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FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1987

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REPORT

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Special
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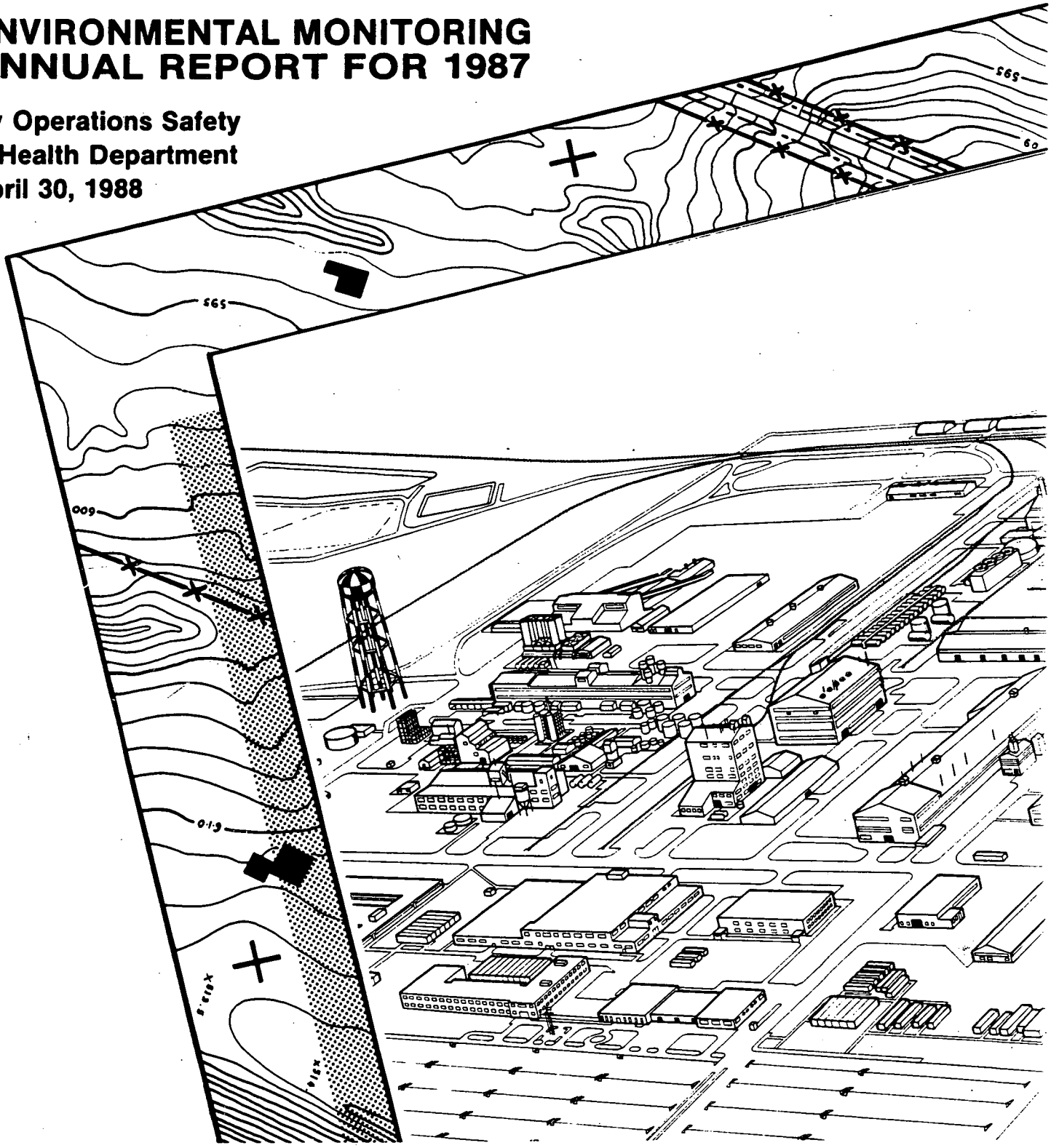
FEED MATERIALS PRODUCTION CENTER

ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1987

By Operations Safety
& Health Department
April 30, 1988



Prepared for:
U.S. Department of Energy
Oak Ridge Operations Office
Under Contract
DE-AC05-860R21600

Westinghouse Materials Company of Ohio
P.O. Box 398704 Cincinnati, Ohio 45239-8704

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FMPC-2135
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Feed Materials Production Center

Environmental Monitoring Annual Report for 1987

by

Operations Safety & Health Department

Westinghouse Materials Company of Ohio

P.O. Box 398704

Cincinnati, Ohio 45239-8704

April 30, 1988

Prepared for:

U. S. Department of Energy
Oak Ridge Operations Office

Under contract DE-AC05-86OR21600

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CONVERSION TABLE

Traditional radiological units (curie, roentgen, rad and rem) are used throughout this report. Wherever possible, the more scientifically acceptable *Systeme Internationale* (S.I.) units (becquerel, coulomb/kg, gray and sievert) are also presented in parentheses. The metric system of units of measurement is the primary system used for nonradiological parameters. The English system equivalent units are frequently presented in parentheses.

To facilitate conversion of data from one system to another, the table below may be useful.

1 centimeter (cm)	=	0.3937 inch (in)
1 meter (m)	=	39.37 inches (in)
1 kilometer (km)	=	0.62 mile (mi)
1 milliliter (ml)	=	0.0338 ounce (oz)
	=	0.061 cubic inch (in^3)
	=	1 cubic centimeter (cm^3)
1 liter (l)	=	1.057 quart (qt)
	=	61.02 cubic inches (in^3)
1 gram (g)	=	0.0353 ounce (oz)
	=	0.0022 pound (lb)
1 kilogram (kg)	=	2.2 pounds (lb)
1 curie (Ci)	=	3.7×10^{10} disintegrations per second (d/s)
1 becquerel (Bq)	=	1 disintegration per second (d/s)
	=	27 picocuries (pCi)
1 millicurie (mCi)	=	0.001 curie (Ci)
1 microcurie (μCi)	=	0.000001 curie (Ci)
1 picocurie (pCi)	=	1×10^{-12} curie (Ci)
	=	2.22 disintegrations per minute (d/m)
	=	0.037 Bq
1 roentgen (R)	=	2.58×10^{-4} coulombs per kilogram of air (C/kg)
1 rad	=	0.01 gray (Gy)
1 rem	=	0.01 sievert (Sv)
1 millirem (mrem)	=	0.001 rem

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Acronyms

ALARA	As Low as Reasonably Achievable
AMS	Air Monitoring Station
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BDN	Biodenitrification
BOD_5	Five Day Biochemical Oxygen Demand
BMP	Best Management Practices
BTU	British Thermal Units
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CIS	Characterization Investigation Study
DFO	Director's Findings and Orders
DOE	Department of Energy
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EMR	Environmental Monitoring Report
EMSL	Environmental Monitoring and Support Laboratory
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center

Acronyms (Continued)

ICRP	International Commission on Radiological Protection
MGD	Million Gallons per Day
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NQA	Nuclear Quality Assurance
NRC	Nuclear Regulatory Commission
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
OEPA	Ohio Environmental Protection Agency
OAC	Ohio Administrative Code
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
PCB	Polychlorinated biphenyls
PET	Proficiency Environmental Testing
PTI	Permit To Install
PTO	Permit To Operate
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation and Feasibility Study

Acronyms (Continued)

SAQA	Site Analytical Quality Assurance
SC	Specific Conductivity
TDS	Total Dissolved Solids
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act
TOX	Total Organic Halogen
TSS	Total Suspended Solids
USEPA	U. S. Environmental Protection Agency
WMCO	Westinghouse Materials Company of Ohio

Executive Summary

Routine environmental monitoring is conducted at the Feed Materials Production Center (FMPC) and surrounding areas 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 far below standards as reasonably achievable.

Environmental Standards

Environmental radiation protection standards, pollution emission control requirements, and toxic and hazardous material regulations are established by the United States Environmental Protection Agency (USEPA), or in their absence, by the Department of Energy (DOE), and must be consistent with the recommendations of the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). The FMPC also must comply with USEPA and Ohio EPA (OEPA) standards for nonradioactive contaminants.

Reporting the Results of the Environmental Monitoring Program

Each year, results of the Environmental Monitoring Program are published in an environmental monitoring report in accordance with requirements of DOE Order 5484.1. The FMPC distributes this report to state and federal regulatory agencies, other interested organizations, and members of the public. During 1987, improvements were made in the range and scope of regular monitoring, sampling procedures and equipment, and data management. 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 approximately 213 out of 4,083 individual environmental samples in 1987 were well below the DOE and USEPA radiological standards. This demonstrates 95% compliance with these standards.

Estimating Radiation Dose

To ensure that radiation protection standards for the public are met, estimates of the radiation doses via air, water, soil, sediment, plant, and animal pathways were made and compared to DOE and USEPA standards. The estimate of the radiation dose the maximally-exposed offsite resident could receive to the lung was 8.9 mrem (0.089 milliSieverts [mSv]), which is 12% of the USEPA standard for airborne radionuclide emissions. The effective dose equivalent (the weighted average for all body organs) that same individual would receive was 1.2 mrem (0.012 mSv), which is 1.2% of the DOE standard for all pathways. This individual's estimated external whole body dose received was 0.00028 mrem (2.8×10^{-6} mSv), which is 0.0011% of the USEPA standard.

Estimated exposure to the nearest resident to the FMPC was calculated as if he were outside his home 100% of the time for an entire year. His annual dose would be 9.5 mrem (0.095 mSv), which is 9.5% 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 are limited to a small, sparsely-populated offsite area.

An assessment was made of radiation dose from drinking Great Miami River water and water from the offsite well with the highest uranium concentration. The estimate of the annual

radiation dose an individual would receive if that individual drank only from the Great Miami River at the point where the FMPC discharges its treated effluent (allowing for dilution) was 1.3 mrem or 0.013 mSv to the bone, and the effective (weighted average) dose was 0.064 mrem or 0.00064 mSv (0.03 and 1.6% of the DOE standards for the whole body and bone, respectively). The bone and effective (weighted average) doses an individual would receive over a year's time if that individual drank only from the offsite wells with the highest uranium concentration (none of which is used as a source of drinking water) were estimated at 540 mrem (5.4 mSv) and 36 mrem (0.36 mSv), which are 11 and 36% of the DOE standard.

An assessment also was made of the radiation dose above background to an individual at the location of each air monitoring station at the FMPC fenceline and at offsite locations. All estimated effective dose equivalents were less than 5% of the DOE guidelines. An additional assessment was also made of the total dose to the entire population living within an 80 km (50 mi) radius of the FMPC. The estimated effective (weighted average) dose to the population within 80 km (50 mi) of the FMPC was 29 person-rem (0.29 person-sievert). This 29 person-rem can be compared with approximately 900,000 person-rem effective dose to the same population from natural background and medical diagnostic dose (360 mrem / person / year x population within 80 km radius).

Air Pathways

The largest overall potential source of radiation exposure to the public from the operation of the FMPC is via the air pathway. Specific sources of radiation exposure by the air pathway to the public can be through airborne contaminants which are introduced to the human food chain in soil, vegetation, farm and garden produce, and milk. Total estimated uranium emissions to the atmosphere in 1987 were 35.4 kg (77.9 lbs) or 0.024 Curies (8.9 x 10^8 Becquerels), and were 20% higher than 1986 emissions. Of this total, 32.2 kg were discharged from Plant 8 scrubbers. Although total production from all plants in 1987 was lower compared to 1986, Plant 8 production increased 19%. Average uranium concentrations measured at fenceline air monitoring stations ranged from 25% lower to 7% higher than average values for 1986. The average uranium concentration of all seven fenceline monitors was 10% lower than the 1986 average.

Radon measurements made in 1987 indicated that, within the standard deviation of the measurements, there was no significant difference in radon concentration between background locations and FMPC fenceline locations.

Average uranium concentrations (both onsite and offsite) in routinely-collected soils for 1987 were slightly higher than average values at the same locations and depths in 1986. These increased soil concentrations may result from differences in analytical techniques due to a change in laboratories, rather than actual increases in uranium. Uranium concentrations in soils sampled offsite were within the range considered normal for the area and do not represent a significant source of potential radiation exposure.

Parallel soil and vegetation, farm and garden produce, and milk were also sampled in 1987. Uranium and fluoride concentrations in vegetation samples measured in 1987 did not change significantly from concentrations measured in 1986. Average uranium concentrations in farm and garden produce were low and appear to represent normal levels. The average uranium concentration in milk collected in 1987 was below the laboratory minimum detectable value of less than 0.7 pCi/l (0.03 Bq/l).

Water Pathways

Additional pathways for radiation to the public may be due to effluent discharged to the Great Miami River from the FMPC outfall and to Paddy's Run via the storm-sewer outfall ditch. These pathways include groundwater, surface water, sediment, and aquatic wildlife (i.e. fish).

Results for onsite groundwater sampling indicated no significant differences in uranium concentration or gross alpha and gross beta radioactivity from 1986 averages, with the exception of well 303, which is west of Pit 3. All but three onsite wells and three offsite wells had uranium concentrations which are within the

range of natural background for this area. The uranium concentrations in and radiation exposure from the water in these three offsite wells (none of which is currently used as a source of drinking water) were 36% of the DOE interim guidelines.

Data from the fourth and fifth rounds of groundwater sampling for 94 radioactive and nonradioactive pollutants as part of the Resource Conservation and Recovery Act (RCRA) groundwater monitoring program are included in this report. Forty-one wells onsite and offsite were sampled for this effort. The results from the first semiannual sampling or fifth round were compared statistically with the results of the first four quarterly sampling rounds. The results of this comparison indicate that statistically-significant changes in pH, specific conductance, and Total Organic Carbon (TOC) have occurred. The results were provided to both OEPA and USEPA in November 1987, and are summarized in this report. A detailed groundwater quality assessment program is currently underway as part of the Remedial Investigation/Feasibility Study (RI/FS), which is part of the Federal Facility Compliance Agreement (FFCA) between USEPA and DOE.

Another potential source of radiation to the public from the FMPC is via the surface water pathway. The total amount of uranium discharged into Paddy's Run from stormwater runoff to the storm-sewer outfall ditch was 0.32 kg (2.2×10^{-4} Curies or 8.2×10^{6} Becquerels) which was only 2% of the 1986 release. This is a result of decreased flow to the storm-sewer outfall ditch due to operation of the Stormwater Retention Basin. In 1987, the total amount of uranium discharged into the Great Miami River at the plant effluent discharge line was 770 kg (0.52 Ci or 1.9×10^{10} Bq) which was 68% higher than 1986 discharges and 119% of the DOE standard. This increase was due to an increase in the effluent flow rate and refining operations at Plant 2/3 in 1987, and a decrease in settling capacity because the Clearwell and Pit 5 ceased operation in 1987.

Radionuclides are not the only concern in effluent discharges. Nonradiological constituents must be monitored as well. During 1987, the National Pollutant Discharge Elimination System (NPDES) limits were exceeded at the FMPC 133 times out of 1,600 total measurements of six different nonradiological parameters. Thus, the NPDES daily maximum or monthly average permit limits were satisfied more than 85% of the time. Programs are continuing to reduce sources of pollutants and NPDES violations.

Sediment is also a potential pathway for radiation to the public. In 1987, average concentrations of uranium and other radionuclides 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 background levels for the area. Above-background concentrations of uranium, thorium, and radium isotopes in 1987 were measured in sediments collected from an area of the storm-sewer outfall ditch closest to the Stormwater Retention Basin. In general, isotopic uranium, thorium and radium concentrations increased in sediments near the Stormwater Retention Basin and decreased toward the confluence of the storm-sewer outfall ditch and Paddy's Run. Uranium, thorium, and radium isotope concentrations collected in 1987 from Paddy's Run were determined to be at natural background levels for the area.

Aquatic pathways are another potential source of radiation to the public from FMPC effluent to the Great Miami River and Paddy's Run. The overall average uranium concentration in fish from the Great Miami River was lower in 1987 than for fish collected in 1986; this may be the result of lower laboratory detection limits. In 1987, average uranium concentrations in fish were not significantly different upstream or downstream from the FMPC outfall and were therefore considered to be at natural background levels.

Waste Management Activities

During 1987, the FMPC shipped 441, 325 cubic feet of low-level radioactive wastes offsite for disposal. This is about the volume of a seven-story, 80 x 80 ft. building. These wastes included sump sludges, slags, and neutralized raffinates generated by production processes, and other materials contaminated with low levels of radioactivity which are not economically feasible to recover.

Hazardous and mixed hazardous wastes stored at the FMPC were sampled and analyzed during 1987 to determine their physical and chemical characteristics for FMPC compliance with requirements of the Resource Conservation and Recovery Act (RCRA). Some 149 samples of the drummed wastes were collected to determine their physical and chemical characteristics for purposes of materials compatibility and disposal acceptance, and 766 drums of contaminated waste oils were shipped offsite for incineration. In 1987, RCRA closure plans for Pit 4, the Barium Chloride Waste Salt Treatment Facility, and the Trane Thermal Liquid Waste Incinerator were prepared for USEPA review.

Wastes at the FMPC governed by the Toxic Substances Control Act (TSCA) include articles such as electrical capacitors that contain polychlorinated biphenyls (PCB's). In 1987, the FMPC prepared 112 large, low-voltage capacitors for offsite shipment and disposal by incineration in a USEPA-approved unit.

Conventional solid wastes include nonradioactive materials such as sanitary waste, boiler plant waste, and nonprocess trash. During 1987, a trash segregation project for process and nonprocess area trash was initiated, and it substantially reduced the amount of contaminated trash that must be shipped offsite for disposal as low-level radioactive waste.

Special Studies and Significant Events

Federal Facility Compliance Agreement. On July 18, 1986, the DOE and the USEPA jointly signed a Federal Facility Compliance Agreement (FFCA). The purpose of the FFCA is to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly investigated so that appropriate remedial response actions can be formulated, assessed and implemented.

FFCA activities performed or initiated in 1987 and discussed in this section include the following: Remedial Investigation and Feasibility Study; Characterization Investigation Study; Stabilization of the K-65 Silos; and RCRA Groundwater Quality Assessment for Waste Pit 4.

In 1987, the site-wide Remedial Investigation and Feasibility Study (RI/FS), which is a requirement of both the FFCA and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), was initiated at the FMPC. The purpose of the RI/FS is to determine the nature and extent of any release of hazardous or radioactive substances at or from the FMPC, and to develop and recommend remedial action alternatives to protect public health and the environment from any determined releases.

On June 1, 1987, a ten-month Characterization Investigation Study (CIS) of the FMPC Waste Storage Area was completed in accordance with the FFCA. This study involved collecting technical data in order to determine the locations, volume, and nature of material in the Waste Storage Area. Data from the CIS is being used to enhance and modify sampling activities for the site-wide RI/FS.

Also under the FFCA, interim stabilization of the two K-65 waste storage silos was initiated in 1987. The stabilization project includes the construction and operation of a radon treatment system designed to reduce the whole body radiation dose to personnel working on the silos. The project also includes applying polyurethane foam to both the inside and outside of the K-65 Silos. The external foam applications were completed in 1987; internal foaming of the silos is slated for 1988.

In response to the RCRA section of the FFCA, a Groundwater Quality Assessment Program Plan was submitted in November 1987 noting that Pit 4 may be affecting groundwater quality at the FMPC. Statistical comparisons required for RCRA detection monitoring of groundwater wells placed around Pit 4 indicate that some statistically significant changes in indicator parameters such as pH, specific conductance, and TOC have occurred. Future RCRA groundwater monitoring activities at the FMPC will be coordinated and implemented as part of the ongoing RI/FS.

Director's Findings and Orders. In May 1987, the OEPA issued the Director's Findings and Orders (DFO) detailing certain scheduled compliance actions which, by law, DOE and FMPC must address. DFO activities performed or initiated in 1987 and discussed in this section include the Best Management Practices Plan and a Study of FMPC Effluent Discharge to the Great Miami River.

As required by the DFO, development of a Best Management Practices (BMP) Plan for spill control at the FMPC was begun in 1987. Implementation of the BMP Plan should minimize the potential for releases of significant amounts of toxic or hazardous substances from the FMPC to surface waters. The BMP Plan will include guidelines for hazardous materials inventory/spill risk assessment, spill reporting and recordkeeping procedures, material storage and compatibility, and good housekeeping practices and spill prevention. In addition, all FMPC employees will be scheduled for BMP training in spill prevention and control in 1988.

In accordance with the DFO, an investigation of the FMPC discharge to the Great Miami River was initiated in 1987 to determine the environmental impact associated with use of the FMPC effluent line. As part of the study, the effluent line was inspected and cleaned; the overall condition of the pipeline appeared satisfactory and no leaks, cracked sections, or faulty sewer joints were observed. A hydrogeologic study was conducted using computer modeling, river bed sediment and groundwater sampling, and piezometric (aquifer water level elevation) mapping. Preliminary results of the study concluded that the impact of the pipeline effluent on the quality of water pumped from the Great Miami River buried valley aquifer is insignificant under average conditions. The study will be completed as part of the ongoing sitewide RI/FS.

Unusual Events. In August, a spill of about 200 pounds of uranium oxide (black oxide) occurred in Plant 4. Here, uranium tetrafluoride (green salt) is produced by reacting uranium dioxide to anhydrous hydrogen fluoride. The material escaped from a processing feedhopper when a gas seal failed. Ventilation systems were immediately shut off to ensure that no material was released from the building. The spill was quickly isolated and cleaned up without injury. WMCO investigated the spill and published the results in a WMCO Unusual Occurrence Report dated August 31, 1987.

In September, a maximum of 270 pounds of anhydrous hydrogen fluoride gas was released from the Pilot Plant roof. Anhydrous hydrogen fluoride gas is a product of uranium hexafluoride conversion to uranium tetrafluoride. The release occurred when a rupture disc on an anhydrous hydrogen fluoride transfer line overpressure protection system was activated. The Pilot Plant was immediately evacuated and the FMPC Emergency Operations Center (EOC) was activated. Within ten minutes, the leak was stopped and the area was flushed with water to reduce fumes. The only injury to FMPC employees consisted of minor eye and skin irritation. Air monitor readings taken during and after the event indicated that there was no offsite impact. DOE investigated the release and published the results in a DOE Incident Investigation Board Report dated September 29, 1987.

Conclusions

In summary, dose calculations show that there were no harmful effects to the public and the environment from FMPC operations in 1987. Estimated doses to the public were well below standard values, and all but a few areas that were sampled showed radionuclide concentrations within the range of concentrations expected for naturally-occurring radionuclides. New studies and additional control measures have enabled the FMPC to further evaluate the environment, and to institute additional remedial actions. New methods and programs will be added to continue to reduce emissions and exposures.

Chapter One — Introduction

The FMPC conducts routine environmental monitoring to assure that radiation exposure and plant effluent discharges are below the standards set by DOE and are maintained below those standards consistent with the ALARA (As Low As Reasonably Achievable) principle. The results of that program for 1987 are described in this Environmental Monitoring Report (EMR). The EMR is the responsibility of the Operations Safety and Health Department of the Westinghouse Materials Company of Ohio (WMCO). WMCO has operated the FMPC since January 1, 1986 for the DOE, which owns the facility.

The FMPC produces uranium metal products 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 1987, 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). Figure 2 is a detailed map of the FMPC site.

The production of uranium metal products generally begins with uranium compounds known as green salt (UF_4) and orange oxide (UO_3) for their color, but may begin with uranium hexafluoride (UF_6) 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 (UO_2), and subsequently reacted with anhydrous hydrogen fluoride to produce uranium tetrafluoride (green salt). In 1987, 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 machined to the dimensions specified by other DOE sites.

Following a description of the area surrounding the FMPC in Chapter 2, the FMPC's Quality Assurance Program is discussed in Chapter 3. Chapter 4 describes the calculation of radiation dose from exposure to FMPC effluents. The methods of data collection and analysis, along with the results of the monitoring and sampling, are discussed in Chapter 5. Chapter 6 addresses waste handling onsite and shipments from the FMPC, and Chapter 7 describes environmental studies that were conducted and incidents which occurred at the FMPC during 1987.

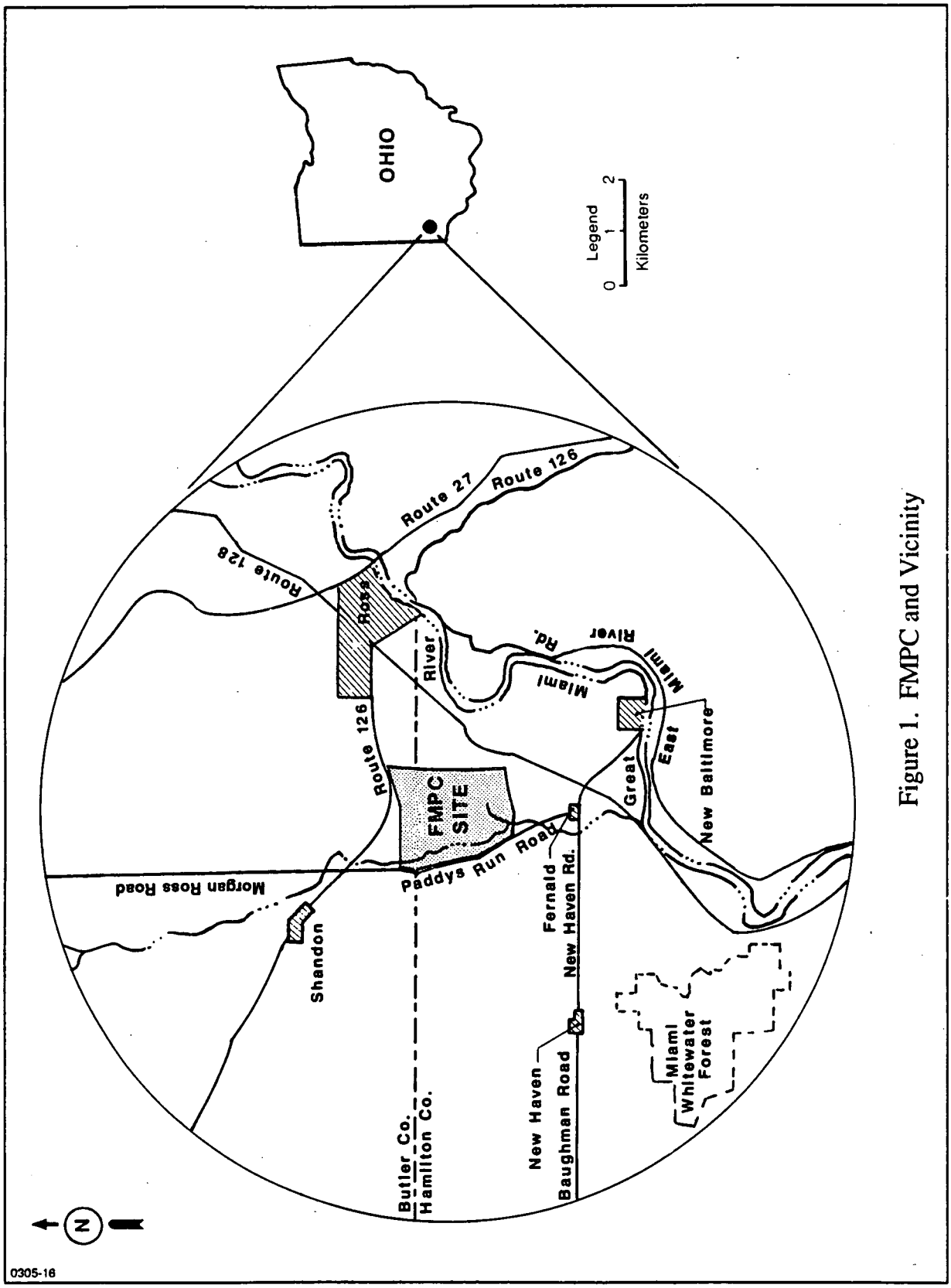
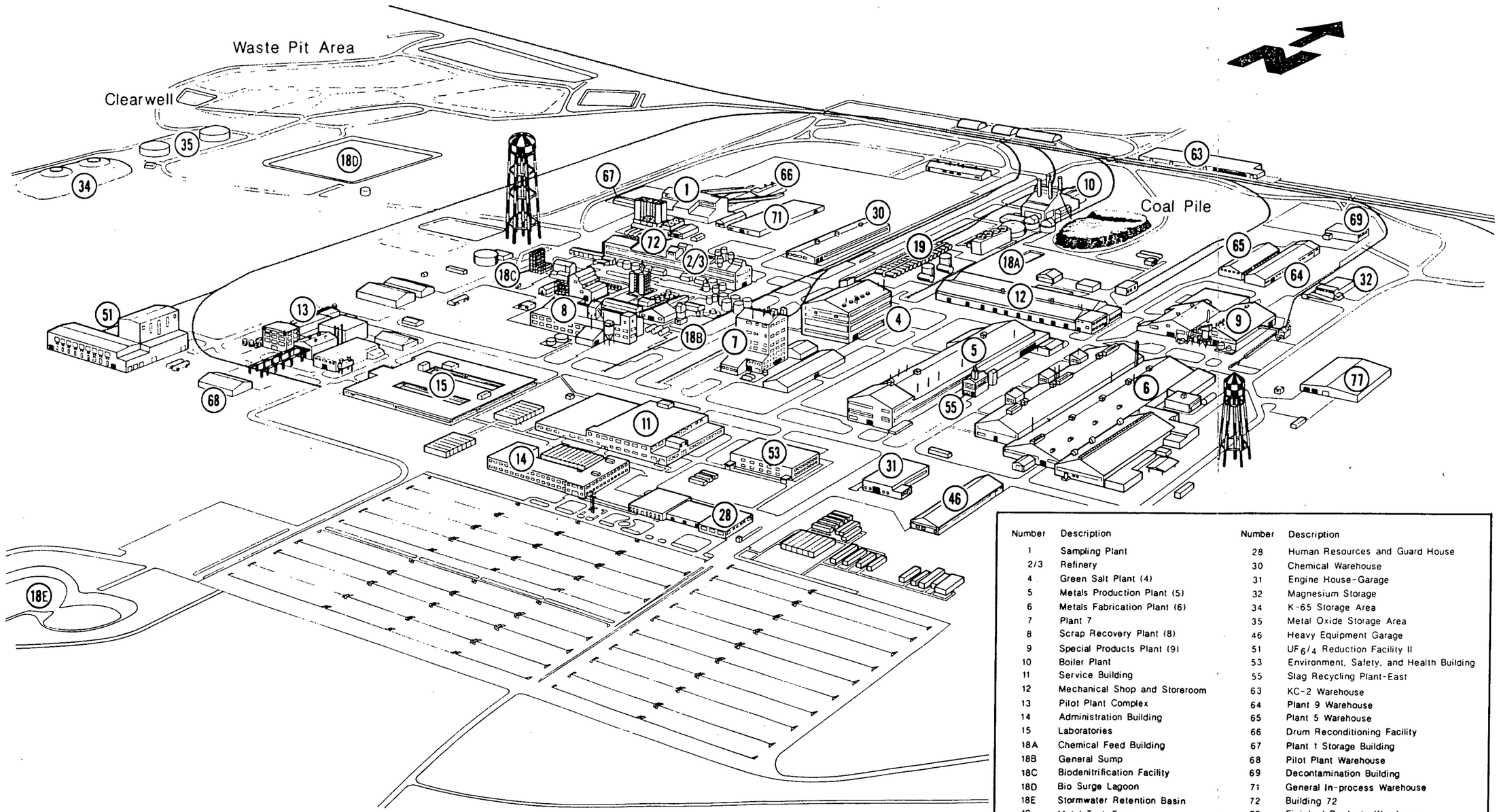


Figure 1. FMPC and Vicinity



Number	Description	Number	Description
1	Sampling Plant	28	Human Resources and Guard House
2/3	Refinery	30	Chemical Warehouse
4	Green Salt Plant (4)	31	Engine House-Garage
5	Metals Production Plant (5)	32	Magnesium Storage
6	Metals Fabrication Plant (6)	34	K-65 Storage Area
7	Plant 7	35	Metal Oxide Storage Area
8	Scrap Recovery Plant (8)	46	Heavy Equipment Garage
9	Special Products Plant (9)	51	$UF_6/_4$ Reduction Facility II
10	Boiler Plant	53	Environment, Safety, and Health Building
11	Service Building	55	Slag Recycling Plant-East
12	Mechanical Shop and Storeroom	63	KC-2 Warehouse
13	Pilot Plant Complex	64	Plant 9 Warehouse
14	Administration Building	65	Plant 5 Warehouse
15	Laboratories	66	Drum Reconditioning Facility
18A	Chemical Feed Building	67	Plant 1 Storage Building
18B	General Sump	68	Pilot Plant Warehouse
18C	Biodenitrification Facility	69	Decontamination Building
18D	Bio Surge Lagoon	71	General In-process Warehouse
18E	Stormwater Retention Basin	72	Building 72
19	Metal Tank Farm	77	Finished Products Warehouse

Figure 2. FMPC Site 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 described 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 and south 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 3). 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.

