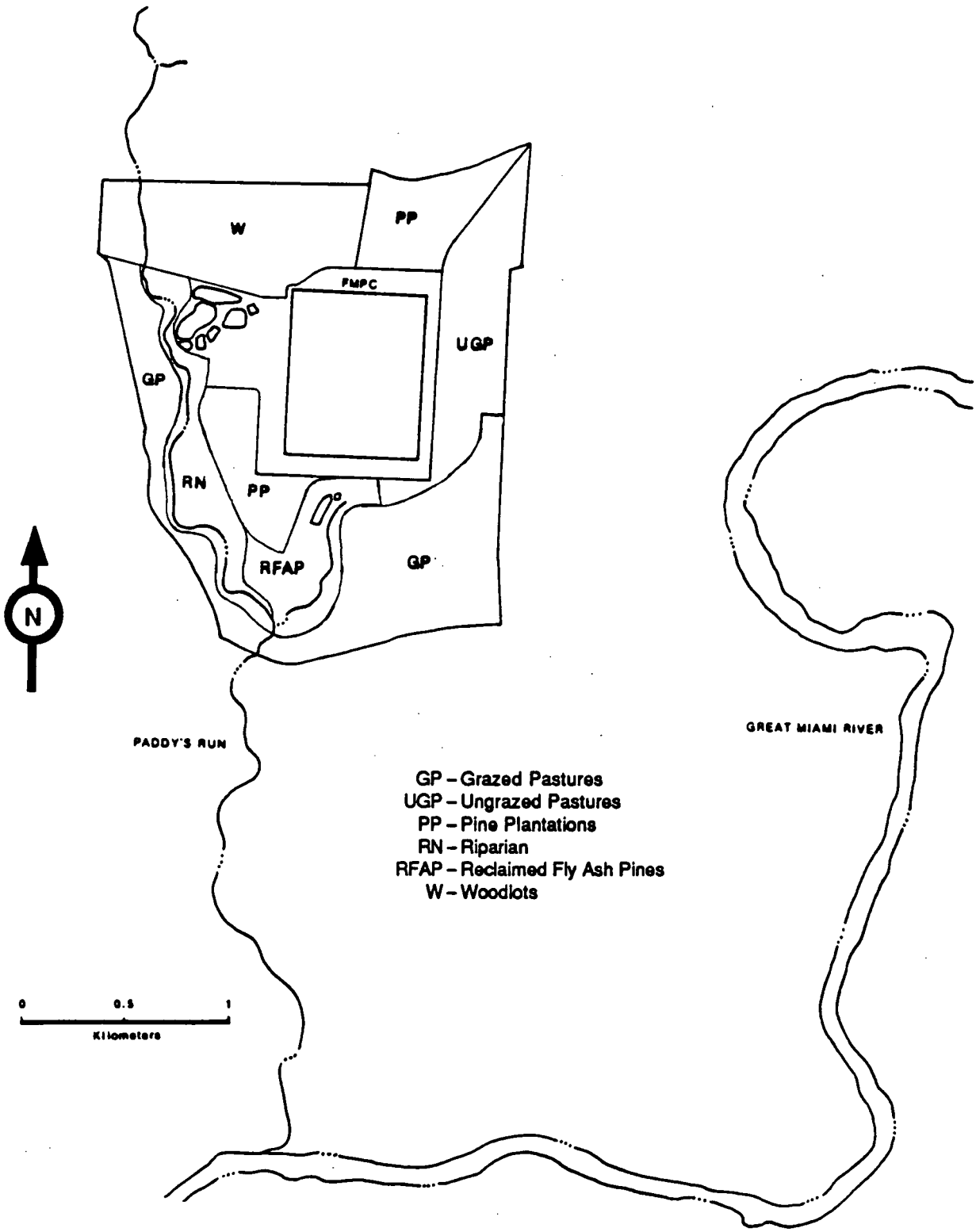

FIGURE 38: *Generalized Habitats on the FMPC*

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This study noted apparently healthy populations of most organisms on the FMPC site. Some populations at the FMPC appeared stressed in the same way as populations off-site may be stressed by construction and farming, and by drought conditions that were present as the study was taking place. Future ecological studies are being planned.

FMPC-OEPA Split Sampling

In 1986, the FMPC participated in a split sampling program with the Ohio EPA to further enhance the quality assurance program at the FMPC. Surface water, groundwater, and soil samples were collected both on and off the FMPC site. Only water sample data is presently available for comparison. Water samples were analyzed for alpha, beta and uranium concentrations by WMCO and the OEPA, and a comparison of the results shows that the data are very similar with no great discrepancies.

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Appendix A — 1986 Results of FMPC Sampling Program

The FMPC designed and conducted numerous sampling procedures to give accurate indications of the effects of the facility's operation on the environment in 1986. The results of this sampling are provided in the tables on the following pages.

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TABLE 1: *Summary of Radiation Exposure Due to 1986 Emissions* [1]

Exposure	Organ	Dose Equivalent 50-year Commitment mrem	(mSv)	Standard[2] mrem	% of Standard
I. Maximum Individual Dose					
A. All Pathways from all Airborne Releases [3]	Effective	3.7×10^{-1}	(3.7×10^{-3})	1.0×10^{2}	0.37
	Whole Body[4]	2.2×10^{-4}	(2.2×10^{-6})	2.5×10^{1}	0.00088
	Bone Endosteum	3.9×10^{-1}	(3.9×10^{-3})	7.5×10^{1}	0.52
	Pulmonary	2.9×10^{0}	(2.9×10^{-2})	7.5×10^{1}	3.9
B. Ingestion[5]					
Great Miami River Water	Effective	6.0×10^{-3}	(6.0×10^{-5})	1.0×10^{2}	0.006
	Bone Endosteum	9.0×10^{-2}	(9.0×10^{-4})	5.0×10^{3}	0.0018
Off-site Well 15[6]	Effective	3.5×10^{1}	(3.5×10^{-1})	1.0×10^{2}	35.0
	Bone Endosteum	5.2×10^{2}	(5.2×10^{0})	5.0×10^{3}	10.4
C. Direct External Exposure	Whole Body[7]	1.8×10^{1}	(1.8×10^{-1})	1.0×10^{2}	18.0
II. Individual in Ross, Ohio Inhalation Pathway [5]	Effective	2.8×10^{-1}	(2.8×10^{-3})	1.0×10^{2}	0.28
	Bone Endosteum	5.4×10^{-1}	(5.4×10^{-3})	7.5×10^{1}	0.72
	Pulmonary	2.1×10^{0}	(2.1×10^{-2})	7.5×10^{1}	2.8
III. 80 km Population Total [3]	Effective	9.6×10^{0}	(9.6×10^{-2})	NA[8]	...
	Whole Body	6.6×10^{-3}	(6.6×10^{-5})	NA[8]	...
	Bone Endosteum	1.0×10^{1}	(1.0×10^{-1})	NA[8]	...
	Pulmonary	7.5×10^{1}	(7.5×10^{-1})	NA[8]	...

1. Including exposure due to Uranium, Sr-90, Tc-99, Ru-106, Cs-137, Np-237, Pu-238, Pu-239, Pu-240.
2. Standard: Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities, published November 14, 1985, adopts the standards of 40 CFR 61, Subpart H (NESHAP) for Air Pathway Exposure (25 mrem whole body, 75 mrem to any organ), and adopts the recommendations of ICRP 26 for prolonged periods of exposure for all pathways (100 mrem effective dose, 100 mrem whole body dose, 5 rem to any organ).
3. Dose calculations provided by ORNL using AIRDOS; 80 km population dose is expressed as person-rem.
4. Whole body dose equivalent provided by ORNL. It results from radionuclides not deposited throughout the body; therefore the whole body dose equivalent from all radionuclides released at FMPC results from external exposure only.
5. Dose equivalent calculation based on environmental measurements according to ICRP 26/30 Methodology. ICRP 26/30 based 50-year commitment dose conversion factors.
6. Off-site well 15 contained the highest concentration of uranium measured in off-site wells in 1986. Dose calculations show maximum hypothetical dose from off-site well water ingestion.
7. Calculated from measured exposure at the nearest residence west of the K-65 storage silos.
8. NA = Not Applicable.

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TABLE 2: *External Radiation Exposure, 1986*			
Sampling Location[1]	Exposure Rate[2] in µR/hr		
	Minimum	Maximum	Average
AMS 1	5.5	12.7	8.9
AMS 2	8.4	11.0	9.3
AMS 3	7.7	11.1	8.9
AMS 4	7.1	11.1	8.7
AMS 5	7.7	11.6	9.0
AMS 6	12.3	15.0	13.6
AMS 7	7.4	10.4	8.7
Background[3]			9.0

1. See Figure 3.
2. Continuous monitoring with environmental TLD's processed quarterly.
3. Background average exposure rate obtained from pressurized ionization chamber data at two offsite locations.

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TABLE 3: *Population Distribution Within 80 km (48 mi) of the FMPC*

Compass Sector	Estimated Population[1] 0-8 km (0-4.8 mi)	8-16 km (4.8-9.6 mi)	16-32 km (9.6-19.2 mi)	32-80 km (19.2-48 mi)
N	445	3,395	6,743	29,597
NNE	221	18,959	12,805	148,079
NE	489	32,001	36,705	557,783
ENE	2,489	25,760	29,830	55,078
E	512	40,770	70,762	85,240
ESE	713	54,533	150,630	107,365
SE	1,606	36,467	247,846	118,490
SSE	985	28,932	207,202	51,946
S	669	19,214	53,673	39,116
SSW	390	4,217	10,614	21,987
SW	185	2,957	13,066	16,574
WSW	440	4,961	3,930	19,199
W	519	1,765	3,292	31,629
WNW	157	1,361	5,211	21,605
NW	511	1,433	1,802	37,945
NNW	519	1,134	21,042	71,493
Totals	10,850	277,859	875,153	1,413,126
Total in all sectors: 2,576,988				

1. Based on "Report of Findings, Population Studies for DOE Feed Materials Production Center, Near Fernald, Ohio, for NLO, Inc.," May 18, 1981.

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TABLE 4: *Particulates, Uranium and Gross β Concentration in Air*

Sampling Location[1]	Particulates[2] μg/m³					Uranium[2] μCi/ml x 10^{-15}					Beta[2] μCi/ml x 10^{-15}				
	Number of Samples	Minimum	Maximum	Average	95% C.L.[3]	Number of Samples	Minimum	Maximum	Average	95% C.L.[3]	Number of Samples	Minimum	Maximum	Average	95% C.L.[3]
AMS 1	47	14.0	55.7	33.3	0.6	48	0.39	11.27	2.52	17.85	49	11.65	97.56	28.47	16.53
AMS 2	47	18.5	64.2	33.6	0.6	49	0.15	10.70	2.31	19.02	49	5.37	108.81	29.73	16.85
AMS 3	48	20.0	60.0	37.1	0.6	48	0.67	26.61	5.17	17.75	49	17.05	104.17	35.51	16.44
AMS 4	50	16.0	61.7	38.6	0.6	51	0.27	10.68	1.43	18.32	51	12.67	97.97	28.78	16.38
AMS 5	47	3.2	61.4	32.4	0.6	49	0.16	6.94	1.28	18.78	49	3.66	124.91	27.94	18.79
AMS 6	45	18.4	69.8	36.2	0.6	46	0.32	9.48	1.51	18.10	46	14.94	141.06	29.65	18.14
AMS 7	49	2.1	53.9	31.9	0.6	50	0.17	5.77	0.88	17.62	50	9.08	183.48	28.52	17.62
AMS 8	19	6.1	69.6	33.5	1.0	20	0.23	14.37	3.72	24.20	20	7.51	81.23	35.34	25.20
AMS 9	17	21.2	73.8	36.5	1.1	17	0.82	30.50	6.49	24.75	17	18.55	90.89	39.89	26.10

1. See Figure 3.
2. The following guidelines were used for comparison:
   a. Particulates = 75 μg/m³ (annual geometric mean) as stated in Ohio Administrative Code Number 3745-17-02.
   b. Uranium = 2.0 x 10^{-12} μCi/ml as stated in DOE Order 5480.1, Chapter XI. Attachment 1, Table 2.
   c. Gross β = 3.7 x 10^{-10} μCi/ml as stated in DOE Order 5480.1, Chapter XI. Attachment 1, Table 2.
3. C.L. = Average Concentration x + the value shown; derived from log-transformed data = t(α = 0.05, df) Sx.

TABLE 5: *Radionuclides in Air*

Concentration of Radionuclides at Air Monitoring Stations[1,2,3] in $\mu Ci/m^3 \times 10^{-12}$

Radionuclide	Derived Concentration Guides[4] $\mu Ci/m^3 \times 10^{-6}$	AMS 1	AMS 2	AMS 3	AMS 4	AMS 5	AMS 6	AMS 7	AMS 8	AMS 9
Cs-137	400	300 ± 60	320 ± 49	320 ± 68	300 ± 62	210 ± 49	320 ± 70	300 ± 59	<51	<38
Np-237	0.02	<0.35	<0.24	<0.41	<0.25	<0.38	<0.24	<0.23	<0.25	<0.25
Pu-238	0.03	0.24 ± 0.24	0.12 ± 0.12	1.2 ± 0.68	0.51 ± 0.38	1.1 ± 0.38	2.4 ± 0.12	<0.12	1.0 ± 0.38	11 ± 1.2
Pu-239/240	0.02	1.4 ± 0.6	0.86 ± 0.49	3.8 ± 1.1	0.25 ± 0.25	0.38 ± 0.19	0.84 ± 0.49	<0.12	1.0 ± 0.51	4.3 ± 0.76
Pu-241	1	7.3 ± 0.6	5.4 ± 0.04	14.0 ± 1.2	5.1 ± 0.65	2.6 ± 0.30	4.3 ± 0.59	2.0 ± 1.0	7.3 ± 5.1	27 ± 2.1
Ra-226	1	65 ± 21	49 ± 22	59 ± 26	30 ± 18	35 ± 16	30 ± 15	49 ± 19	41 ± 18	49 ± 21
Ra-228	3	<12	<12	<14	<13	<49	<12	<12	<62	<62
Ru-106[5]	30	1300 ± 430	1100 ± 240	1000 ± 620	1300 ± 460	1100 ± 350	1100 ± 430	1000 ± 430	<570	<810
Sr-90	9	970 ± 49	110 ± 73	23 ± 43	70 ± 49	46 ± 38	41 ± 41	65 ± 49	600 ± 110	51 ± 62
Tc-99	2000	1100 ± 78	490 ± 81	1600 ± 180	840 ± 84	380 ± 65	350 ± 51	570 ± 76	410 ± 120	970 ± 130
Th-228	0.04	5.4 ± 2	12 ± 3.8	19 ± 4.1	14 ± 3.8	6.2 ± 0.97	8.1 ± 1.4	5.1 ± 1.3	11 ± 1.4	20 ± 2.5
Th-230	0.04	17 ± 3.5	20 ± 4.9	51 ± 6.8	27 ± 5.1	14 ± 0.97	17 ± 2.4	11 ± 1.8	23 ± 2.5	27 ± 2.5
Th-232	0.007	3.8 ± 1.7	5.1 ± 2.7	14 ± 4.1	9.6 ± 2.7	5.6 ± 0.86	4.6 ± 1.1	4.1 ± 1.1	7.6 ± 1.0	9.2 ± 1.4
U-234	0.09	630 ± 20	780 ± 20	1500 ± 32	490 ± 16	290 ± 12	390 ± 15	220 ± 10	1300 ± 30	3400 ± 120
U-235	0.1	31 ± 0.7	39 ± 0.76	74 ± 1.1	24 ± 0.51	15 ± 0.32	20 ± 0.49	11 ± 0.29	65 ± 1.0	160 ± 3.0
U-236	0.1	39 ± 0.9	49 ± 0.86	90 ± 2.0	30 ± 0.62	18 ± 0.49	23 ± 0.59	13 ± 0.32	65 ± 1.2	160 ± 3.0
U-238	0.1	890 ± 15	1140 ± 15	2200 ± 35	620 ± 13	440 ± 10	600 ± 12	280 ± 8.1	2000 ± 32	4500 ± 78

1. See Figure 3.
2. Reported in units of $\mu Ci/m^3 \times 10^{-12}$ of air, uncertainties are counting uncertainties only at the 95% C.L.
3. A composite of 52 weekly samples for AMS 3, 53 samples for all other boundary stations.
4. Derived concentration guides from DOE Memo from W.A. Vaughan, August 5, 1985 to Joe Lagrone. Continuous inhalation of this concentration will result in an effective dose equivalent of less than 100 mrem/yr (1 mSv/yr).
5. Composite sample activity adjusted to midpoint of sampling.

TABLE 6: *Radon In Ambient Air*

Sampling Location[1]	Radon[2] pCi/l						
	Set 1[3]	Set 2	Set 3	Set 4	Set 5	1986 Average	1985 Average
AMS 1	0.31 (0.011)	0.14 (0.005)	0.83 (0.031)	0.50 (0.019)	1.40 (0.052)	0.64 (0.024)	0.81 (0.030)
AMS 2	0.37 (0.014)	0.61 (0.023)	1.12 (0.041)	0.50 (0.019)	1.60 (0.059)	0.84 (0.031)	0.82 (0.030)
AMS 3	0.60 (0.022)	1.04 (0.038)	0.54 (0.020)	0.50 (0.019)	0.70 (0.026)	0.68 (0.025)	0.28 (0.010)
AMS 4	0.55 (0.020)	0.40 (0.015)	0.70 (0.026)	0.50 (0.019)	0.60 (0.022)	0.55 (0.020)	0.56 (0.021)
AMS 5	0.43 (0.016)	0.18 (0.007)	0.91 (0.034)	1.00 (0.037)	0.40 (0.015)	0.58 (0.022)	0.80 (0.030)
AMS 6	0.33 (0.012)	0.81 (0.030)	0.91 (0.034)	0.70 (0.026)	0.50 (0.019)	0.65 (0.024)	0.67 (0.025)
AMS 7	0.31 (0.011)	0.98 (0.036)	1.51 (0.056)	1.40 (0.052)	0.60 (0.022)	0.96 (0.036)	1.01 (0.037)
AMS 8	...[4]	...	...	...	0.60 (0.022)	0.60 (0.022)	...
AMS 9	...	...	...	...	0.50 (0.019)	0.50 (0.019)	...
OS 1	0.19 (0.007)	1.29 (0.048)	0.50 (0.019)	0.40 (0.015)	0.60 (0.022)	0.60 (0.022)	0.59 (0.022)
OS 2	0.29 (0.011)	1.29 (0.048)	0.56 (0.021)	0.20 (0.007)	0.50 (0.019)	0.57 (0.021)	0.37 (0.014)
OS 3	...	...	...	...	0.80 (0.030)	0.80 (0.030)	...
OS 4	...	...	...	1.10 (0.041)	0.70 (0.026)	0.90 (0.033)	...
OS 5	...	...	...	0.60 (0.022)	0.80 (0.030)	0.70 (0.026)	...

1. See Figure 3.
2. Bq/l in parentheses.
3. Sets were replaced at about two month intervals.
4. "..." No data collected.

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TABLE 7: *Thoron (Rn-220) in Ambient Air,[1] 1986*

Sampling Location[2]	Rn-220 pCi/l Set 1[3]	Set 2[4]	Average
AMS 1	0.2	LD[5]	LD
AMS 2	0.0	LD	LD
AMS 3	LD	LD	LD
AMS 4	0.3	LD	LD
AMS 5	0.4	LD	LD
AMS 6	0.4	LD	LD
AMS 7	0.7	LD	0.20 (0.007)
AMS 8	- - - [6]	0.1	0.10 (0.004)
AMS 9	- - -	LD	LD
OS 1	0.2	0.3	0.25 (0.009)
OS 2	LD	0.1	LD
OS 3	- - -	0.3	0.30 (0.011)
OS 4	0.6	LD	0.25 (0.009)
OS 5	0.2	LD	LD

1. Calculated: (Rn-220 + Rn-222) - Rn-222 = Rn-220 (thoron); Bq/l in parentheses.
2. See Figure 3.
3. Third quarter, 1986.
4. Fourth quarter, 1986.
5. "LD" less than minimum detectable.
6. "- - -" No data collected.

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TABLE 8: *Uranium in Off-site Well Water, 1986*

Sampling Point[1]	Number of Samples	Concentration pCi/l					
		Minimum	Maximum	Average[2]		95% C.L.[3]	% of Standard[4]
1	12	0.270	0.54	.25	(.01)	0.054	0.05
2	NS[5]	NS	NS	NS	NS	NS	NS
3	12	0.081	0.54	.29	(.01)	0.081	0.05
4	12	0.81	2.16	1.09	(.04)	0.24	0.20
5	12	0.81	1.35	1.09	(.04)	0.16	0.20
6	11	0.81	1.62	1.08	(.04)	0.14	0.20
7	12	0.81	1.35	.95	(.04)	0.081	0.17
8	12	0.27	0.81	.55	(.02)	0.081	0.10
9	12	0.81	1.35	.81	(.03)	0.081	0.15
10	12	0.27	0.54	.39	(.01)	0.081	0.07
11	12	0.54	1.35	.91	(.03)	0.14	0.17
12	12	71	225	147	(5.44)	24.5	26.7
13	12	0.27	0.81	.41	(.02)	0.11	0.07
14	12	0.54	1.1	.68	(.03)	0.081	0.12
15	12	141	256	193	(7.15)	20.2	35.1
16	12	0.27	1.1	.47	(.02)	0.11	0.09
17	10	23	41	31	(1.2)	3.8	5.67
18	12	0.27	0.54	.30	(.01)	0.054	0.05
19	12	0.081	0.54	.21	(.01)	0.054	0.05
20	10	0.081	0.27	.15	(.01)	0.054	0.002
21	12	0.27	0.54	.29	(.01)	0.081	0.05
22	12	0.54	0.81	.61	(.02)	0.054	0.11
23	12	0.27	1.1	.56	(.02)	0.14	0.10
24	4[6]	0.27	0.54	.36	(.01)	0.054	0.07
25	12	0.081	0.54	.28	(.01)	0.081	0.05
26	12	0.27	0.54	.30	(.01)	0.081	0.05
27	6[7]	0.27	0.54	.38	(.01)	0.081	0.07

1. See Figure 11.
2. Bq/l in parentheses.
3. C.L. = Average Concentration ± the value shown in parentheses = $t(\alpha = 0.05, df)\ S\bar{x}$.
4. Percent of Standard relates to the average value reported. Standard used is 550 pCi/l (20.4 Bq/l) as stated in DOE Memo from W.A. Vaughan, August 5, 1985, to Joe LaGrone.
5. NS = Not Sampled at the homeowner's request.
6. Quarterly determination at homeowner's request.
7. Due to a change in sampling locations, only five samples taken at this location were used in statistical analyses.

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TABLE 9: *Uranium in On-site Well Water, 1986*

Sampling Point[1]	Number of Samples	Concentration pCi/l					
		Minimum	Maximum	Average[2]		95% C.L.[3]	% of Standard[4]
P1	4	0.068	0.27	0.20	(0.0080)	0.22	0.037
P2	4	0.068	0.27	0.14	(0.0050)	0.22	0.025
P3	2	0.14	0.14	0.14	(0.0050)	NA[5]	0.025
T1s	4	6.8	8.7	7.8	(0.29)	2.2	1.41
T1d	4	0.068	0.20	0.14	(0.0050)	0.17	0.025
T3	4	1.3	1.8	1.4	(0.050)	0.65	0.25
T4	4	4.3	8.8	6.1	(0.23)	6.5	1.1
T5	4	2.0	2.6	2.7	(0.10)	0.87	0.49
T8s	4	0.47	0.081	0.68	(0.025)	0.43	0.12
T8d	4	0.20	0.20	0.20	(0.0080)	NA	0.039
T9	3	0.74	1.3	0.68	(0.025)	1.1	0.12
T10	4	11	14	12	(0.45)	4.3	2.2
T11	4	0.068	0.20	0.14	(0.0050)	0.22	0.025

1. See Figure 11.
2. Bq/l in parentheses.
3. C.L. = Average Concentration ± the value shown = $t(\alpha = 0.05, df)\ S\bar{x}$.
4. DOE Memo from W.A. Vaughan, August 5, 1985, to Joe LaGrone establishes a standard of 550 pCi/l (20.4 Bq/l). Percent of Standard relates to the average value.
5. NA = Not Applicable.

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TABLE 10: *Gross Alpha Concentration in On-site Well Water, 1986*

Sampling Point[1]	Number of Samples	Concentration pCi/l Minimum	Maximum	Average[2]		95% C.L.[3]	% of Standard[4]
P1	4	0.86	2.2	1.4	(0.050)	1.4	4.5
P2	4	0.50	1.8	0.90	(0.033)	1.4	3.0
P3	2	2.7	0.63	0.45	(0.017)	0.58	1.5
T1s	4	10	17	12	(0.45)	8.6	41
T1d	4	0.77	0.99	0.90	(0.033)	0.29	3.0
T3	4	2.1	5.0	3.6	(0.13)	2.9	12
T4	4	3.0	5.0	4.1	(0.15)	2.9	14
T5	4	3.1	7.6	4.1	(0.15)	7.2	14
T8s	4	1.9	2.4	2.3	(0.083)	7.8	7.5
T8d	4	0.59	0.99	0.90	(0.033)	0.72	3.0
T9	3	1.1	2.3	1.8	(0.067)	1.4	6.0
T10	4	8.6	17	14	(0.50)	14	45
T11	4	0.72	2.7	1.4	(0.050)	2.9	4.5

1. See Figure 11.
2. Bq/l in parentheses.
3. C.L. = Average Concentration ± the value shown = $t(\alpha = 0.05, df)\ S\bar{x}$.
4. DOE Memo from W.A. Vaughan, August 5, 1985, to Joe LaGrone establishes a standard of 30 pCi/l (1.1 Bq/l). Percent of Standard relates to the average value.

3

TABLE 11: *Gross Beta Concentration in On-site Well Water, 1986*

Sampling Point[1]	Number of Samples	Concentration pCi/l Minimum	Maximum	Average[2]		95% C.L.[3]	% of Standard[4]
P1	4	3.8	4.6	4.1	(0.15)	1.4	14
P2	4	1.8	1.9	1.8	(0.067)	0.14	6.0
P3	2	1.8	4.6	3.2	(0.12)	4.3	11
T1s	4	8.1	14	10	(0.38)	7.2	35
T1d	4	1.0	3.5	1.9	(0.070)	2.9	6.3
T3	4	4.6	6.3	5.4	(0.20)	1.4	18
T4	4	5.9	8.4	7.7	(0.28)	2.9	26
T5	4	5.5	6.2	5.9	(0.22)	1.4	20
T8s	4	3.5	5.0	4.1	(0.15)	2.9	14
T8d	4	1.3	3.0	1.8	(0.067)	2.9	6.1
T9	3	6.1	7.2	6.8	(0.25)	1.4	23
T10	4	21	34	23	(0.83)	14	75
T11	4	3.0	3.6	3.2	(0.12)	1.4	11

1. See Figure 11.
2. Bq/l in parentheses.
3. C.L. = Average Concentration ± the value shown = $t(\alpha = 0.05, df)\ S\bar{x}$.
4. DOE Memo from W.A. Vaughan, August 5, 1985, to Joe LaGrone establishes a standard of 30 pCi/l (1.1 Bq/l). Percent of Standard relates to the average value.

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TABLE 12: *Radionuclides Released at Discharge 001, 1986*

Radionuclide[1]	Total Curies 1985	Total Curies 1986[2]		Average Concentration[3] pCi/l		Standard[4] pCi/l	% of Standard[5]
Cs-137	9.2×10^{-3}	$< 1.0 \times 10^{-3}$	$(< 3.8 \times 10^{7})$	$< 1.5 \times 10^{0}$	$(< 5.5 \times 10^{-2})$	3000	< 0.05
Np-237	$< 1.7 \times 10^{-4}$	$< 1.0 \times 10^{-5}$	$(< 3.8 \times 10^{5})$	$< 1.5 \times 10^{-2}$	$(< 5.5 \times 10^{-4})$	3	< 0.5
Pu-238	7.5×10^{-6}	$< 1.0 \times 10^{-5}$	$(< 3.8 \times 10^{5})$	$< 1.5 \times 10^{-2}$	$(< 5.5 \times 10^{-4})$	400	< 0.004
Pu-239/240	1.5×10^{-5}	$< 1.0 \times 10^{-5}$	$(< 3.8 \times 10^{5})$	$< 1.5 \times 10^{-2}$	$(< 5.5 \times 10^{-4})$	300	< 0.005
Ra-226	$< 3.8 \times 10^{-3}$	$< 4.6 \times 10^{-3}$	$(< 1.7 \times 10^{8})$	$< 6.6 \times 10^{0}$	$(< 2.4 \times 10^{-1})$	100	< 6.6
Ra-228	$< 3.6 \times 10^{-3}$	$< 4.1 \times 10^{-3}$	$(< 1.5 \times 10^{8})$	$< 6.0 \times 10^{0}$	$(< 2.2 \times 10^{-1})$	100	< 6.0
Ru-106	$< 4.4 \times 10^{-4}$	$< 1.0 \times 10^{-2}$	$(< 3.8 \times 10^{8})$	$< 1.5 \times 10^{1}$	$(< 5.5 \times 10^{-1})$	600	< 2.5
Sr-90	5.2×10^{-3}	9.0×10^{-4}	(3.3×10^{7})	1.3×10^{0}	(4.8×10^{-2})	1000	0.1
Tc-99	8.3×10^{0}	1.5×10^{0}	(5.7×10^{10})	2.2×10^{3}	(8.2×10^{1})	100000	2.2
Th-232	$< 1.1 \times 10^{-2}$	5.4×10^{-4}	(2.0×10^{7})	7.8×10^{-1}	(2.9×10^{-2})	50	1.6
U-234	1.5×10^{-1}	1.1×10^{-1}	(4.0×10^{9})	1.6×10^{2}	(5.7×10^{0})	500	32
U-235	7.4×10^{-3}	5.9×10^{-3}	(2.2×10^{8})	8.5×10^{0}	(3.2×10^{-1})	600	1.4
U-236	4.9×10^{-3}	2.0×10^{-2}	(7.4×10^{8})	2.9×10^{1}	(1.1×10^{0})	500	5.8
U-238	2.0×10^{-1}	1.8×10^{-1}	(6.5×10^{9})	2.5×10^{2}	(9.4×10^{0})	600	42
Uranium	4.1×10^{-1}	3.1×10^{-1}	(1.2×10^{10})	4.5×10^{2}	(1.7×10^{1})	550	82

1. Radionuclide concentrations in the plant effluent discharged to the Great Miami River through a buried pipeline, (with the exception of the three radium isotopes, thorium, ruthenium, and uranium) are determined from two 6-month composites.
2. Bq in parentheses.
3. Bq/l in parentheses.
4. As stated in DOE Memo from W.A. Vaughan, August 5, 1985, to Joe LaGrone.
5. Percent of Standard relates to the average value reported.

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TABLE 13: *Radionuclides in Surface Water, 1986*

page 1 of 2

Radionuclide	Sampling Point[1]	Number of Samples[2]	Concentration[3] pCi/l Minimum	Maximum	Average		95% C.L.[4]	% of Standard[5]	Standard pCi/l[6]
Gross Alpha[7]	W1	52	1	5	3	(0.09)	0.3	8	30
	W3	52	1	5	3	(0.1)	0.3	9	
	W4	52	1	8	3	(0.1)	0.3	9	
	W5	52	1	9	2	(0.07)	0.3	0.6	
	W7	24	1.9	639	39	(1.4)	53	128	
	W8	28	2.2	93	11	(0.40)	6.5	36	
	W9	42	0.81	15	2.8	(0.10)	0.81	9.4	
	W10	40	0.81	82	11	(0.40)	5.7	36	
	W11	32	3.5	416	23	(0.83)	26	75	
Gross Beta[7]	W1	52	3	10	5	(0.2)	0.3	18	30
	W3	52	3.2	14	5.8	(0.21)	0.54	19	
	W4	52	0.81	55	6.6	(0.24)	1.9	22	
	W5	52	2.4	16	5.1	(0.19)	0.54	1.7	
	W7	24	7.6	144	27	(0.98)	13	89	
	W8	28	4.6	68	26	(0.95)	6.5	86	
	W9	42	0.54	12	4.7	(0.18)	0.81	16	
	W10	40	0.81	38	7.7	(0.29)	2.4	26	
	W11	32	4.0	164	13	(0.46)	10	42	
Cs-137	W1	2	<5	<10.0	<8	(< 0.3)	NA	<0.3	3000
	W3	2	<5	<8	<7	(< 0.2)	NA	<0.2	
	W4	2	<8	<8	<8	(< 0.3)	NA	<0.3	
Ra-226	W1	12	<0.5	<0.5	<0.5	(<0.02)	NA[8]	<0.5	100
	W3	12	<0.5	<0.5	<0.5	(< 0.02)	NA	<0.5	
	W4	12	<0.5	<0.5	<0.5	(< 0.02)	NA	<0.5	
	W5	6	<0.5	<0.5	<0.5	(< 0.02)	NA	<0.5	
	W7	10	<0.5	<0.8	<0.5	(< 0.02)	NA	<0.5	
	W8	2	<0.5	<0.5	<0.5	(< 0.02)	NA	<0.5	
Ra-228	W1	12	<0.5	<0.8	<0.5	(< 0.02)	NA	<0.5	100
	W3	12	<0.5	<1	<0.6	(< 0.02)	NA	<0.6	
	W4	12	<0.5	<0.8	<0.5	(< 0.02)	NA	<0.5	
	W5	6	<0.5	<1	<0.6	(< 0.02)	NA	<0.6	
	W7	10	<0.5	<1	<0.7	(< 0.03)	NA	<0.7	
	W8	2	<0.5	<0.5	<0.5	(< 0.02)	NA	<0.5	
Sr-90	W1	2	<1.1	<1.4	<1.3	(< 0.050)	NA	<0.13	1000
	W3	2	1.6	1.9	1.7	(0.060)	0.81	0.17	
	W4	2	2.2	2.4	2.3	(0.080)	0.54	0.23	

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TABLE 13: *Radionuclides in Surface Water, 1986*

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Radionuclide	Sampling Point[1]	Number of Samples[2]	Concentration[3] pCi/l Minimum	Maximum	Average		95% C.L.[4]	% of Standard[5]	Standard pCi/l[6]
Tc-99	W1	2	2	5	3	(0.1)	0.4	0.003	100,000
	W3	2	5	7	6	(0.2)	0.5	0.006	
	W4	2	5	6	6	(0.2)	0.1	0.006	–
U-234	W1	2	0.81	0.81	0.74	(0.030)	0.020	0.15	500
	W3	2	0.81	0.81	0.83	(0.030)	0.010	0.17	
	W4	2	0.81	1.1	0.88	(0.030)	0.020	0.18	
U-235	W1	2	0.030	0.030	0.030	(0.0010)	0.00040	0.005	600
	W3	2	0.030	0.030	0.040	(0.0010)	0.000030	0.007	
	W4	2	0.030	0.030	0.040	(0.0010)	0.0010	0.007	
U-236	W1	2	0.0050	0.0050	0.0060	(0.00020)	0.00010	0.001	500
	W3	2	0.0080	0.0080	0.0090	(0.00030)	0.00020	0.002	
	W4	2	0.011	0.027	0.012	(0.00050)	0.0010	0.002	
U-238	W1	2	0.81	0.81	0.75	(0.030)	0.0050	0.13	600
	W3	2	0.81	1.1	0.90	(0.030)	0.010	0.15	
	W4	2	0.81	1.1	1.9	(0.020)	0.040	0.16	
Uranium	W1	52	0.81	3.0	1.2	(0.05)	0.0030	0.030	550
	W3	52	0.81	2.4	1.4	(0.05)	0.0040	0.25	
	W4	52	0.81	4.6	1.4	(0.05)	0.0060	0.26	
	W5	52	0.54	6.8	1.1	(0.04)	0.0090	0.19	
	W7	24	0.54	718	49	(1.8)	2.3	8.8	
	W8	28	1.4	112	9.5	(0.35)	0.29	1.7	
	W9	42	0.81	5.4	1.8	(0.070)	0.010	0.33	
	W10	40	1.1	126	11	(0.42)	0.26	2.0	
	W11	32	5.4	589	29	(1.1)	1.4	5.2	

1. See Figure 19.
2. Samples are composited for radium analyses as follows: one-month composites of daily samples from W1 and W3; one-month composites of weekly samples from W4 two-month composites of weekly samples from W5 and one-month composites of all available weekly samples from W7. Semiannual composites were used for those isotopes where two samples are noted.
3. Bq/l in parentheses.
4. C.L. = Average ± the value shown; = $t(\alpha = 0.05, df)\ S\bar{x}$.
5. Percent of guideline relates to the average value reported.
6. As stated in DOE Memo from W.A. Vaughan, August 5, 1985, to Joe LaGrone.
7. Gross alpha and Gross beta activity values contain activity of uranium and radium in the samples, thus are highly conservative.
8. NA = Not Applicable.