The total rainfall for 1987 was 82.8 cm (32.6 in), slightly below this area's average of 95.8 cm (37.7 in). The greatest amount of precipitation was 12.9 cm (5.1 in) in July, while the least precipitation was 2.3 cm (0.92 in) in January.

Leading Economic Activities

The major economic activities in the area are farming and raising dairy and beef cattle. These activities also account for the majority of the land use in the area around the FMPC. 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 floodplain some distance inland. In addition, a water company located 2 km (1.25 mi) upstream of the FMPC outfall (this is where 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. The Great Miami River is not a source of public drinking water between the FMPC and the Ohio River (approximately 29 km (18 mi) south of the FMPC). Although the Great Miami River is fished, it is considered unsuitable for swimming due to the turbulence of the water.

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.

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 this program is described in the next chapter.

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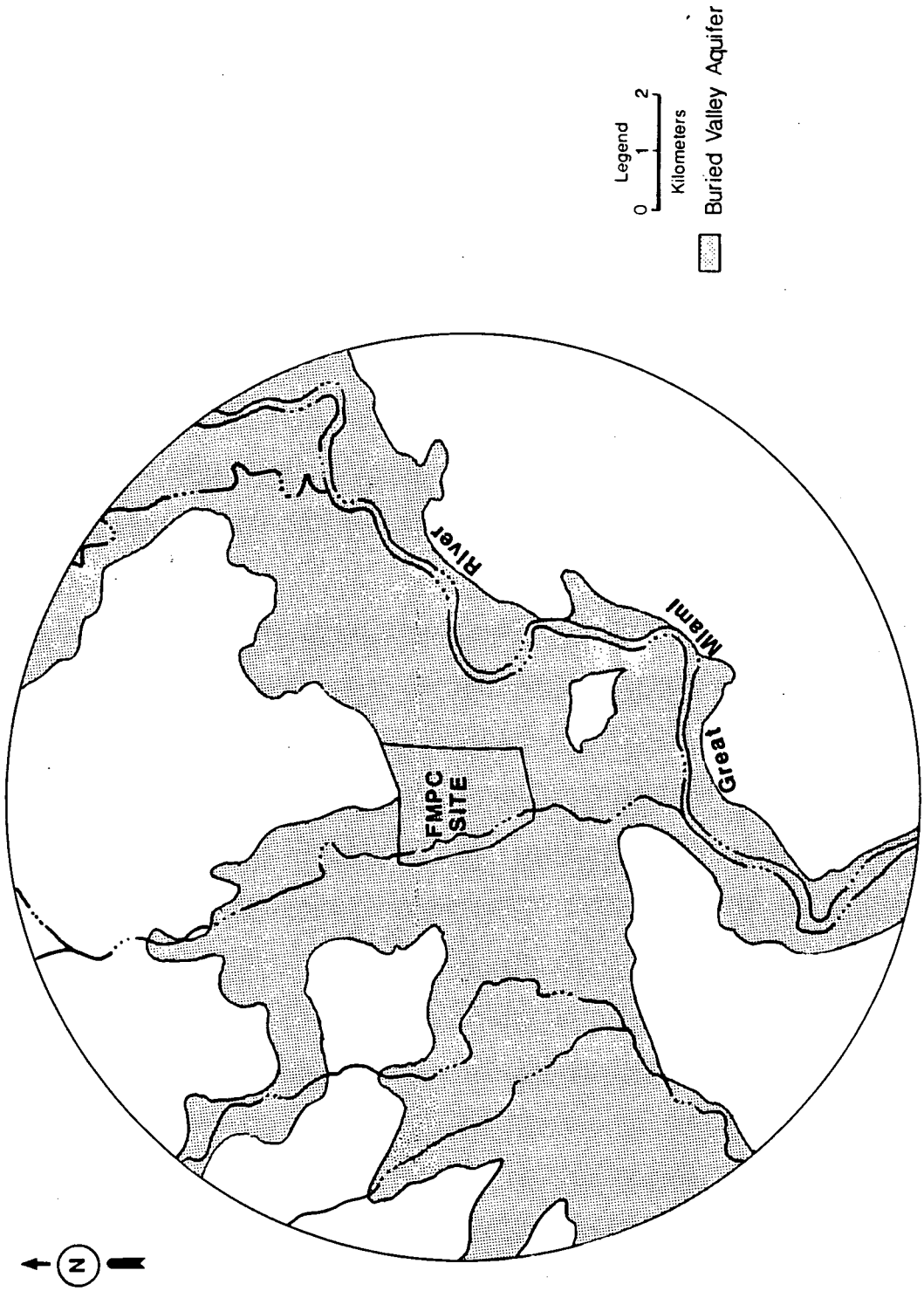

Figure 3. Buried Valley Aquifer Underlying the FMPC Site and Vicinity

Chapter Three
Verifying the Data

The integrity of the Environmental Monitoring Program and this report depends on the accuracy of the sample collection and analysis 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

Sampling procedures must be comprehensive so that one is certain that the sample collected is representative of the media being investigated. Since quality assurance is critical in collecting samples, all environmental sampling procedures must include the following:

- Representative sampling sites
- Proper collection techniques and chain-of-custody procedures
- Maps, diagrams, and forms used in sampling
- Special precautions to prevent contamination in sampling
- Sample preservation methods
- Equipment calibration procedures
- Maximum holding time for samples
- Shipping requirements
- Recordkeeping procedures.

Analytical Laboratory Quality Assurance

Quality assurance is an integral part of the FMPC analytical laboratories' operations. Laboratory QA consists of a structured program of actions taken to help ensure that reliable results are obtained when analyzing environmental samples. Laboratory QA is designed to:

- Make certain that analytical methodologies comply with applicable USEPA regulatory requirements
- Provide a means to systematically and objectively evaluate analytical performance
- Identify problems so that they can be promptly corrected
- Detect and prevent the use of questionable data.

QA surveillance of FMPC analytical laboratories is conducted by the Site Analytical Quality Assurance (SAQA) section. SAQA prepares control samples which are submitted to the laboratories for analysis along with field samples. Control samples include National Bureau of Standards reference materials, USEPA radionuclide solutions, compounds of precisely known purity, standardized reference solutions, duplicate field samples, and field samples to which known amounts of contaminates have been added. At least 10% of the total number of samples are control samples which are analyzed with the field samples.

SAQA evaluates the control sample results and regularly submits reports to the WMCO analytical laboratories for use in identifying potential areas of concern. If a significant problem is indicated, SAQA notifies the laboratories so that corrective actions can be

initiated and suspect results for field samples can be evaluated and rejected. In addition to SAQA control samples, the individual laboratories perform daily instrument calibrations and stability checks and routinely analyze reagent blanks and standards along with the field samples.

Because of the great number of analyses required to support all the various environmental monitoring activities, the FMPC uses commercial laboratories to supplement its own analytical resources. Commercial laboratories must meet stringent requirements before being selected to provide environmental analytical services. To select the best qualified laboratory, a review of various QA specifications including personnel qualifications, analytical procedures, sample handling and preservation, data evaluation and recordkeeping, and requirements for precision, accuracy, and minimum detectable levels is conducted. Test samples are then sent to the candidate laboratories to evaluate their analytical capabilities. Onsite audits of the laboratories' facilities and operations are conducted by FMPC personnel before final selections are made. Upon selecting the laboratories, control samples are submitted regularly with field samples in order to continue monitoring their performance.

Comparing Results

In addition to the procedures described above, the FMPC also regularly takes part in several QA programs with outside organizations. The FMPC participates in DOE's Quality Assurance Program which is conducted by its Environmental Measurements Laboratory (EML). In this program, the FMPC receives and analyzes samples of water, soil and air and submits results for comparison to the results obtained by EML. In making the interlaboratory comparison, a ratio is computed by dividing the FMPC result by the EML result for each sample. If the results agree exactly, the ratio is one. The average value of the ratios for all samples analyzed in 1987 was 1.13, which is less than a 15% average variation and indicates good agreement with EML.

Laboratories which perform NPDES permit analyses are required to participate in a QA program administered by the USEPA. Since NPDES samples are analyzed in-house, FMPC laboratories are included in this program. As stipulated by the USEPA, a corresponding QA sample must be analyzed for each parameter listed in the NPDES permit. The NPDES permit parameters which are analyzed by FMPC laboratories are discussed in Chapter Five, under *Sampling FMPC Liquid Effluents*. The USEPA evaluates the results for the QA samples only as satisfactory or unsatisfactory. All FMPC results submitted during 1987 were assessed as satisfactory by the USEPA.

The USEPA also maintains a QA service for water and wastewater analyses. The USEPA's Environmental Monitoring and Support Laboratory (EMSL) in Cincinnati, Ohio maintains an inventory of quality assurance samples for an extensive number of nonradioactive regulated pollutants. These are intended for periodic use as independent checks on each laboratory's own QA activities and involve no regulatory or reporting requirements. A range of acceptable values for each parameter is provided with the control samples for use by the laboratories to evaluate their performance. QA samples from EMSL are obtained and distributed to FMPC analytical laboratories by the SAQA section. The laboratories report their results to SAQA for comparison to the USEPA reference values. The results for all EMSL QA samples analyzed by FMPC laboratories during 1987 were within the range of acceptable values specified by the USEPA.

Another QA practice at the FMPC is the analysis of Proficiency Environmental Testing (PET) samples. PET samples are solutions which consist of known quantities of standard anions and cations of interest to FMPC. Each month, the SAQA section submits PET samples to the various onsite laboratories which analyzes them concurrently with field samples. Results obtained for the QA samples are compiled by the SAQA section and submitted for evaluation. A report is then provided to SAQA comparing the FMPC laboratories' results to the reference values for each sample and to the results obtained by other laboratories participating in the PET program. The use of this commercially-available service provides an additional resource for detecting analytical problems so that corrective actions can be initiated and errors eliminated.

To further enhance the QA Program, the FMPC initiated a split sampling program in 1987 with the Ohio Department of Health (ODH). Surface water, groundwater, sediment, and milk samples were collected. Three months of water sample data were available for comparison for this report (Table 1). FMPC and ODH analyzed water samples for total uranium concentrations; a comparison of the results showed that the data are very similar with no significant discrepancies.

In late 1986, the FMPC also initiated a QA program with the commercial laboratory which is used for offsite air filter analysis. The purpose of the QA program was to assess the commercial laboratory's analytical results for air filters containing known amounts of uranium. The amounts of uranium added to the filters were in the range of results routinely reported by the laboratory and varied by a factor of ten. Twenty-five quality control samples were analyzed from late 1986 through 1987. Analytical results from the contract laboratory demonstrated an average error of less than 10% for the QA air filters. This performance was considered satisfactory for analyses at environmental levels. Figure 4 shows the ratio of contract laboratory analyses to FMPC spikes for the 25 samples included in the study. The values ranged from 0.57 to 1.35 with an average of 0.91. This QA program for air filter analyses will continue in 1988.

In addition, during 1987 a series of four air filters from AMS 3 were split in thirds and analyzed by FMPC, a contract laboratory, and a USEPA laboratory. Although the analytical methods used by the three laboratories differed, the results of the analyses were generally within the measurement errors reported by the respective laboratories.

Data Validation, Reduction and Reporting

Laboratory data is checked to assure that the analyses requested were performed, and that the data provided appear accurate. The data is evaluated for the following:

- Central tendency and dispersion using arithmetic mean, geometric mean, range, and standard deviation
- Precision and accuracy within and between laboratories
- 95% Confidence limits for the mean.

The data is reduced to a more meaningful and easy-to-comprehend form which can be tabulated or charted. Tabular data include ranges, averages, 95% confidence limits, and percent of standard. Comparisons between years are often made to indicate long-term trends. This information is evaluated and interpreted where possible. Plant operations, remedial activities, pollution control, analytical techniques, and incidents during the year are considered in the interpretation of the data.

Summary

The verification of data for environmental monitoring is a comprehensive program. Appropriate sampling procedures must be followed and proper analytical procedures practiced, data must be verified, validated, and presented in meaningful form, and results must be properly reported. The next chapter describes how some of this data is used to estimate effects of radiation exposures to individuals and population groups.

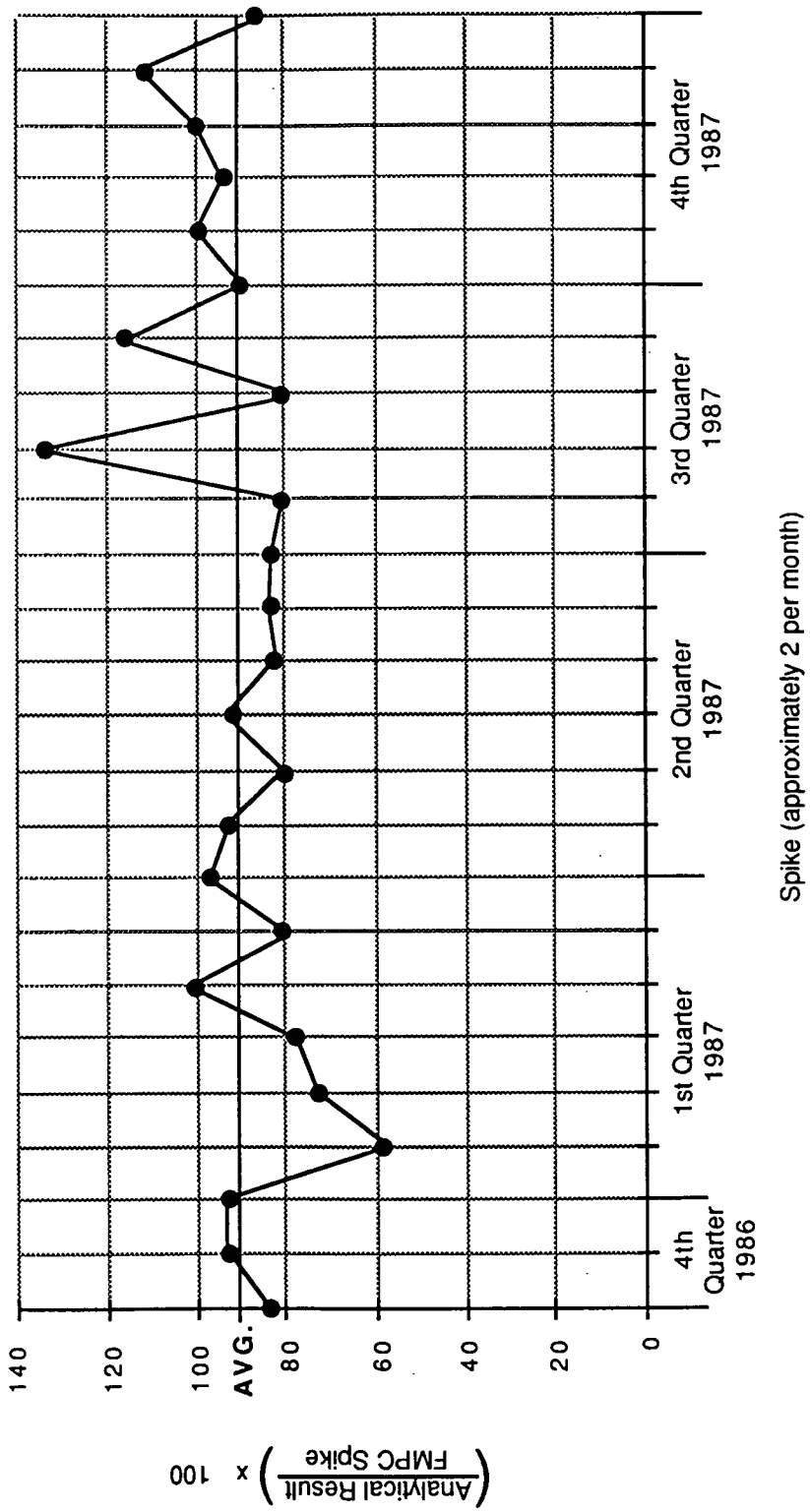

Figure 4. Uranium-Spiked Air Filter Analyses Processed by Contract Laboratory

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Chapter Four
Estimating Radiation Dose

Radiological data is evaluated to determine whether persons in the area around the FMPC have received possible radiation dose from plant operations and to identify areas that need improvement. Radiation dose estimates are based on data collected throughout the year to support the FMPC Environmental Monitoring Program.

This chapter describes how radiation exposures are calculated using the AIRDOS computer program as required by USEPA NESHAP regulations. These calculations are made by 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 (50 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 and the environmental standards that must be complied with. General information about radon is 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 in the surrounding environment are compared to the background radiation levels considered natural in this area. In this way, the impact of FMPC operations can be assessed.

Uranium is the heaviest naturally-occurring element, by atomic weight, 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, with each radionuclide decaying at its own 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 also called thoron.

Neither of the isotopes of radon is found in significant quantities in the materials processed at the FMPC. Before delivery to the site, the recycled feed materials undergo a chemical process which removes the long-lived precursors of radon and thoron.

However, the FMPC does store materials that produce radon and thoron. Radium-226, the immediate precursor of radon, is a component of the material stored in the K-65 Silos. Thorium-228, a precursor of thoron, is a component of the material stored in the Plant 8 silo and bins and in the thorium warehouse 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 offsite exposure than thoron, which has a half-life of less than one minute.

These and other radioactive materials are closely controlled to minimize impact on the public or the environment. By monitoring radiation levels in the environment and calculating radiation dose to the public, the FMPC can identify areas that need improvement. The application of a urethane foam layer to the exterior of the K-65 Silo domes (see Chapter 7) is one ongoing effort at the FMPC to reduce emissions from this source.

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 National Emission Standards for Hazardous Air Pollutants (NESHAP) guideline.

Effective dose equivalent represents a weighted average of exposures to specific organs as defined by ICRP.[1] The effective dose equivalent incorporates exposures from inhalation and ingestion as well as from 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. To calculate the effective dose equivalent, all of the organ doses (multiplied by their respective weighting factors) are summed.

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, 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 resulting from 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.

Curie (Ci) and *Becquerel (Bq)* are units of radioactivity that measure the rate of 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 is equivalent to a mass of 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, and is a measure of the ionization in air due to a source of radioactivity.

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 environmental standards established by DOE, USEPA, and OEPA are used to monitor any potential effects of FMPC production operations on health and the environment.

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 DOE standard for prolonged radiation 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 NESHAP regulation, which became effective in February 1985, is 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 is not included in the NESHAP standard.

Under the Safe Drinking Water Act, USEPA Drinking Water Guidelines have been developed for various parameters.[4,5] As there is currently no approved drinking water standard for total uranium, FMPC is using an interim standard of 40 pCi/l (1.48 Bq/l) adopted by DOE for natural uranium in drinking water. For gross alpha and gross beta activity, FMPC is using the USEPA drinking water standards of 15 pCi/l (0.56 Bq/l) and 50 pCi/l (1.9 Bq/l) respectively. These standards apply only to drinking water supplies and are not applicable to surface water or monitoring wells which are not used as a potable water supply.

Using AIRDOS to Estimate Radiation Dose

The calculations involved in estimating airborne radiation dose in the environment are very complex. A number of computer programs aid in these calculations, and the FMPC used the computer code program known as AIRDOS, which is required by USEPA for compliance with the Clean Air Act (CAA). 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
- Stack discharge velocity
- Meteorological data
- Population distribution data
- Particle solubility.

AIRDOS computes the committed dose equivalents due to airborne releases of radionuclides through all inhalation, ingestion, and direct radiation pathways, and estimates the radiation dose an individual would receive over the next 50 years due to FMPC releases during 1987. Calculations follow the standards established by ICRP Reports 26 and 30, with some modifications recommended by the USEPA.[1]

Estimating Maximum Dose to an Individual Member of the Public

The maximum radiation dose to an individual is based on the calculated concentrations of radionuclides at the location of the nearest resident (1,128 meters or 0.7 mi north of the FMPC). Based on 1987 airborne emissions, calculations were made 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. Radionuclides discharged in 1987 are tabulated in Table 2. The results are:

- 8.9 mrem (0.089 mSv) to the pulmonary tissue
- 1.8 mrem (0.018 mSv) to the bone surface
- 1.2 mrem (0.012 mSv) committed effective dose equivalent
- 0.00028 mrem (2.8×10^{-6} mSv) external whole body dose (Table 3).

Also included are the doses calculated at each air monitoring station (Table 4). 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. Dose estimates for 1987 are higher than 1986 estimates, which were the lowest calculated offsite doses since operations began. The increase in 1987 can be attributed to two factors. First, there was approximately a 20% increase in airborne releases of uranium from 29.4 kg in 1986 to 35.4 kg in 1987 due to increased production from Plant 8. Second, the estimated uranium released in 1987 was 100% insoluble compared with 40% insoluble in 1986. This change in solubility, caused by a change in chemical form of the uranium in 1987, increases the calculated lung dose by a factor of approximately 2.5. When both of these factors are combined, the lung dose estimate increased 207% from 1986 to 1987. The committed effective dose equivalent increased 224%, and the external whole body dose estimate

increased 27%. All of these calculated doses are within DOE and USEPA guidelines for airborne releases.

Besides using the AIRDOS program to calculate maximum doses resulting from the airborne emissions pathway, maximum doses from other potential pathways were calculated or measured. Dose measurements were made for external radiation by using a pressurized ionization chamber and thermoluminescent dosimeters (TLD's). 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), TLD's measure ambient beta-gamma radiation levels (Table 5). The maximum annual exposure was measured at AMS 6, the station closest to the waste materials stored in the K-65 Silos on the west side of the site. To assess external doses 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 external gamma dose to the nearest resident (in the unlikely scenario of that resident remaining outside at home 100% of the time) was conservatively calculated at 9.5 mrem (0.095 mSv) in 1987. This is less than 10% of the DOE standard. It should be noted that the background external gamma dose rate from natural sources measured at several locations surrounding the FMPC was 59 mrem (0.59 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 a period of 50 years if, during the year 1987, 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 1.3 mrem (0.013 mSv) to the bone surface, and an effective dose equivalent of 0.064 mrem (0.00064 mSv).[6] The bone dose equivalent increase from drinking river water containing FMPC effluents would be less than 33% of the USEPA standard for drinking water. The USEPA has not established an effective dose equivalent standard for drinking water.

Since offsite wells 12 and 15 (which are not used as potable water sources) had the highest above-background uranium concentration in 1987, the potential radiation dose an individual could receive over a 50-year period from drinking only the water from those wells was calculated (Table 3). The effective dose equivalent is 36 mrem (0.36 mSv), which is 36% of the standard, and 540 mrem (5.4 mSv) to the bone surface, which is 10.8% 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 concluded that 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 considered the dose from ingesting uranium in the vegetables; the calculated effective dose equivalent is 3×10^{-8} mrem (3×10^{-10} mSv) and is considered insignificant and not even measurable. The calculations were based on an annual consumption of 84 pounds of potatoes. 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 Doses at Other Locations

In 1987, calculations were made of potential doses due to measured airborne uranium concentrations at all of the air monitoring stations around the FMPC (Figure 5). Average uranium air concentrations at AMS 1 through 13 were entered into the AIRDOS-EPA computer program. Estimated lung doses and effective dose equivalents for a person breathing that air for all of 1987 are presented in Table 4. An estimate was made of doses that would be accumulated 50 years into the future resulting from calendar year 1987 inhalations.

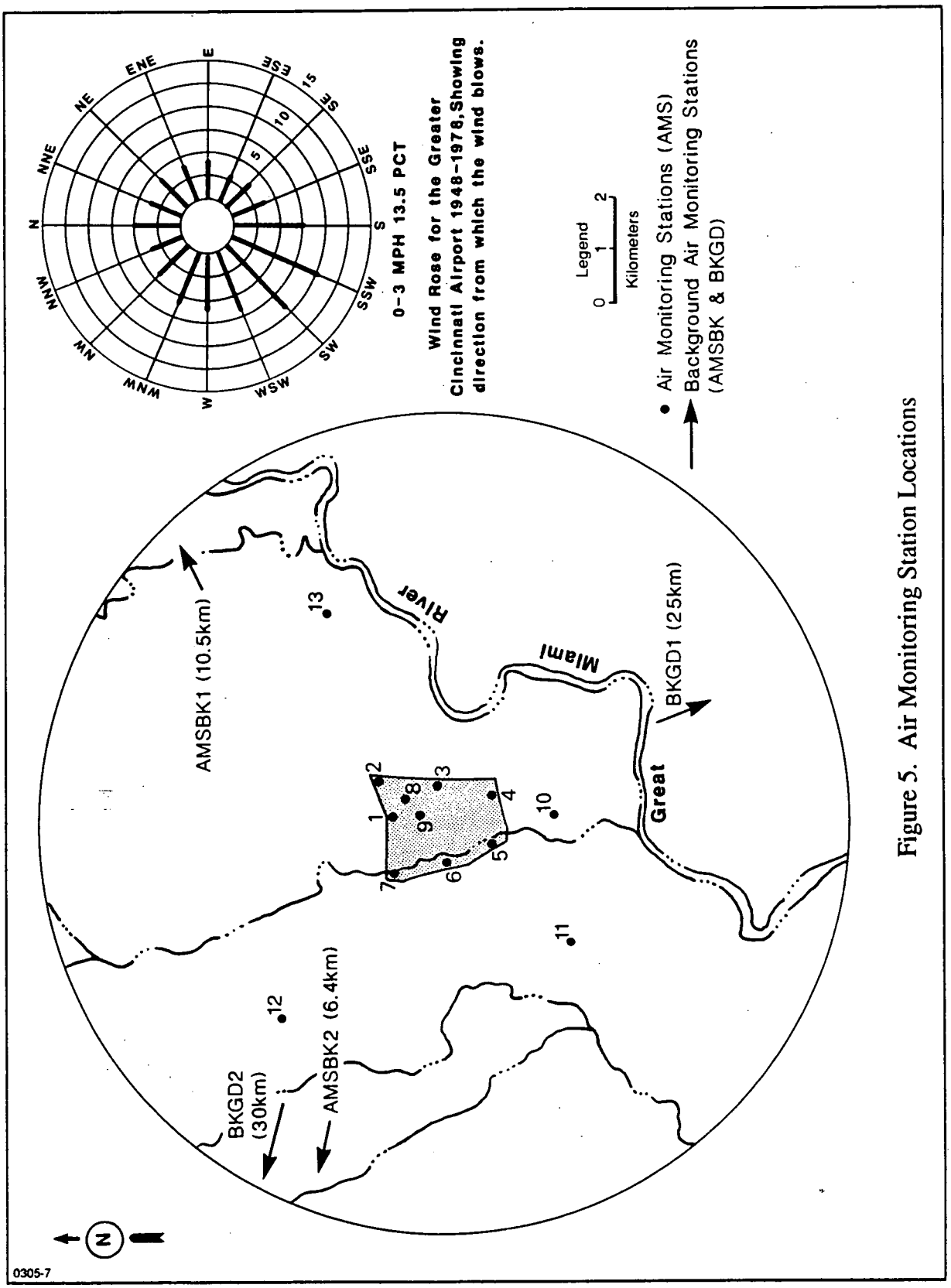

Figure 5. Air Monitoring Station Locations

As expected, the highest estimated doses were calculated at the two onsite stations and at the fenceline station, AMS 3, which is nearest to the location of the former incinerator. Also as expected, the lowest estimated doses were at the offsite locations AMS 10, 11 and 12.

Onsite effective dose equivalents at AMS 8 and 9 were estimated to be 4.4 mrem (0.044 mSv) and 8.6 mrem (0.086 mSv) respectively.

Fenceline effective dose equivalents at AMS 1 through 7 were estimated to be an average of 1.9 mrem (0.019 mSv) with a maximum of 4.9 mrem (0.049 mSv) at AMS 3 and a minimum of 0.9 mrem (0.009 mSv) at AMS 7.

Offsite effective dose equivalents at AMS 10 through 13 were estimated to be an average of 0.7 mrem (0.007 mSv) with a maximum of 1.3 mrem (0.013 mSv) at AMS 13 and a minimum of 0.3 mrem (0.003 mSv) at AMS 12. These calculated doses are a fraction of the annual background radiation dose received by individuals living in this area (Table 3).

Estimating the 80 km (50 mi) Population Dose

AIRDOS was also used to calculate the weighted average estimate of radiation dose to the human population within 80 km (50 mi) of the FMPC over 50 years (Table 6). The dose due to 1987 airborne emissions was 29 person-rem (0.29 person-Sv) (Table 4). The total external whole body dose for the 80 km (50 mi) population was 0.008 person-rem (8×10^{-5} person-Sv) due to 1987 airborne emissions. As a comparison, the annual external whole body dose due to natural radiation for the same population group is 900,000 person-rem (9,000 person-Sv).

Dose from Radon

One of the public's primary concerns about FMPC operations is the potential release of radon to the air. Because of this concern and the increased awareness about natural radon concentrations in homes, FMPC expanded its radon monitoring program in 1987. The expanded program consists of 18 onsite monitoring locations, 16 fenceline locations, and five offsite locations (Figures 6 and 7).

A new offsite air monitoring station, AMS 12, was installed at Shandon in 1987, and two additional background locations were installed in the two least-prevalent wind directions more than 20 km (12 mi) from the FMPC (identified as BKGD-1 and BKGD-2 in Figure 6). The program also includes real-time continuous radon monitors which were installed at four locations along the K-65 exclusion fence. These monitors are not used for fenceline dose calculations, but are expected to provide data for estimating occupational doses near the K-65 Silos.

In order to provide a basis for comparison with the expanded program, all former monitoring locations were also included in the 1987 radon monitoring program. In 1987 all air monitoring stations are identified with AMS numbers (Figure 5 and Table 7). The 1986 air monitoring station numbers and their 1987 equivalents are compared in Table 8.

The largest contributor to the average annual effective dose equivalent to individuals in the U.S. population is from natural background concentrations of radon and its decay products. At an average of 200 mrem/yr (2 mSv/yr), naturally-occurring radon accounts for 56% of the 360 mrem/yr (3.6 mSv/yr) background dose in the U.S.[7] Although the FMPC is not required to calculate the dose due to radon under NESHAP, the DOE standards specify that emissions of Radon-222 to uncontrolled areas must be less than 3.0 pCi/l (0.11 Bq/l).

When all 23 fenceline locations (the 16 from the expanded radon monitoring program plus the seven from the former program) are averaged for the entire year, the overall average fenceline radon concentration is 1.15 pCi/l (0.043 Bq/l) (Figures 6 and 7 and Table 9). When all four background locations (BKGD1, BKGD2, AMSBK1, and AMSBK2) are included, the average background concentration is 0.66 pCi/l (0.024 Bq/l). Analytical errors for radon cups as stated by the vendor average about ± 32% at the 95% confidence level. FMPC analysis of five duplicate cups deployed for three months at the same location along the FMPC fence (FMPC—K) indicate a higher average error of ±89% for these detectors in the environment. When measurement errors are considered, average fenceline radon concentrations are within the range of average

background concentrations. The data shows no distinct trends in the prevalent wind direction.

If the six fenceline locations along Paddy's Run Road closest to the K-65 Silos (FMPC-J through O in Figure 7) were singled out and averaged over the year, the average radon concentration at those locations (1.7 ± 1.0 pCi/l or 0.063 ± 0.037 Bq/l) would also fall within the range of background concentrations when measurement errors are considered. It should be noted that the 1987 radon data included only one month during which the K-65 Silo domes were covered with foam. It can be concluded that, at the FMPC fenceline (the closest uncontrolled area), radon concentrations are well within DOE guidelines of 3.0 pCi/l above background. Although the data indicate that the west fenceline concentrations are slightly above background, this cannot be established with certainty because of the high measurement errors inherent in the radon monitoring system.

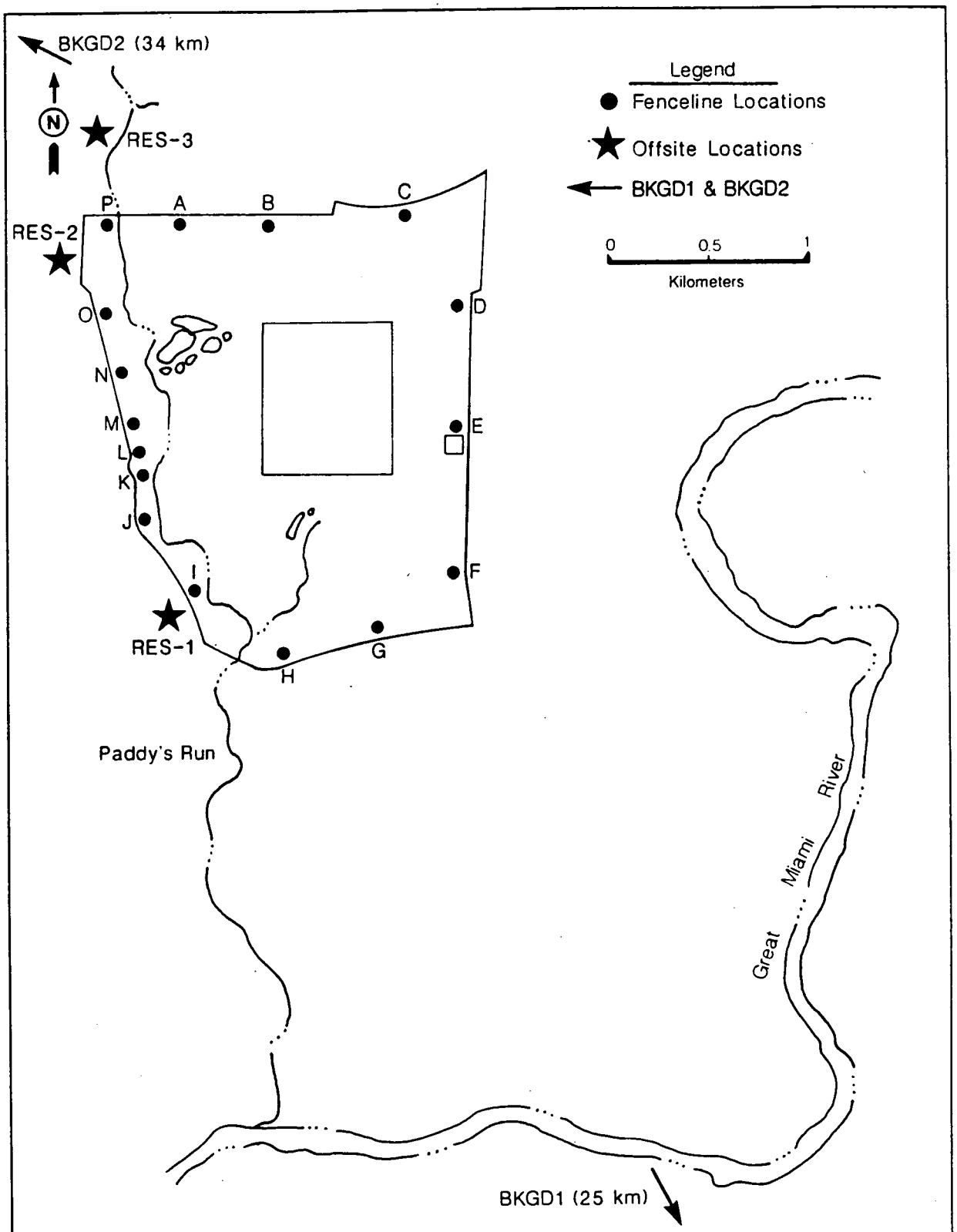

Figure 6. Offsite and Fenceline Radon Monitoring Locations

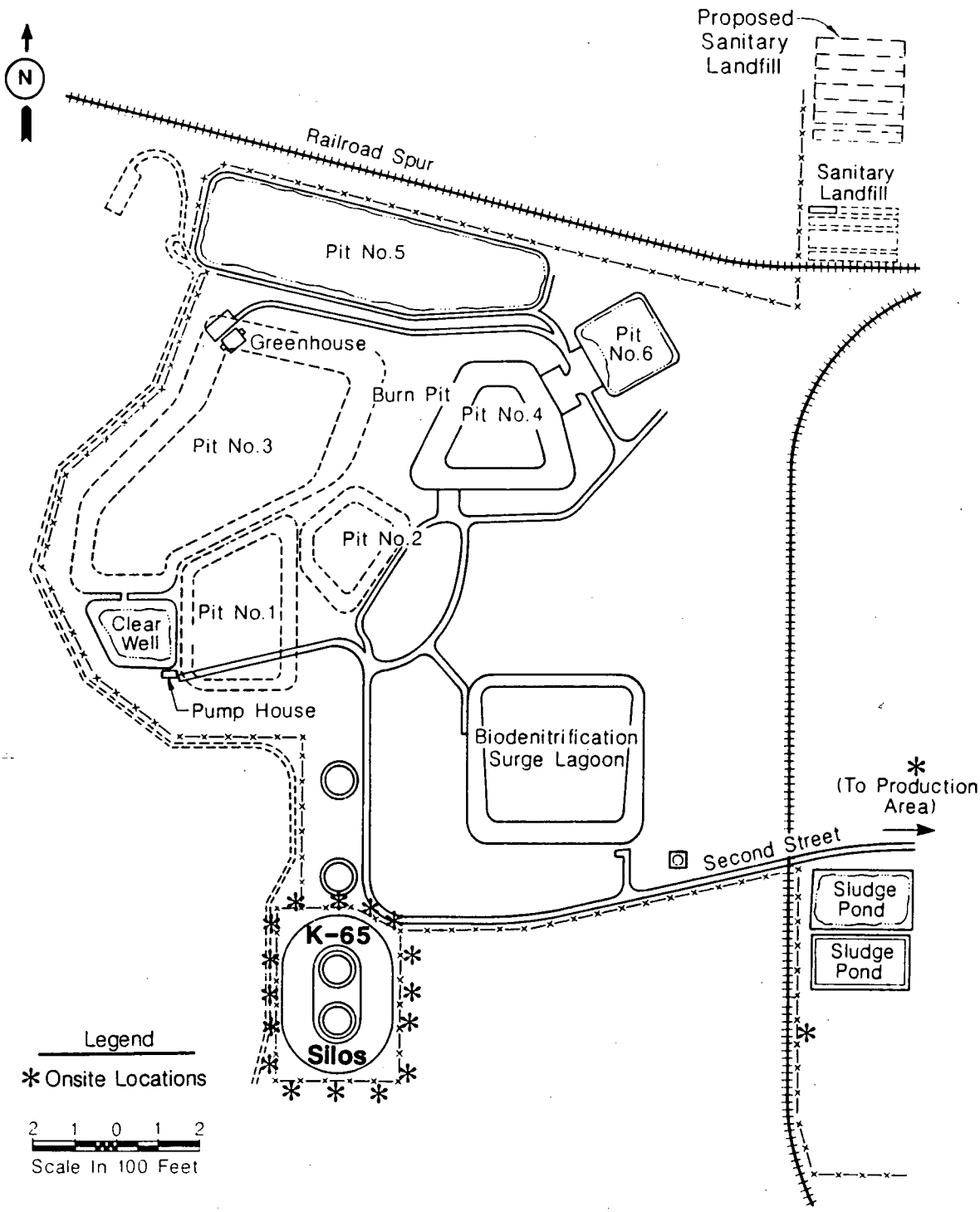

Figure 7. Onsite Radon Monitoring Locations – Waste Storage Area

Chapter Five
Collecting and Analyzing Samples

In order to accurately determine the radiation doses and plant effluent discharges from operations at the FMPC, significant amounts of data for potential sources and pathways were collected and analyzed. This chapter describes the FMPC's methods for collecting and analyzing data for the Environmental Monitoring Program, and is organized into two major sections - air pathways and water pathways.

Air Pathways

The largest overall potential source of radiation exposure to the public from the operation of the FMPC is via the air pathway. Specific sources of radiation exposure by the air pathway to the public can be through airborne contaminants which are introduced to the human food chain in soil, vegetation, farm and garden produce, and milk. This section describes the various sampling programs which are implemented at the FMPC to monitor these media for radiological and nonradiological parameters. These sampling programs are discussed in the following sections:

- Sampling Air
- Sampling Soil
- Sampling Parallel Soil and Vegetation
- Sampling Farm and Garden Produce
- Sampling Milk.

Sampling the Air

Based on state and federal codes and regulations, the FMPC monitors air emissions for both radiological and nonradiological parameters. These monitoring programs are described in the following paragraphs.

Radiological Parameters. The conversion of impure uranium compounds to reactor-grade feed materials generates airborne radioactive particulates. Ventilation and air-filtration systems reduce employee exposure to these particles and reduce their release into the environment.

There are seven high-volume air monitoring stations located along the FMPC fenceline (AMS 1 - 7) to continuously collect samples of airborne particulates (Figure 5 on page 17). In addition, two air monitoring stations are located onsite (AMS 8 and AMS 9) and four offsite (AMS 10 - 13). The air monitoring station at Shandon (AMS 12), was added in the first quarter of 1987.

Samples were collected and analyzed at weekly intervals. At each sampler, air was 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 were accounted for. Filters were accurately weighed before and after sample collection to obtain the weight of the collected particulates. The filter was then dissolved in acid and the solutions were analyzed for uranium content and beta activity. A portion of each of these solutions was retained to provide a yearly composite, which was then analyzed for trace radionuclides such as isotopes of neptunium, plutonium, and thorium.

Table 10 presents the results of the air sampling in 1987 for average particulate and uranium concentrations and beta activity from various radionuclides. Comparisons were made using the data from the FMPC 1985 through 1987 EMR's. The concentrations of uranium measured at five of the seven fenceline air monitoring stations in 1987 were lower than the concentrations measured in 1986, but the differences are not

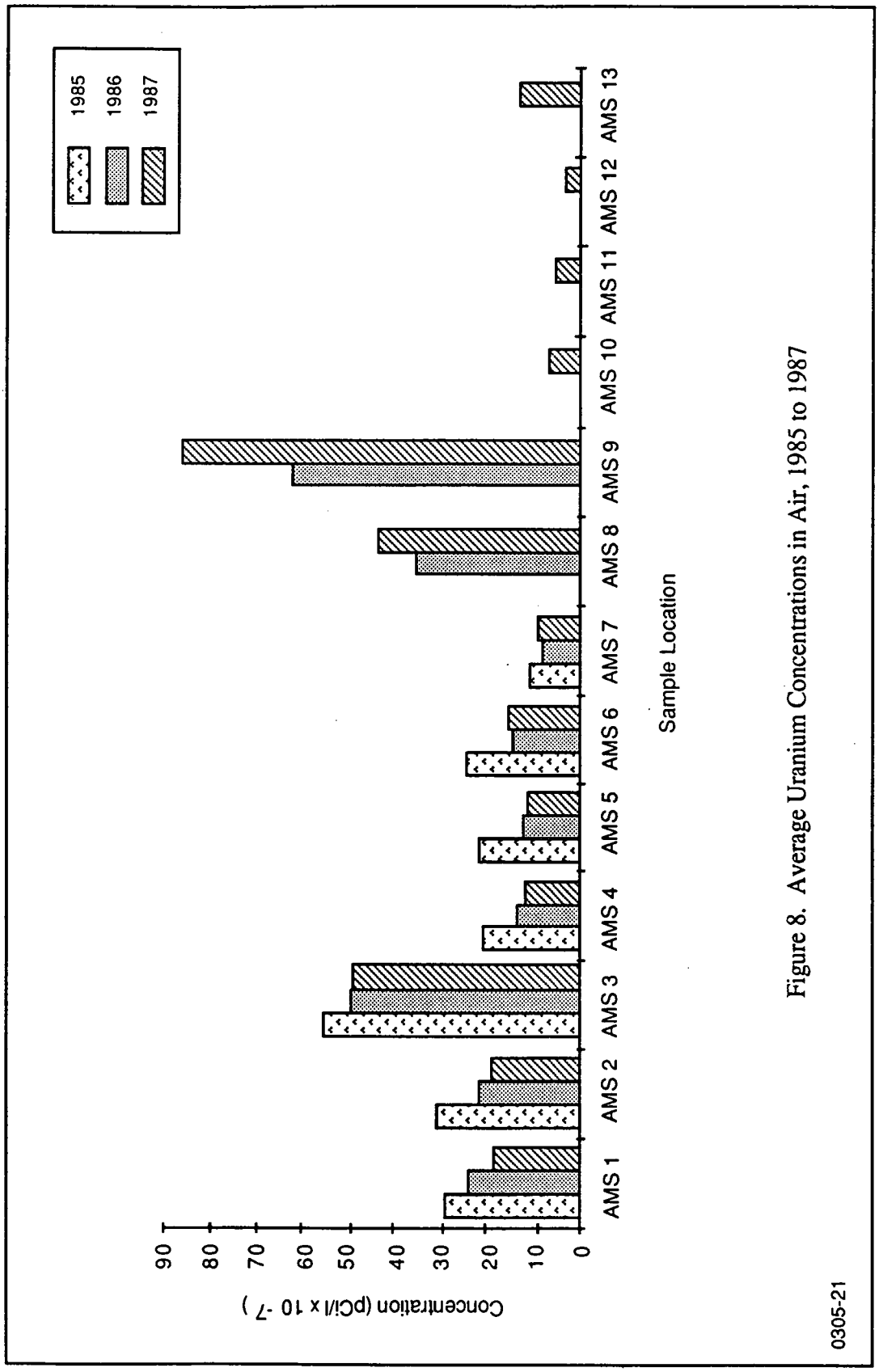

Figure 8. Average Uranium Concentrations in Air, 1985 to 1987

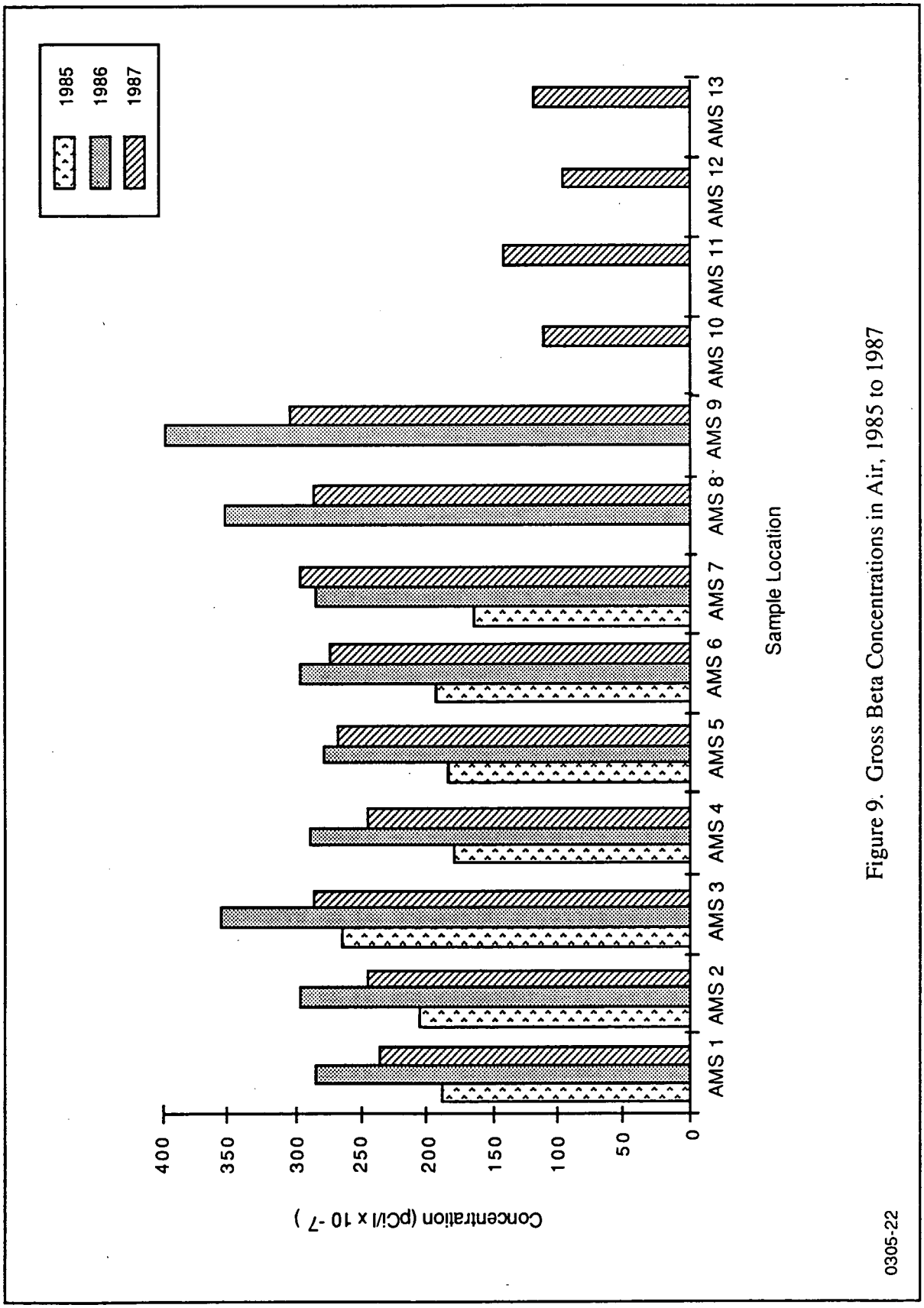

Figure 9. Gross Beta Concentrations in Air, 1985 to 1987

considered to be statistically significant (Figure 8). In 1987, beta concentrations at six of the seven fenceline air monitoring stations were lower than in 1986 (Figure 9). Concentrations of all airborne trace radionuclides in 1987 were well within the applicable DOE guidelines (Table 11). For most of these radionuclides, the reported 1987 concentrations were higher than 1986 (Figures 10 through 14). This general increase in reported concentrations can be partially explained by the increased stack discharges (a 20% increase for uranium) in 1987. The rest of the increase is attributed to the fact that the FMPC began using a different laboratory in 1987 to analyze environmental samples. At very low radionuclide concentrations, such as those frequently present in environmental samples, differences in analytical results between laboratories is not unexpected. The highest concentration of a trace radionuclide reported in Table 11 is less than 1% of the DOE guideline.

During 1987, a total of 35.4 kg (77.9 lbs) or 0.024 Ci (8.9×10^8 Bq) of uranium was released into the atmosphere from the FMPC. Of this total, 32.2 kg (91%) were discharged from Plant 8 scrubbers. While total production from all plants in 1987 was down compared to 1986, Plant 8 production increased 19%. Total FMPC stack discharges of uranium for 1987 increased 20% from 1986 when 29.4 kg (0.020 Ci) of uranium were discharged. This increase correlates well with Plant 8 production increases.

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 in the prevailing wind direction).

The 1987 results of the analysis of total suspended particulate (or airborne dust) concentrations from the FMPC fenceline air monitoring stations ranged from 29.0 to 34.8 $\mu g/m^3$, and were 7% lower than the 1986 results (Table 10; Figure 15). The highest average concentration of particles in 1987 was found at AMS 4 (as in 1986) and AMS 7. Elevated concentrations at these stations may be due to their location near large tracts of flat farmland where wind-borne dust is more prevalent. The 1987 results were slightly lower at all fenceline air monitoring stations except for AMS 7, which increased slightly.

Nonradiological Parameters. In addition to monitoring airborne radiological parameters, the FMPC monitored production processes for nonradiological pollutants including sulfur dioxide (SO_2) and nitrogen oxides (NO_x).

Section 3745-17-11 of the Ohio Administrative Code establishes the maximum permissible levels of particulate emissions from industrial processes.[8] At the FMPC, particulate emissions from these processes were well within the established guidelines.

The OEPA established the limits for particulates emitted by the steam-generation plant at the FMPC (OAC rule 3745-17-10). Electrostatic precipitators maintained these emissions below the limit of 0.06 kg (0.13 lb) per million British Thermal Units (BTU) output, as listed in the most recent Permits to Operate for the boilers.

The OEPA also set the limits for SO_2 emissions for stationary facilities (OAC rule 3745-18-37[s]). Under these rules, SO_2 emissions from the steam-generation plant were limited to 0.9 kg (2.0 lb) of SO_2 per million BTU output 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 were not exceeded at the FMPC steam-generation plant, coal containing less than 1% sulfur was used.

The State of Ohio has no established NO_x emission limits for FMPC industrial process sources since the site is located in a Priority III Region which is exempt from such limits. Presently the FMPC maintains NO_x emissions at 100 ppm NO_x or less for monitored process sources.

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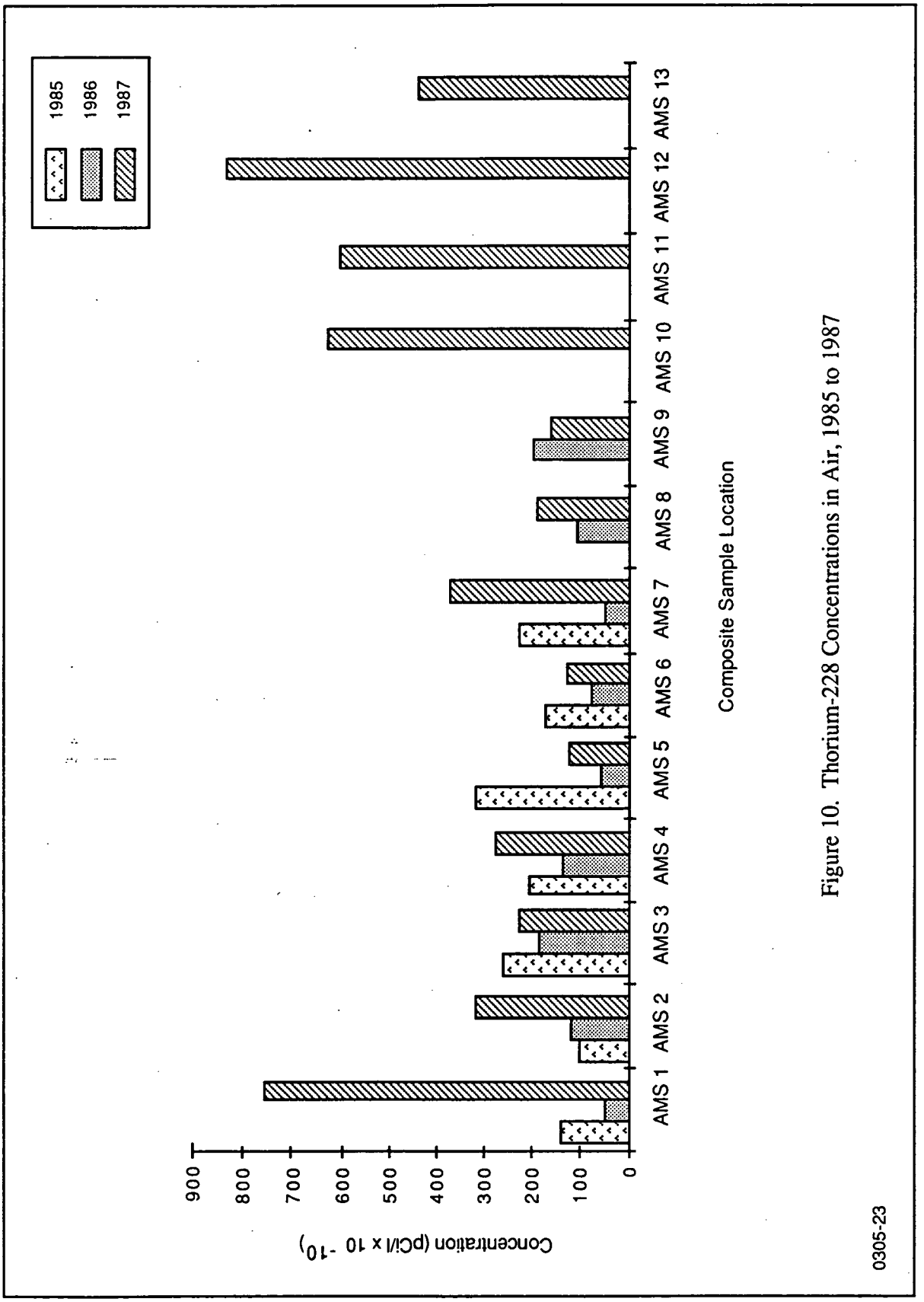