TABLE 14: *Radiosotopes in Great Miami River, Paddy's Run and Storm Sewer Outfall Ditch Sediments, 1986* [1]

		Isotope Concentration pCi/g (dry weight)													
		Tc-99	Ra-223	Ra-224	Ra-226	Ra-228	Pu-238	U-234	Th-230	U-235	U-238	Pu-239/240	U-236	Th-232	Th-228
Paddy's Run above Storm Sewer Outfall															
	minimum	...	0.078	0.19	0.4	0.2	0.0012	0.17	0.22	0.0029	0.0007	0.00099	0.0014	0.03	0.04
	maximum	...	0.48	1.3	4.5	1.1	0.043	3.8	2.4	0.85	5.7	0.52	1.3	0.84	2.7
	average	4.6[2]	0.22	0.51	0.86	0.52	0.0096	0.44	0.47	0.028	0.75	0.024	0.042	0.22	0.48
	95% CL[3]	...	0.029	0.0020	0.0049	0.0019	0.0040	0.0018	0.0016	0.00012	0.0052	0.033	0.043	0.00091	0.0027
Storm Sewer Outfall															
	minimum	0.11	0.10	0.064	0.17	0.30	0.0023	1.7	0.38	0.055	2.0	0.0048	0.024	0.13	0.45
	maximum	5.4	0.64	1.3	1.3	1.8	0.17	24.0	4.7	1.0	31.0	0.11	1.5	3.4	2.6
	average	1.5	0.29	0.57	0.68	0.74	0.028	6.2	1.3	0.24	7.8	0.024	0.35	0.63	0.84
	95%CL[3]	0.73	0.072	0.12	0.11	0.17	0.015	2.1	0.40	0.086	2.7	0.0097	0.14	0.27	0.18
Paddy's Run below Storm Sewer Outfall															
	minimum	0.81	0.095	0.20	0.49	0.23	0.0050	0.28	0.22	0.0074	0.35	0.0015	0.30	0.0094	0.0058
	maximum	38.0	0.40	1.7	1.9	1.3	0.057	21.0	3.4	1.2	37.0	0.077	1.0	0.58	2.3
	average	11.0	0.23	0.54	0.83	0.53	0.016	3.4	0.78	0.18	5.2	0.015	0.53	0.22	0.28
	95% CL[3]	0.93	0.0018	0.0045	0.0043	0.0040	0.00021	0.057	0.0080	0.0037	0.097	0.00022	0.0018	0.0015	0.0070
Great Miami River															
	minimum	...	0.16	0.25	0.39	0.19	0.0047	0.16	0.15	0.0028	0.16	0.0018	0.0027	0.090	0.33
	maximum	...	0.31	0.82	1.1	0.78	0.032	0.46	1.3	0.0090	0.61	0.0062	0.031	0.31	0.64
	average	<0.51[4]	0.22	0.48	0.75	0.49	0.013	0.23	0.55	0.0066	0.25	0.0035	0.01	0.21	0.51
	95% CL[3]	...	0.0061	0.0055	0.0071	0.0064	0.0003	0.0025	0.0100	0.0001	0.0037	0.0001	0.0003	0.0019	0.0027

1. See Figure 27.
2. All samples less than detectable, except one sample at the confluence of Paddy's Run and the Storm Sewer Outfall.
3. 95% C.L. = Average concentration ± value shown. Derived from t (α = 0.05, df) Sx.
4. All samples less than detectable.

TABLE 15: *Uranium Concentrations in Routine Soil Samples, 1986*

Sampling Location[1]	Depth Sampled	Concentration[2] pCi/g dry wt. 1985		1986	
1	0 - 5 cm	4.35	(0.16)	4.67	(0.17)
	5 - 10 cm			3.39	(0.13)
2	0 - 5 cm	1.95	(0.07)	10.16	(0.38)
	5 - 10 cm			6.03	(0.22)
3	0 - 5 cm	35.88	(1.33)	46.37	(1.72)
	5 - 10 cm			31.14	(1.15)
4	0 - 5 cm	3.05	(0.11)	5.42	(0.20)
	5 - 10 cm			6.36	(0.24)
5	0 - 5 cm	2.88	(0.11)	6.16	(0.23)
	5 - 10 cm			4.06	(0.15)
6	0 - 5 cm	1.25	(0.05)	6.79	(0.25)
	5 - 10 cm			3.99	(0.15)
7	0 - 5 cm	0.42	(0.02)	3.42	(0.13)
	5 - 10 cm			2.35	(0.09)
8	0 - 5 cm	0.43	(0.02)	2.30	(0.09)
	5 - 10 cm			1.90	(0.07)
9	0 - 5 cm	1.71	(0.06)	2.44	(0.09)
	5 - 10 cm			2.23	(0.08)
10	0 - 5 cm	0.42	(0.02)	1.42	(0.05)
	5 - 10 cm			1.35	(0.05)
11	0 - 5 cm	14.15	(0.52)	. . .[3]	
	5 - 10 cm			. . .[3]	
12	0 - 5 cm	0.67	(0.02)	1.56	(0.06)
	5 - 10 cm			1.83	(0.07)
13	0 - 5 cm	0.44	(0.02)	1.93	(0.07)
	5 - 10 cm			2.44	(0.09)
14	0 - 5 cm	0.61	(0.02)	2.50	(0.09)
	5 - 10 cm			3.39	(0.13)
15	0 - 5 cm	0.35	(0.01)	2.03	(0.08)
	5 - 10 cm			1.96	(0.07)

1. See Figure 28.
2. < ± 20% uncertainty in results; Bq/g dry wt. in parentheses.
3. ". . . " Sample collected but lost.

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TABLE 16: *Uranium And Fluoride In Vegetation Samples, 1986*

Sampling Location[2]	Distance in km from FMPC[3]	Grass[1] Total Uranium (pCi/g dry)[4]		95% CL[5]	Fluoride (ppm)	% of Standard[6]
1	6.5	0.06	(0.002)	0.04	4.6	5.8
2	4.1	0.24	(0.009)	0.04	4.4	5.5
3	6.2	0.09	(0.003)	0.04	6.2	7.8
4	8.7	0.13	(0.005)	0.04	5.5	6.9
5	2.7	0.21	(0.008)	0.04	5.2	6.6
6	1.4	0.13	(0.005)	0.04	5.6	7.0
7	1.5	0.13	(0.005)	0.04	3.8	4.7
8	1.3	0.39	(0.014)	0.04	5.1	6.3
9	1.0	0.72	(0.027)	0.08	4.6	5.8
10	0.7	3.25	(0.120)	0.04	6.7	8.3
11	0.8	0.49	(0.018)	0.06	4.4	5.5
12	1.9	0.43	(0.016)	0.04	6.0	7.5
13	0.7	0.40	(0.015)	0.04	5.2	6.5
14	0.8	4.29	(0.159)	0.60	5.7	7.1
15	0.7	0.60	(0.022)	0.08	4.5	5.6
16	0.7	2.29	(0.085)	0.20	7.6	9.6
17	2.3	0.31	(0.011)	0.04	4.8	6.0
18	1.9	0.20	(0.007)	0.04	7.1	8.9
19	4.0	0.06	(0.002)	0.04	4.4	5.6
20	1.4	2.11	(0.078)	0.20	4.7	5.9

1. Plant material primarily brome grass (Bromus sp.), but other genera represented: Allium, Daucus, Hordeum, Medicago, Melilotus, Poa, Secale, and Triticum.
2. See Figure 31.
3. For the purpose of this table, the center of the production area (Figure 30) was used for distance measurements.
4. Bq/g in parentheses.
5. CL = ± 2 sigma.
6. No Ohio standard established; Kentucky standard of 80 ppm used.

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TABLE 17: *Average Uranium Concentration in Soil, Fertilizer and Farm/Garden Produce Within 63 km of the FMPC, 1986* (Page 1 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Soil/Fertilizer[2]							
Soil	4.6	2.4	5.7	2.4	...[3]	...	2.7
Fertilizer	3.5	121	...	...	0.03	...	24
Leafy Vegetables[2]							
Cabbage	...	0.2 ± 0.05[5]	...	...	...	...	...
Collard	...	...	...	...	...	...	...
Pepper Plant	0.05[6]	...	...	...	...	...	...
Raspberry Leaves	...	...	...	...	...	...	...
Roots & Stems[2]							
Beets	...	...	...	...	...	...	...
Carrots	...	...	...	...	...	...	...
Onions	...	...	...	...	...	...	...
Potato flesh	< 0.01[6]	< 0.02[6]	0.01 ± 0.02[7]	...	...	...	< 0.003[4,6]
Potato skin	< 0.03[4,6]	< 0.03[4,6]	0.05[4] ± 0.01[5]	...	...	...	< 0.05[4,6]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\, S\bar{x}$.

TABLE 17: *Average Uranium Concentration in Soil, Fertilizer and Farm/Garden Produce Within 63 km of the FMPC, 1986* (Page 2 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Soil/Fertilizer[2]						
Soil	2.7	2.4	3.0	2.1	...	2.2
Fertilizer	...	8.9	20	2.0	...	...
Leafy Vegetables[2]						
Cabbage	...	...	...	0.1 ± 0.05[6]	...	...
Collard	...	...	...	...	...	0.1 ± 0.2[7]
Pepper Plant	...	0.05[6]	...	...	...	...
Raspberry Leaves	...	...	...	...	...	0.02 ± 0.05[7]
Roots & Stems[2]						
Beets	...	...	< 0.02[6]	...	...	...
Carrots	...	...	< 0.02[4,6]	< 0.1[4,6]	...	...
Onions	...	...	0.1[4] ± 0.02[5]	...	...	...
Potato flesh	...	< 0.003[4,6]	...	...	< 0.01[6]	0.01 ± 0.01[7]
Potato skin	...	< 0.02[4,6]	...	...	< 0.02[4,6]	< 0.08[6]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = t (α = 0.05, df) $S\bar{x}$.

TABLE 17: *Average Uranium Concentration in Soil, Fertilizer and Farm/Garden Produce Produce Within 63 km of the FMPC, 1986* (Page 3 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Fruit[2]							
Beans, Pinto	...	...	...	...	...	<0.001[6]	...
Corn	...	...	...	...	<0.01	...	...
Peppers, Green	<0.02[6]	0.03 ±0.01[5]	...	<0.11[6]	...	...	...
Peppers, Hot	<0.03[4,6]	...	...	...	...	...	...
Raspberry	...	...	...	...	...	...	...
Squash Butter	...	...	...	...	0.02 ±0.05[7]	...	...
Squash Yellow	...	...	...	...	...	...	...
Tomato	0.03[4] ±0.01[5]	<0.01[6]	0.01 ±0.02[7]	<0.01[4,6]	<0.01[6]	...	<0.01[6]
Zucchini	...	...	...	...	...	...	...

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

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TABLE 17: *Average Uranium Concentration in Soil, Fertilizer and Farm/Garden Produce Within 63 km of the FMPC, 1986* (Page 4 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Fruit[2]						
Beans, Pinto	...	...	...	...	...	<0.02[6]
Soy Beans	...	...	...	...	...	...
Corn	...	<0.01[6]	...	<0.01[6]	...	<0.01[6]
Peppers, Green	...	<0.02[6]	...	...	...	<0.03[6]
Peppers, Hot	...	...	0.2[4] ± 0.08	...	...	...
Raspberry	...	...	...	...	...	<0.03[6]
Squash Butter	...	...	...	0.01 ± 0.08[7]	...	0.1 ± 0.1[7]
Squash Yellow	...	...	...	...	...	<0.05[6]
Tomato	0.01[6]	0.02 ± 0.02[7]	<0.01[6]	<0.01[4,6]	...	<0.08[6]
Zucchini	...	...	...	...	...	0.01 ± 0.02[7]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = t (α = 0.05, df) $S\bar{x}$.

TABLE 18: *Average Thorium 228 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986*
(Page 1 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Leafy Vegetables[2]							
Cabbage	...[3]	< 0.02[6]	...	...	...	...	...
Collard	...	...	...	...	...	...	...
Pepper Plant	0.03 ± 0.02[7]	...	...	...	...	...	...
Raspberry Leaves	...	...	...	...	...	...	...
Roots & Stems[2]							
Beets	...	...	...	...	...	...	...
Carrots	...	...	...	...	...	...	...
Onions	...	...	...	...	...	...	...
Potato flesh	< 0.001[4] ± 0.0005[5]	< 0.005[7]	< 0.05[7]	...	...	...	< 0.002[6]
Potato skin	< 0.02[4] ± 0.005[5]	0.05[4] ± 0.005[5]	0.01[4] ± 0.008[5]	...	...	...	0.2[4] ± 0.008[5]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. ". . ." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 18: *Average Thorium 228 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986* (page 2 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Leafy Vegetables[2]						
Cabbage	...	...	...	0.002 ± 0.003	...	...
Collard	...	...	...	...	...	0.001 ± 0.002[7]
Pepper Plant	...	0.02 ± 0.03[7]	...	...	...	...
Raspberry Leaves	...	...	...	...	...	0.005 ± 0.003[7]
Roots & Stems[2]						
Beets	...	...	0.02 ± 0.005[5]	...	...	...
Carrots	...	...	0.003[4] ± 0.001[5]	< 0.003[4] ± 0.001[5]	...	
Onions	...	...	0.003[4] ± 0.001[5]	...	...	...
Potato flesh	...	< 0.002[4] ± 0.001[5]	...	...	< 0.001[4] ± 0.0005[5]	< 0.003[6]
Potato skin	...	± 0.03[4]	...	...	0.01[4] ± 0.005[5]	0.02 ± 0.01[7]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 18: *Average Thorium 228 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986*
(page 3 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Fruit[2]							
Beans, Pinto	...	...	...	...	...	...	...
Corn	...	...	...	...	< 0.002[6]	...	...
Peppers, Green	< 0.005[6]	< 0.003[6]	...	< 0.005[4,6]	...	...	...
Peppers, Hot	< 0.005[4,6]	...	...	...	...	...	...
Raspberry	...	...	...	...	...	...	...
Squash Butter	...	...	...	...	< 0.003[6]	...	...
Squash Yellow	...	...	...	...	...	...	...
Tomato	< 0.005[4,6]	0.02 ± 0.03	< 0.002[6]	< 0.003[6]	< 0.008[6]	...	< 0.02[7]
Zucchini	...	...	...	...	...	...	...