Figure 10. Thorium-228 Concentrations in Air, 1985 to 1987

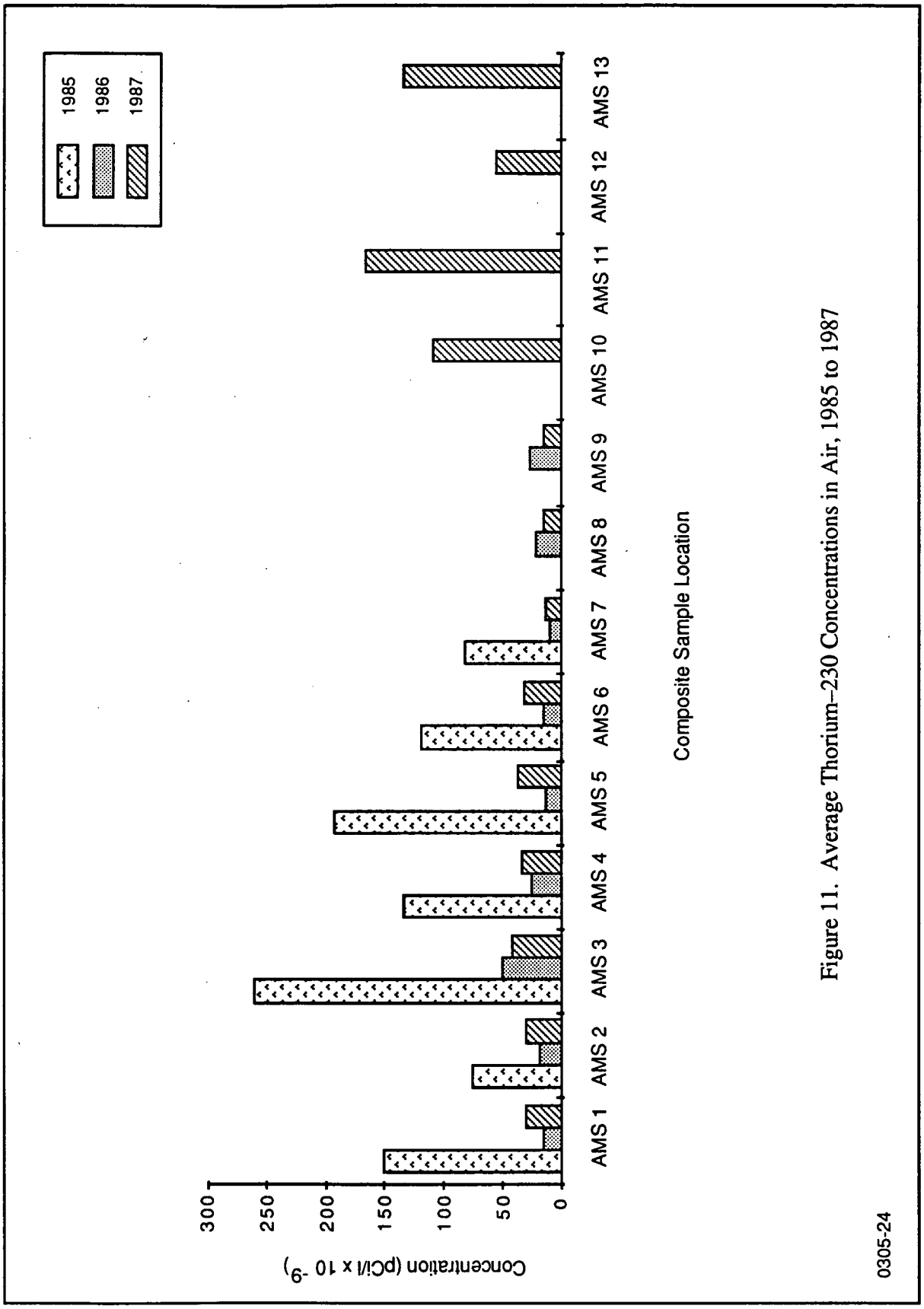

Figure 11. Average Thorium–230 Concentrations in Air, 1985 to 1987

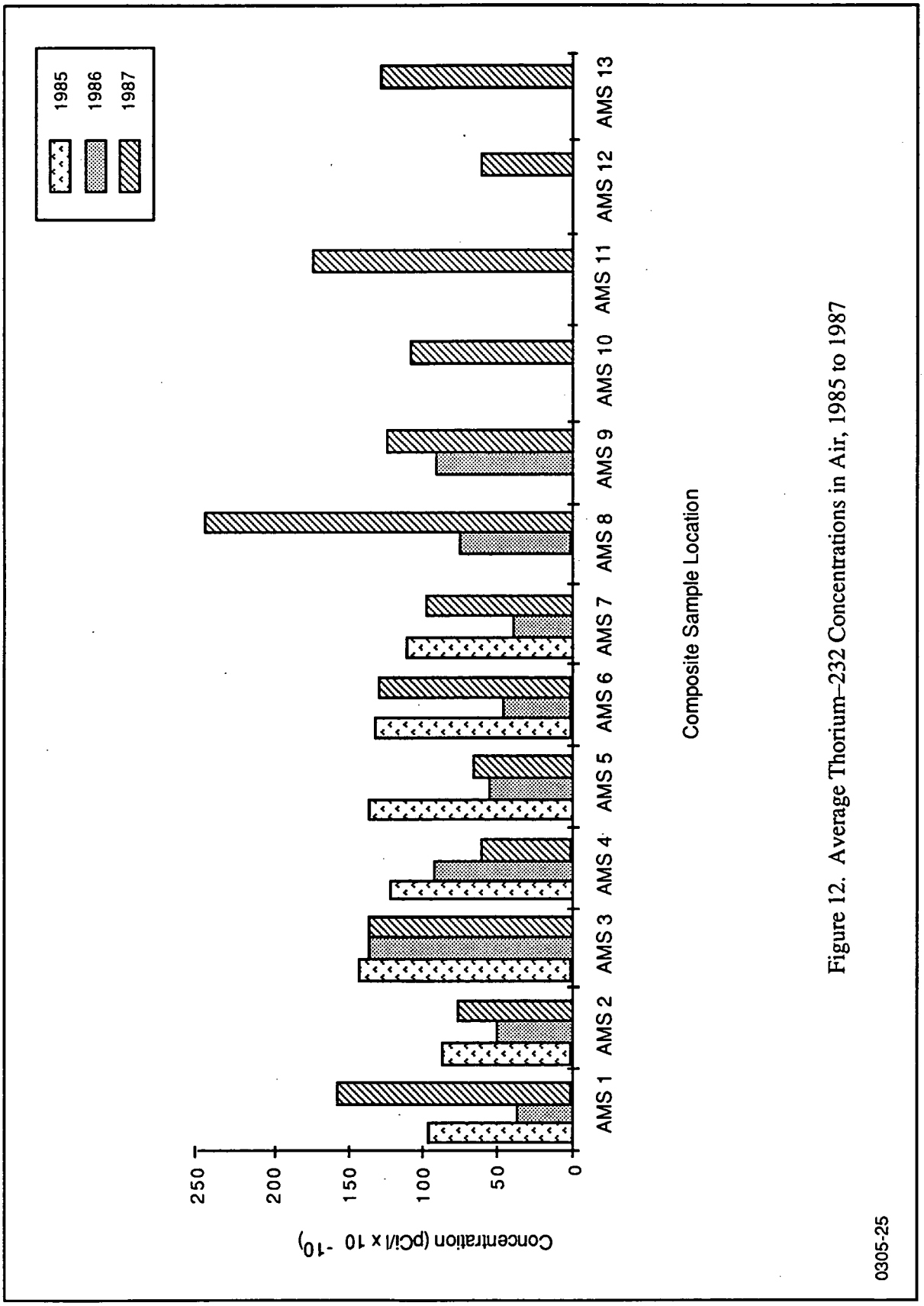

Figure 12. Average Thorium–232 Concentrations in Air, 1985 to 1987

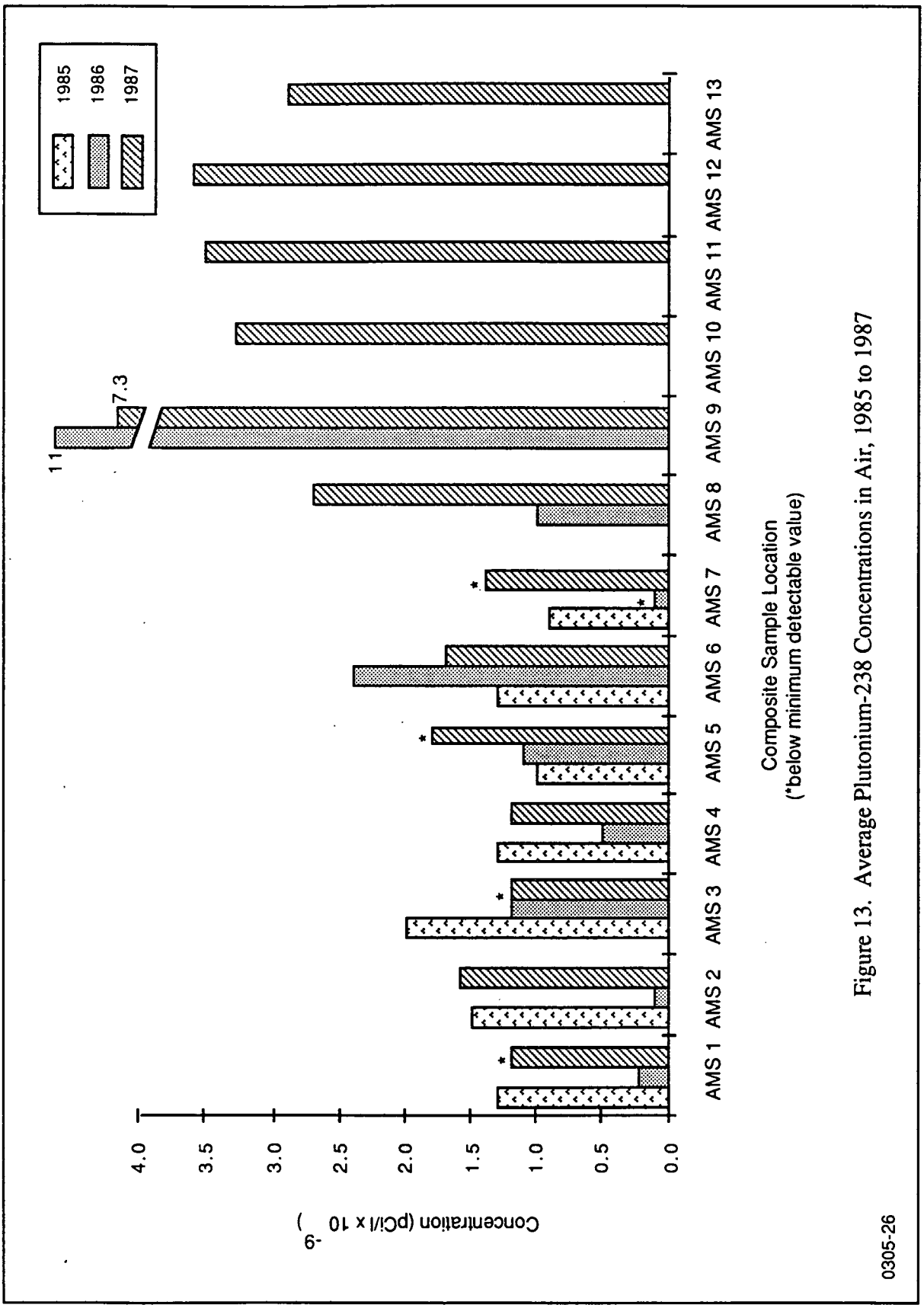

Figure 13. Average Plutonium-238 Concentrations in Air, 1985 to 1987

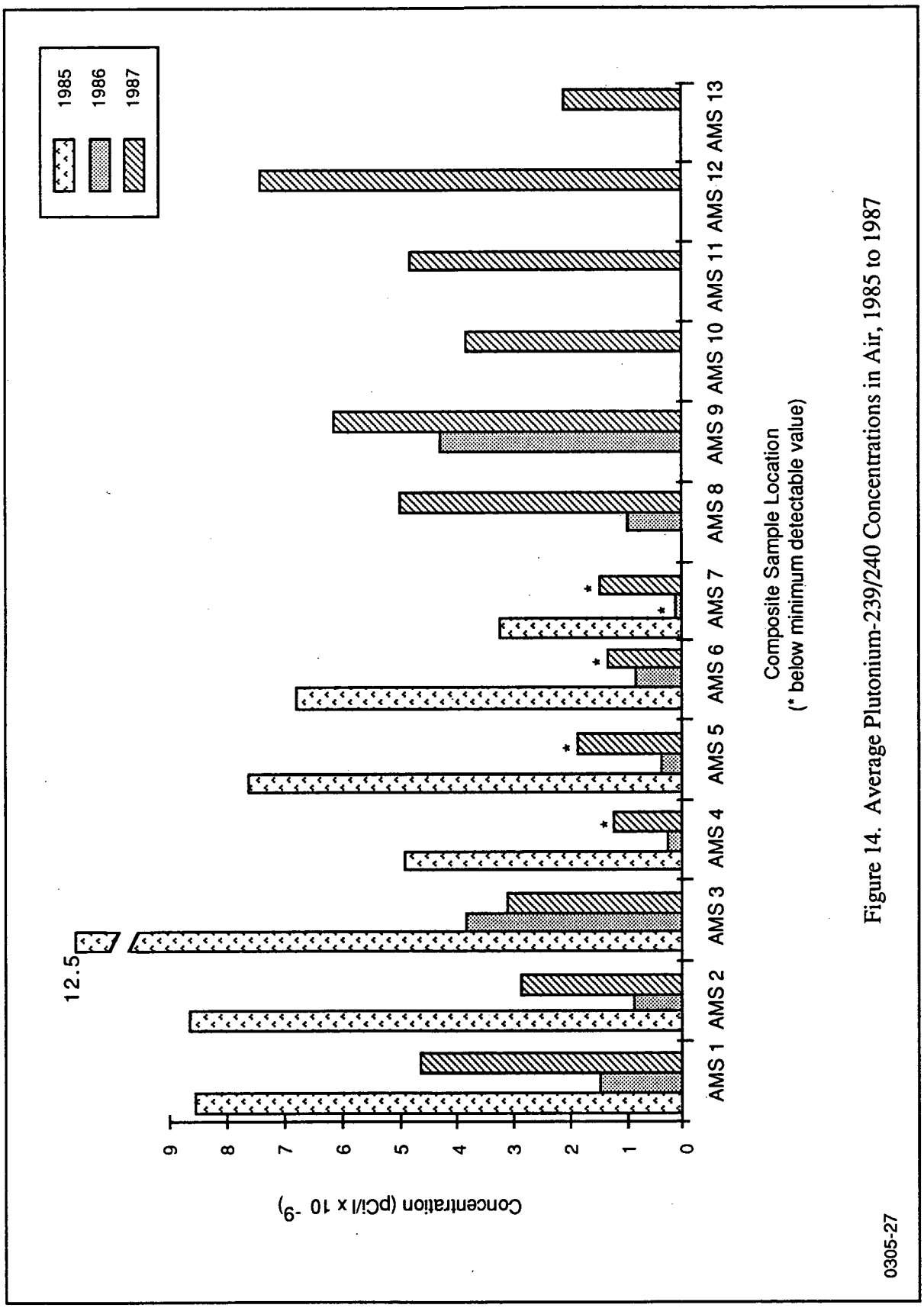

Figure 14. Average Plutonium-239/240 Concentrations in Air, 1985 to 1987

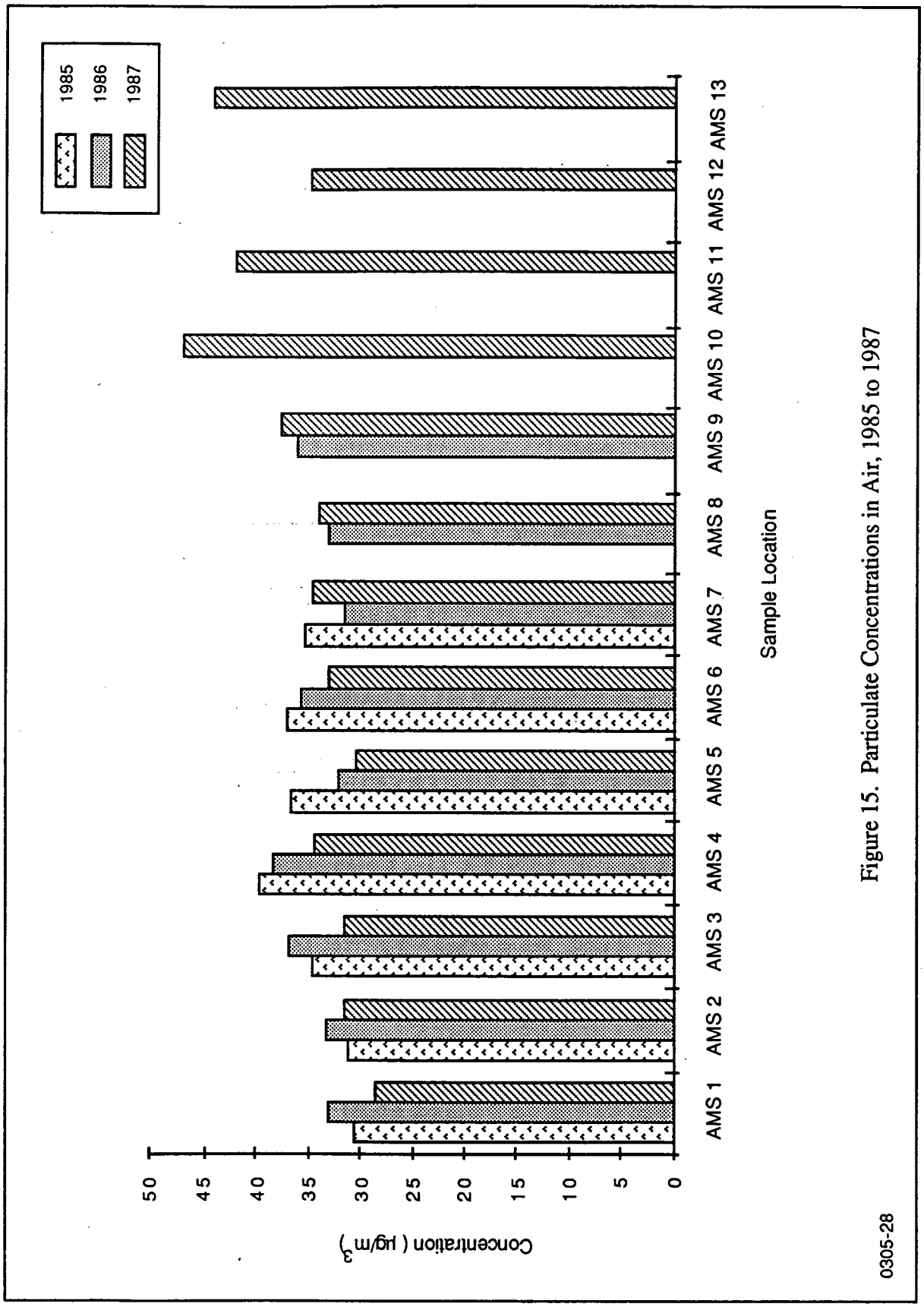

Figure 15. Particulate Concentrations in Air, 1985 to 1987

This standard is maintained by ventilating potential sources of NO_x to a bubblecap tower where they are scrubbed before they are released into the atmosphere.

Smaller sources of potential NO_x 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 Soil

As part of the routine soil monitoring program, annual soil samples were collected from each of the eighteen onsite and offsite locations (Figure 16). Each 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.

No DOE or USEPA standards have been established for most soil radionuclide levels. The Nuclear Regulatory Commission (NRC) established a concentration of 35 pCi (1.3 Bq) of natural uranium per gram (= 50 ppm) of soils which is the level generally used as an interim guideline. DOE, however, requires that guidelines for residual radionuclide concentrations in soil material be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. A soil pathways study, which will establish soil guidelines for the FMPC, is currently underway at the University of Cincinnati and will be completed in 1988.

For the purposes of comparison, 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) occur together naturally in soil.

Soils sampled at the eighteen locations were analyzed for total uranium concentration (Table 12). In 1987, all routine soil locations, except locations 4 and 9, showed slightly higher uranium concentrations than in 1986. A different laboratory was used to analyze uranium in soil in 1987; this may account for the difference. All routine soil locations sampled in 1987 had uranium concentrations within the range considered natural background (values listed above) for southwestern Ohio.

In 1987, soil analyses from the 0-5 cm (0-2 inches) depth were generally sightly higher than 1986 results (Figure 17). This year, as in the past, uranium concentrations from soil sampled at this depth did not differ significantly from concentrations found at the 5-10 cm (2 to 4 inches) depth. The highest uranium concentration in soil (56.0 pCi/g or 2.07 Bq/g for 0-5 cm depth) measured in 1987 was taken from sampling location 3 near the eastern boundary of the FMPC (Figure 16). This is most likely a remnant concentration resulting from previous operation of an incinerator adjacent to the Sewage Treatment Plant. Higher uranium concentrations have been noted at this location for the past several years.

Sampling Parallel Soil and Vegetation

In 1987, parallel samples of vegetation and soil were collected at 20 onsite and offsite locations (Figure 18). Each vegetation sample of about 500 g (wet weight) was a composite of a number of subsamples. Each subsample consisted of all above-ground plant material which was clipped near ground level from a 0.5 m (1.5 feet) diameter circular quadrant. Five of these subsamples would equal 1 m^2 (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 vegetation ranged from 0.11 to 1.03 pCi/g dry wt. or 0.0040 to 0.0381 Bq/g dry wt., respectively (Table 13). Standards for uranium in vegetation have not been established. The average uranium concentration in vegetation for 1987 (0.315 pCi/g or 0.0117 Bq/g dry wt.) was lower than in 1986. This difference may be the result of a change in analytical laboratories used to analyze the vegetation samples this year. In 1987, there was no association between the uranium concentration in

the vegetation at each sampling point and distance from the FMPC.

Fluoride concentrations in vegetation ranged from 2.49 to 11.9 µg/g (ppm) in 1987. Since the state of Ohio does not have a standard for fluoride in vegetation, the Kentucky standard of 80 ppm was used for comparison (Table 13). The average fluoride concentration in vegetation was 4.75 ppm in 1987, which is about 6% of the Kentucky standard. Again, there was no association between observed fluoride concentration in the vegetation at each sampling point and distance from the FMPC.

Parallel soil samples were taken at the same locations as vegetation samples using the procedure described for routine soil monitoring (see Sampling Soil, this chapter and Figure 18). Soil samples were analyzed for total uranium.

Uranium concentrations in parallel soil samples ranged from 1.2 to 23.8 pCi/g dry wt. or 0.045 to 0.882 Bq/g dry wt., respectively. For 1987, all parallel soil sampling locations had uranium concentrations within the range considered background for southwestern Ohio. The average uranium concentration in parallel soil samples for 1987 was 5.62 pCi/g or 0.208 Bq/g dry wt. There was no association between the uranium concentration in the parallel soil samples and distance from the FMPC, or between uranium concentrations in soil and vegetation samples (Table 13).

Sampling Farm and Garden Produce

Radionuclides that occur naturally or are deposited in the soil by airborne dust may be taken up by plants and animals and ultimately find their way into the human food chain. In order to monitor produce grown on farms and gardens ranging from 1.7 km (1.0 mi) to over 62 km (38 mi) from the FMPC, samples of vegetables, soil, and fertilizer from nine area farms and gardens were analyzed for uranium content (Figure 19).

Leafy vegetables, roots and stems, and fruits did not show significantly different concentrations of uranium. Uranium concentrations in vegetables were generally lower than those found in parallel vegetation samples. A number of vegetables analyzed exhibited concentrations of uranium that were less than detectable levels. There was no association between uranium concentration, distance from the FMPC (remote or otherwise), vegetable type, or farm from which they came (Table 14).

No relationship was found between soil or fertilizer and uranium concentrations in vegetables. Uranium concentrations in two samples of fertilizer were slightly higher than in soil found on the farms in which that fertilizer was used.

Sampling Milk

In 1987, the FMPC conducted monthly sampling of milk produced by cows grazing on the FMPC land adjacent to the site and at a background dairy in Indiana, about 30 km (19 mi) west of the FMPC. The average uranium concentration present in the milk samples was below the laboratory's minimum detectable range of less than 0.7 pCi/l (0.03 Bq/l), and did not vary between the two locations.

Water Pathways

Additional pathways for radiation to the public may be due to effluent discharged from the FMPC outfall and to Paddy's Run via the storm-sewer outfall ditch. These pathways include groundwater, surface water, FMPC liquid effluent, sediment, and aquatic wildlife (i.e. fish). This section describes the various sampling programs at the FMPC which monitor these media for radiological and nonradiological parameters. These sampling programs are discussed in the following sections:

- Sampling Groundwater
- Sampling Surface Water
- Sampling FMPC Liquid Effluent
- Sampling Sediment
- Sampling Fish.

Sampling Groundwater

As part of the overall Environmental Monitoring Program, groundwater sampling is divided into

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onsite, offsite, and RCRA groundwater monitoring programs. The monitoring wells in each program are sampled according to specific schedules (monthly, quarterly, semiannually), and the samples are analyzed for specific parameters (radiological, nonradiological). The schedules and analysis for the programs differ to some extent, and are described in the following sections along with background information on how the wells are identified.

A total of 35 onsite wells and 28 offsite wells were sampled as part of the Environmental Monitoring Program (Figures 20 and 21). There were 22 different onsite well locations; however, 12 of these locations were cluster wells. A cluster well is a grouping of two or more wells of different depths at the same location which are used to sample different waterbearing zones within the groundwater aquifer.

Onsite monitoring wells are now numbered using the 100-, 200-, 300- and 400- series nomenclature. Table 15 is a conversion chart showing onsite well name equivalents for 1986 and 1987. This system, used for the RI/FS, denotes in which of the four different waterbearing zones the monitoring well extends. Figure 22 is a geologic cross-section which shows the four waterbearing zones within the buried valley aquifer which underlies the FMPC. Wells extending into the perched aquifer within the shallow glacial till (approximately 35 feet deep) are denoted as 100-series. Wells extending into the upper portion of the upper sand and gravel aquifer (approximately 70 feet deep) are denoted as 200-series. The 300-series wells are completed within the lower portion of the sand and gravel aquifer, approximately 120 feet deep. The 400-series wells are installed in the sand and gravel aquifer which underlies the "blue clay" layer. Wells P1, P2 and P3 are FMPC Production Wells which supply potable water for the site from the 400-series aquifer.

Offsite wells are numbered sequentially as locations are added to the monitoring program. RI/FS series nomenclature has not been assigned to offsite wells since depth data for these privately-owned water supply wells is generally not available.

Twenty-eight offsite wells belonging to individuals and companies in the vicinity of the FMPC were sampled monthly for total uranium. Onsite monitoring wells 204, 211, 301, 303, 305, 308, 309, 310, 401, 408, and production wells P1, P2, and P3 (400-series) were all sampled monthly and quarterly for both radiological and nonradiological parameters. All the onsite wells and offsite wells 8, 12, 15, 17 and 26 were sampled quarterly in 1986 and semiannually in 1987 as part of the FMPC RCRA Monitoring Program (Figure 23). This sampling, which includes radiological and nonradiological parameters, was performed according to guidelines set forth by the USEPA in RCRA regulations.[11, 12]

Results of all groundwater sampling were compared to National Primary and Secondary Drinking Water Regulations as well as the DOE guidelines for radiation protection. A study by the U.S. Geological Survey states that natural background levels for uranium in groundwater in most areas in the U. S. range from 0.68 to 6.8 pCi/l (0.025 to 0.25 Bq/l).[13]

Onsite Monitoring Wells, Radiological Parameters. During 1987, water samples were collected and analyzed monthly for uranium concentration from thirteen onsite wells (Figure 20). Quarterly samples from the onsite wells were analyzed for uranium concentrations and gross alpha and beta concentrations.

Figure 24 shows average uranium concentrations from 1985 to 1987 for the onsite wells. Wells 301, 305, 308, 309, and 310 showed slight increases in average uranium concentration in 1987 over previous years (Table 14). Well 303, which is located near Pit 3, showed a significant increase in average uranium concentration which can be attributed to high analytical results received in the last quarter of 1987. The origin of this increase will be addressed in the ongoing RI/FS. A slight decrease was observed in well 204. Wells near the Waste Storage Area (204, 301 and 310) and well 303 had the highest average uranium concentrations in 1987 (5.4, 9.4, 14 and 65 pCi/l or 0.20, 0.35, 0.51 and 2.4 Bq/l, respectively).

Figure 25 shows the average gross alpha concentrations in onsite wells from 1985 to 1987. Wells 301, 309, P1, and P2 showed slight

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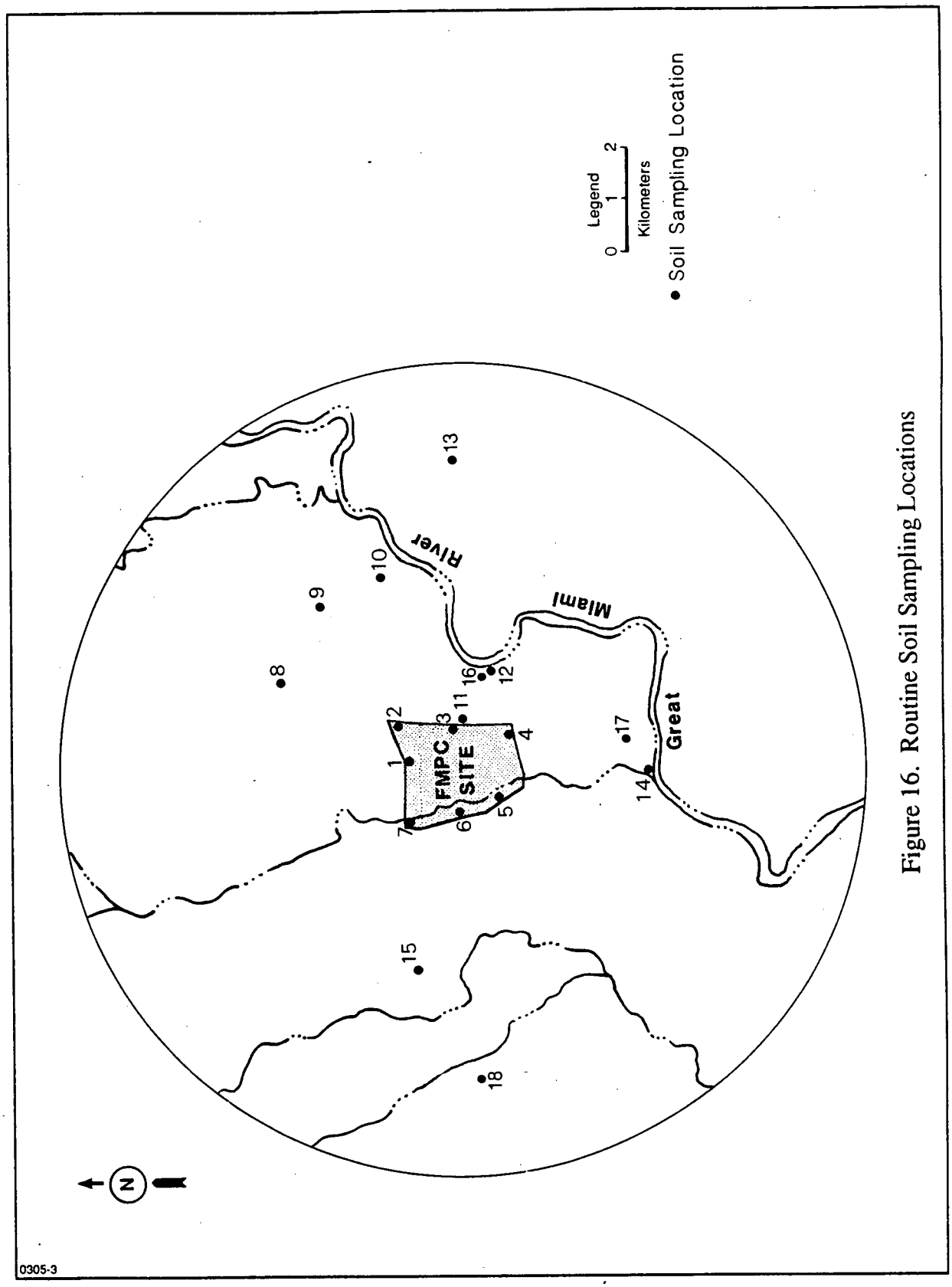

Figure 16. Routine Soil Sampling Locations

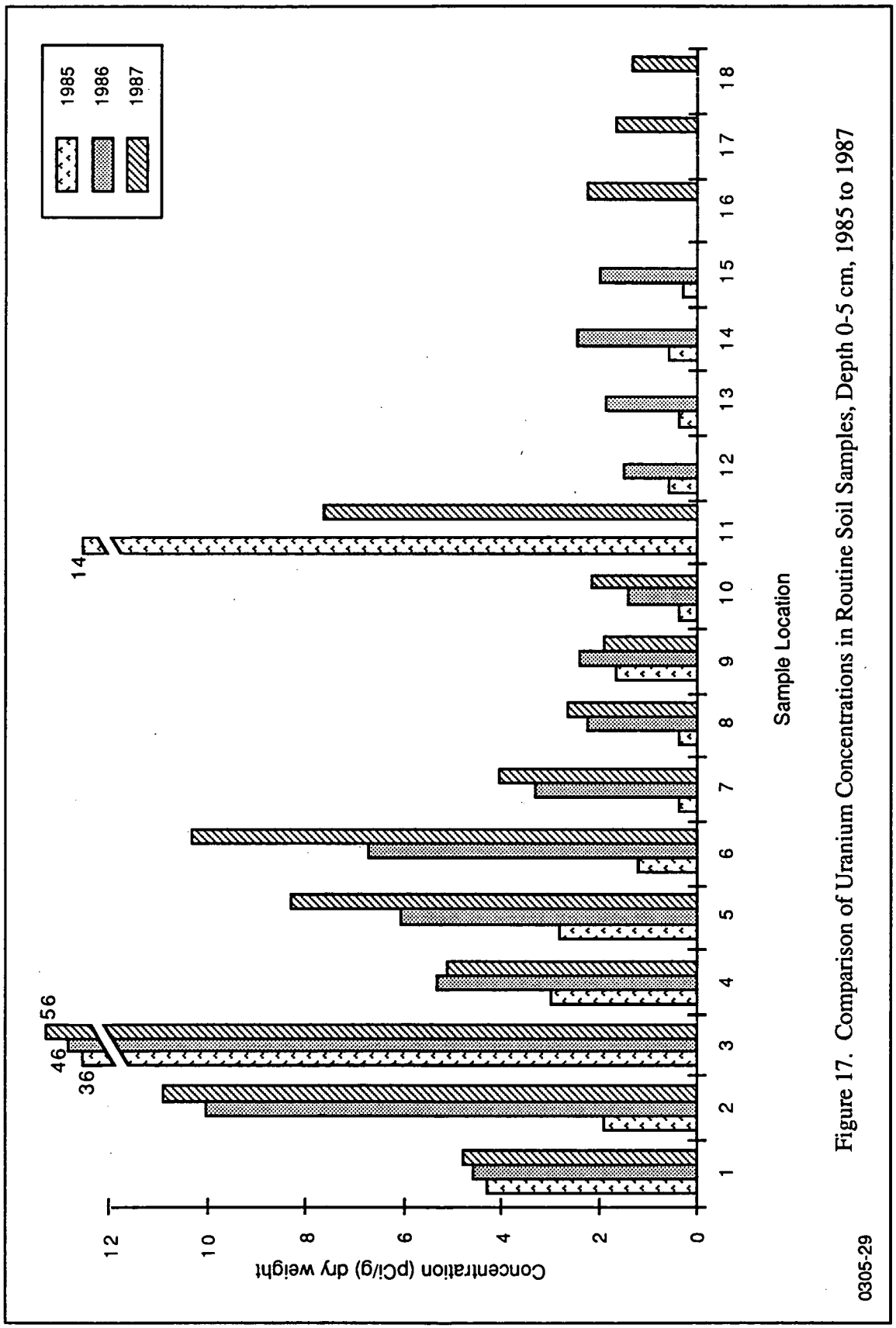

Figure 17. Comparison of Uranium Concentrations in Routine Soil Samples, Depth 0-5 cm, 1985 to 1987