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 18: *Average Thorium 228 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986* (page 4 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Fruit[2]						
Beans, Pinto	...	...	...	...	...	<0.01[6]
Corn	...	<0.001[6]	...	<0.001[6]	...	<0.002[6]
Peppers, Green	...	<0.003[4,6]	...	...	...	<0.03[6]
Peppers, Hot	...	...	<0.01[4,6]	...	...	...
Raspberry	...	...	...	...	...	<0.003[6]
Squash Butter	...	...	...	<0.002[6]	...	<0.005[6]
Squash Yellow	...	...	...	...	...	<0.03[6]
Tomato	<0.002[6]	0.01 ± 0.02[7]	<0.002[6]	0.002[4] ± 0.001[5]	...	<0.002[6]
Zucchini	...	...	...	...	...	<0.008[6]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 19: *Average Thorium 230 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986*
(Page 1 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Leafy Vegetables[2]							
Cabbage	...[3]	<0.01[6]	...	...	...	...	...
Collard	...	...	...	...	...	...	...
Pepper Plant	0.02 ± 0.005[5]	...	...	...	...	...	...
Raspberry Leaves	...	...	...	...	...	...	...
Roots & Stems[2]							
Beets	...	...	...	...	...	...	...
Carrots	...	...	...	...	...	...	...
Onions	...	...	...	...	...	...	...
Potato flesh	0.002 ± 0.002[7]	<0.003[6]	<0.002[6]	...	...	...	0.001 ± 0.003[7]
Potato skin	0.02[4] ± 0.005[5]	0.05[4] ± 0.005[6]	0.02[4] ± 0.008[5]	...	...	...	0.03[4] ± 0.008[5]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 19: *Average Thorium 230 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986* (page 2 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Leafy Vegetables[2]						
Cabbage	...	...	...	0.002 ± 0.002[7]	...	...
Collard	...	...	...	...	...	0.002 ± 0.02[7]
Pepper Plant	...	0.05 ± 0.2[7]	...	...	...	...
Raspberry Leaves	...	...	...	...	...	0.008 ± 0.003[5]
Roots & Stems[2]						
Beets	...	...	0.01 ± 0.05[7]	...	...	...
Carrots	...	...	0.01 ± 0.005[5]	0.05[4] ± 0.01[5]	...	
Onions	...	...	0.002[4] ± 0.02[5]	...	...	...
Potato flesh	...	0.002[4] ± 0.0005[5]	...	...	0.001[6]	0.01 ± 0.02[7]
Potato skin	...	0.03[4] ± 0.008[5]	...	...	0.01[4] ± 0.005[5]	0.02 ± 0.005[7]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 19: *Average Thorium 230 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986*
(page 3 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Fruit[2]							
Beans, Pinto	...	...	...	...	...	...	...
Corn	...	...	...	...	< 0.001[6]	...	...
Peppers, Green	0.005 ± 0.01[7]	< 0.005[6]	...	< 0.005[4,6]	...	...	...
Peppers, Hot	< 0.005[4,6]	...	...	...	...	...	...
Raspberry	...	...	...	...	...	...	...
Squash Butter	...	...	...	...	< 0.002[6]	...	...
Squash Yellow	...	...	...	...	...	...	...
Tomato	< 0.005[4,6]	0.02 ± 0.02[7]	0.002 ± 0.002[7]	< 0.005[4,6]	< 0.002[6]	...	< 0.02[6]
Zucchini	...	...	...	...	...	...	...

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 19: *Average Thorium 230 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986* (page 4 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Fruit[2]						
Beans, Pinto	...	...	...	...	...	0.01[6]
Corn	...	0.002 ± 0.003[7]	...	<0.001[6]	...	<0.002[6]
Peppers, Green	...	<0.003[6]	...	...	...	0.05[6]
Peppers, Hot	...	...	<0.01[4]	...	...	...
Raspberry	...	...	...	...	...	<0.005[6]
Squash Butter	...	...	...	<0.003[6]	...	<0.003[6]
Squash Yellow	...	...	...	...	...	<0.02[6]
Tomato	<0.002[6]	0.03 ± 0.008[5]	0.005 ± 0.003[5]	0.002[4] ± 0.001[5]	...	<0.003[6]
Zucchini	...	...	...	...	...	<0.01[6]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 20: *Average Thorium 232 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986*
(Page 1 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Leafy Vegetables[2]							
Cabbage	...[3]	<0.01[6]	...	...	...	...	...
Collard	...	...	...	...	...	...	...
Pepper Plant	0.01 ± 0.01[5]	...	...	...	...	...	...
Raspberry Leaves	...	...	...	...	...	...	...
Roots & Stems[2]							
Beets	...	...	...	...	...	...	...
Carrots	...	...	...	...	...	...	...
Onions	...	...	...	...	...	...	...
Potato flesh	0.002 ± 0.002[7]	<0.003[6]	<0.002[6]	...	...	...	<0.001[6]
Potato skin	0.01[4] ± 0.003[5]	0.02[4] ± 0.005[5]	<0.01[4,6]	...	...	...	0.02[4] ± 0.008[5]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

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TABLE 20: *Average Thorium 232 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986* (page 2 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Leafy Vegetables[2]						
Cabbage	...	...	...	<0.001[6]	...	...
Collard	...	...	...	...	...	0.001 ±0.001[7]
Pepper Plant	...	0.03 ±0.01[7]	...	...	...	...
Raspberry Leaves	...	...	...	...	...	0.01 ±0.003[5]
Roots & Stems[2]						
Beets	...	...	0.01 ±0.03[7]	...	...	...
Carrots	...	...	0.01[4] ±0.003[5]	0.02[4] ±0.01[5]	...	
Onions	...	...	0.003[4] ±0.001[5]	...	...	...
Potato flesh	...	0.001[4] ±0.001[5]	...	...	<0.002[6]	<0.002[6]
Potato skin	...	0.01[4] ±0.008[5]	...	...	0.01[4] ±0.003[5]	0.01 ±0.01[7]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 20: *Average Thorium 232 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986*
(page 3 of 4)

Location[1]							
Garden Number	1	2	3	4	5	6	7
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9
Fruit[2]							
Beans, Pinto	...	...	...	...	...	...	...
Corn	...	...	...	...	< 0.001[6]	...	...
Peppers, Green	0.001 ± 0.003[7]	< 0.01[6]	...	< 0.01[4,6]	...	...	...
Peppers, Hot	< 0.01[4,6]	...	...	...	...	...	...
Raspberry	...	...	...	...	...	...	...
Squash Butter	...	...	...	...	< 0.002[6]	...	...
Squash Yellow	...	...	...	...	...	...	...
Tomato	< 0.008[4,6]	0.011 ± 0.005[7]	< 0.001 ± 0.002[7]	< 0.003[4,6]	< 0.002[6]	...	< 0.024[6]
Zucchini	...	...	...	...	...	...	...

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

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TABLE 20: *Average Thorium 232 Concentration in Farm/Garden Produce Within 63 km of the FMPC, 1986* (page 4 of 4)

Location[1]						
Garden Number	8	9	10	11	12	13
Approx. Dist. (km)	2.0	6.2	1.7	43.5	33.8	3.9
Fruit[2]						
Beans, Pinto	...	...	...	...	...	<0.01[6]
Corn	...	<0.002[6]	...	<0.001[6]	...	<0.002[6]
Peppers, Green	...	<0.003[6]	...	...	...	<0.01[6]
Peppers, Hot	...	...	<0.01[4,6]	...	...	...
Raspberry	...	...	...	...	...	<0.01[6]
Squash Butter	...	...	...	<0.002[6]	...	<0.002[6]
Squash Yellow	...	...	...	...	...	<0.02[6]
Tomato	<0.002[6]	0.003 ±0.03[5]	0.003 ±0.03[5]	0.001[4] ±0.001[5]	...	<0.002[6]
Zucchini	...	...	...	...	...	<0.008[6]

1. Garden numbers shown correspond to locations shown in Figure 29.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037 Bq/pCi.
3. "..." No sample collected.
4. Single sample.
5. ± 2 sigma counting error.
6. "<" refers to 2 sigma counting error.
7. 95% CL = $t(\alpha = 0.05, df)\ S\bar{x}$.

TABLE 21: *Radioisotopes in Milk, 1986*[1]

Analysis	Number of Samples	Ohio[2] Location Concentration pCi/l[4]		Ohio[2] Location 95% CL[5]	Kentucky[3] Location Concentration pCi/l[4]		Kentucky[3] Location 95% CL[5]
Gross Alpha	1	< 40	(< 1.5)	NA[6]	< 40	(< 1.5)	NA
Gross Beta	1	1400	(58.1)	3.70	1400	(58.1)	3.70
Total Uranium	6	< 6.8	(< 0.25)	NA	< 6.8	(< 0.03)	NA
U-234	1	< 0.1	(< 0.004)	NA	< 0.1	(< 0.004)	NA
U-235	1	< 0.1	(< 0.004)	NA	< 0.1	(< 0.004)	NA
U-236	1	< 0.1	(< 0.004)	NA	< 0.1	(< 0.004)	NA
Sr-90	1	1.70	(0.063)	0.3	1.20	(0.044)	0.4
Tc-99	1	< 20	(< 0.74)	NA	< 10	(< 0.37)	NA
Ra-226	1	0.1	(0.004)	0.05	0.11	(0.004)	0.05
Ra-228	1	< 2	(< 0.07)	NA	< 2	(< 0.07)	NA
Th-228	1	< 1	(< 0.04)	NA	< 0.9	(< 0.03)	NA
Th-230	1	< 0.9	(< 0.03)	NA	< 0.9	(< 0.03)	NA
Th-232	1	< 0.8	(< 0.03)	NA	< 0.9	(< 0.03)	NA

1. Standards have not yet been established.
2. Dairy adjacent to the FMPC.
3. Dairy in Northern Kentucky.
4. Bq/l shown in parenthesis.
5. 95% CL= ± 2 sigma.
6. NA = Not Applicable.

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TABLE 22: *Uranium Concentration in Fish, 1986*

Sampling Point[1]	Family[2]	Number of Samples	Concentration[3] pCi/g Minimum	Maximum	Average[4]		95% C.L.[5]
1	1	6	0.06	0.1	0.08	(0.003)	1.0
	2	7	0.02	0.07	0.05	(0.002)	1.0
	3	6	0.05	0.1	0.08	(0.003)	2.0
	4	3	0.05	0.1	0.09	(0.003)	4.0
	5	3	0.05	0.1	0.07	(0.002)	3.0
	Total	25	0.02	0.1	0.07	(0.003)	0.6
2	1	6	0.03	0.06	0.05	(0.002)	1.0
	2	5	0.04	0.07	0.05	(0.002)	2.0
	3	5	0.03	0.1	0.06	(0.002)	2.0
	4	3	0.05	0.1	0.1	(0.004)	4.0
	5	4	0.05	0.09	0.07	(0.003)	2.0
	Total	23	0.03	0.1	0.06	(0.002)	0.7
3	1	2	0.09	0.1	0.1	(0.004)	10.0
	3	16	0.04	0.2	0.07	(0.003)	1.0
	4	6	0.04	0.09	0.06	(0.003)	1.0
	5	1	0.05	0.05	0.05	(0.002)	ND[6]
	Total	25	0.04	0.2	0.02	(0.003)	0.6

1. See Figure 32.
2. Family: 1 = Cyprinidae (carp)
   2 = Catastomidae (carpsucker, redhorse)
   3 = Centrarchidae, Sciaenidae (bass, sunfish, drum)
   4 = Clupeidae (gizzard shad)
   5 = Ictaluridae (catfish)
3. All concentrations in pCi(U)/g dry; wet wt: dry wt ratio ~3.4:1.
4. Bq/g in parentheses.
5. CL = Avg conc x + the value shown. Derived from log transformed data; $2*t(\alpha = 0.05, df)S\bar{x}$.
6. ND = Not Determined.

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TABLE 23: *Nitrate-Nitrogen in On-site Well Water, 1986*

Sampling Point[1]	Number of Samples	Concentration mg/l				
		Minimum	Maximum	Average	95% C.L.[2]	% of Standard[3]
P1	4	0.1	3.6	1.0	1.5	10
P2	4	0.1	0.2	0.1	0.14	1
P3	2	0.1	0.1	0.1	NA[4]	1
T1s	4	< 0.1	0.1	< 0.1	NA	1
T1d	4	< 0.1	0.1	< 0.1	NA	1
T3	4	< 0.1	0.1	< 0.1	NA	1
T4	4	0.2	2.1	1.2	2.3	12
T5	4	< 0.1	0.1	< 0.1	NA	1
T8s	4	< 0.1	0.1	< 0.1	NA	1
T8d	4	< 0.1	0.1	< 0.1	NA	1
T9	3	2.2	2.6	2.4	0.64	24
T10	4	145	164	154	26.9	1540
T11	4	0.1	0.6	0.3	0.64	3

1. See Figure 11.
2. C.L. = Average Concentration ± the value shown = $t(\alpha = 0.05, df)\ S\bar{x}$.
3. 10 mg/l per 40 CFR Part 141, National Interim Primary Drinking Water Standard. Percent of Standard relates to the average value.
4. NA = Not Applicable

TABLE 24: *Sulfate in On-site Well Water, 1986*						
Sampling Point[1]	Number of Samples	Concentration mg/l				
		Minimum	Maximum	Average	95% C.L.[2]	% of Standard[3]
P1	4	104	117	112	17.3	44.8
P2	4	10	47	27	50	10
P3	2	41	94	68	85	27
T1s	4	64	125	86	76	35
T1d	4	6	43	28	51	11
T3	4	55	87	77	41	31
T4	4	54	62	58	9.3	23
T5	4	69	75	72	7.0	29
T8s	4	75	80	77	7.4	31
T8d	4	9	11	10	2.6	4.0
T9	3	71	78	76	13	30
T10	4	652	672	672	90.2	269
T11	4	71	79	76	9.3	30

1. See Figure 11.
2. C.L. = Average Concentration ± the value shown = t (α =0.05, df) $S\bar{x}$
3. 250 mg/l per 40 CFR Part 143, National Interim Secondary Drinking Water Standards.

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TABLE 25: *Chloride in On-site Well Water, 1986*

Sampling Point[1]	Number of Samples	Concentration mg/l				
		Minimum	Maximum	Average	95% C.L.[2]	% of Standard[3]
P1	4	9	40	31	41	13
P2	4	21	23	22	2.2	8.8
P3	2	13	14	13	1.6	5.4
T1s	4	17	19	17	2.6	7.1
T1d	4	6	43	27	51	11
T3	4	22	23	22	1.6	9.0
T4	4	20	26	22	7.0	9.0
T5	4	15	18	16	3.8	6.4
T8s	4	20	21	20	1.4	8.3
T8d	4	11	13	11	2.7	4.7
T9	3	20	22	21	2.6	8.4
T10	4	14	92	67	115	27
T11	4	21	22	21	1.3	8.5

1. See Figure 11.
2. C.L.= Average Concentration ± the value shown = t (α = 0.05, df) $S\bar{x}$.
3. 250 mg/l per 40 CFR Part 143, National Interim Secondary Drinking Water Standard. Percent of Standard relates to the average value.

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TABLE 26: *pH in On-site Well Water, 1986*				
Sampling Point[1]	Number of Samples	pH range		
P1	4	7.2	to	7.7
P2	4	7.4	to	7.7
P3	2	7.4	to	7.5
T1s	4	7.3	to	7.4
T1d	4	7.3	to	7.6
T3	4	7.3	to	7.5
T4	4	7.4	to	7.4
T5	4	7.3	to	7.4
T8s	4	7.3	to	7.5
T8d	4	7.3	to	7.5
T9	3	7.4	to	7.5
T10	4	6.8	to	7.0
T11	4	7.3	to	7.6

1. See Figure 11.

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TABLE 27: *Metals in Off-site Well Water, 1986*

Sampling Point[1]	Concentation mg/l															
	Ag[2]	As[2]	Ba[2]	Ca	Cd[2]	Cr[2]	Cu[3]	Fe[3]	K	Mg	Mn[3]	Na	Ni	Pb[2]	Se[2]	Zn[3]
1	< 0.03	0.024	0.382	87.4	< 0.002	< 0.005	< 0.025	4.430	0.824	21.7	0.021	10.0	< 0.005	< 0.005	< 0.0025	0.262
3	< 0.03	0.015	0.491	74.5	< 0.002	< 0.005	< 0.025	3.330	0.960	25.2	0.031	29.8	< 0.005	< 0.005	< 0.0025	< 0.025
4	< 0.03	< 0.005	< 0.200	158.0	< 0.002	< 0.005	< 0.025	< 0.050	1.470	65.0	< 0.020	53.0	< 0.005	< 0.005	< 0.0025	0.038
5	< 0.03	< 0.005	< 0.200	169.0	< 0.002	< 0.005	< 0.025	0.560	1.450	54.0	0.041	25.6	< 0.005	< 0.005	< 0.0025	0.032
6	< 0.03	<.0.005	< 0.200	84.3	< 0.002	< 0.005	0.039	< 0.050	12.800	29.6	< 0.020	11.6	< 0.005	< 0.005	< 0.0025	0.494
7	< 0.03	< 0.005	< 0.200	111.0	< 0.002	< 0.005	< 0.025	1.800	1.620	33.4	0.150	8.7	< 0.005	< 0.005	< 0.0025	0.082
8	< 0.03	< 0.005	< 0.200	94.3	< 0.002	< 0.005	< 0.025	0.106	2.280	28.4	0.131	15.5	< 0.005	< 0.005	< 0.0025	< 0.025
9	< 0.03	< 0.005	< 0.200	72.1	< 0.002	< 0.005	< 0.025	0.091	2.910	28.2	0.296	26.5	< 0.005	< 0.005	< 0.0025	< 0.025
10	< 0.03	< 0.005	< 0.200	83.6	< 0.002	< 0.005	0.234	2.440	1.590	27.3	0.238	10.1	< 0.005	0.007	< 0.0025	0.066
11	< 0.03	< 0.005	< 0.200	74.8	< 0.002	< 0.005	0.046	0.120	1.700	24.9	< 0.020	10.9	< 0.005	< 0.005	< 0.0025	0.247
12	< 0.03	< 0.005	< 0.200	60.3	< 0.002	< 0.005	< 0.025	< 0.050	2.300	18.9	< 0.020	12.6	< 0.005	< 0.005	< 0.0025	0.139
13	< 0.03	< 0.005	< 0.200	97.6	< 0.002	< 0.005	0.065	< 0.050	2.220	31.6	0.028	10.3	< 0.005	< 0.005	0.0030	0.066
14	< 0.03	< 0.005	< 0.200	121.0	< 0.002	< 0.005	< 0.025	0.897	4.400	33.3	0.299	14.2	< 0.005	< 0.005	< 0.0025	< 0.025
15	< 0.03	< 0.005	< 0.200	90.7	< 0.002	< 0.005	0.077	< 0.050	2.790	25.6	< 0.020	12.3	< 0.005	< 0.005	< 0.0025	0.096
16	< 0.03	< 0.005	< 0.200	98.0	< 0.002	< 0.005	< 0.025	2.040	1.760	26.7	0.341	10.7	< 0.005	< 0.005	< 0.0025	< 0.025
17	< 0.03	< 0.005	< 0.200	97.1	< 0.002	< 0.005	< 0.025	1.140	2.250	22.5	0.393	11.4	< 0.005	< 0.005	< 0.0025	< 0.025
18	< 0.03	< 0.005	< 0.200	109.0	< 0.002	< 0.005	< 0.025	3.390	1.980	29.3	0.253	8.5	< 0.005	< 0.005	< 0.0025	< 0.025
19	< 0.03	0.043	< 0.200	96.0	< 0.002	< 0.005	< 0.025	1.310	15.400	49.0	0.257	12.0	< 0.005	< 0.005	< 0.0025	< 0.025
21	< 0.03	< 0.005	< 0.200	107.0	< 0.002	< 0.005	< 0.025	1.500	1.850	29.1	0.261	8.4	< 0.005	< 0.005	< 0.0025	0.054
22	< 0.03	< 0.005	< 0.200	84.0	< 0.002	< 0.005	< 0.025	0.053	2.300	22.2	0.071	10.1	< 0.005	< 0.005	< 0.0025	< 0.025
23	< 0.03	< 0.005	< 0.200	86.3	< 0.002	< 0.005	0.026	< 0.050	1.510	26.0	0.040	7.2	< 0.005	< 0.005	< 0.0025	0.094
25	< 0.03	< 0.005	< 0.200	110.0	< 0.002	< 0.005	0.026	< 0.050	1.790	32.3	< 0.020	7.2	< 0.005	< 0.005	< 0.0025	< 0.025
26	< 0.03	< 0.005	< 0.200	103.0	< 0.002	< 0.005	< 0.025	3.250	1.410	26.7	0.331	5.8	< 0.005	< 0.005	< 0.0025	0.100
28	< 0.03	< 0.005	< 0.200	88.1	< 0.002	< 0.005	< 0.025	0.392	1.640	26.9	0.082	4.4	< 0.005	< 0.005	< 0.0025	< 0.025

1. Samples were not taken at sampling points 2, 20, 24, & 27.
2. EPA Drinking Water Standards: (Taken from 40 CFR Part 141 National Interim Primary Drinking Water Regulations-Support B-Maximum Contaminant Levels, July 1, 1984). Ag = 0.05 ppm; As = 0.05 ppm; Ba = 1.0 ppm; Cd = 0.010 ppm; Cr = 0.05 ppm; Pb = 0.05 ppm; Se = 0.01 ppm.
3. EPA Drinking Water Standards: (Taken from 40 CFR Part 143 National Secondary Drinking Water Regulations-Section 143.3-Secondary Maximum Contaminant Level Cu = 1.0 ppm; Fe = 0.3ppm; Mn = 0.05 ppm; Zn = 5.0 ppm.

TABLE 28: *NPDES Data, 1986*

Parameter	Units	Number of Samples	Daily Minimum	Daily Maximum	Annual Average	NPDES Permit Limits: Daily Maximum	NPDES Permit Limits: Monthly Average	Percent Compliance
Discharge 001 (MH175)								
Flow Rate	MGD	Continuous	0.199	1.092	0.501	NA[1]	NA[1]	NA[1]
pH	pH Units	Daily Grab	6.9	9.7	NA[1]	Range = 6.5 to 10.0		100
Suspended Solids[2]	mg/l	53	<2	31	<5.5	60	20	100
Ammonia (as N)	kg/day	53	0.1	4	0.8	43	28	100
Oil & Grease	mg/l	53	<5	9	<5	15	NA[1]	100
Residual Chlorine	mg/l	26[3]	<0.02	0.09	<0.03	0.1	NA[1]	100
Nitrate (as N)	kg/day	53	6	849	148	3180	1590	100
Discharge 002 (Storm Sewer Outfall)								
Flow Rate	MG/Event	Continuous	0.002	1.057	0.150	NA[1]	NA[1]	NA[1]
pH	pH Units	Grab/Event	7.4	8.3	NA[1]	Range = 6.5 to 9.0		100
Suspended Solids[2]	mg/l	57	<2	223	<21	100	30	93
Oil & Grease	mg/l	57	<5	15	<5	15	NA[1]	100
Sampling Location 001A (Sewage Treatment Plant)								
Flow Rate	MGD	Continuous	0.033	0.274	0.121	NA[1]	NA[1]	NA[1]
pH	pH Units	Daily Grab	7	8.2	NA[1]	Range = 6.5 to 9.0		100
BOD 5[2]	mg/l(kg/day)	53	3(1.4)	20(6.7)	8(3.7)	40(10.0)	20(5.0)	94
Suspended Solids[2]	mg/l(kg/day)	53	1(0.7)	21(11.4)	7(4.1)	40(10.0)	20(5.0)	92
Fecal Coliform[2]	MPN/100ml	27[3]	7	2000	66[4]	2000	1000	96
Sampling Locations 001B & C (Combined General Sump & Clearwell)								
Flow Rate	MGD	Continuous	0.000	0.512	0.116	NA[1]	NA[1]	NA[1]
Suspended Solids	kg/day	53	0.3	11.5	2.7	12.8	6.2	100
Chromium (+6)	kg/day	53	0.0001	0.009	0.0021	0.008	0.004	94
Chromium (total)	kg/day	53	0.0001	0.102	0.0070	0.102	0.050	100
Iron	kg/day	53	0.0023	0.57	0.05	0.85	0.41	100
Nickel	kg/day	53	0.0001	0.256	0.016	0.256	0.124	100
Copper	kg/day	53	0.0001	0.017	0.005	0.051	0.025	100
Sampling Location 001D (Lift Station)								
Flow Rate	MGD	Continuous	0.091	0.648	0.245	NA[1]	NA[1]	NA[1]
Suspended Solids[2]	mg/l	53	<2	26	<4	100	30	100
Oil & Grease	mg/l	89	<5	6	<5	15	NA[1]	100

1. NA = Not Applicable
2. Flow-weighted averages.
3. Monitoring not required during winter months.
4. Geometric mean.

TABLE 29: *Ion and pH Levels in Surface Water, 1986*

Parameter	Sampling Point[1]	Number of Samples	Concentration (mg/l) Minimum	Maximum	Average	95% C.L.[2]	% of Standard[4]	Standard[3]
Fluoride	W1	52	0.2	0.7	0.4	0.03	21	1.8 mg/l
	W3	52	0.2	0.6	0.4	0.03	21	
	W4	52	0.2	0.6	0.4	0.03	20	
	W5	12	0.1	0.6	0.2	0.08	13	
	W7	11	0.2	1.3	0.45	0.25	25	
	W8	12	0.1	0.4	0.2	0.05	9	
	W9	12	0.1	0.8	0.3	0.1	14	
	W10	12	0.1	1.0	0.3	0.2	17	
	W11	12	0.2	1.1	0.3	0.2	17	
Nitrate (as N)	W1	52	0.8	10	3.9	0.47	39	10 mg/l
	W3	52	0.4	10	3.8	0.47	38	
	W4	51	0.4	10	3.9	0.48	39	
	W5	12	0.2	2.6	1.4	0.45	14	
	W7	10	0.1	3.1	1.7	0.62	17	
	W8	11	0.1	3.0	0.70	0.66	7	
	W9	12	0.3	2.1	1.4	0.37	14	
	W10	12	0.1	2.1	1.4	0.42	14	
	W11	12	0.2	3.1	1.5	0.56	15	
Chloride	W1	52	16	94	48	4.5	19	250 mg/l
	W3	52	16	93	48	4.5	19	
	W4	52	15	93	48	4.4	19	
	W5	12	9.0	44	29	7.1	11	
	W7	12	9.0	122	33	21	13	
	W8	12	20	171	57	27	23	
	W9	12	10	35	25	4.9	10	
	W10	12	10	36	24	4.8	10	
	W11	12	9.0	34	23	3.9	9	
pH[4]	W1	52	8.0	9.2	NA[5]	NA[5]	NA[5]	6.5 - 9.0
	W3	52	7.9	9.3				
	W4	52	7.9	9.3				
	W5	52	7.6	8.7				
	W7	24	7.2	8.4				
	W8	28	7.0	8.3				
	W9	42	7.8	8.5				
	W10	40	7.8	8.5				
	W11	32	7.8	8.6				

1. See Figure 19.
2. C.L. = Average Concentration ± value shown; = $t(\alpha = 0.05, df)S\bar{x}$.
3. Ohio EPA Water Quality Standards, Administrative Code Chapter 3745-1 (Public Water Supply Use Designation).
4. pH is reported in standard units.
5. NA = Not Applicable.

Appendix B – Sampling Groundwater for RCRA Parameters

The FMPC relies on the data from several programs to monitor the effects of its operation on the environment. The FMPC/RCRA monitoring program is one example of a groundwater monitoring program. In 1986, all on-site wells and off-site wells 8, 12, 15, 17, and 26 were sampled quarterly. In many instances, cross comparisons between three laboratories was used to verify data. Identification letters and numbers of off-site wells sampled and reported for the RCRA program are not the same as the identification letters and numbers used in this report. Well 8 in the EMR is identified as SW-2 in the RCRA sampling data, well 12 is OS-1, well 15 is OS-2, well 17 is OS-3, and well 26 is 15d. All on-site wells have the same identification numbers for RCRA sampling and the EMR. (See Figure 39 on page 131.) Final discussion of the significance of RCRA sampling will be made in the Environmental Monitoring Annual Report for 1987. Initially, no unusual data has been observed. USEPA Region 5 is also reviewing this data and should make their findings known in the future.

This appendix lists the parameters analyzed for the RCRA groundwater sampling program, and also includes the results in series of tables.

Parameters Analyzed for RCRA Groundwater Sampling

A. For General Water Quality

1. Chloride
2. Iron
3. Manganese
4. Phenols (total)
5. Sodium
6. Sulfate

B. For Indicators of Contamination (Quadruplicate Analysis)

1. pH
2. Specific Conductance
3. Total Organic Carbon (TOC)
4. Total Organic Halogen (TOX)

C. For Drinking Water Suitability

1. Arsenic
2. Barium

3. Cadmium
4. Chromium
- Hexavalent
- Total
5. Fluoride
6. Lead
7. Mercury
8. Nitrate (as N)
9. Selenium
10. Silver
11. Gross alpha
12. Gross beta
13. Radium
14. Endrin
15. Lindane
16. Methoxychlor
17. Toxaphene
18. 2,4-D
19. 2,4,5-TP Silvex
20. Coliform Bacteria

D. Other Metals, Organics, and Site Specific Parameters

1. Nickel
2. Cyanide
3. Copper
4. Zinc
5. Magnesium
6. Calcium
7. Phosphorus
8. Chlorobenzene
9. Chlorodibromomethane
10. Chloroethane
11. 2-chloroethylvinyl Ether
12. Chloroform
13. Dichlorobromomethane
14. Dichlorodifluoromethane
15. Total Dissolved Solids (TDS)
16. Total Potassium
17. Chemical Oxygen Demand (COD)
18. perChloroethylene
19. cis-1,2-Dichloroethylene
20. Tributylphosphate
21. Acrolein
22. Acrylonitrile
23. Benzene
24. bis (chloromethyl) Ether
25. Bromoform
26. Bromodichloromethane
27. Bromomethane
28. Carbontetrachloride
29. Chloromethane
30. 1,2-Dichlorobenzene
31. 1,3-Dichlorobenzene
32. 1,4-Dichlorobenzene
33. 1,1-Dichloroethane
34. 1,2-Dichloroethane
35. 1,1-Dichloroethylene
36. 1,2-Dichloropropane
37. 1,2-Dichloropropylene
38. Ethylbenzene
39. Methylbromide
40. Methylchloride
41. trans-1,2-Dichloroethylene
42. 1,3-Dichloropropene
43. 1,1,2,2-Tetrachloroethane
44. Tetrachloroethylene
45. Toulene
46. 1,1,1-Trichloroethane
47. 1,1,2-Trichloroethane
48. Trichloroethylene
49. Trichlorofluoromethane
50. Vinyl Chloride

E. Radionuclides

1. Potassium 40
2. Total Uranium
3. Radium 226
4. Radium 228
5. Technetium 99
6. Thorium 228
7. Thorium 230
8. Thorium 232
9. Cesium 137
10. Strontium 90
11. Ruthenium 106
12. Neptunium 237
13. Plutonium 238
14. Plutonium 239
15. Plutonium 240

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TABLE 30: *Second Quarter Water Level Elevation, 1986*

Well location	Depth to Water(ft)	Casing Elevation(MSL)	Grade(MSL)	Water Table Elevation(MSL)
P-1	NA	578.66	576.66	NA
P-2	NA	579.16	577.16	NA
P-3	NA	579.36	577.36	NA
1s	61.52	585.55	583.47	524.03
1d	61.50	585.31	583.81	523.81
3	35.72	560.86	559.30	525.14
4	31.00	556.85	556.15	525.85
5	31.84	557.09	555.53	525.25
8s	52.45	576.60	574.90	524.15
8d	53.22	576.62	574.82	523.40
9	30.92	557.23	555.31	526.31
10	64.95	588.39	586.56	523.44
11	60.67	585.78	583.64	525.11
12	31.37	639.67	NA	608.30
13s	68.09	590.37	588.71	522.28
13d	68.08	590.36	588.72	522.28
14s	12.39	535.79	533.76	523.40
14d	12.40	535.81	533.71	523.41
15s	57.21	579.65	577.80	522.44
15d	60.00	579.41	577.80	519.41
16s	18.13	542.28	540.47	524.15
16d	18.06	542.13	540.50	524.07
17s	13.00	536.19	534.43	523.19
17d	13.15	536.35	534.28	523.20
18s	48.17	573.36	571.31	525.19
18d	42.25	573.88	571.56	531.63
19s	61.00	585.38	583.26	524.38
19d	61.00	585.25	583.20	524.25
TP-19	8.73	584.96	582.98	576.23
20s	51.69	574.44	573.42	522.75
20d	51.04	574.71	573.31	523.67
TP-20	4.50	574.73	573.21	570.23
21s	61.53	586.02	594.42	524.29
TP-21	4.60	585.61	584.06	581.01
22s	63.26	587.95	587.93	524.69
TP-22	7.62	588.91	587.93	581.29
SW-2	29.33	NA	NA	NA
OS-1	59.50	581.83	581.35	522.33
OS-2	26.00	NA	NA	NA
OS-3	NA	NA	NA	NA
OS-1A	11.58	NA	NA	NA
*IT-1	57.55	579.93	577.93	522.38
*IT-2	73.80	595.58	593.22	521.78
*IT-5A	72.52	594.22	592.17	521.70
*IT-6	53.60	576.02	574.07	522.42

MSL - Mean Sea Level.
NA - Not Available.
* Not Sampled.