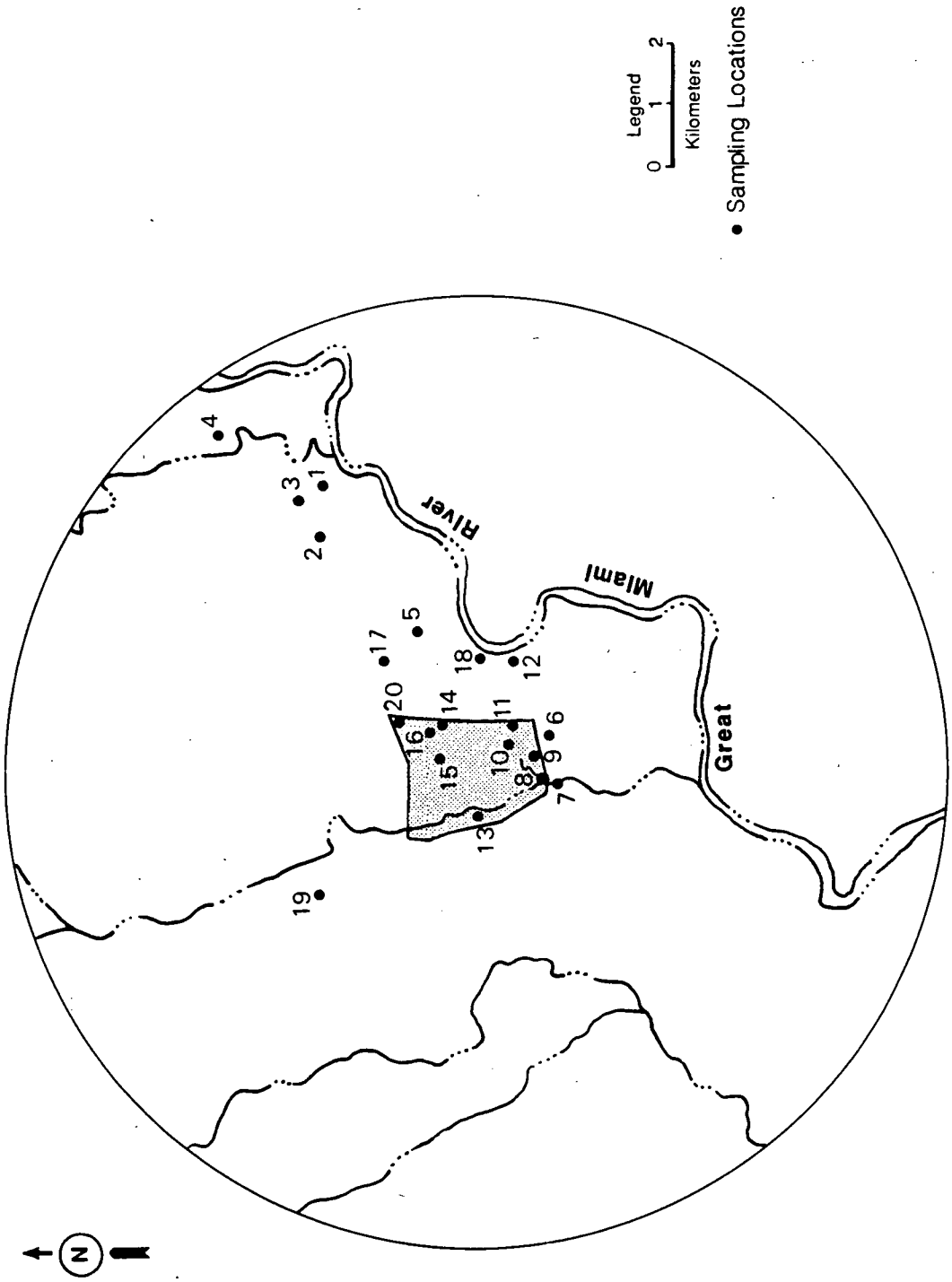

Figure 18. Parallel Soil and Vegetation Sampling Locations

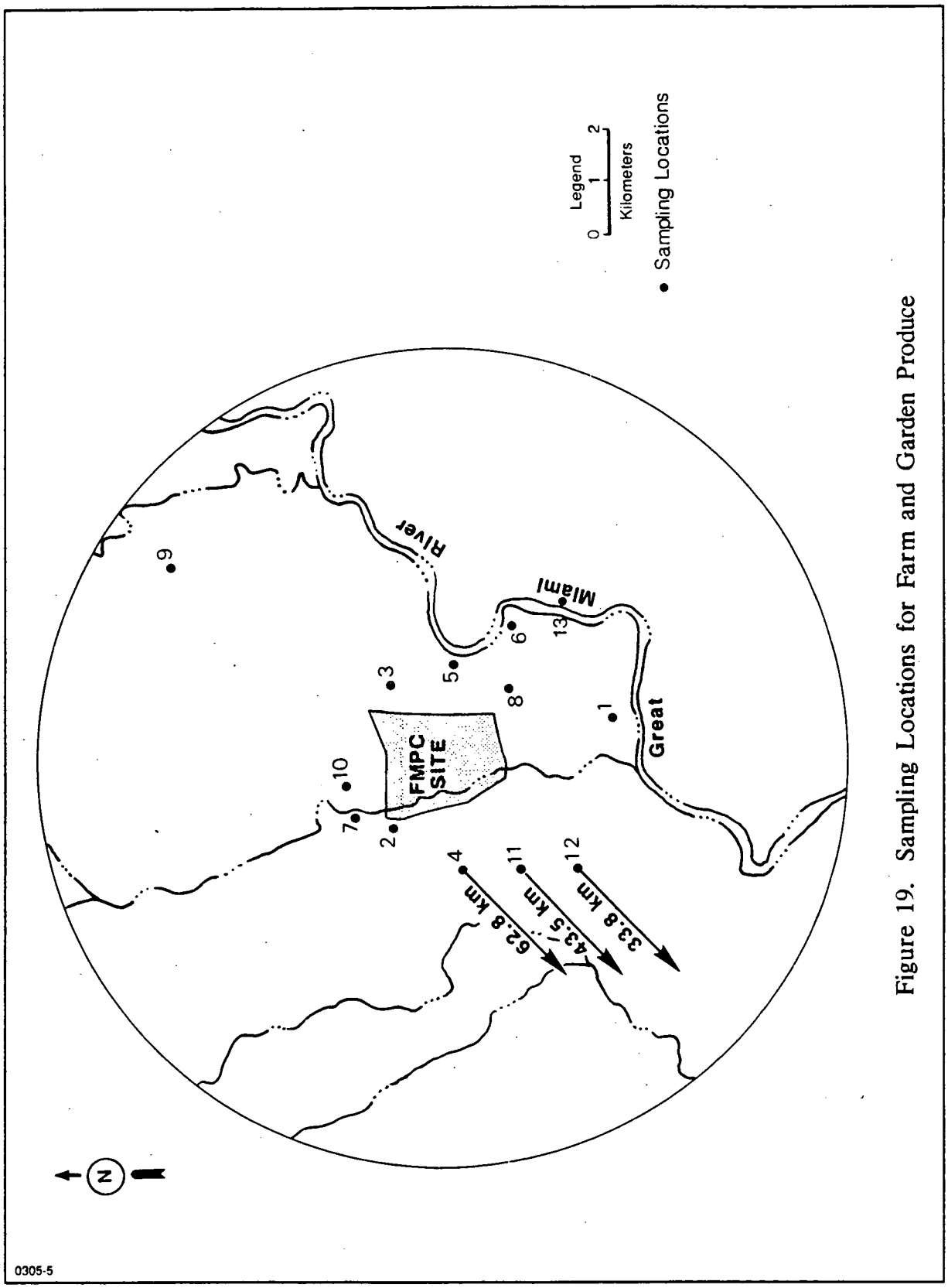

Figure 19. Sampling Locations for Farm and Garden Produce

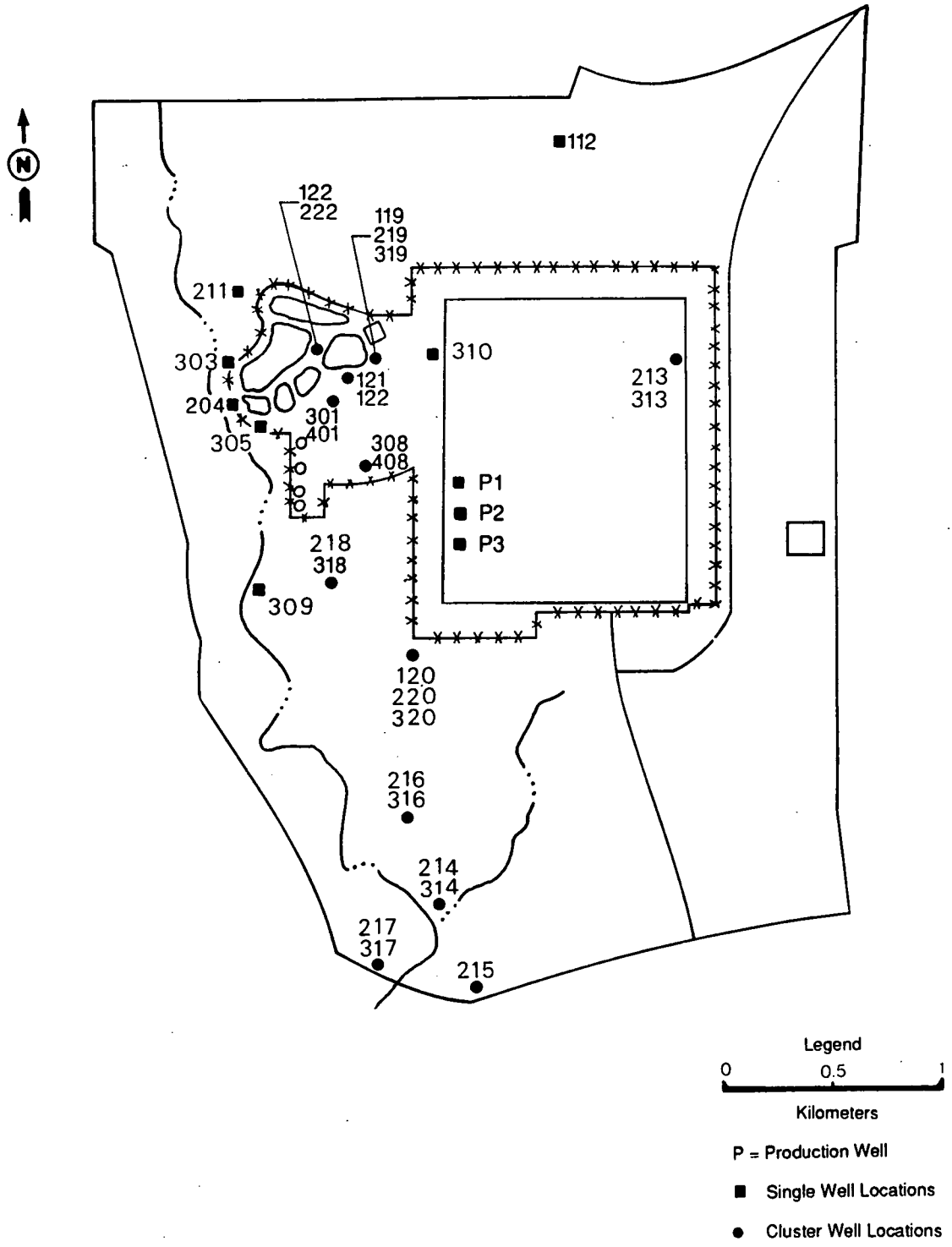

Figure 20. Onsite Monitoring Well Locations

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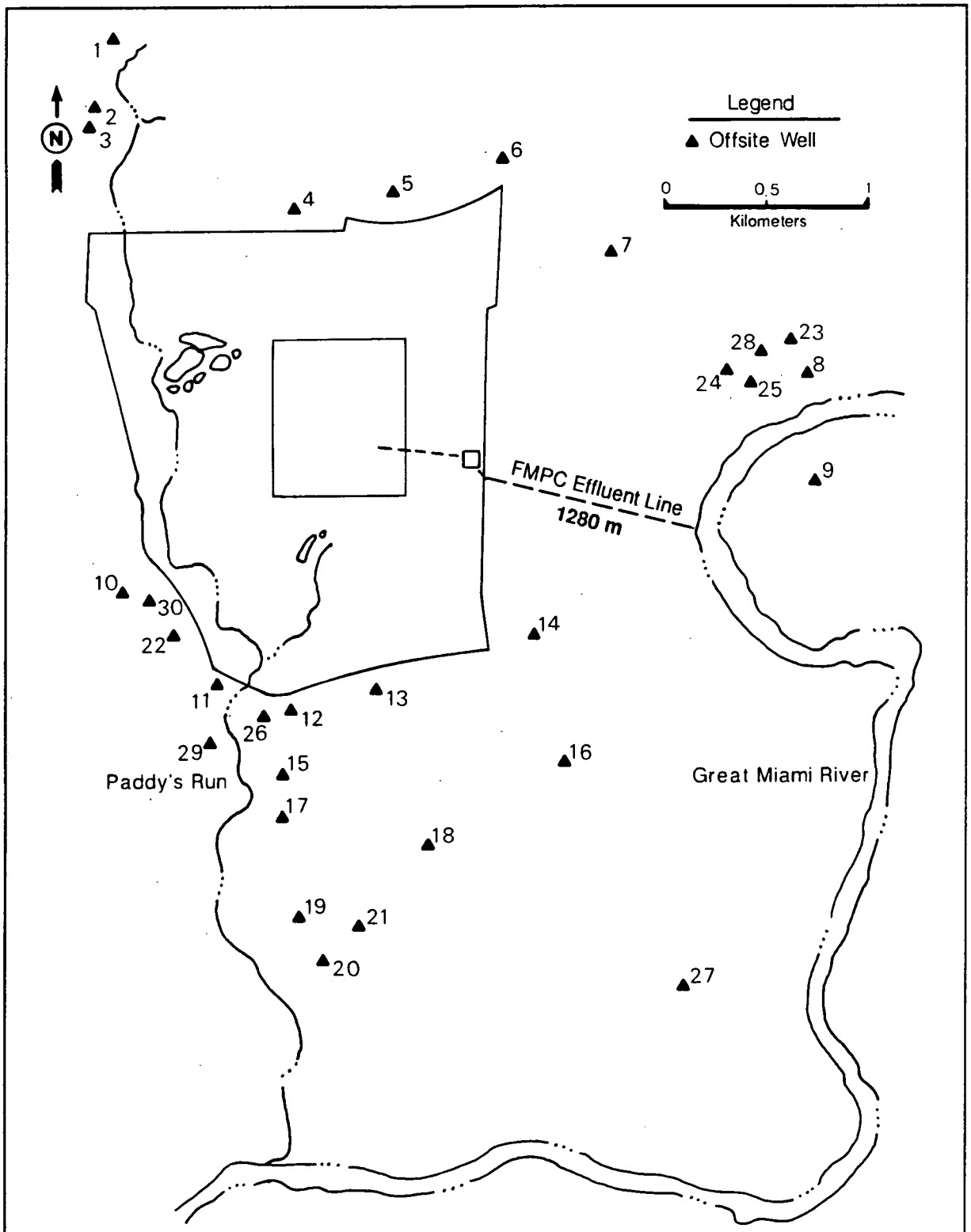

Figure 21. Offsite Monitoring Well Locations

0305-12

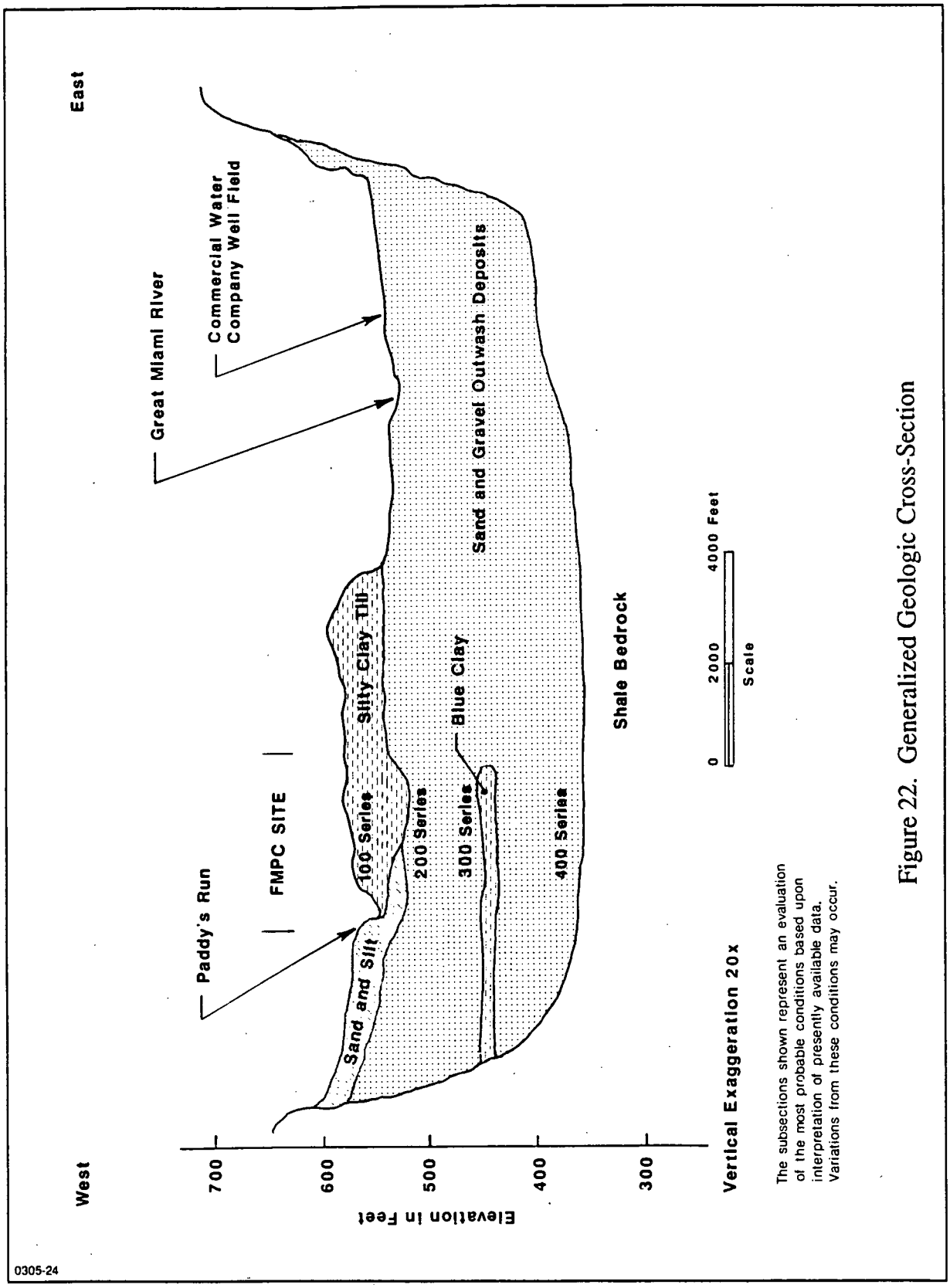

Figure 22. Generalized Geologic Cross-Section

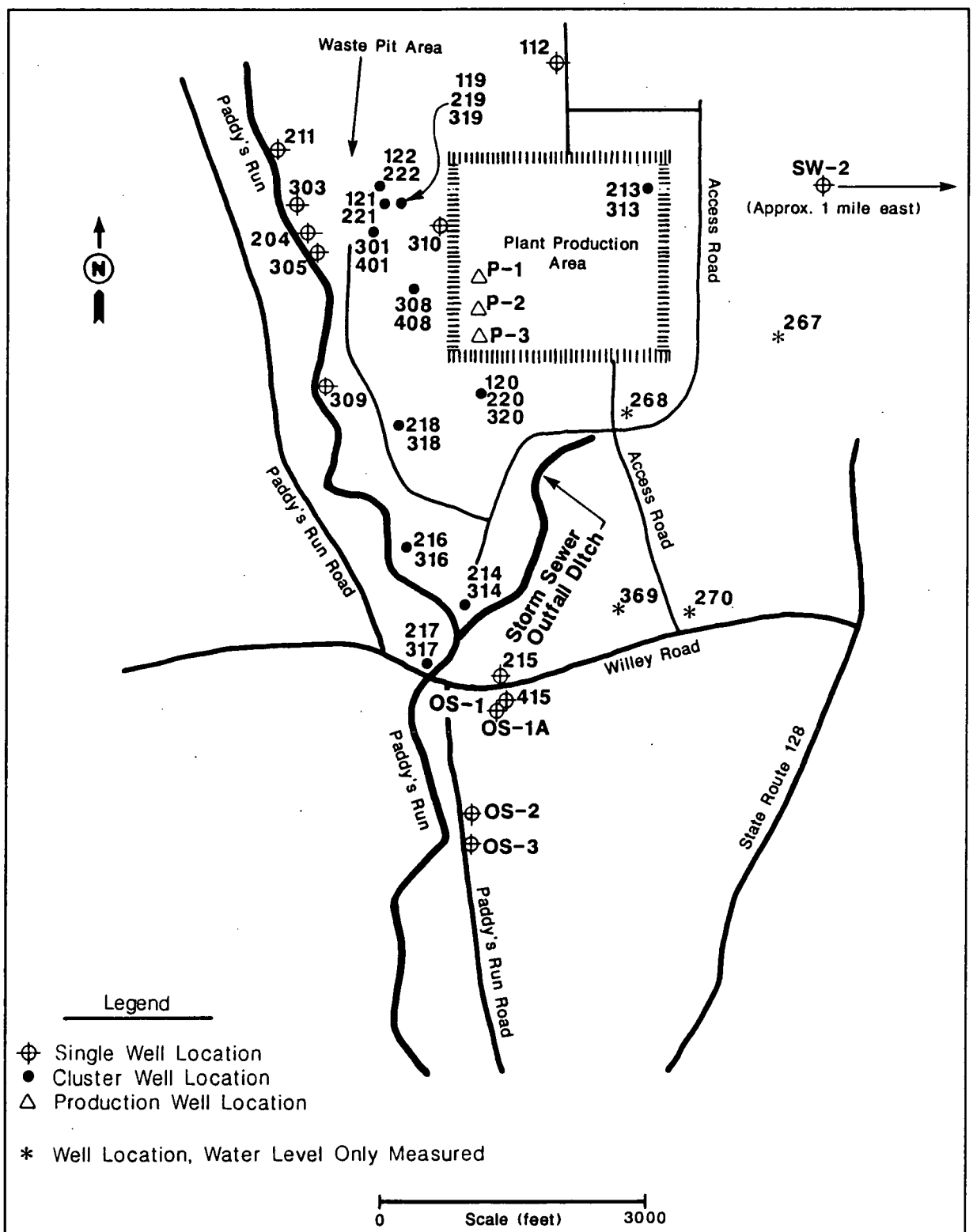

Figure 23. RCRA Well Locations

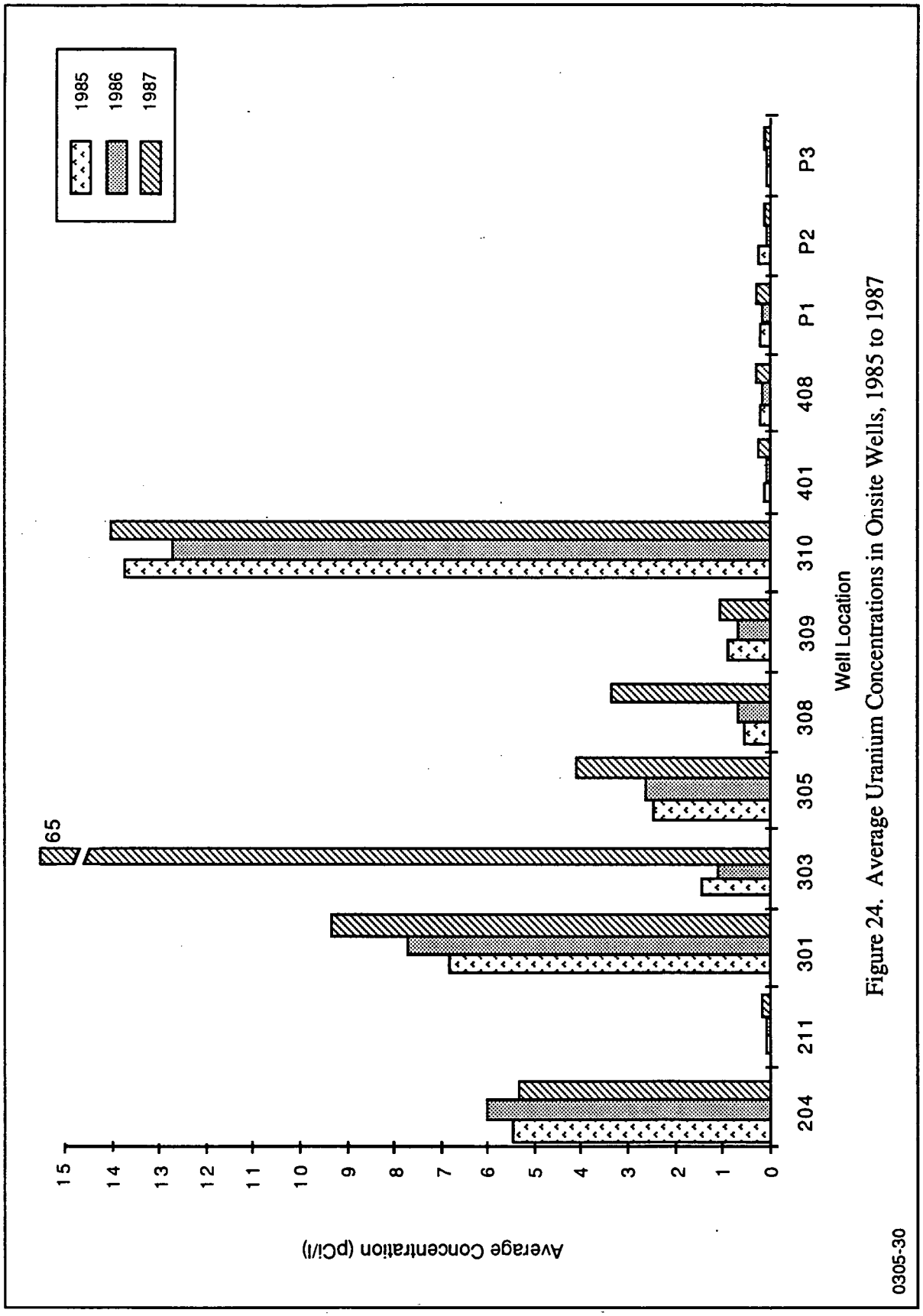

Figure 24. Average Uranium Concentrations in Onsite Wells, 1985 to 1987

increases in alpha activity in 1987 over previous years (Table 17). Well 303 showed a significant increase in alpha activity which reflects the corresponding increase in uranium concentration. Slight decreases were observed in wells 305, 308, and 310. Gross alpha concentrations were highest in 1987 in wells 310 and 301 (11 and 15 pCi/l or 0.40 and 0.55 Bq/l, respectively), which are located east and south of the Waste Storage Area respectively, and in well 303 (16 pCi/l or 0.59 Bq/l).

Figure 26 shows the average gross beta concentrations in the onsite wells from 1985 to 1987. Wells P1, P2, 308, and 310 showed slight increases in beta activity in 1987 over previous years (Table 18). Wells 303 and 309 showed significant increases in beta activity. Wells P3, 301, 204 and 211 showed slight decreases in gross beta activities in 1987 from 1986 levels. Wells 309, 303 and 310 had the highest levels of gross beta concentrations in 1987 (15, 18 and 27 pCi/l or 0.54, 0.65 and 1.0 Bq/l, respectively).

Onsite Monitoring Wells, Nonradiological Parameters. Onsite wells were analyzed quarterly for nitrate concentrations as part of the Onsite Groundwater Monitoring Program. The 1987 average results for nitrate concentrations in all onsite wells were less than 3 mg/l except for well 310, which averaged 118 mg/l (Table 19, Figure 27). Nitrate levels in wells 204 and P2 increased slightly in 1987 from 1986 levels, while levels in wells 309, 310, and P1 decreased. Wells 309 and 204 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 which drains into Paddy's Run, a groundwater recharge zone. All onsite wells had nitrate levels below the USEPA drinking water standards (10 mg/l) except well 310.

The quarterly onsite samples were also analyzed for sulfate, chloride, and pH (Tables 20, 21, and 22). Values for pH remained relatively constant in 1986 and 1987. The 1987 chloride and sulfate results correlate closely to those of 1986, with well 310 exhibiting the highest average concentrations for both of these parameters. The average chloride concentration in well 310 increased in 1987, but other wells did not exhibit clear trends. Average sulfate concentrations in FMPC onsite wells ranged from 6 mg/l in well 401 to 671 mg/l in well 310. Average sulfate concentrations in well P2 increased in 1987, but decreased in wells 301, 308, 309, 401, and P3. Average sulfate levels in individual wells vary considerably from year to year. All onsite wells had chloride levels below the USEPA drinking water standard of 250 mg/l. Only well 310 had sulfate levels above the USEPA standard of 250 mg/l for drinking water.

Offsite Monitoring Wells, Radiological Parameters. Groundwater samples from twenty-eight offsite wells were collected and analyzed monthly for uranium concentration. As in past years, the average uranium concentrations in samples collected in 1987 from all offsite wells, except for wells 12, 15, and 17 (201, 201 and 40 pCi/l or 7.44, 7.44 and 1.5 Bq/l, respectively), were within the range considered natural background for uranium content in groundwater (Table 23). Figures 28 and 29 show average uranium concentrations in offsite wells for 1985-1987. No clear trends were evident in the majority of the offsite wells, and the variation shown probably is due to natural, sampling, and analytical variations.

Contaminated surface water seeping into the aquifer from the storm-sewer outfall ditch and Paddy's Run was identified in 1985 as the source of above-background concentrations of uranium in offsite wells 12, 15 and 17.[14] The Stormwater Retention Basin, which began operations in 1986, has greatly reduced discharges of contaminated stormwater to the storm-sewer outfall ditch and Paddy's Run.

Offsite Monitoring Wells, Nonradiological Parameters. Additional samples were collected and analyzed for sixteen metals from offsite wells in July 1987. The wells are identified and the results provided in Table 24. Concentrations of calcium, iron, and manganese were high, but this is typical for groundwater in this area.[15] Concentrations of silver, arsenic, barium, cadmium, chromium, copper, lead, selenium, and zinc were well below USEPA drinking water guidelines.[4,5] These analyses showed that the FMPC is probably not a source of metals, other than possibly uranium, in offsite groundwater.

RCRA Monitoring Wells. As part of the RCRA Groundwater Monitoring Program, forty-one wells onsite and offsite were sampled for 94 parameters, 15 of which were radiological (Figure 23). 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 analytical results for RCRA sampling rounds 4 and 5 are found in Appendix B. The first quarter of RCRA data was reported in the 1985 EMR and the second and third quarters were reported in the 1986 EMR.[16, 17] A statistical comparison of the first four rounds of analysis is found in Tables 44 through 47 of Appendix B, and is discussed further in Chapter 6 of this report.

Sampling Surface Water

Surface water was sampled for radiological and nonradiological parameters at four onsite and five offsite locations along Paddy's Run and the Great Miami River (Figure 30). Depending on the sampling location, the frequency of collection of surface water varied along with the parameters that were analyzed. The following paragraphs detail these variations.

Surface water grab samples were collected weekly at sampling stations W1, W3, and W4 on the Great Miami River. These samples were analyzed for pH, ions, and radiological parameters such as gross alpha, gross beta, and total uranium. Semiannual composites for the Great Miami River locations were analyzed for ruthenium, cesium, strontium, technetium, and isotopic uranium. One-month composites of daily/weekly river samples were analyzed for isotopic radium. At Paddy's Run locations W5, W7, W8, W9, W10, and W11, weekly grab samples were collected (when water was flowing) and analyzed for pH, gross alpha, gross beta, and total uranium. Two-month composites of weekly samples at W5 were analyzed for isotopic radium, as were monthly composites at W7 (or W8 if W7 is dry).

The 1987 analytical results for radiological parameters in surface water are summarized in Table 25. Nonradiological analytical results for surface water are compiled in Table 26.

Radiological Parameters. Figure 31 shows plots of the average concentrations of total uranium at the surface water sampling points for 1985, 1986, and 1987. Average concentration of total uranium increased very slightly in samples of Great Miami River water at downstream locations W3 and W4. Large decreases in total uranium, however, occurred at Paddy's Run locations W7, W8, W10, and W11 due to operation of the Stormwater Retention Basin in 1987 (Table 25).

For example, total uranium concentration at location W7 on Paddy's Run was 88% lower in 1987 than in 1986 (Table 25). These values reflect the decrease in the total amount of uranium (2.2×10^{-4} Ci or 8.2×10^{6} Bq) discharged via the storm-sewer outfall ditch to Paddy's Run in 1987.

A portion of stormwater runoff from the Waste Storage Area was 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 contained above-background uranium concentrations, and may have contributed to higher uranium concentrations in Paddy's Run.[14] Beginning in August 1986, runoff from Pit 4 was collected in the Stormwater Retention Basin and then discharged into the plant effluent via Pit 6, Pit 5, and the Clearwell. Surface water data from 1987 show that this system helps control the flow of runoff from the Waste Storage Area into Paddy's Run.

Average uranium concentrations measured during 1987 at locations W10 and W11 in Paddy's Run (upstream of the confluence of the storm-sewer outfall ditch and Paddy's Run) were closely approaching those at location W7 (at the confluence). Above-background levels of uranium were found at locations W10 (6.8 pCi/l or 0.25 Bq/l) and W11 (5.8 pCi/l or 0.21 Bq/l), which may reflect a contribution of uranium in surface and shallow groundwater discharge from the Waste Storage Area.

Gross alpha and beta measurements are used to identify areas where analysis of more specific isotopes is indicated. Figure 32 shows a plot of the average gross alpha concentrations at surface water sampling locations during 1985, 1986, and 1987. Gross alpha concentrations decreased significantly at locations W7, W8, W10, and

W11 in 1987. No clear trends were observed at W1, W3, and W4. The highest average gross alpha concentrations were found at locations W7 (6.0 pCi/l or 0.22 Bq/l) and W11 (5.9 pCi/l or 0.22 Bq/l).

Figure 33 shows a plot of the average gross beta concentrations at surface water sampling locations during 1985, 1986, and 1987. Gross beta concentrations increased at locations W3, W4, and W9 in 1987, but decreased at W7, W8, W10, and W11. No clear trends were observed at W1 and W5. The highest average gross beta concentrations were found at W3 (12 pCi/l or 0.45 Bq/l) and W4 (17 pCi/l or 0.61 Bq/l).

Table 27 summarizes the various radionuclides released at surface water monitoring locations in 1987. Most radioisotope concentrations in measured surface water in the Great Miami River and Paddy's Run did not differ significantly from 1986 concentrations. In 1987, radium-226 and -228, uranium-238, and total uranium concentrations were unchanged or lower in Paddy's Run and the Great Miami River. Concentrations of cesium-137, strontium-90, uranium-234, -235, and -236 were higher in 1987 at all three Great Miami River locations. However, the 1987 values were well below the 1985 values. Technetium-99 concentrations were higher in 1987 at sampling locations W1, W2, and W3 in the Great Miami River. The total discharge of technetium-99 from the FMPC via the liquid effluent line to the Great Miami River increased from 1.5 Ci (5.7×10^{10} Bq) in 1986 to 2.7 Ci (9.9×10^{10} Bq) in 1987.

Nonradiological Parameters. Figure 34 shows the nitrate-nitrogen concentrations in surface water at W1, W3, W4, W7, W8, W9, W10, and W11 from 1985 to 1987. Nitrate concentrations have remained relatively constant from 1985 to 1987, although concentrations at sampling points W8 and W9 decreased significantly during this period. In 1987, average nitrate concentrations were higher in the Great Miami River (W1, W3, W4) than in Paddy's Run (Table 26). This may be caused by the discharge into the Great Miami River upstream of the FMPC of municipal and industrial wastes and agricultural runoff, which are sources of nitrates. The data also indicated that operations at the FMPC did not affect nitrate levels in Paddy's Run since there were no significant differences between upstream or downstream concentrations of nitrates in this stream. Nitrate levels in both Paddy's Run and the Great Miami River were below the USEPA drinking water standard of 10 mg/l.