TABLE 31: *Shallow (Till) FMPC Groundwater Sampling Results, Second Quarter 1986* *(All results in ppm except as noted)*

Well location	W-12	W-19TP	W-20TP	W-21TP	W-22TP	OS-1A
Chloride	105.0	265.0	5.0	19.0	34.0	35.0
Iron	3.410	2.100	0.360	1.690	15.800	0.083
Manganese	0.050	1.380	1.020	1.920	1.280	< 0.020
Phenols	< 0.005	< 0.005	< 0.005	0.006	0.007	0.008
Sodium	210.000	56.100	3.680	11.300	174.000	32.700
Sulfate	8.0	660.0	48.0	260.0	1,100.0	130.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	< 0.007	< 0.005	0.008	< 0.005
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	22.300	310.000	120.000	146.000	458.000	141.000
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	0.008	0.010
Chromium						
-Total	< 0.005	< 0.005	< 0.005	< 0.005	0.028	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.005	< 0.005	< 0.010	< 0.005
Copper	< 0.025	< 0.025	< 0.025	< 0.025	< 0.052	< 0.025
Fluoride	1.09	0.38	0.22	0.52	0.97	0.17
Mercury	0.0009	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	10.600	1.140	1.010	1.390	8.090	34.100
Mangesium	9.200	107.000	29.000	74.000	176.000	62.000
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	0.023	< 0.005
Nitrates	< 0.02	0.07	< 0.02	0.19	10.50	8.96
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	0.06	0.11	0.07	0.08	0.35	0.07
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	< 0.025	< 0.025	0.48	0.051
T.D.S.	660	1,820	376	780	2,550	840
C.O.D.	< 10	21	17	12	38	16.
pH-lab[1,2]	7.75	6.72	7.13	7.28	7.07	6.99
Conductivity-lab[1,3]	1,000	2,000	598	999	2,400	1,100
T.O.C.[1]	< 1	4	2	2	5	2
T.O.X.[1,4]	< 10.0	NA	15.5	NA	30.8	19.5
Coliform[5]	6	< 2	29	6	2,600	4,200
Lindane[4]	< 0.2	NA	< 0.2	NA	< 0.2	< 0.2
Endrin[4]	< 0.2	NA	< 0.2	NA	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	NA	< 0.2	NA	< 0.2	< 0.2
Toxaphene[4]	< 0.5	NA	< 0.5	NA	< 0.5	< 0.5
2,4-D[4]	< 0.2	NA	< 0.2	NA	< 0.2	< 0.2
2,4,5-TP,Silvex[4]	< 0.2	NA	< 0.2	NA	< 0.2	< 0.2
VOC's[4]	ND	ND	ND	ND	ND	ND
Gross Alpha[6]	< 15	< 15	< 15	125	37	< 15
Gross Beta[6]	5.0	76.77	< 5.0	335.0	143.0	26.0
Radium, Total[6]	< 5.0	5.84	< 5.0	21.1	< 5.0	< 5.0
Radionuclide Scan[6,7]	< 5	< 5	< 5	< 5	< 5	< 5
Uranium[8]	0.0001	0.90	0.012	3.20	5.06	0.0013

NA = Not Analyzed
ND = Not Detected
1. Average of four tests
2. pH results in standard units
3. Conductivity results in µmhos/cm
4. Concentrations reported in ppb
5. Reported in per 100 ml.
6. Results in pCi/l.
7. Radionuclide scan includes analysis for K-40, Unat., Th-228, Th-230, Th-232, Tc-99, Cs-137, Sr-90, Ru-106, Np-237, Pu-238, Pu-239, Pu-240.
8. WMCO split sample; analyzed for uranium at the FMPC; results in mg/l.

TABLE 32: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Inside Production Area, Second Quarter, 1986 (All results in ppm except as noted)* page 1 of 2.

Well location	W-1s	W-1d	W-3	W-4	W-5	W-8s	W-8d	W-10	W-13s	W-13d	W-19s	W-19d	W-21s	W-22s
Chloride	18.0	27.0	24.0	21.0	16.0	21.0	13.0	82.0	27.0	69.0	39.0	51.0	69.0	38.0
Iron	1.050	6.240	0.750	0.170	2.310	1.190	3.010	0.250	3.180	7.840	0.085	0.060	1.130	0.064
Manganese	0.487	0.416	0.396	< 0.005	0.546	0.217	0.362	4.160	0.183	0.338	0.027	2.360	< 0.020	< 0.020
Phenols	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	0.006	< 0.005	0.008	0.009	0.014	0.007
Sodium	10.400	23.500	7.800	8.500	8.290	9.500	9.700	131.000	12.000	48.800	43.600	75.400	52.900	27.800
Sulfate	74.0	60.0	94.0	66.0	72.0	72.0	12.0	720.0	94.0	230.0	98.0	410.0	92.0	100.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	76.800	98.400	83.100	84.100	110.000	83.000	96.900	377.00	121.000	205.000	143.000	248.000	175.000	122.000
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium														
-Total	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Fluoride	0.13	0.13	0.24	0.24	0.24	0.14	0.22	0.13	0.17	0.15	0.14	0.09	0.19	0.68
Mercury	< 0.0002	< 0.0002	0.0005	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0003	< 0.0002	< 0.0002	< 0.0002
Potassium	2.470	1.010	2.640	2.880	2.660	2.860	1.010	21.900	2.310	4.300	4.710	7.960	10.340	3.540
Magnesium	23.500	27.100	23.300	20.300	26.500	22.900	21.000	73.000	26.300	59.000	41.100	26.400	21.200	34.600
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	0.007	< 0.005	0.005
Nitrates	< 0.02	0.08	< 0.02	2.20	< 0.02	< 0.02	< 0.02	160.00	0.06	< 0.02	72.00	3.70	63.90	28.70
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	< 0.02	0.12	0.04	< 0.02	< 0.02	< 0.02	0.07	0.06	< 0.02	< 0.02	0.04	0.05	0.09	< 0.02

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TABLE 32: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Inside Production Area, Second Quarter, 1986 (All results in ppm except as noted)* page 2 of 2

Well location	W-1s	W-1d	W-3	W-4	W-5	W-8s	W-8d	W-10	W-13s	W-13d	W-19s	W-19d	W-21s	W-22s
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.0025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
T.D.S.	456	476	416	348	560	448	332	2730	468	956	948	1,120	1,100	664
C.O.D.	< 10	12	< 10	< 10	< 10	< 10	11	< 10	11	144	11	< 10	< 10	< 10
pH-lab[1,2]	7.32	7.36	7.40	7.47	7.30	7.40	7.47	6.88	7.24	7.07	7.30	6.96	7.37	7.46
Conductivity-lab[1,3]	599	725	603	546	656	600	519	2,713	686	1,265	1,200.0	1,575	1,255	933
T.O.C.[1]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
T.O.X.[1,4]	47.0	12.0	< 10.0	11.0	< 10.0	19.0	< 10.0	23.3	< 10.0	13.0	18.5	< 10.0	22.3	21.8
Coliform[5]	< 2.0	18.0	< 2.0	2,100.0	< 2.0	9.0	< 2.0	< 2.0	3.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Lindane[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 0.2	< 0.2	< 0.2	< 0.2	<0.2	4.06	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4,5-TP,Silvex[4]	< 0.2	< 0.2	< 0.2	< 0.2	<0.2	0.694	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
VOC's[4]	NA	ND	NA	...	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gross Alpha[6]	< 15.0	< 15.0	< 15.0	< 15.0	< 15.0	< 15.0	< 15.0	< 15.0	< 15.0	< 15.0	15.3	< 15.0	33.0	< 15.0
Gros Beta[6]	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	12.9	< 5.0	< 5.31	794.0	12.2	930.0	73.0
Radium, Total[6]	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	130.0	< 5.0	29.0	< 5.0
Radionuclide Scan[6,7]	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Uranium[8]	0.0093	0.0001	0.0023	0.0058	0.0037	0.0006	0.0003	0.015	0.0021	0.019	0.0011	0.032	0.0018	0.0035
Trichloroethane	...	...	...	0.0044	...	...	...	...	...	...	...	...	...	...

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. Radionuclide scan includes analysis for K-40, U-nat., Th-228, Th-230, Th-232, Tc-99, Cs-137, Sr-90, Ru-106, Np-237, Pu-238, Pu-239, Pu-240.
8. WMCO split sample - analyzed for uranium at the FMPC; results in mg/l.

TABLE 33: *Groundwater Sampling Results FMPC Plant Production Wells, Second Quarter 1986*
(All results in ppm except as noted)

Well Location	P-1	P-2	P-3
Chloride	15.0	22.0	34.0
Iron	3.030	3.960	5.560
Manganese	0.415	0.352	0.403
Phenols	< 0.005	< 0.005	< 0.005
Sodium	7.650	11.200	26.500
Sulfate	50.0	8.0	110.0
Silver	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200
Calcium	86.300	87.900	14.900
Cadmium	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005
Chromium			
-Total	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.005
Copper	< 0.0250	< 0.0250	< 0.0250
Fluoride	0.15	0.20	0.02
Mercury	< 0.0002	< 0.0002	< 0.0002
Potassium	1.610	1.190	3.730
Magnesium	21.100	22.600	32.500
Nickel	< 0.005	< 0.005	< 0.005
Nitrate	< 0.02	0.02	< 0.02
Lead	< 0.005	< 0.005	< 0.005
Phosphorus, total	0.03	0.13	0.10
Selenium	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	< 0.025
T.D.S.	368	368	656
C.O.D.	< 10.0	< 10.0	< 10.0
pH-lab[1,2]	7.43	7.60	7.57
Conductivity-lab[1,3]	540	575	885
T.O.C.[1]	< 1.0	< 1.0	< 1.0
T.O.X.[1,4]	NA	< 10.0	26.0
Coliform[5]	9.0	< 2.0	< 2.0
Lindane[4]	NA	< 0.2	< 0.2
Endrin[4]	NA	< 0.2	< 0.2
Methoxychlor[4]	NA	< 0.2	< 0.2
Toxaphene[4]	NA	< 0.5	< 0.5
2,4-D[4]	NA	< 0.2	< 0.2
2,4,5-TP,Silvex[4]	NA	< 0.2	< 0.2
VOC's[4]	NA	NA	NA
Gross Alpha[6]	< 15	< 15	< 15
Gross Beta[6]	5.76	< 5	< 5
Radium, Total[6]	< 5	< 5	< 5
Radionuclide Scan[6,7]	< 5	< 5	< 5
Uranium[8]	0.0004	0.0002	0.0002

NA = Not Analyzed
ND = Not Detected
1. Average of four tests.
2. pH results in standard units.
3. Conductivity in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. Radionuclide scan includes analysis for K-40, U-nat., Th-228, Th-230, Th-232, Tc-99, Cs-137, Sr-90, Ru-106, Np-237, Pu-238, Pu-239 Pu-240.
8. WMCO split sample; analyzed for uranium at the FMPC; results in mg/l.

TABLE 34: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area,Second Quarter 1986*

(All results in ppm except as noted) page 1 of 4

Well location	W-9	W-11	W-14s	W-14d	W-15s	W-16s	W-16d	W-17s	W-17d
Chloride	22.0	21.0	20.0	18.0	19.0	20.0	19.0	22.0	21.0
Iron	0.210	8.540	5.700	0.150	0.031	1.020	1.300	0.180	1.330
Manganese	0.061	0.169	0.143	< 0.020	< 0.020	0.042	0.051	0.121	1.330
Phenols	0.007	0.007	0.008	0.007	< 0.005	0.005	0.009	0.009	0.008
Sodium	10.300	9.600	9.400	8.200	11.000	10.500	10.400	7.240	7.600
Sulfate	70.0	78.0	68.0	58.0	52.0	56.0	58.0	96.0	80.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	79.900	99.800	89.000	78.700	69.400	92.600	91.700	139.000	92.700
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium									
-Total	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.010	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	0.099	< 0.025	0.025	< 0.027	< 0.025	< 0.025	< 0.025
Fluoride	0.18	0.22	0.29	0.18	0.42	0.21	0.16	0.17	0.11
Mercury	< 0.0002	< 0.0002	< 0.0002	0.0007	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	2.170	0.950	3.410	2.050	2.780	3.070	2.430	1.850	2.130
Magnesium	21.600	25.500	22.100	19.500	19.100	21.000	21.600	30.500	18.300
Nickel	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nitrates	2.96	< 0.02	0.10	2.80	2.60	2.28	2.92	0.13	< 0.02
Lead	< 0.005	< 0.005	< 0.015	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	0.04	0.09	0.12	< 0.02	< 0.05	< 0.02	< 0.02	< 0.02	< 0.02

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. Radionuclide scan includes analysis for K-40, U-nat., Th-228, Th-230, Th-232, Tc-99, Cs-137, Sr-90, Ru-106, Np-237, Pu-238, Pu-239, Pu-240.
8. WMCO split sample - analyzed for uranium at the FMPC; results in mg/l.

TABLE 34: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area, Second Quarter 1986*
(All results in ppm except as noted) page 2 of 4

Well location	W-18s	W-18d	W-20s	W-20d	SW-2	OS-1	W-15d	OS-2	OS-3
Chloride	6.0	2.0	21.0	22.0	30.0	19.0	25.0	36.0	29.0
Iron	32.700	2.500	0.710	1.300	0.104	0.081	3.100	0.005	1.930
Manganese	1.250	0.120	0.070	0.205	0.131	< 0.020	0.309	< 0.020	0.365
Phenols	0.009	0.006	< 0.005	< 0.005	0.007	0.006	< 0.005	0.012	0.011
Sodium	4.440	4.600	11.400	9.100	13.600	13.600	7.630	13.800	11.100
Sulfate	50.0	56.0	76.0	86.0	68.0	58.0	94.0	62.0	70.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	0.035	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	146.000	98.200	115.000	104.000	97.700	73.300	109.000	108.000	94.300
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.200	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium									
-Total	0.025	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005
-Hexavalent	0.010	< 0.005	< 0.005	< 0.005	< 0.005	< 0.006	< 0.005	< 0.005	< 0.005
Copper	0.034	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Fluoride	0.63	0.40	0.20	0.11	0.29	0.58	0.10	0.18	0.20
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	3.160	0.525	2.660	1.920	2.610	2.840	2.000	3.120	2.480
Magnesium	38.800	33.500	20.900	22.000	26.700	18.700	24.600	22.600	22.600
Nickel	0.021	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nitrates	0.67	< 0.02	5.48	0.06	3.40	2.60	0.09	5.04	0.10
Lead	0.012	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	0.26	< 0.02	< 0.002	< 0.002	< 0.02	< 0.02	< 0.02	0.004	0.04

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. Radionuclide scan includes analysis for K-40, U-nat., Th-228, Th-230, Th-232, Tc-99, Cs-137, Sr-90, Ru-106, Np-237, Pu-238, Pu-239, Pu-240.
8. WMCO split sample - analyzed for uranium at the FMPC; results in mg/l.

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TABLE 34: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area,Second Quarter1986*

(All results in ppm except as noted) page 3 of 4

Well location	W-9	W-11	W-14s	W-14d	W-15s	W-16s	W-16d	W-17s	W-17d
Selenium	0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
T.D.S.	408	476	344	316	344	408	372	620	412
C.O.D.	13	15	26	12	< 10	< 10	< 10	< 10	12
pH-lab[1,2]	7.50	7.37	7.67	7.69	7.53	7.60	7.57	7.20	7.42
Conductivity-lab[1,3]	540	643	518	515	534	522	529	790	546
T.O.C.[1]	< 1	< 1	1	1.25	< 1	< 1	< 1	< 1	< 1
T.O.X.[1,4]	11.3	22.8	25.8	26.3	30.0	< 10.0	14.8	30.8	12.0
Coliform[5]	3,400	31	9	< 2	< 2	< 2	6	< 2	3
Lindane[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4,5-TP,Silvex[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
VOC's[4]	ND	ND	ND	ND	...	ND	ND	ND	ND
Gross Alpha[6]	< 15	< 15	< 15	< 15	24.9	< 15	< 15	< 15	< 15
Gross Beta[6]	< 5	8.28	< 5	7.74	25.16	9.67	5.26	< 5	< 5
Radium, Total[6]	< 5	< 5	< 5	< 5	7.14	< 5	< 5	< 5	< 5
Radionuclide Scan[6,7]	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Uranium[8]	0.0011	0.0001	0.020	0.021	0.154	0.012	0.0075	0.0034	0.0008
1,1,1-Trichloroethane...		...	...	...	0.0051	...	...	...	...

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. Radionuclide scan includes analysis for K-40, U-nat., Th-228, Th-230, Th-232, Tc-99, Cs-137, Sr-90, Ru-106, Np-237, Pu-238, Pu-239, Pu-240.
8. WMCO split sample - analyzed for uranium at the FMPC; results in mg/l.

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TABLE 34: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area, Second Quarter1986*
(All results in ppm except as noted) page 4 of 4

Well location	W-18s	W-18d	W-20s	W-20d	SW-2	OS-1	W-15d	OS-2	OS-3
Selenium	0.003	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	0.068	< 0.025	< 0.025	< 0.025	< 0.025	0.092	0.031	0.064	< 0.025
T.D.S.	408	384	376	316	448	NA	452	444	340
C.O.D.	30	< 10	< 10	27	23	16	12	12	11
pH-lab[1,2]	7.51	7.52	7.47	7.41	7.46	7.68	7.51	7.47	7.34
Conductivity-lab[1,3]	550	566	568	578	637	499	612	636	618
T.O.C.[1]	4	1	<1	1	<1	<1	<1	<1	<1
T.O.X.[1,4]	51.5	< 10.0	28.0	15.5	< 10.0	< 10.0	< 10.0	18.0	24.0
Coliform[5]	< 2	< 2	< 2	3	100	9	< 2	< 2	< 2
Lindane[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4,5-TP,Silvex[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
VOC's[4]	ND	ND	ND	ND	ND	NA	NA	NA	NA
Gross Alpha[6]	< 15	< 15	< 15	< 15	< 15	35	< 15	51	< 15
Gross Beta[6]	14	< 5	5.7	< 5	12.37	37	< 5	31	< 5
Radium, Total[6]	< 5	< 5	8	5.9	7.74	36	< 5	6.57	< 5
Radionuclide Scan[6,7]	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Uranium[8]	0.0027	0.0017	0.0005	0.0009	0.0008	0.205	0.0001	0.282	0.035
1,1,1-Trichoroethane	...	...	...	...	...	...	...	...	...

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. WMCO split sample - analyzed for uranium at the FMPC; results in mg/l.

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TABLE 35: *Third Quarter Water Level Elevation, 1986*

Well location	Depth to Water(ft)	Casing Elevation(MSL)	Grade(MSL)	Water Table Elevation(MSL)
P-1	NA	578.66	576.66	NA
P-2	NA	579.16	577.16	NA
P-3	NA	579.36	577.36	NA
1s	63.82	585.55	583.47	521.73
1d	62.94	585.31	583.81	522.37
3	37.73	560.86	559.30	523.13
4	33.41	556.85	556.15	523.44
5	34.00	557.09	555.53	523.09
8s	55.20	576.60	574.90	521.40
8d	54.93	576.62	574.82	521.69
9	34.00	557.23	555.31	523.23
10	66.43	588.39	586.56	521.96
11	62.43	585.78	583.64	523.35
12	34.87	639.67	637.48	604.80
13s	69.91	590.37	588.71	520.46
13d	69.85	590.36	588.72	520.51
14s	14.29	535.79	533.76	521.50
14d	14.37	535.81	533.71	521.44
15s	59.00	579.65	577.80	520.65
15d	60.00	579.41	577.80	519.41
16s	20.50	542.28	540.47	521.78
16d	20.35	542.13	540.50	521.78
17s	14.69	536.19	534.43	521.50
17d	14.89	536.35	534.28	521.46
18s	50.64	573.36	571.31	522.72
18d	47.52	573.88	571.56	526.36
19s	62.80	585.38	583.26	522.58
19d	62.78	585.25	583.20	522.47
TP-19	7.42	584.96	582.98	577.54
20s	53.65	574.44	573.42	520.79
20d	53.00	574.71	573.31	521.71
TP-20	6.92	574.73	573.21	567.81
21s	63.27	586.02	594.42	522.75
TP-21	4.72	585.61	584.06	580.89
22s	65.00	587.95	587.93	522.95
TP-22	7.30	588.91	587.93	581.61
SW-2	31.33	NA	NA	NA
OS-1	63.67	581.33	581.35	518.16
OS-2	26.87	NA	NA	NA
OS-3	NA	NA	NA	NA
OS-1A	13.90	581.83	581.83	567.93
*IT-1	59.27	579.93	577.93	520.66
*IT-2	75.56	595.58	593.22	520.02
*IT-5A	74.27	594.22	592.17	519.95
*IT-6	55.35	576.02	574.07	520.67

MSL - Mean Sea Level.
NA - Not Available.
* Not Sampled.

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TABLE 36: *Shallow (Till) FMPC Groundwater Sampling Results, Third Quarter 1986* *(All results in ppm except as noted)*

Well location	W-12	W-19TP	W-20TP	W-21TP	W-22TP	OS-1A
Chloride	100.0	1,030.0	3.0	19.0	56.0	32.0
Iron	0.618	2.240	69.800	1.740	22.700	0.463
Manganese	< 0.020	2.260	2.490	1.920	2.680	< 0.020
Phenols	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	191.000	144.000	4.970	11.600	21.700	32.700
Sulfate	8.0	400.0	48.0	240.0	1,300.0	150.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.002
Arsenic	< 0.005	< 0.005	0.025	0.006	0.011	< 0.005
Barium	< 0.200	< 0.200	0.746	0.292	< 0.200	< 0.200
Calcium	21.900	539.000	250.000	153.000	426.000	141.000
Cadmium	< 0.002	< 0.002	0.003	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	0.006	< 0.005	< 0.005	0.011
Chromium						
-Total	< 0.005	< 0.005	0.101	< 0.005	0.040	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.010	< 0.005	< 0.010	< 0.005
Copper	< 0.025	< 0.025	0.105	< 0.025	0.037	< 0.025
Fluoride	1.05	0.25	0.30	0.55	1.34	0.25
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	11.100	1.230	17.500	1.620	10.700	28.100
Magnesium	7.300	154.000	106.000	70.000	194.000	55.000
Nickel	< 0.005	0.012	0.105	< 0.005	0.037	< 0.005
Nitrates	0.03	0.02	0.04	0.02	< 0.02	11.20
Lead	< 0.005	< 0.005	0.021	< 0.005	< 0.005	< 0.005
Phosphorus, total	0.03	0.34	0.41	0.08	< 0.02	0.02
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	0.400	< 0.025	0.255	0.099
T.D.S.	672.0	3,570.0	428.0	544.0	2,430.0	694.0
C.O.D.	< 10.0	36.0	50.0	< 10.0	25.0	< 10.0
pH-lab[1,2]	7.74	6.58	7.00	7.17	6.83	6.92
Conductivity-lab[1,3]	1,100	3,400	665	900	2,580	1,050
T.O.C.[1]	1.0	5.5	3.0	3.0	6.0	3.0
T.O.X.[1,4]	8,270.0	176.0	61.5	< 10.0	22.8	< 10.0
Coliform[5]	< 5	9	< 10	50	< 5	10,000
Lindane[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
2,4,5-TP,Silvex[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VOC's[4]	ND	..	..	ND	..	..
1,1 Dichloroethane	..	17.1	..	..	..	..
Cis-1, 2-Dichloroethene	..	5.1	..	..	..	..
1,1,1 Trichloroethane	..	..	16.1	..	..	..
Acetone	..	..	..	..	73.0	88.0
2- Propanol	..	..	..	..	21.5	..
Gross Alpha[6]	3.46	2.0	< 1.0	16.3	288.0	< 1.0
Gross Beta[6]	10.9	45.4	3.72	386.0	423.0	27.4
Uranium[7]	< 0.0001	0.36	0.031	2.76	4.28	0.0022

NA = Not Analyzed
ND = Not Detected
1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm
4. Concentrations reported in ppb
5. Reported in per 100 ml.
6. Results in pCi/l.
7. WMCO split sample analyzed for uranium at the FMPC; results in mg/l.

TABLE 37: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Inside Production Area, Third Quarter 1986* *(All results in ppm except as noted)* page 1 of 2

Well location	W-1s	W-1d	W-3	W-4	W-5	W-8s	W-8d	W-10	W-13s	W-13d	W-19s	W-19d	W-21s	W-22s
Chloride	17.0	19.0	21.0	21.0	14.0	21.0	11.0	80.0	25.0	64.0	41.0	52.0	45.0	61.0
Iron	0.906	5.800	0.752	0.539	2.080	4.750	2.840	0.264	3.140	7.350	0.070	< 0.050	0.438	< 0.050
Manganese	0.468	0.332	0.374	0.069	0.457	0.369	0.434	4.220	0.161	0.327	< 0.020	2.440	0.028	< 0.020
Phenols	< 0.005	< 0.005	0.011	< 0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005
Sodium	9.300	15.400	8.600	9.500	8.610	9.200	8.100	132.000	10.800	39.400	34.700	69.400	34.600	26.200
Sulfate	72.0	11.0	82.0	62.0	68.0	32.0	10.0	640.0	110.0	260.0	96.0	385.0	74.0	98.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	98.500	89.000	78.300	82.900	108.000	56.000	82.400	418.000	118.000	212.000	135.000	231.000	159.000	133.000
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium														
-Total	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.040	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Fluoride	0.22	0.17	0.24	0.25	0.40	0.12	0.21	0.11	0.19	0.14	0.28	0.12	0.39	0.55
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	2.250	0.980	2.580	2.550	2.560	2.650	1.130	18.700	2.140	4.400	5.030	7.420	10.600	4.160
Magnesium	24.800	22.800	22.600	21.800	27.500	24.200	21.500	69.000	26.800	51.000	34.400	26.800	23.200	38.700
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nitrates	0.003	0.02	< 0.02	1.40	0.05	0.03	0.02	153.00	< 0.02	0.06	49.20	0.09	80.80	40.80
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	< 0.02	0.13	< 0.02	< 0.02	< 0.02	< 0.02	0.10	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

TABLE 37: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Inside Production Area, Third Quarter 1986* *(All results in ppm except as noted)* page 2 of 2

Well location	W-1s	W-1d	W-3	W-4	W-5	W-8s	W-8d	W-10	W-13s	W-13d	W-19s	W-19d	W-21s	W-22s
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	< 0.025	< 0.025	0.025	0.052	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
T.D.S.	388.0	392.0	416.0	392.0	508.0	228.0	332.0	2,550.0	448.0	1,020.0	704.0	1,040.0	916.0	800.0
C.O.D.	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
pH-lab[1,2]	7.23	7.39	7.38	7.55	7.36	7.41	7.41	6.89	7.14	6.97	7.29	7.01	7.28	7.50
Conductivity-lab[1,3]	620	600	600	573	680	380	540	2,750	720	1,300	1,100	1,350	1,280	1,040
T.O.C.[1]	1.0	1.0	1.0	1.0	< 1.0	1.0	< 1.0	1.75	2.25	1.0	< 1.0	1.0	1.0	1.0
T.O.X.[1,4]	39.2	< 10.0	65.5	18.0	120.0	< 10.0	< 10.0	< 10.0	< 10.0	1,400.0	863.0	49.3	< 10.0	< 10.0
Coliform[5]	6	3	< 2	350	17	3,700	550	9	3	< 2	<2	< 5	< 2	3
Lindane[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.5	< 0.5
Toxaphene[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0.	< 1.0	< 1.0
2,4,5-TP,Silvex[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VOC's[4]	NA	...	NA	NA	NA	...	...	...	...	ND	ND	...	...	ND
1,1,1 Trichloroethane...	...	2.0	...	...	...	6.0	...	...	...	...	...	...	10.5	...
Carbon Disulfide	...	...	...	...	...	...	32.3	...	...	...	NA	NA	NA	NA
Butanol	...	...	...	...	...	...	180.0	...	...	...	NA	NA	NA	NA
Trichloroethane	...	...	...	...	...	...	...	1.7	...	...	NA	NA	NA	NA
Acetone	...	...	...	...	...	...	...	...	735.0	...	...	490.0	...	...
2-Propanol	...	...	....	...	...	...	...	...	29,600.0	...	...	830.0	...	...
Gross Alpha[6]	< 1.0	< 1.0	< 1.0	1.29	< 1.0	< 1.0	< 1.0	< 1.0	2.89	< 1.0	3.47	1.7	11.4	3.81
Gross Beta[6]	4.8	< 1.0	25.5	< 1.0	3.2	1.66	< 1.0	1.88	1.31	3.23	430.0	< 1.0	867.0	50.1
Uranium[7]	0.011	0.0002	0.0022	0.0087	0.0041	0.0032	0.0010	0.019	0.0011	0.018	0.010	0.019	0.0046	0.0043

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. WMCO split sample - analyzed for uranium at ther FMPC; results in mg/l.

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TABLE 38: *Groundwater Sampling Results FMPC Plant Production Wells, Third Quarter 1986*
(All results in ppm except as noted)

Well Location	P-1	P-2	P-3[1]
Chloride	33.0	20.0	
Iron	7.660	3.430	
Manganese	0.388	0.320	
Phenols	< 0.005	< 0.005	
Sodium	24.800	11.400	
Sulfate	94.0	27.0	
Silver	< 0.030	< 0.030	
Arsenic	< 0.005	< 0.005	
Barium	< 0.200	< 0.200	
Calcium	127.000	91.100	
Cadmium	< 0.002	< 0.002	
Cyanide	< 0.005	< 0.005	
Chromium			
-Total	< 0.005	< 0.005	
-Hexavalent	< 0.005	< 0.005	
Copper	< 0.025	< 0.025	
Fluoride	0.22	0.23	
Mercury	< 0.0002	< 0.0002	
Potassium	3.350	1.337	
Magnesium	33.500	24.300	
Nickel	0.012	0.022	
Nitrate	0.02	0.02	
Lead	< 0.005	< 0.005	
Phosphorus total	0.24	0.15	
Selenium	< 0.0025	< 0.0025	
Zinc	< 0.025	< 0.025	
T.D.S.	576.0	456.0	
C.O.D.	< 10.0	10.0	
pH-lab[2,3]	7.60	7.64	
Conductivity-lab[2,4]	820	598	
T.O.C.[2]	< 1	< 1	
T.O.X.[2,5]	57.5	< 10.0	
Coliform[6]	29	< 2	
Lindane[5]	< 0.2	< 0.2	
Endrin[5]	< 0.2	< 0.2	
Methoxychlor[5]	< 0.2	< 0.2	
Toxaphene[5]	< 0.5	< 0.5	
2,4-D[5]	< 1.0	< 1.0	
2,4,5-TP,Silvex[5]	< 0.5	< 0.5	
VOC's[5]	NA	NA	
Gross Alpha[7]	3.47	< 1.0	
Gross Beta[7]	24.3	5.25	
Uranium[8]	0.0001	0.0001	

NA = Not Analyzed.
1. Well was not sampled due to pump repair work
2. Average of four tests
3. pH results in standard units.
4. Conductivity results in µmhos/cm.
5. Concentrations reported in ppb.
6. Reported in per 100 ml.
7. Results in pCi/l
8. WMCO split sample– analyzed for uranium at the FMPC; results in mg/l.

1'H1

TABLE 39: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area, Third Quarter 1986*
(All results in ppm except as noted) page 1 of 4

Well location	W-9	W-11	W-14s	W-14d	W-15s	W-16s	W-16d	W-17s	W-17d
Chloride	21.0	45.0	19.0	18.0	21.0	22.0	19.0	28.0	18.0
Iron	0.434	2.820	1.440	0.130	0.294	0.557	< 0.050	< 0.050	1.540
Manganese	0.063	0.160	0.083	< 0.020	< 0.020	0.031	< 0.020	0.096	0.290
Phenols	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006
Sodium	9.500	8.200	10.500	9.800	11.400	9.200	8.500	7.490	8.840
Sulfate	80.0	78.0	50.0	58.0	52.0	52.0	50.0	100.0	74.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	79.300	94.000	88.400	845.000	73.900	78.900	71.900	142.000	92.700
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium									
-Total	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	0.115	< 0.025	< 0.025	0.030	< 0.025	< 0.025	< 0.025
Fluoride	0.21	0.26	0.34	0.22	0.48	0.22	0.20	0.18	0.17
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	2.290	1.150	3.670	2.010	2.770	2.480	2.090	1.930	2.090
Magnesium	22.500	26.700	20.100	20.400	20.400	21.500	19.400	30.800	18.700
Nickel	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nitrates	3.10	< 0.02	2.06	0.48	2.24	2.24	2.64	0.07	0.03
Lead	< 0.005	< 0.005	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	< 0.025	0.07	0.19	0.05	0.05	0.07	0.02	< 0.02	< 0.02

TABLE 39: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area, Third Quarter 1986*

(All results in ppm except as noted) page 2 of 4

Well location	W-18s	W-18d	W-20s	W-20d	SW-2	OS-1	W-15d	OS-2	OS-3
Chloride	5.0	2.0	22.0	22.0	28.0	34.0	24.0	38.0	24.0
Iron	2.740	2.540	0.172	1.240	< 0.050	< 0.050	2.630	< 0.050	1.410
Manganese	0.141	0.204	0.034	0.184	0.130	< 0.020	0.282	< 0.020	0.347
Phenols	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	0.012	0.013	0.022
Sodium	4.550	3.990	8.500	8.500	11.200	118.000	6.260	11.000	9.600
Sulfate	49.0	58.0	67.0	82.0	78.0	53.0	108.0	62.0	66.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	117.000	91.500	87.700	91.300	101.000	82.600	107.000	82.000	85.800
Cadmium	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium									
-Total	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Fluoride	0.27	0.34	0.20	0.16	0.26	0.50	0.19	0.22	0.25
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	1.780	0.768	2.640	2.010	2.390	2.730	1.470	3.200	2.580
Magnesium	29.600	33.500	20.600	22.800	27.700	19.900	25.200	22.900	22.000
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005
Nitrates	0.78	< 0.02	4.52	0.05	2.76	2.66	0.05	4.24	0.07
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	0.17	< 0.02	< 0.02	< 0.02	< 0.02	0.16	< 0.02	< 0.02	< 0.02

TABLE 39: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area, Third Quarter 1986*
(All results in ppm except as noted) page 3 of 4

Well location	W-9	W-11	W-14s	W-14d	W-15s	W-16s	W-16d	W-17s	W-17d
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	0.048	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
T.D.S.	404	404	468	424	400	372	292	580	456
C.O.D.	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
pH-lab[1,2]	7.45	7.36	7.63	7.87	7.36	7.01	7.75	7.03	7.20
Conductivity-lab[1,3]	595	668	535	540	560	535	510	830	590
T.O.C.[1]	1	1	1.5	1	2	<1	<1	1	1
T.O.X.[1]	< 10.0	39.3	30.8	< 10.0	58.3	19.0	26.5	< 10.0	25.3
Coliform[5]	3,600	6	86	< 2	< 2	860	< 2	310	< 2
Lindane[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
2,4,5-TP,Silvex[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	<.0.5	< 0.5
VOC's[4]	..	..	ND	..	..	ND	ND	ND	...
Acetone	8,670	..	..	..	..	..	..	..	58.5
2-Propanol	26,400.0	..	..	..	..	..	..	..	130.0
Carbon Disulfide	..	6.3	..	..	..	..	..	..	..
Butanol	..	195.0	..	..	..	..	..	..	..
Tetracloroethene	..	..	..	1.1	..	..	..	..	
1,1,1 Trichloroethane	...	..	..	..	2.9	..	..	..	..
Trichloroethene	..	..	..	..	3.7	..	..	..	..
Gross Alpha[6]	<1	<1	<1	6.9	70	1.4	1.21	2.13	<1
Gross Beta[6]	5.91	6.1	<1	7.08	21.5	<1	<1	2.77	6.03
Uranium[7]	0.0015	0.0002	0.025	0.027	0.163	0.017	0.0094	0.0044	0.0009

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. WMCO split sample - analyzed for uranium at the FMPC; results in mg/l.