Figure 35 shows the average fluoride concentrations in surface water at locations W1, W3, W4, W5, W7, W8, W9, W10, and W11 from 1985 to 1987. The average fluoride levels at locations W1, W3, and W4 (the Great Miami River) were higher than those in Paddy's Run. Fluoride levels in 1987 were relatively low (0.5 mg/l or less), and these levels were below the USEPA drinking water standards of 1.4 to 2.4 mg/l (Table 26).

Sampling FMPC Liquid Effluents

At the FMPC there are three separate systems for treating liquid wastes. These systems are for process wastewater, sanitary wastewater, and stormwater runoff. Figure 36 summarizes the flow paths of the liquid waste streams and the major points of treatment, and Figure 37 is a map of NPDES effluent sampling locations.

Radiological Parameters. In 1987, liquid effluent samples were collected continuously by an automatic sampler in proportion to the total flow at Discharge 001 (Manhole-175) which is the final access point in the FMPC effluent line into the Great Miami River. Twenty-four-hour composite samples at Discharge 001 were collected daily and analyzed for uranium content and alpha and beta radioactivity. One-month composites of the daily samples were analyzed for radium-226 and radium-228. Two semiannual composite samples were analyzed for 14 other radionuclides.

The total amount of uranium (770 kg) present in the liquid effluent discharged into the Great Miami River at Discharge 001 in 1987 was 68% greater than in 1986 (0.52 Ci or 1.9×10^{10} Bq) (Table 27). The increase may be attributed to several factors: a 15% increase in flow in 1987 (due in part to an increase in volume of stormwater pumped to the Great Miami River);

(Text continues on page 61.)

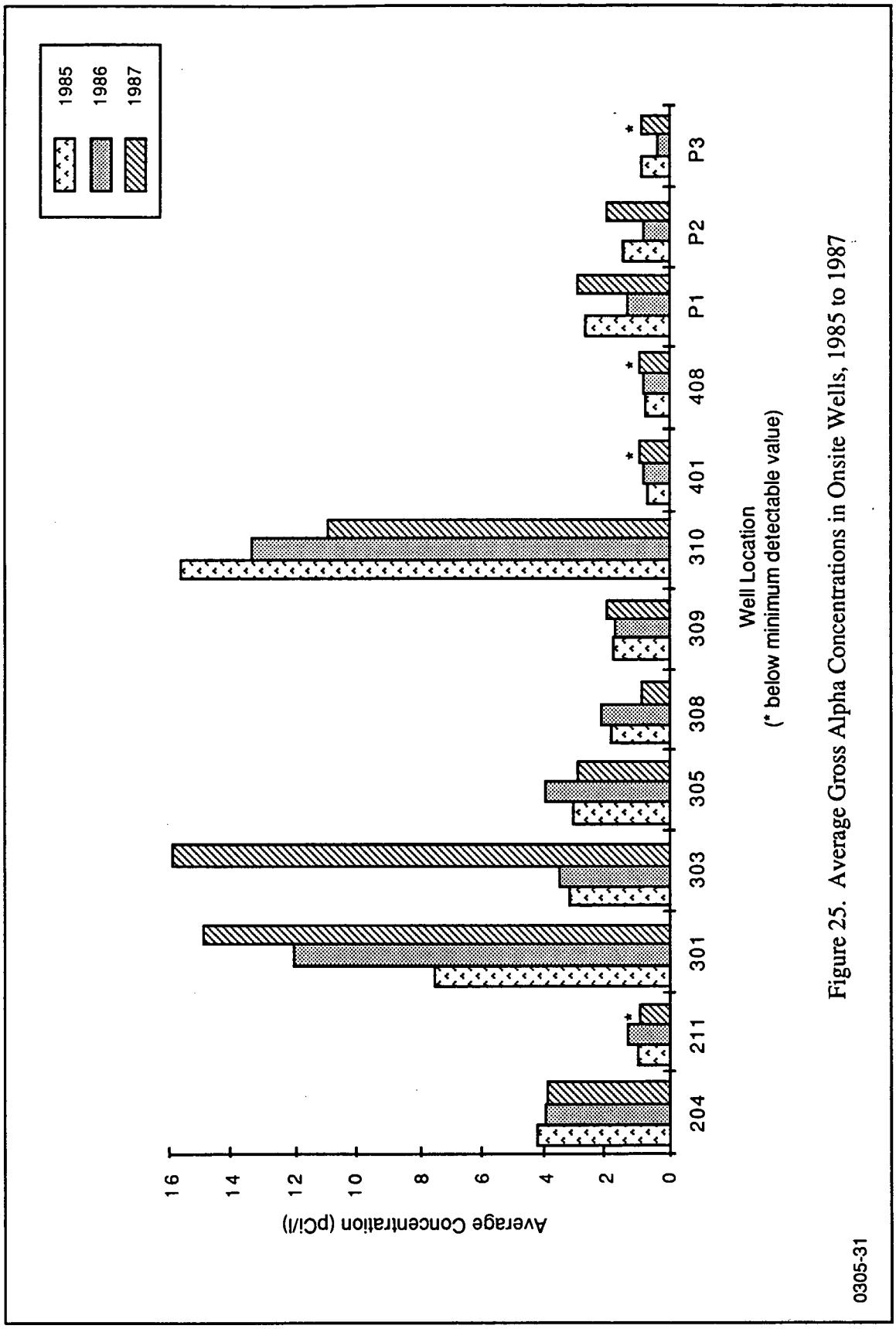

Figure 25. Average Gross Alpha Concentrations in Onsite Wells, 1985 to 1987

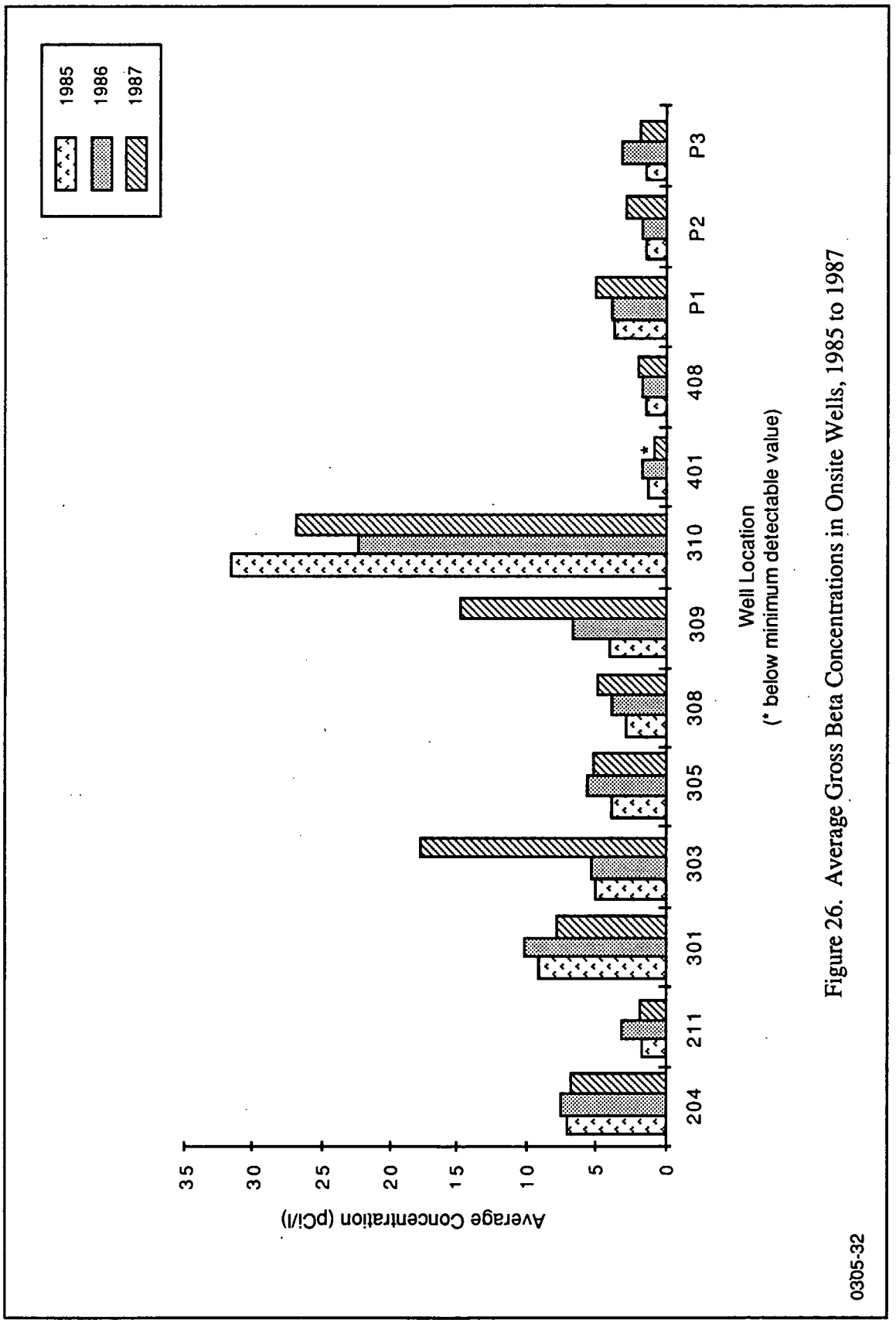

Figure 26. Average Gross Beta Concentrations in Onsite Wells, 1985 to 1987

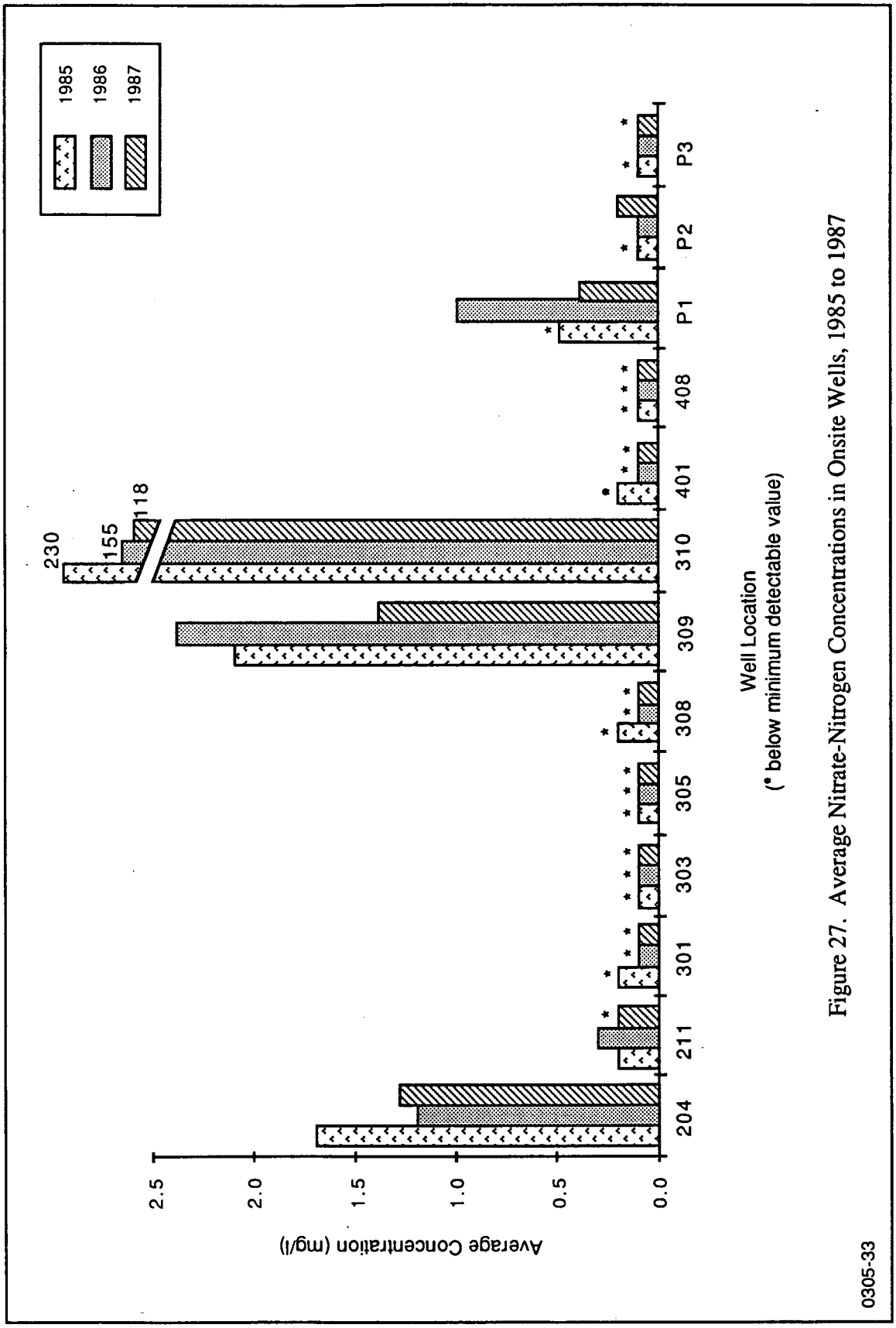

Figure 27. Average Nitrate-Nitrogen Concentrations in Onsite Wells, 1985 to 1987

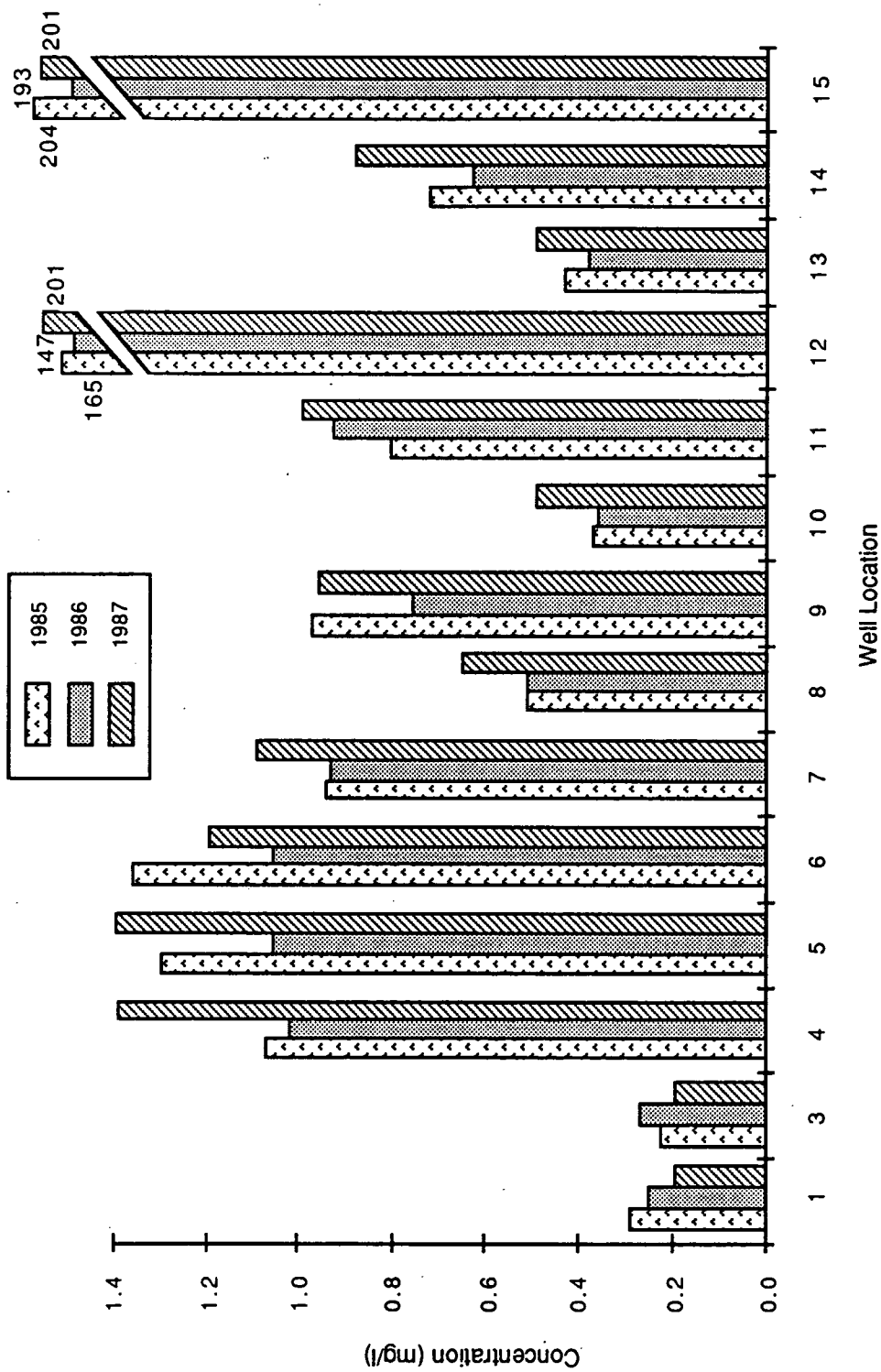

Figure 28. Average Uranium Concentrations in Offsite Wells, 1985 to 1987

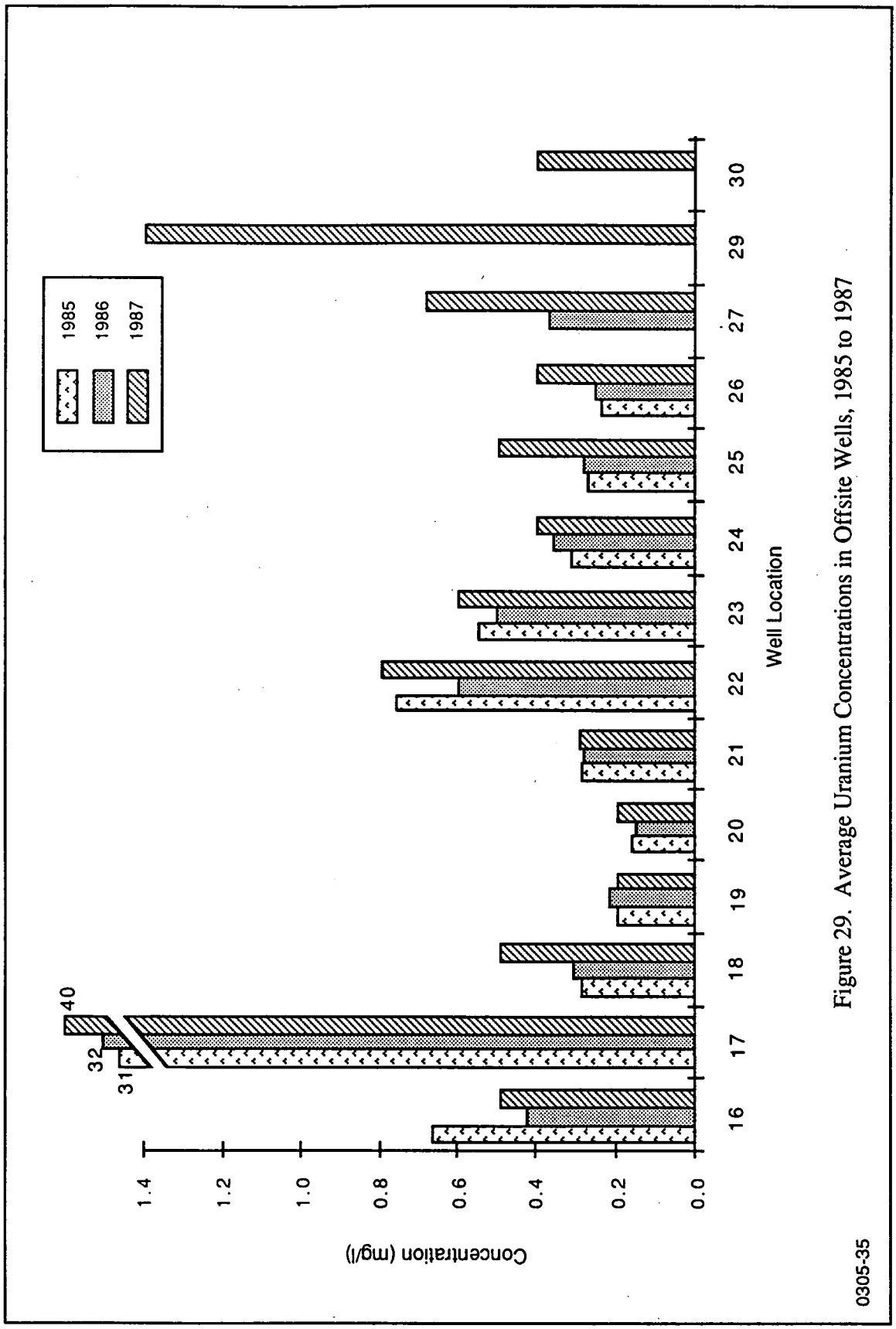

Figure 29. Average Uranium Concentrations in Offsite Wells, 1985 to 1987

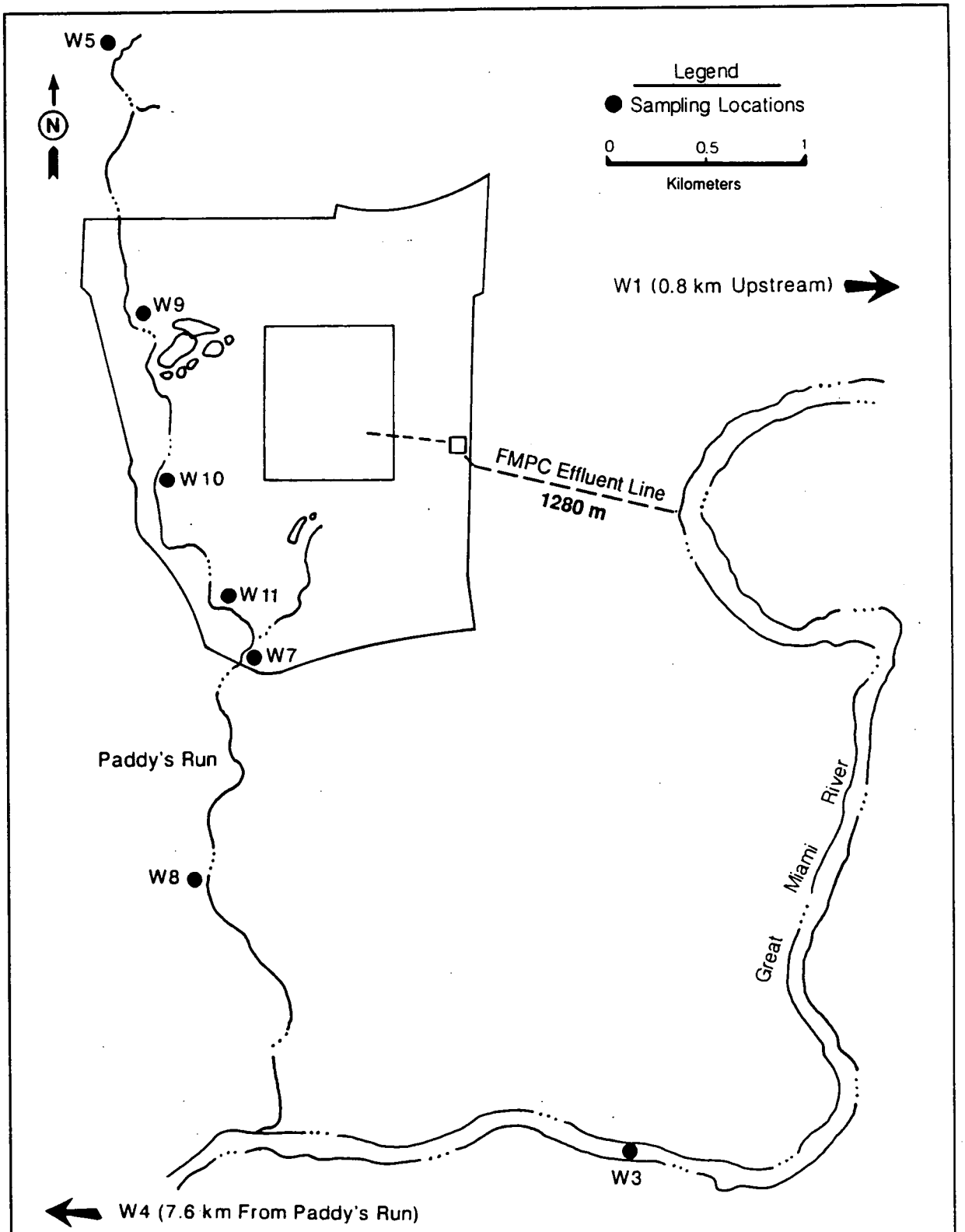

Figure 30. Surface Water Sampling Locations

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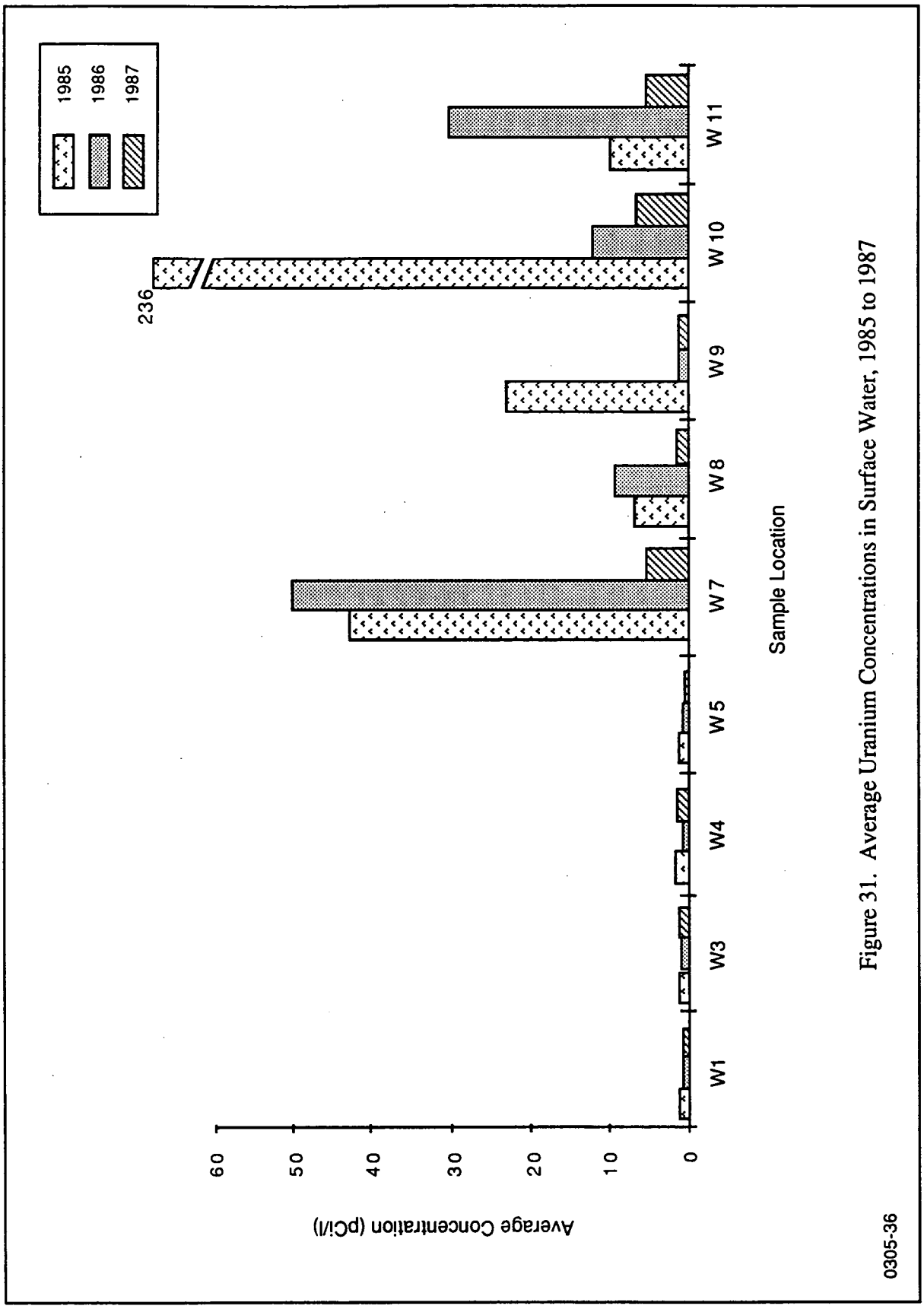