TABLE 39: *Sand and Gravel Aquifer FMPC Groundwater Sampling Results Outside Production Area, Third Quarter 1986*

(All results in ppm except as noted) page 4 of 4

Well location	W-18s	W-18d	W-20s	W-20d	SW-2	OS-1	W-15d	OS-2	OS-3
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.089	0.057	0.055	< 0.025
T.D.S.	362	380	446	606	456	318	354	384	444
C.O.D.	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
pH-lab[1,2]	7.26	7.19	7.40	7.35	7.28	7.40	7.35	7.39	7.31
Conductivity-lab[1,3]	595	600	580	600	678	420	543	650	620
T.O.C.[1]	1	< 1	< 1	< 1	< 1	< 1	< 1	1	1
T.O.X.[1]	< 10	73.8	18.3	36.3	6,440	< 10	< 10	< 10	< 10
Coliform[5]	6	< 5	< 2	< 2	< 2	2,400	< 2	25	< 2
Lindane[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toxaphene[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 3.0	< 1.0	< 1.0	< 1.0
2,4,5-TP,Silvex[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VOC's[4]	ND	ND	ND	..	ND	..	NA	NA	NA
Acetone	..	..	..	3,600.0	..	..	..	..	..
2-Propanol	..	..	..	8,390.0	..	..	..	..	..
1,1,1 Trichloroethane...		..	..	..	..	2.0	...	...	...
Gross Alpha[6]	< 1	< 1	< 1	1.21	< 1	42.3	< 1	48.5	< 1
Gross Beta[6]	1.37	13.8	6.07	4.77	9.40	38.5	3.0	19.0	8.47
Uranium[7]	0.0023	0.0013	0.0005	0.0007	0.0006	0.233	0.0002	0.260	0.048

NA = Not Analyzed
ND = Not Detected

1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Reported in per 100 ml.
6. Results in pCi/l.
7. WMCO split sample - analyzed for uranium at the FMPC; results in mg/l.

TABLE 40: *FMPC Radionuclide Scan Results, Third Quarter 1986* (*All results in pCi/ml except as noted*) page 1 of 4

Location	W-12			W-15D			W-19 TP		
Parameters	Howard Lab	EAL Lab	WMCO Lab	Howard Lab	EAL Lab	WMCO Lab	Howard Lab	EAL Lab	WMCO Lab
Potassium 40	$< 1.0 \times 10^{-3}$	$< 2.222 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.709 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.976 \times 10^{-1}$	...
Total Uranimum[1]	$< 1.0 \times 10^{-3}$	0.0013	< 0.0001	$< 1.0 \times 10^{-3}$	0.00035	0.0002	$< 1.0 \times 10^{-3}$	0.32	0.36
Radium 226	$< 1.0 \times 10^{-3}$	$< 3.373 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 2.751 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 3.025 \times 10^{-2}$	...
Radium 228	$< 1.0 \times 10^{-3}$	$< 5.649 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 6.096 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 6.367 \times 10^{-2}$	...
Technetium 99	$< 1.0 \times 10^{-3}$	1.71×10^{-2}	...	$< 1.0 \times 10^{-3}$	$< 1.2 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	2.74×10^{-2}	...
Thorium 228	$< 1.0 \times 10^{-3}$	8.3×10^{-5}	...	$< 1.0 \times 10^{-3}$	$< 4.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	1.7×10^{-4}	...
Thorium 230	$< 1.0 \times 10^{-3}$	$< 3.8 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	2.2×10^{-4}	...
Thorium 232	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	3.9×10^{-5}	...
Cesium 137	$< 1.0 \times 10^{-3}$	$< 1.764 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 1.396 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 1.670 \times 10^{-2}$	...
Strontium 90	$< 1.0 \times 10^{-3}$	$< 4.0 \times 10^{-4}$	...	$< 1.0 \times 10^{-3}$	1.1×10^{-4}	...	NA	$< 8.0 \times 10^{-4}$	...
Ruthenium 106	$< 1.0 \times 10^{-3}$	$< 1.395 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.880 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.260 \times 10^{-1}$	...
Neptunium 237	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...	$< 1.0 \times 10^{-3}$	1.4×10^{-4}	...	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...
Plutonium 238	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	6.1×10^{-5}	...
Plutonium 239[2]	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	5.2×10^{-5}	...
Plutonium 240[2]	$< 1.0 \times 10^{-3}$	...	...	$< 1.0 \times 10^{-3}$	...	...	$< 1.0 \times 10^{-3}$	...	...

NA = not analyzed.
1. Total U for EAL and WMCO results in mg/l
2. Total Pu 239, 240

TABLE 40: *FMPC Radionuclide Scan Results, Third Quarter 1986* *(All results in pCi/ml except as noted)* page 2 of 4

Location	W-19s			W-19d			W-21 TP		
Parameters	Howard Lab	EAL Lab	WMCO Lab	Howard Lab	EAL Lab	WMCO Lab	Howard Lab	EAL Lab	WMCO Lab
Potassium 40	$< 1.0 \times 10^{-3}$	$< 3.460 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.476 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.861 \times 10^{-1}$	...
Total Uranimum[1]	$< 1.0 \times 10^{-3}$	0.00435	0.010	$< 1.0 \times 10^{-3}$	0.03	0.019	$< 1.0 \times 10^{-3}$	3.44	2.76
Radium 226	$< 1.0 \times 10^{-3}$	$< 4.051 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 4.051 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 3.416 \times 10^{-2}$	...
Radium 228	$< 1.0 \times 10^{-3}$	$< 8.603 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 8.603 \times 10^{-2}$	...	2.47	$< 4.199 \times 10^{-2}$	...
Technetium 99	$< 1.0 \times 10^{-3}$	1.67	...	$< 1.0 \times 10^{-3}$	2.38×10^{-2}	...	$< 1.0 \times 10^{-3}$	4.61×10^{-2}	...
Thorium 228	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-4}$	...	$< 1.0 \times 10^{-3}$	$< 8.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	2.8×10^{-4}	...
Thorium 230	$< 1.0 \times 10^{-3}$	9.5×10^{-5}	...	$< 1.0 \times 10^{-3}$	$< 7.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	6.08×10^{-4}	...
Thorium 232	$< 1.0 \times 10^{-3}$	$< 6.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	4.4×10^{-5}	...
Cesium 137	$< 1.0 \times 10^{-3}$	$< 2.330 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 2.330 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 1.225 \times 10^{-2}$	...
Strontium 90	$< 1.0 \times 10^{-3}$	7.09×10^{-4}	...	$< 1.0 \times 10^{-3}$	7.93×10^{-4}	...	$< 1.0 \times 10^{-3}$	6.7×10^{-4}	...
Ruthenium 106	$< 1.0 \times 10^{-3}$	$< 1.638 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.638 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.289 \times 10^{-1}$	...
Neptunium 237	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-4}$	...
Plutonium 238	$< 1.0 \times 10^{-3}$	1.8×10^{-5}	...	$< 1.0 \times 10^{-3}$	2.7×10^{-5}	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...
Plutonium 239[2]	$< 1.0 \times 10^{-3}$	1.8×10^{-5}	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...
Plutonium 240[2]	$< 1.0 \times 10^{-3}$	...	...	$< 1.0 \times 10^{-3}$	...	...	$< 1.0 \times 10^{-3}$	...	...

NA = not analyzed.
1. Total U for EAL and WMCO results in mg/l
2. Total Pu 239, 240

TABLE 40: *FMPC Radionuclide Scan Results, Third Quarter 1986* *(All results in pCi/ml except as noted)* page 3 of 4

Location	W-21s			W-22 TP			W-22s		
Parameters	Howard Lab	EAL Lab	WMCO Lab	Howard Lab	EAL Lab	WMCO Lab	Howard Lab	EAL Lab	WMCO Lab
Potassium 40	$< 1.0 \times 10^{-3}$	$< 3.594 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.945 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 2.050 \times 10^{-1}$	...
Total Uranimum[1]	$< 1.0 \times 10^{-3}$	0.00358	0.0046	$< 1.0 \times 10^{-3}$	4.71	4.28	$< 1.0 \times 10^{-3}$	0.0085	0.0043
Radium 226	$< 1.0 \times 10^{-3}$	$< 3.520 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 3.876 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 2.881 \times 10^{-2}$	...
Radium 228	$< 1.0 \times 10^{-3}$	$< 7.910 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 5.743 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 5.909 \times 10^{-2}$	...
Technetium 99	$< 1.0 \times 10^{-3}$	4.18	...	$< 1.0 \times 10^{-3}$	1.72×10^{-2}	...	$< 1.0 \times 10^{-3}$	2.41×10^{-1}	...
Thorium 228	$< 1.0 \times 10^{-3}$	3.3×10^{-4}	...	$< 1.0 \times 10^{-3}$	6.91×10^{-4}	...	$< 1.0 \times 10^{-3}$	$< 4.0 \times 10^{-5}$	...
Thorium 230	$< 1.0 \times 10^{-3}$	8.9×10^{-5}	...	$< 1.0 \times 10^{-3}$	1.24×10^{-3}	...	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...
Thorium 232	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	6.34×10^{-4}	...	$< 1.0 \times 10^{-3}$	2.3×10^{-5}	...
Cesium 137	$< 1.0 \times 10^{-3}$	1.956×10^{-2}	...	$< 1.0 \times 10^{-3}$	$< 2.009 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 1.415 \times 10^{-2}$	...
Strontium 90	NA	1.96×10^{-2}	...	$< 1.0 \times 10^{-3}$	2.59×10^{-3}	...	1.39	6.67×10^{-4}	...
Ruthenium 106	$< 1.0 \times 10^{-3}$	$< 2.234 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 2.094 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.386 \times 10^{-1}$	...
Neptunium 237	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-4}$	...
Plutonium 238	$< 1.0 \times 10^{-3}$	$< 8.0 \times 10^{-6}$	...	$< 1.0 \times 10^{-3}$	$< 9.0 \times 10^{-6}$	...	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...
Plutonium 239[2]	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...
Plutonium 240[2]	$< 1.0 \times 10^{-3}$	...	...	$< 1.0 \times 10^{-3}$	...	...	$< 1.0 \times 10^{-3}$	...	...

NA = not analyzed.
1. Total U for EAL and WMCO results in mg/l
2. Total Pu 239, 240

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3.

TABLE 40: *FMPC Radionuclide Scan Results, Third Quarter 1986*
(All results in pCi/ml except as noted) page 4 of 4

Location	OS-1			OS-2		
Parameters	Howard Lab	EAL Lab	WMCO Lab	Howard Lab	EAL Lab	WMCO Lab
Potassium	$< 1.0 \times 10^{-3}$	$< 1.350 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.666 \times 10^{-1}$	...
Total Uranimum[1]	$< 1.0 \times 10^{-3}$	0.25	0.233	$< 1.0 \times 10^{-3}$	0.334	0.260
Radium 226	$< 1.0 \times 10^{-3}$	$< 3.318 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 3.030 \times 10^{-2}$	...
Radium 228	$< 1.0 \times 10^{-3}$	$< 4.698 \times 10^{-2}$	...	2.22	$< 6.350 \times 10^{-2}$	...
Technetium 99	$< 1.0 \times 10^{-3}$	3.01×10^{-2}	...	$< 1.0 \times 10^{-3}$	6.56×10^{-3}	...
Thorium 228	$< 1.0 \times 10^{-3}$	$< 8.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 1.7 \times 10^{-4}$	...
Thorium 230	$< 1.0 \times 10^{-3}$	$< 5.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 7.0 \times 10^{-5}$	...
Thorium 232	$< 1.0 \times 10^{-3}$	$< 1.5 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...
Cesium 137	$< 1.0 \times 10^{-3}$	$< 1.743 \times 10^{-2}$	...	$< 1.0 \times 10^{-3}$	$< 1.619 \times 10^{-2}$	...
Strontim 90	$< 1.0 \times 10^{-3}$	4.9×10^{-4}	...	1.12	2.8×10^{-4}	...
Ruthenium 106	$< 1.0 \times 10^{-3}$	$< 1.825 \times 10^{-1}$	...	$< 1.0 \times 10^{-3}$	$< 1.395 \times 10^{-1}$	...
Neptunium 237	$< 1.0 \times 10^{-3}$	3.6×10^{-4}	...	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...
Plutonium 238	$< 1.0 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 6.0 \times 10^{-5}$	...
Plutonium 239[2]	$< 1.0 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...	$< 1.0 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...
Plutonium 240[2]	$< 1.0 \times 10^{-3}$	...	...	$< 1.0 \times 10^{-3}$	...	...

NA = not analyzed.
1. Total U for EAL and WMCO results in mg/l
2. Total Pu 239, 240

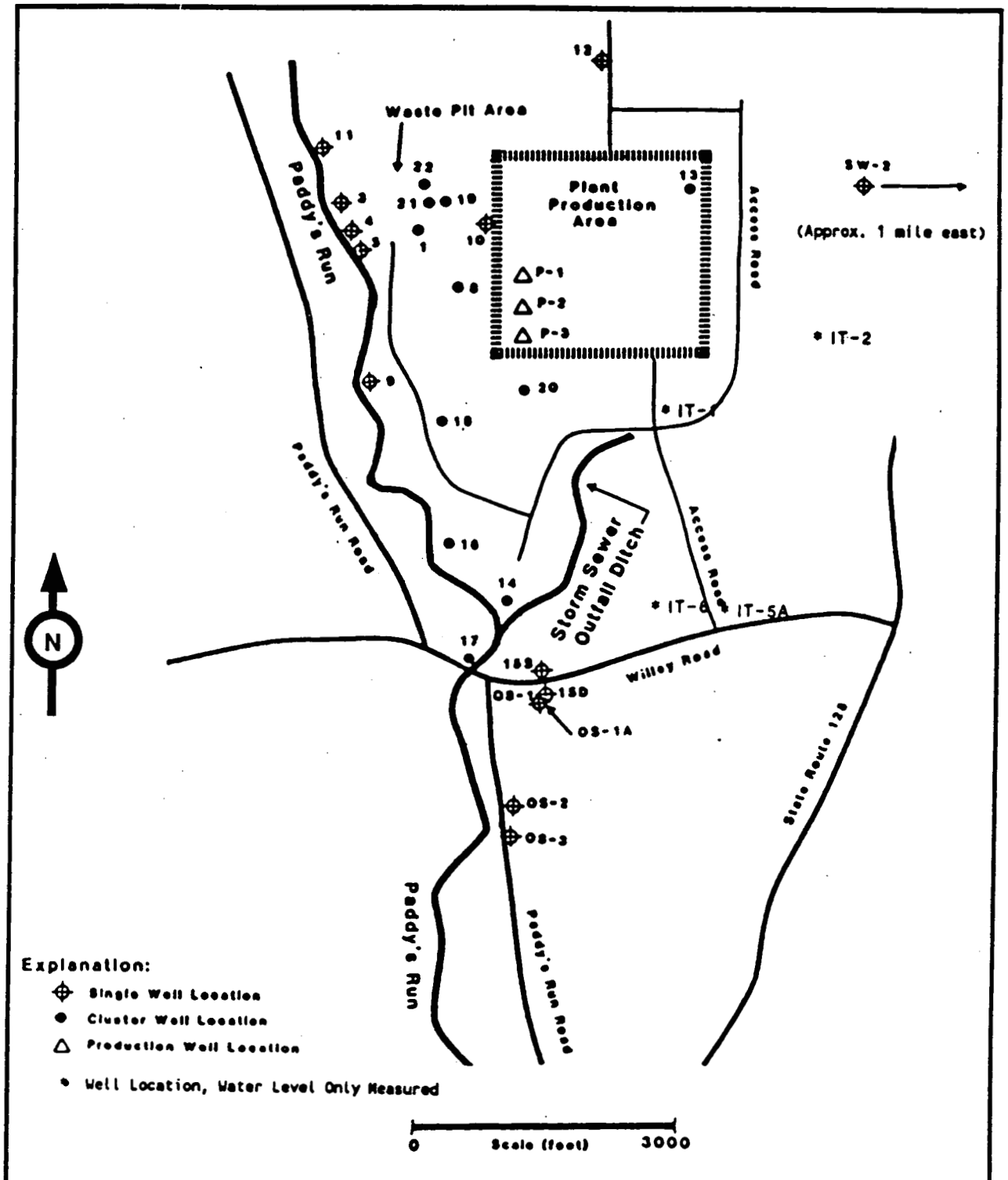

FIGURE 39: *RCRA Well Locations*

Appendix C – Summary of Historical Uranium Discharges to the Air, 1951 to 1984

Year	Plant Wide Discharge (kgU)
1951	123.0
1952	499.0
1953	2,077.8
1954	15,119.2
1955	32,976.2
1956	13,595.4
1957	8,045.2
1958	5,513.4
1959	5,127.4
1960	4,872.8
1961	3,516.4
1962	4,568.0
1963	6,036.4
1964	5,253.4
1965	7,044.8
1966	3,048.5
1967	2,924.7
1968	4,655.2
1969	3,898.1
1970	1,487.8
1971	772.0
1972	614.4
1973	496.0
1974	234.8
1975	318.0
1976	169.1
1977	191.9
1978	222.0
1979	154.7
1980	266.5
1981	587.2
1982	279.8
1983	181.2
1984	377.5

GRAND TOTAL = 135,247.8 kgU
This total rounded up to 136,000 kgU