Figure 31. Average Uranium Concentrations in Surface Water, 1985 to 1987

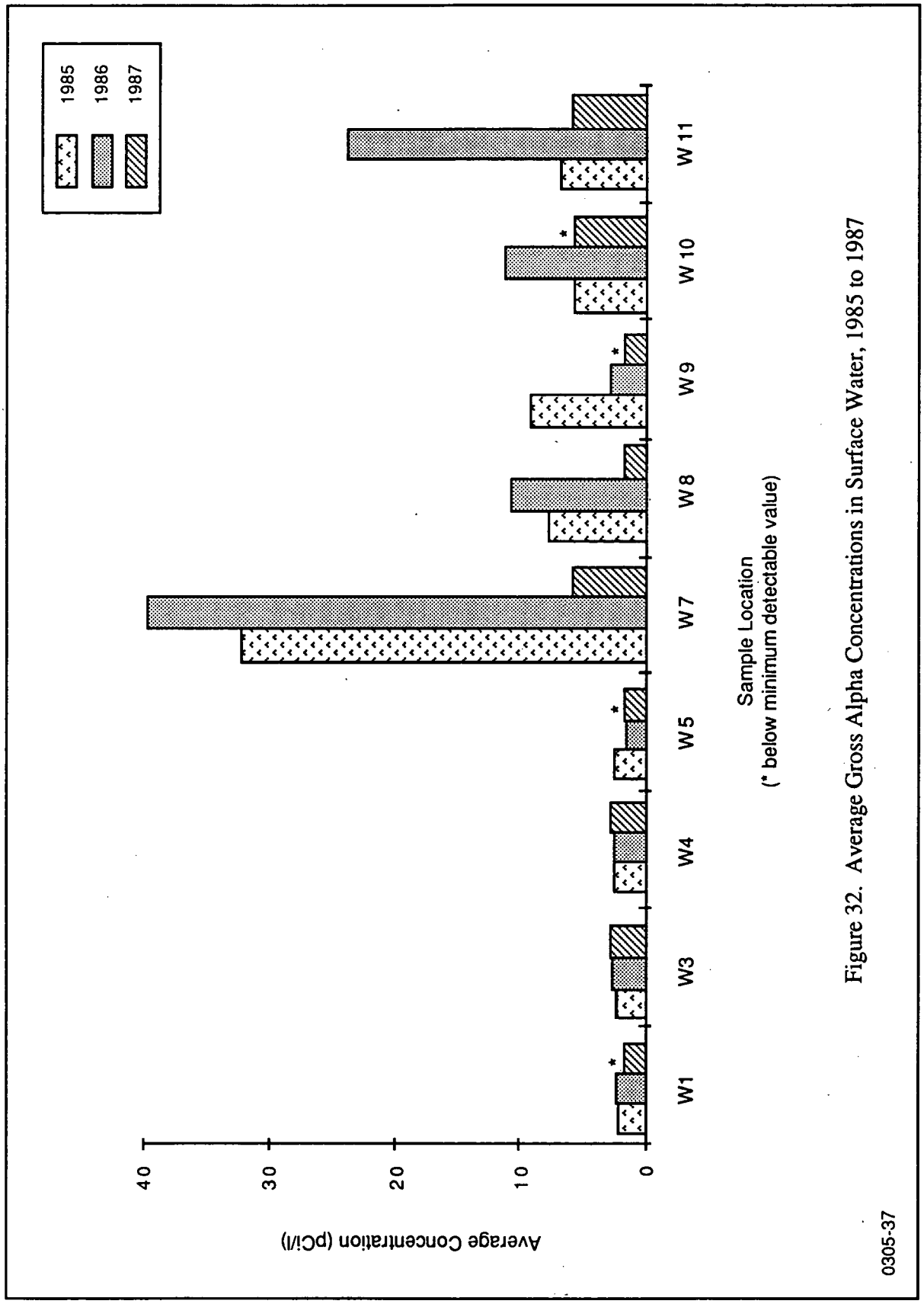

Figure 32. Average Gross Alpha Concentrations in Surface Water, 1985 to 1987

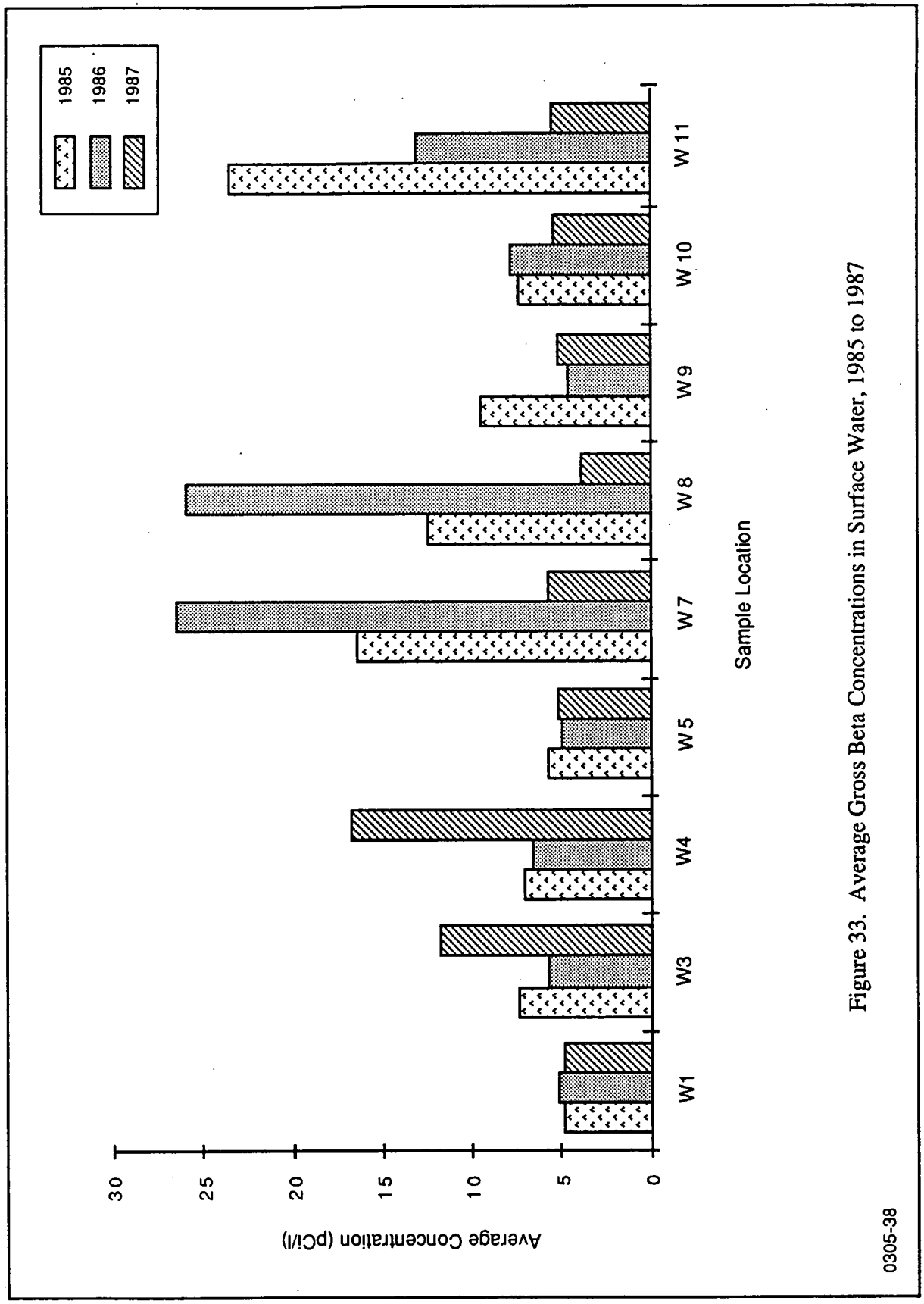

Figure 33. Average Gross Beta Concentrations in Surface Water, 1985 to 1987

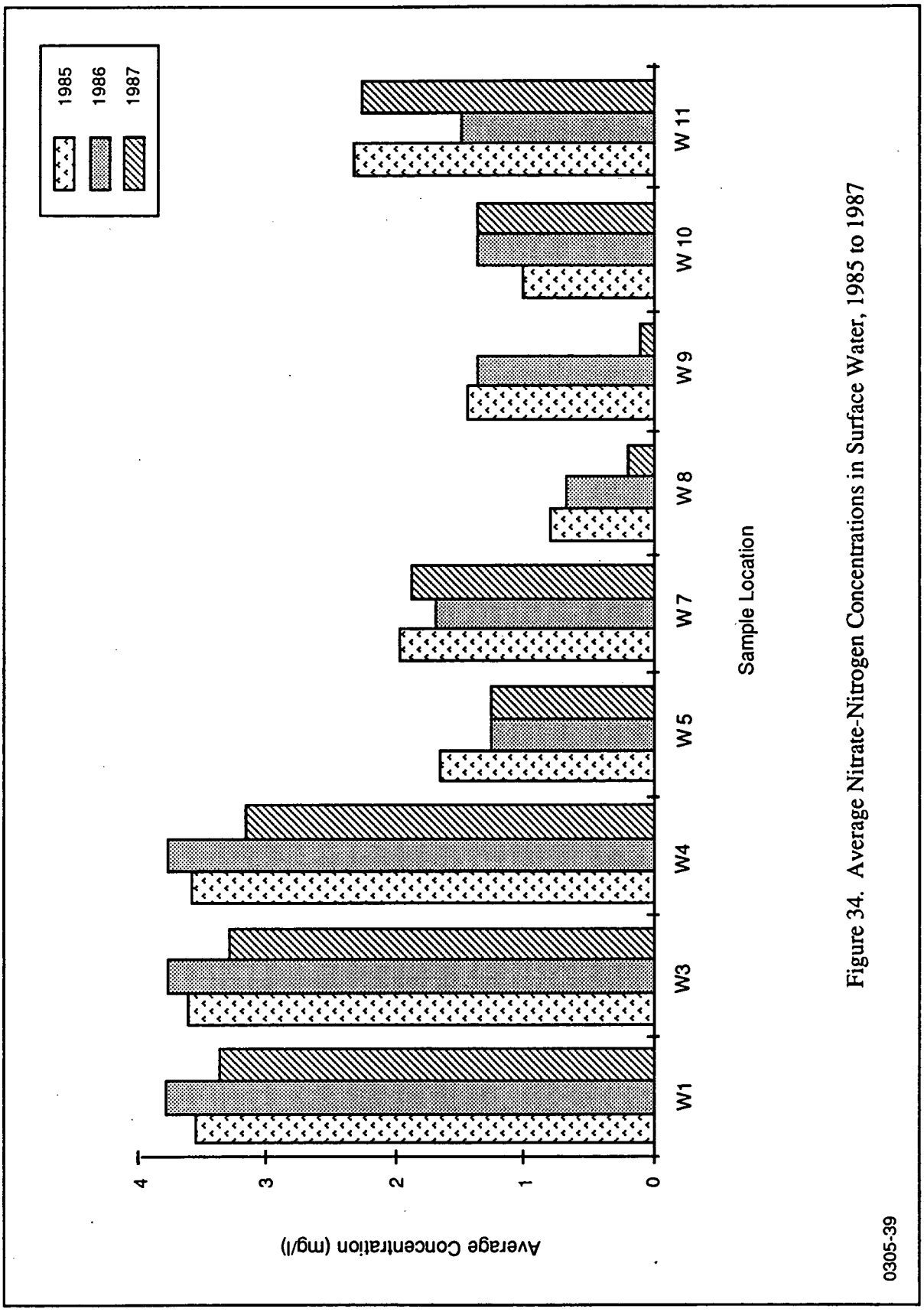

Figure 34. Average Nitrate-Nitrogen Concentrations in Surface Water, 1985 to 1987

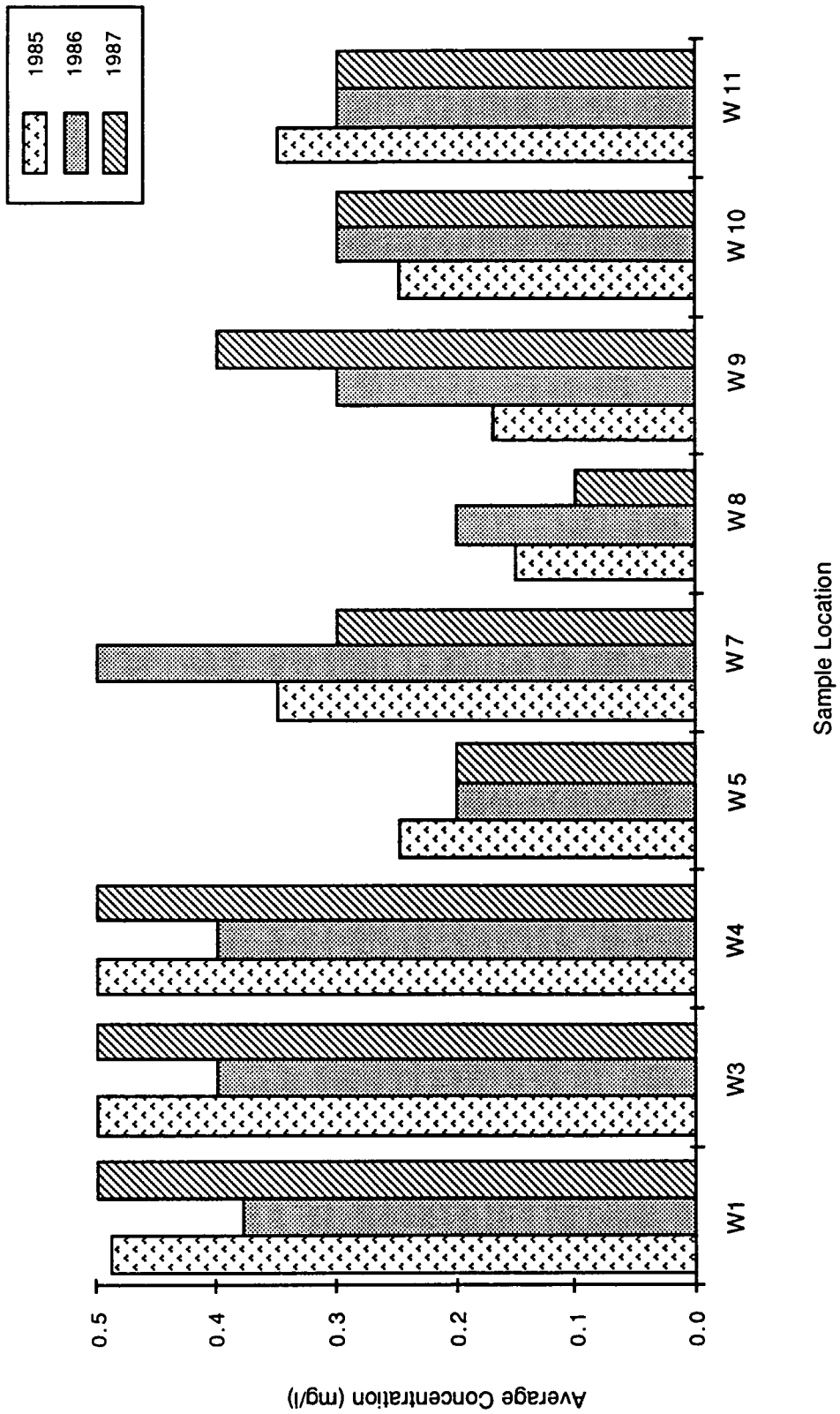

Figure 35. Average Fluoride Concentrations in Surface Water, 1985 to 1987

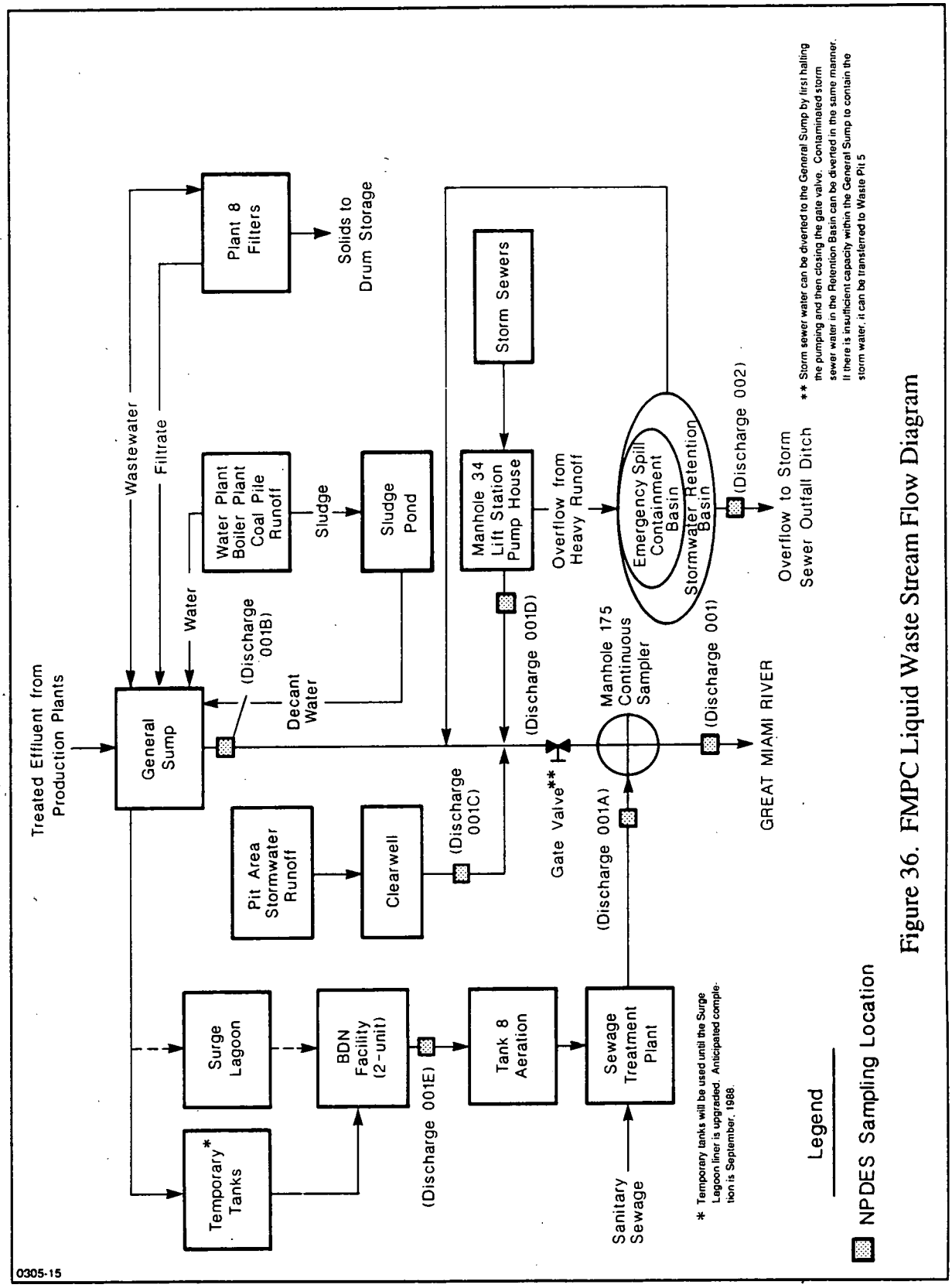

Figure 36. FMPC Liquid Waste Stream Flow Diagram

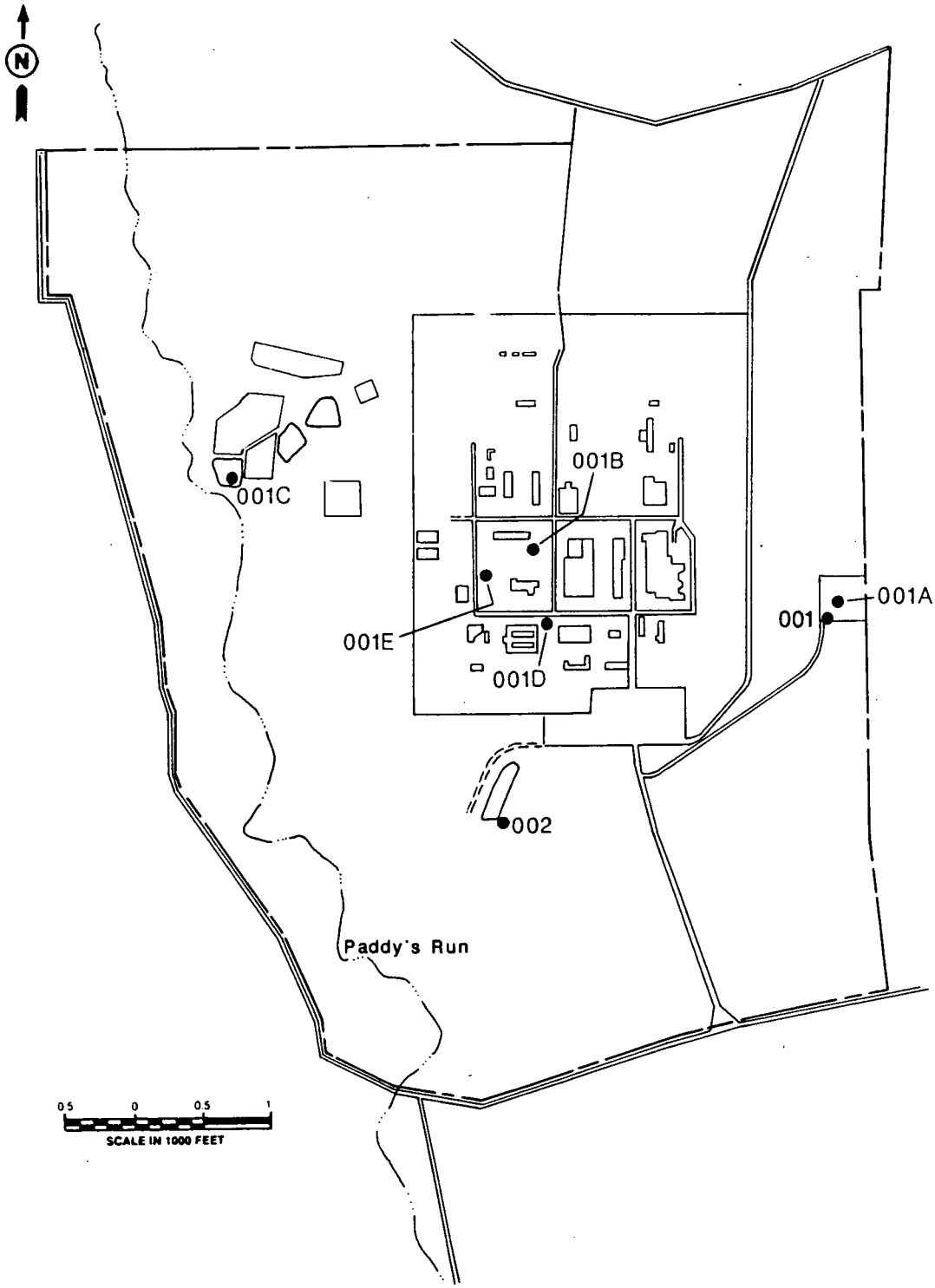

Figure 37. NPDES Effluent Sampling Locations at the FMPC

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an increase in refinery operations at the FMPC in 1987; and a decrease in settling capacity due to the Clearwell and Pit 5 going offline in 1987 (as required by the DFO).

The total amount of uranium present in stormwater runoff which flows into the storm-sewer outfall ditch during overflow from the Stormwater Retention Basin (Discharge 002) was 0.33 kg (2.2×10^{-4} Ci or 8.2×10^{-6} Bq), which was 98% lower in 1987 than 1986. The significant decrease in total uranium at Discharge 002 resulted from the reduction in flow to the storm-sewer outfall ditch due to successful operation of the Stormwater Retention Basin in 1987. Stormwater from the retention basin is pumped to MH-175 for discharge to the Great Miami River.

Figures 38 and 39 compare some radionuclides measured at Discharge 001 during 1987 to values from 1985 and 1986. Cesium-137, ruthenium-106, plutonium-238 and -239/240, thorium-228, -230 and -232, and neptunium-237, if present at all, were at concentrations less than the minimum detectable by the analytical methods used (Table 27).

Concentrations of strontium-90, technetium-99, uranium-234, -238, and total uranium rose slightly in 1987 at Discharge 001, as compared to 1986, but were less than or equal to 1985 values. Uranium-236 discharges decreased in 1987 compared with discharges during 1986. The sum of the ratios of all isotopes discharged from the FMPC to the Great Miami River increased from 1.0 in 1986 to about 1.5 in 1987, which is 146% of the DOE guidelines. The sum of the ratios is calculated by summing the percentages of the DOE guideline calculated for each isotope discharged. If the sum exceeds unity, draft DOE Order 5488.XX will require that a cost-benefit analysis for isotope removal using the best available technology be conducted.

Nonradiological Parameters. There are seven onsite sampling locations regulated by the FMPC NPDES permit, which was issued by the USEPA and is administered by the OEPA. The FMPC must characterize effluent streams by analyzing samples collected at these seven locations. The permit specifies sampling schedules, and the results are reported monthly to the OEPA.

Over 1,600 samples were collected at seven 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 85% of the time in 1987 (Table 28). More than 90% of the noncompliances in 1987 involved the Sewage Treatment Plant. It exceeded the limit for five-day biochemical oxygen demand (BOD_5) 46 times, the limit for total suspended solids (TSS) 59 times, and the limit for fecal coliform bacteria 16 times. Approximately 5% of the noncompliances involved TSS at the General Sump. About 2% of the noncompliances involved nitrate limits at the Biodenitrification Facility, and 2% involved TSS at Discharge 001.

As measured at Discharge 001, the FMPC released an average of 2,180 m^3/d or 2.18 million liters of water per day (0.576 million gallons/d) into the Great Miami River in 1987, a 15% increase over 1986 discharges (Table 28). In 1987, a total of 288 cubic meters or 287,661 liters (0.076 million gallons) of runoff water was discharged into Paddy's Run via the storm-sewer outfall ditch.

Several major changes in treatment of FMPC process effluents took place in 1987. First, on February 28, 1987, OEPA requested that Pit 5 and the Clearwell be taken off-line as a way to protect the groundwater. Since this time, wastewater flows have been routed from the General Sump to the Biosurge Lagoon, and from there to the Biodenitrification Facility. The Biosurge Lagoon was taken off-line in October 1987 to prepare for the upgrade of the liner which is slated for spring 1988. While the Biosurge Lagoon was out of service, flows were routed to two nearby temporary tanks designed to hold process wastewater flows while the liner is upgraded.

Testing of the Biodenitrification Facility was begun during the spring of 1987. The successful testing and operation of the two-tower facility has allowed the FMPC to meet NPDES discharge limits for nitrates 90% of the time since the Biodenitrification Facility began operation. The average nitrate concentrations in the plant effluent at Discharge 001 decreased from an average of 78 mg/l during 1986 to an average of 36 mg/l in 1987 (Table 28). However, the effluent from the Biodenitrification Facility

contained an average of 300 mg/l of both BOD_5 and TSS in 1987.

Since June 1987, the effluent from the Biodenitrification Facility was routed to the Sewage Treatment Plant to remove BOD_5 and TSS. Treating this effluent has caused NPDES compliance problems at the Sewage Treatment Plant since flow rate, BOD_5, and TSS concentrations have increased. Before June 1987, the average mass loading (flow x concentration) from sanitary wastewater to the Sewage Treatment Plant was approximately 80 kg/d BOD_5 and approximately 60 kg/d TSS. From June to December of 1987, the combined loadings (from sanitary wastewater and biodenitrification effluent) have been approximately 250 kg/d BOD_5 and approximately 350 kg/d TSS. This represents more than a three-fold increase for BOD_5 and nearly a six-fold increase for TSS, and the Sewage Treatment Plant has been unable to handle the large increase in BOD_5 and TSS loadings.

The NPDES concentration limits for BOD_5 and TSS at the Sewage Treatment Plant were complied with 79 and 60% of the time, respectively, during 1987; compliance rates for BOD_5 and TSS mass limits were even lower, 38 and 27% respectively (Table 28). Compliance for mass limits was low because current NPDES mass limits for BOD_5 and TSS are based on plant population and wastewater flow rates in 1980 when both were significantly lower than in 1987. Another change in wastewater treatment flow that significantly affected wastewater quality in 1987 was the operation of the Stormwater Retention Basin. In 1987, nearly all FMPC stormwater was pumped to the Great Miami River, rather than discharged into the storm sewer outfall ditch. The Stormwater Retention Basin overflowed only one time in 1987 and that was during a period of high rainfall on July 13. A total of 76,000 gallons of water was discharged to Paddy's Run during this overflow; water samples were taken and analyzed for NPDES parameters (Table 28). Analytical data from water samples collected at Paddy's Run during 1987 showed a large improvement in water quality as result of Stormwater Retention Basin operation (Tables 25 and 26). An additional 4.3 million gallon basin is being installed adjacent to the existing Stormwater Retention Basin. The expanded exceed 11 million gallons, and will be able to contain a 10-year 24-hour rainfall. Installation of this new basin, which is scheduled for operation by December 31, 1988 under the OEPA (DFO), will further improve water quality in Paddy's Run.

Sampling Sediment

Sediment samples were collected and analyzed for radiological parameters from nine locations along the Great Miami River, and from 51 locations along Paddy's Run and the storm-sewer outfall ditch (Figure 40). Sediment samples were taken at 100 meter intervals along Paddy's Run from the northern boundary of the FMPC to its confluence with the storm-sewer outfall ditch, 200 meter intervals along Paddy's Run from the storm-sewer outfall ditch to the Great Miami River, and at 100 meter intervals along the entire storm-sewer outfall ditch. Three separate samples were collected at each location in Paddy's Run and the storm-sewer outfall ditch, one from each bank and one from the center of the stream bed. All sediments were analyzed for technetium-99 and isotopes of uranium, thorium, radium, and plutonium.

There are currently no DOE or USEPA standards for uranium or other radionuclides in sediment. Background uranium concentrations for sediments in Paddy's Run and the Great Miami River have not been established as yet. Characterization studies for Paddy's Run and Great Miami River sediments, including sediment sampling and analysis for radiological constituents, will be addressed in the ongoing Remedial Investigation and Feasibility Study at the FMPC.

Average radionuclide concentrations in sediment samples collected in 1987 varied slightly at each location (Table 29). Average concentrations of plutonium-238, -239/240, and technetium-99 remained consistent for sediments sampled at the Great Miami River, Paddy's Run, and the storm-sewer outfall ditch.

In 1987, there was no significant difference between the average uranium, thorium, and radium concentrations found in the samples from locations upstream or downstream of the FMPC effluent line to the Great Miami River (Table 29). For this report, uranium, thorium, and radium concentrations in Great Miami River sediments above the FMPC outfall are considered

to be at background levels commonly found in the area (Figure 40). Background concentrations for total uranium, thorium and radium in sediments (1.22, 1.92 and 2.49 pCi/g, respectively) were averaged from four locations along the Great Miami River sediments north of the FMPC outfall.

In 1987, above-background concentrations of uranium, thorium and radium were measured in sediments collected from the storm-sewer outfall ditch (Table 29). In general, isotopic uranium, thorium and radium concentrations increased in sediments near the Stormwater Retention Basin and decreased toward the confluence of the storm-sewer outfall ditch and Paddy's Run. This trend is expected since 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 three offsite wells.[14]

Uranium, thorium, and radium isotope concentrations collected in 1987 from Paddy's Run were at levels determined to be background (see concentrations listed above). Radionuclide concentrations between locations along Paddy's Run did not follow any cross-sectional or longitudinal trends; slight variations may be due to sediment flushing during heavy storms, differential settling of sediments in bends or pools, or groundwater infiltration. There was no correlation between uranium concentrations in the sediments from Paddy's Run and uranium in surface water from Paddy's Run (Figure 30 and Table 25).

Sampling Fish

Fish were collected from three areas of the Great Miami River in September 1987, with the aid of a fisheries research team from the University of Cincinnati (Figure 41). Using electroshocking techniques, the team collected 229 fish representing 19 species: 51 from sampling location 1; 56 from location 2; and 122 from location 3. A total of 61 fish from all three locations 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 laboratory for uranium analysis.

A University of Cincinnati study determined that the fish populations in the Great Miami River have not changed appreciably since 1984.[18] The same types of fish were collected in the same types of habitats in the river. Some river habitats changed from 1985 to 1987 due to gravel quarrying and removal of the dam at sampling location 3. The university scientists report that populations of fish throughout the river have remained healthy between 1985 and 1987.

The overall average uranium concentration in fish collected in 1987 was lower than the average for fish collected in 1986 (Table 30). In 1987, average uranium concentrations in fish were not significantly different upstream or downstream from the FMPC outfall and were therefore considered to be at natural background levels. Lower uranium levels in 1987 may be a result of lower laboratory detection limits, since a different laboratory was used to analyze fish in 1987.

In addition to sampling and analyzing environmental media to monitor effects of FMPC production on the environment, several programs for management of stored onsite waste were developed in 1987. These programs are described in Chapter 6, "Waste Management Activities." The following chapter, Chapter 7, highlights special studies and significant events which were initiated or completed at the FMPC in 1987.

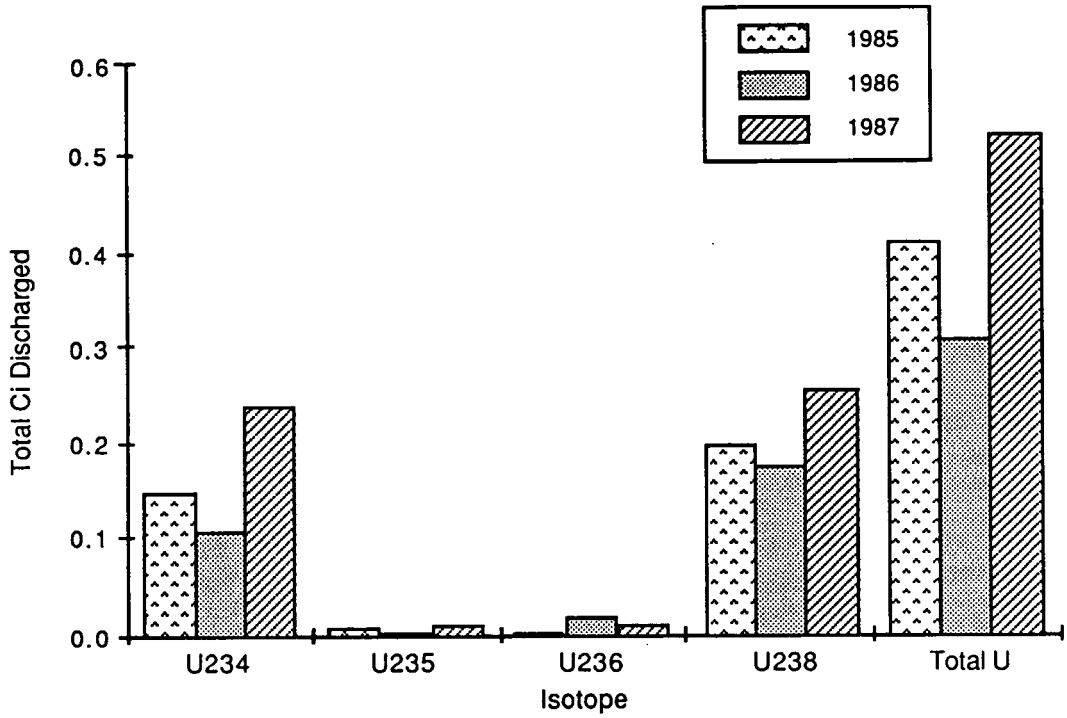

Figure 38. Radionuclides Discharged at NPDES Sampling Point 001, 1985 to 1987

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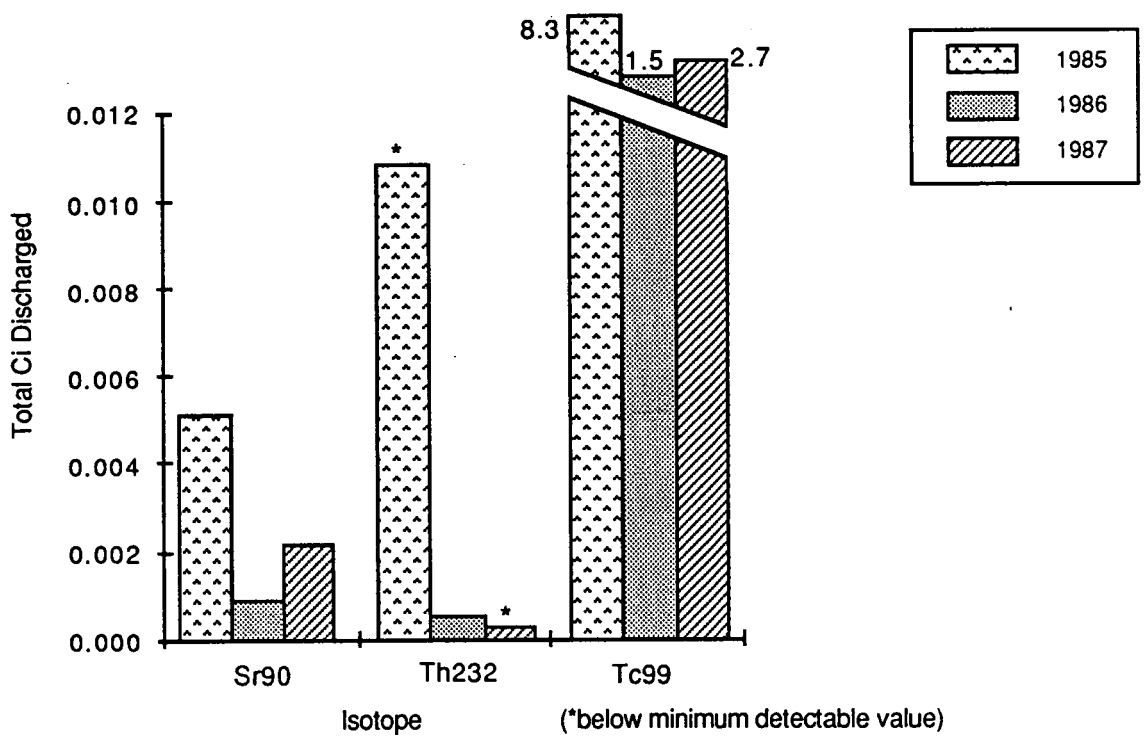

Figure 39. Radionuclides Discharged at NPDES Sampling Point 001, 1985 to 1987

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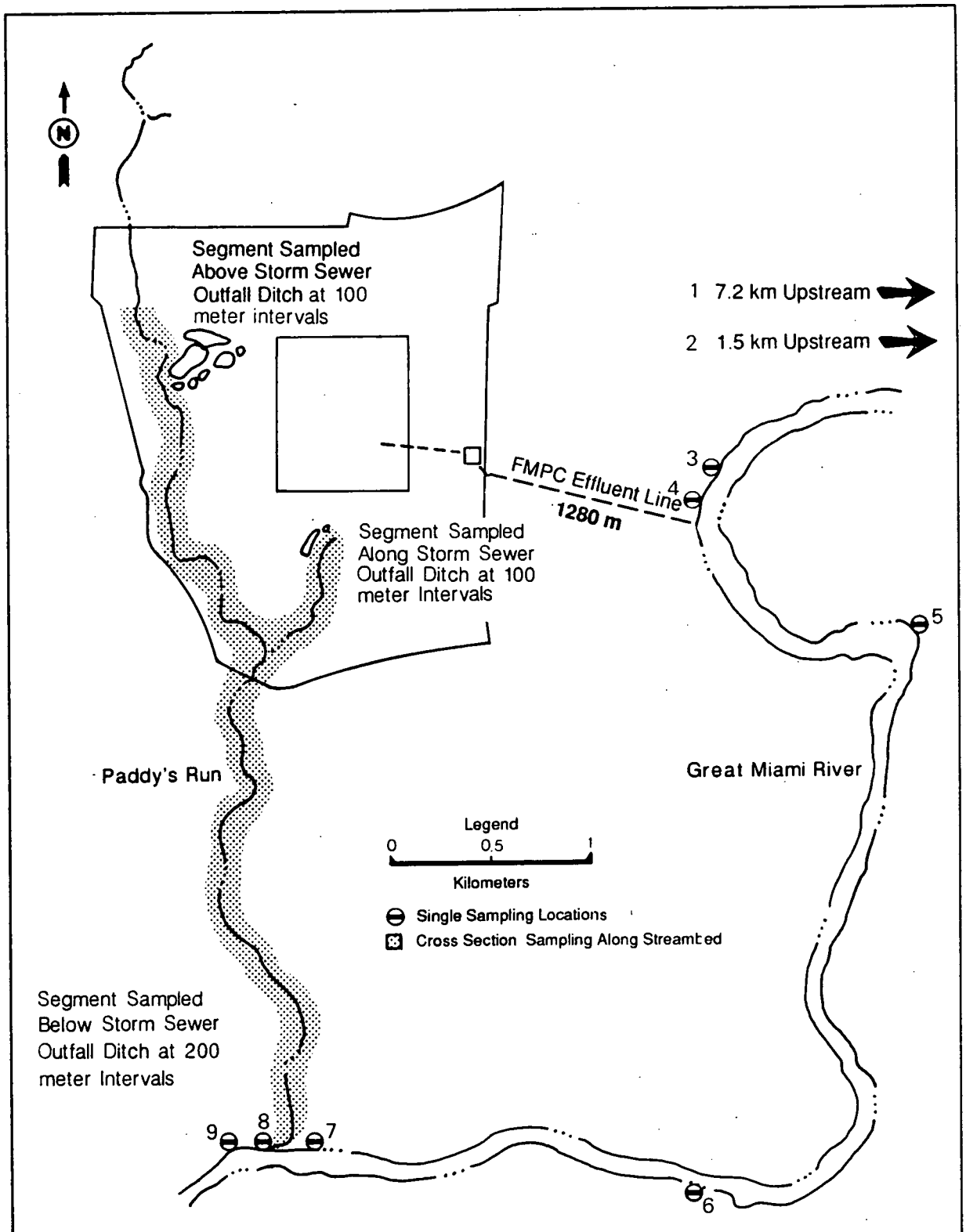

Figure 40. Sediment Sampling Locations

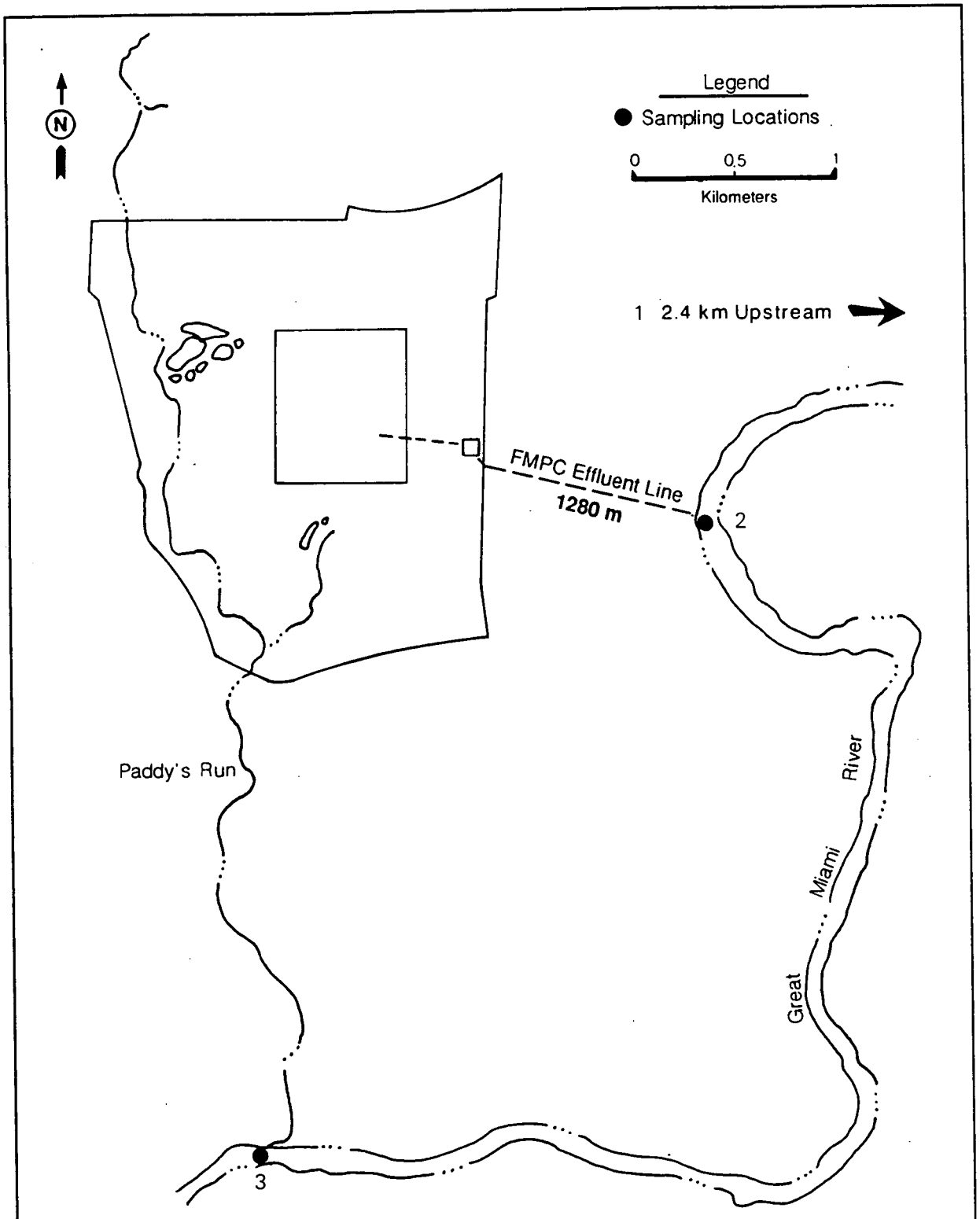

Figure 41. Fish Sampling Locations

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Chapter Six
Waste Management Activities

Operations at the FMPC generate materials which are not economically feasible to recycle. These materials, designated as wastes, are governed by federal, state, and local regulations. In order to determine the proper methods for handling and disposing of these wastes, the FMPC must determine the specific components of the wastes. This is known as characterizing the wastes, and is an important and necessary part of waste management. This chapter highlights 1987 waste management activities at the FMPC, including storing, shipping, and disposing of low-level radioactive waste, hazardous and mixed hazardous waste, and conventional solid waste.[19]

Low-level Radioactive Waste Management

Low-level radioactive wastes consist primarily of materials generated during the production of uranium metal. These wastes include slags, sump sludges, neutralized raffinates, and to a lesser amount, dust collector residues, uranium metal chips, and spilled uranium salts. Other types of low-level radioactive wastes include materials which have become contaminated upon contact with depleted uranium. Examples are wooden pallets, metal drums, rags, paper trash, construction rubble, scrap metal and soil. Sediments from the Stormwater Retention Basin and the Biodenitrification Surge Lagoon and sludges from the water treatment plants are also considered low-level radioactive wastes (Figure 42).

Most of the low-level wastes at the FMPC are packaged and shipped offsite for disposal. In fact, low-level waste shipments offsite in 1987 totalled 441,325 cubic feet (Table 31).

The largest quantity of low-level radioactive waste generated at the FMPC is magnesium fluoride (MgF_2) slag. The slag is produced during the reduction of UF_4 with magnesium, and is contaminated with depleted uranium and uranium oxide. During 1987, shipments for offsite disposal of low-level MgF_2 totalled 44,002 cubic feet.

The second largest quantity of low-level radioactive waste generated at the FMPC is slag leach filter cake. This is the neutralized, filtered material that is produced by the recycling of MgF_2 containing enriched uranium. During 1987, 26,455 cubic feet of slag leach filter cake and sump cake (the dried sludge from the water treatment plants onsite) were shipped offsite for disposal.

Uranium-contaminated scrap wood such as wooden pallets is collected from the entire production area and stored on a portion of the Plant 1 concrete pad. Loose wood is packaged into wooden boxes or sea/land containers and shipped offsite for disposal. Approximately 231,505 cubic feet of contaminated scrap wood were packaged and shipped offsite for disposal during 1987.

Scrap metal generated during demolition and maintenance activities at the FMPC is surveyed at the point of generation to determine its level of contamination for storage and disposal purposes. During 1987, 4,600 tons of scrap metal

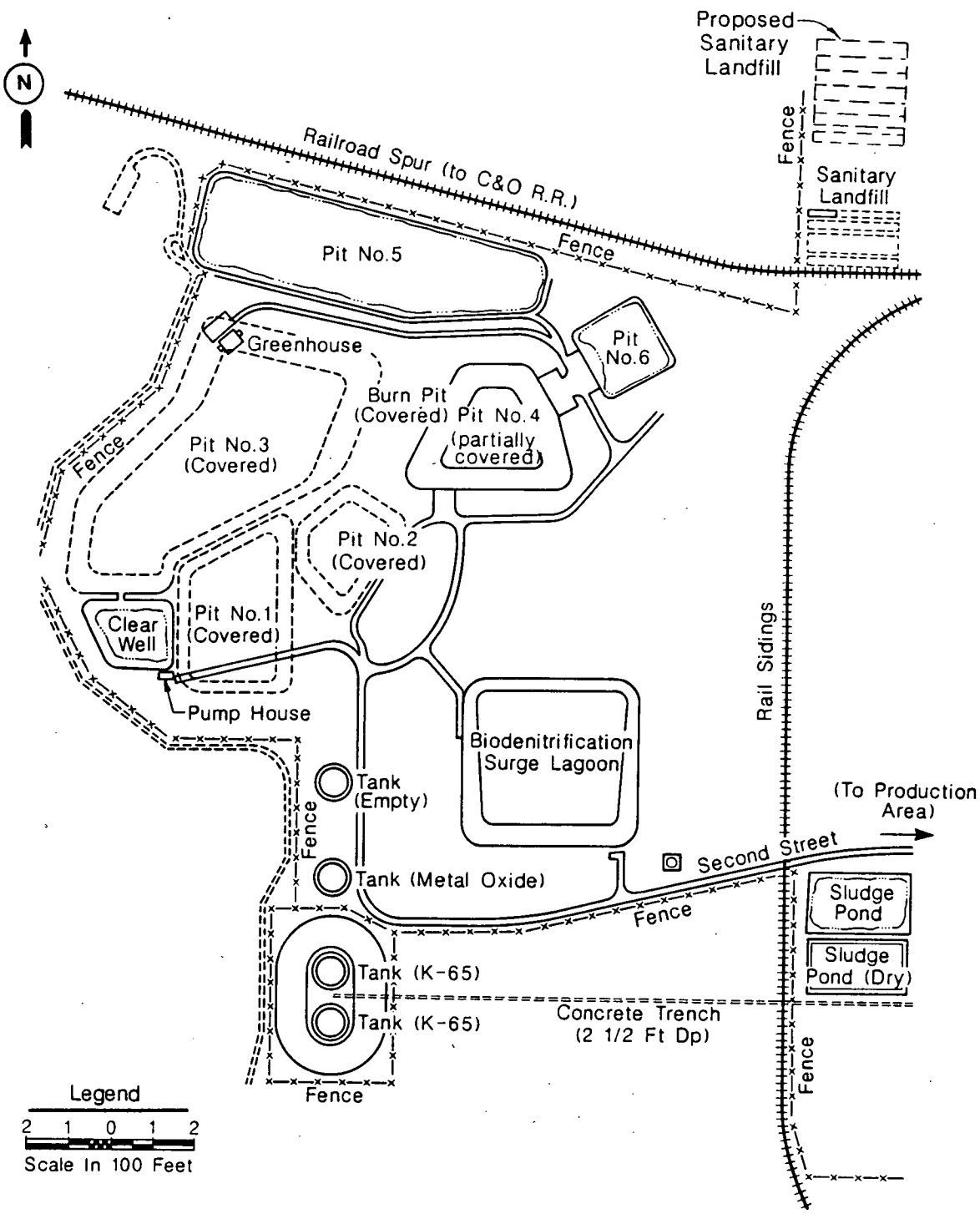

Figure 42. Map of the FMPC Waste Storage Area

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stored on the decontamination pad were separated into six categories: high- and low-level contaminated salvageable ferrous metal, high- and low-level contaminated salvageable nonferrous metal, and high- and low-level contaminated refuse. This segregation project created space for additional metal storage, improved environmental conditions around the storage pad, and prepared the metal for Phase II of DOE's Scrap Reclamation Program.

Contaminated scrap ferrous and copper metal that is potentially usable is transported to the scrap yard, segregated, and placed in its respective storage pile for future reclamation and return into the private sector. Unusable metal refuse, including nonmetals, mixed metals, and metals contaminated with hazardous waste, is packaged and prepared for shipment offsite. Contaminated metal refuse disposal shipments for 1987 totaled 17,619 cubic feet.

Noncontaminated scrap metal that is potentially usable is stockpiled and stored, either for use onsite, or it is shipped to local scrap dealers. Clean scrap metal which is currently not reusable is stored onsite for future disposal.

Contaminated trash from the production area is collected in specially marked and controlled dumpsters located throughout the production area. This trash is then transported to Plant 2/3, where it is compacted into bales and packaged in nylon-reinforced plastic bags for shipment offsite. During 1987, approximately 41,000 cubic feet of contaminated trash was shipped offsite for proper low-level disposal.

Sewage treatment sludge is concentrated in the Sewage Treatment Plant's anaerobic digester. During the 1987 summer months, approximately 25,000 gallons of digested sludge were pumped to the sludge drying beds at the Sewage Treatment Plant. After drying, this material will be drummed and shipped to Plant 1 for sampling before being sent to the Scrap Recovery Plant for incineration. After incineration, the ash is drummed as low-level waste and shipped offsite for disposal.

Low-level wastes from the nine FMPC plants and the laboratory are currently placed in containers in preparation for shipment offsite. At the beginning of fiscal year 1987, (October 1, 1986) an equivalent of 91,000 55-gallon drums of waste was in backlog storage. In addition, the FMPC generated about 30,000 drums of new waste during fiscal year 1987. By the end of the fiscal year (September 30, 1987), backlogged wastes had been reduced to about 77,000 drums.

Additional low-level waste shipments offsite for 1987 totaled 78,928 cubic feet. These materials included clothing and plastic, furnace salts, dust collector residues, burnable material, unrecoverable residues, roofing materials, contaminated oil, dust collector bags, and contaminated soil and rocks.

Asbestos, present at the FMPC in some construction rubble, presents a health threat through inhalation. Asbestos removal activities are underway as part of various onsite construction projects. FMPC provides DOE with all the applicable regulatory notifications associated with asbestos removal projects. Asbestos reporting requirements are specified by NESHAP, 40 CFR 61 Subpart M. During 1987, 1,776 cubic feet of asbestos removed from the FMPC were shipped offsite for proper disposal.

Hazardous and Mixed Hazardous Waste Management

The FMPC must analyze and characterize potentially hazardous wastes according to RCRA regulations. Wastes that are designated as hazardous or mixed radioactive/hazardous are subject to stringent handling, storage, transport, and disposal requirements.

Hazardous wastes at the FMPC consist of material generated onsite, both currently and historically, as well as wastes sent from other facilities. The FMPC currently generates two types of hazardous wastes:

- Paints/thinners
- 1,1,1-trichloroethane.

Historically, the FMPC generated additional materials classified as hazardous or mixed wastes:

- Tetrachloroethylene
- Beryllium
- Chromic acid
- Xylene.

In addition, the FMPC functions as a storage facility for mixed wastes generated at RMI, Inc. and other government facilities. These facilities sampled and characterized the wastes before sending them to the FMPC in order to determine proper labeling, storage, and disposal requirements. In the past, some of these mixed wastes have been treated or disposed of at the FMPC, but the majority have been stored, pending treatment, characterization, or shipment to another DOE facility. These wastes consist of:

- Barium chloride
- Spent solvents
- 1,1,1-trichloroethane
- Used oil/lathe coolant
- Solvent still bottoms.

Most of the hazardous wastes at the FMPC are stored in 55-gallon drums at designated locations onsite. In order to comply with RCRA, the FMPC collected approximately 149 samples during 1987 of the entire onsite drummed waste inventory. Analytical results are expected in early 1988.

Additional wastes are stored in the spent solvent bulk storage tanks at the Pilot Plant. Each of these tanks has a capacity of 10,000 gallons. During 1987, samples of spent solvent were collected for analysis from differing depths within the tanks to give representative analytical results of the tanks' contents.

Pit 4, previously used as a repository for barium chloride contaminated with uranium, was sampled and characterized as part of the Waste Storage Area characterization completed in 1987 (Figure 42). This pit had been designed as a long-term storage facility for low-level radioactive waste. However, Pit 4 operations were discontinued in June 1986, and the pit has been covered pending final closure. The RCRA closure plan for Pit 4 was submitted to USEPA for review in 1987.

In 1987, two other RCRA closure plans were prepared for USEPA review. These plans addressed the decontamination and decommissioning of two out-of-service hazardous waste treatment units at the FMPC: the Barium Chloride Waste Salt Treatment Facility and the Trane Thermal Liquid Waste Incinerator. Also, a revised RCRA Part A permit application was prepared in 1987 to address various changes in the status of the RCRA compliance program at the FMPC.

Solvent-contaminated waste oil was also sampled and analyzed during 1987, and the data forwarded to the Oak Ridge Hazardous Waste Disposal Facility for approval for incineration. The Oak Ridge facility approved the shipments, and the FMPC transported 766 drums of contaminated waste oil to Oak Ridge between June and November for incineration.

Wastes Governed by the Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) requires the FMPC to prepare annual reports concerning the status of articles containing polychlorinated biphenyls (PCB's) present at the FMPC. This report addresses the number of PCB articles in service, the number removed from service, the dates of removal, storage, and offsite shipment, and methods of disposal.

At the end of 1987, approximately 112 large, low-voltage capacitors that have been removed from service over the past several years were in storage at the FMPC. Due to the radioactive surface contamination of these capacitors, special arrangements for their storage and disposal were required. In December 1987, DOE-ORO approved FMPC plans to ship 24 drums containing the 112 PCB-contaminated capacitors there for incineration. This shipment was completed in January 1988.

In addition to shipping the current inventory of stored capacitors offsite for disposal, a physical survey was conducted in October 1987 in order to inventory the number of PCB and non-PCB capacitors remaining in service at the FMPC. The survey indicated a total of 396 liquid-filled electrical capacitors in use at the FMPC, with 116 of them containing a PCB liquid.

Conventional Solid Waste Management

Conventional solid wastes generated at the FMPC consist of nonradioactive materials such as boiler plant waste, and nonprocess trash.

The Boiler Plant produces fly ash, sludges from boiler water treatment, and runoff from the coal pile. During 1987, the Boiler Plant produced approximately 2,807 tons of fly ash. This fly ash is stored onsite at the existing fly ash pile located south of the west parking lot.
Sludges from Boiler Plant operations, as well as runoff from the coal pile currently drain to a retention pond south of the coal pile. Lime sludge produced in FMPC water treatment systems is collected in lime sludge beds on the western side of the plant. These lime sludge beds are nearly full, and with wastes from the treatment of potable water added to the beds, the remaining capacity will be exceeded. Alternative options for water treatment sludge containment are currently under consideration.

During 1987, the segregation of nonprocess area trash was initiated in order to reduce the amount of contaminated trash generated onsite. Nonprocess area trash includes cafeteria waste and paper from office areas outside the process area. This trash is monitored to ensure that it has not become contaminated, and is sent to a local sanitary landfill for disposal.

In the past, contaminated trash from the process area and uncontaminated trash from the nonprocess area were combined, resulting in substantial quantities of contaminated trash. The segregation activities implemented during 1987 eliminate combining contaminated trash with noncontaminated trash, thus reducing the volume of waste that must be treated as contaminated waste.

Chapter Seven Special Studies and Significant Events

In addition to the data collections and analysis performed at the FMPC, several additional studies were initiated or completed in 1987. A number of significant events also occurred at the FMPC during 1987. The studies and events discussed in this chapter include:

- Federal Facility Compliance Agreement
- OEPA Director's Findings and Orders
- Water Compliance Activities
- Air Compliance Activities
- Solid Waste Compliance Activities
- Additional Activities
- Unusual Events.

Federal Facility Compliance Agreement

On July 18, 1986, the DOE and the USEPA jointly signed a Federal Facility Compliance Agreement (FFCA). The purpose of the FFCA is to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly investigated so that appropriate remedial response actions can be formulated, assessed, and implemented. The FFCA involves FMPC compliance with existing environmental statutes and regulations, including the CAA, CERCLA, and RCRA. FFCA activities performed or initiated in 1987 and discussed in this section include:

- Remedial Investigation and Feasibility Study
- Characterization Investigation Study
- Stabilization of the K-65 Silos
- RCRA Drummed Waste Characterization
- RCRA Groundwater Quality Assessment for Waste Pit 4
- Dispersion Modeling for Radon from the K-65 Silos and Structures Containing Thorium
- Stack Sampling and Testing.

Remedial Investigation and Feasibility Study

In 1987, a site-wide Remedial Investigation and Feasibility Study (RI/FS) was initiated at the FMPC in response to the FFCA and as a requirement of CERCLA. The purpose of the Remedial Investigation (RI) is to determine the nature and extent of any release of hazardous or radioactive substances, pollutants, or contaminants, and to gather all necessary data to support the Feasibility Study (FS).

The purpose of the Feasibility Study is to develop, evaluate, and recommend remedial action alternatives to protect public health, public welfare, and the environment from releases or threatened releases of hazardous or radioactive substances, pollutants, or contaminants at or from the FMPC. A detailed Work Plan for performing the Feasibility Study will be developed at a later date, and will be

based on the progressive findings of the Remedial Investigation.

The Scope of Work for the Remedial Investigation at the FMPC has been designed to satisfy the following objectives:

- To identify and characterize the existing sources of radiological and chemical contamination
- To determine the nature and extent of radiological and chemical contaminants or pollutants in air, soil, sediments, surface water, and ground water media, and to characterize their occurrence in aquatic and terrestrial organisms both on and offsite
- To identify the pathways and mechanisms for radiological and chemical constituent migration, and conduct public health risk assessments and environmental impact studies
- To develop, validate, and apply various site models in order to augment the current understanding of the site environment
- To provide necessary information to identify, evaluate, and select the most environmentally-sound and cost-effective alternatives in the FS.

These objectives are addressed as tasks within the RI Work Plan, which is comprised of several supporting documents that direct and control the technical activities being conducted. One of these documents, *Sampling Plans*, provides justification and specific methodological and control guidance for all field work to be conducted during the RI. The progress of the sampling activities included in the seven sampling plans will be discussed in detail below. As of December 1987, no analytical results from samples collected during the RI/FS were available for presentation and analysis.

The *Radiation Measurement Plan* focuses on characterizing the surface radiation fields within the FMPC. Radiation measurements are used to locate and quantify radioactive materials at various locations at the FMPC. These locations will be surveyed along a 100-foot and 1,000-foot rectangular grid system. As of December 1987, 136 of 850 grid points were surveyed. Completion of this task is expected in May 1988.

The *Surface Soils Sampling Plan* determines the effect that FMPC operations and waste disposal have had on the near-surface soils, and the degree to which contaminated soils contribute to offsite migration of contaminants. As of December 1987, 135 surface soil samples were collected for analysis. The completion of the soils sampling program will follow completion of the radiation survey.

The *Groundwater Sampling Plan* determines the effect that FMPC operations and waste disposal practices have had on groundwater. The study will focus on identifying sources of groundwater contamination, pathways for contaminant transport, and receptors or potential receptors of the contaminants.

To support this plan, approximately 92 monitoring wells are proposed for installation during the RI/FS, including 77 onsite wells and 15 offsite wells. Three different water-bearing zones will be intercepted by the proposed monitoring wells (Figure 43). Forty-two shallow wells (100-series), twenty-two intermediate depth wells (200-series), twenty-two deep wells (300-series), and up to six 400-series wells will be installed (Figures 44 through 48). Groundwater sampling will be performed after all wells are installed and on three later occasions during different seasonal conditions.

As of December 1987, 27 of the 92 monitoring wells have been installed. The total footage of these wells is 1,476 feet, representing 22% of the estimated 6,750 feet to be drilled.

The overall objective of the *Subsurface Soils Sampling Plan* is to provide additional detail on the subsurface stratigraphy in the site area, the lateral and vertical extent of radionuclide and hazardous chemical contamination of subsurface soils, and the geochemical and geotechnical properties of subsurface soils.

(Text continues on page 81.)

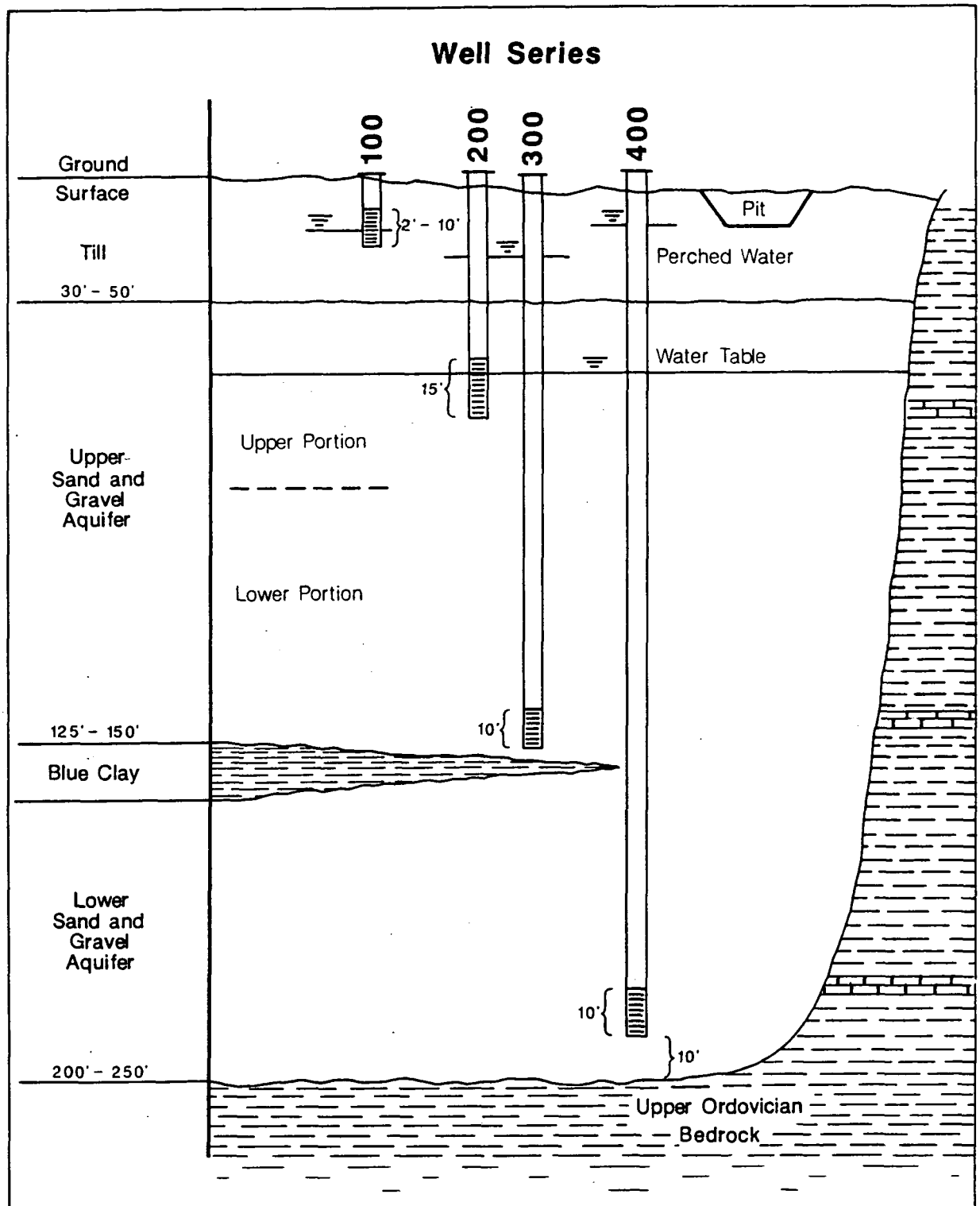

Figure 43. RI/FS General Monitoring Well Depths and Screen Locations

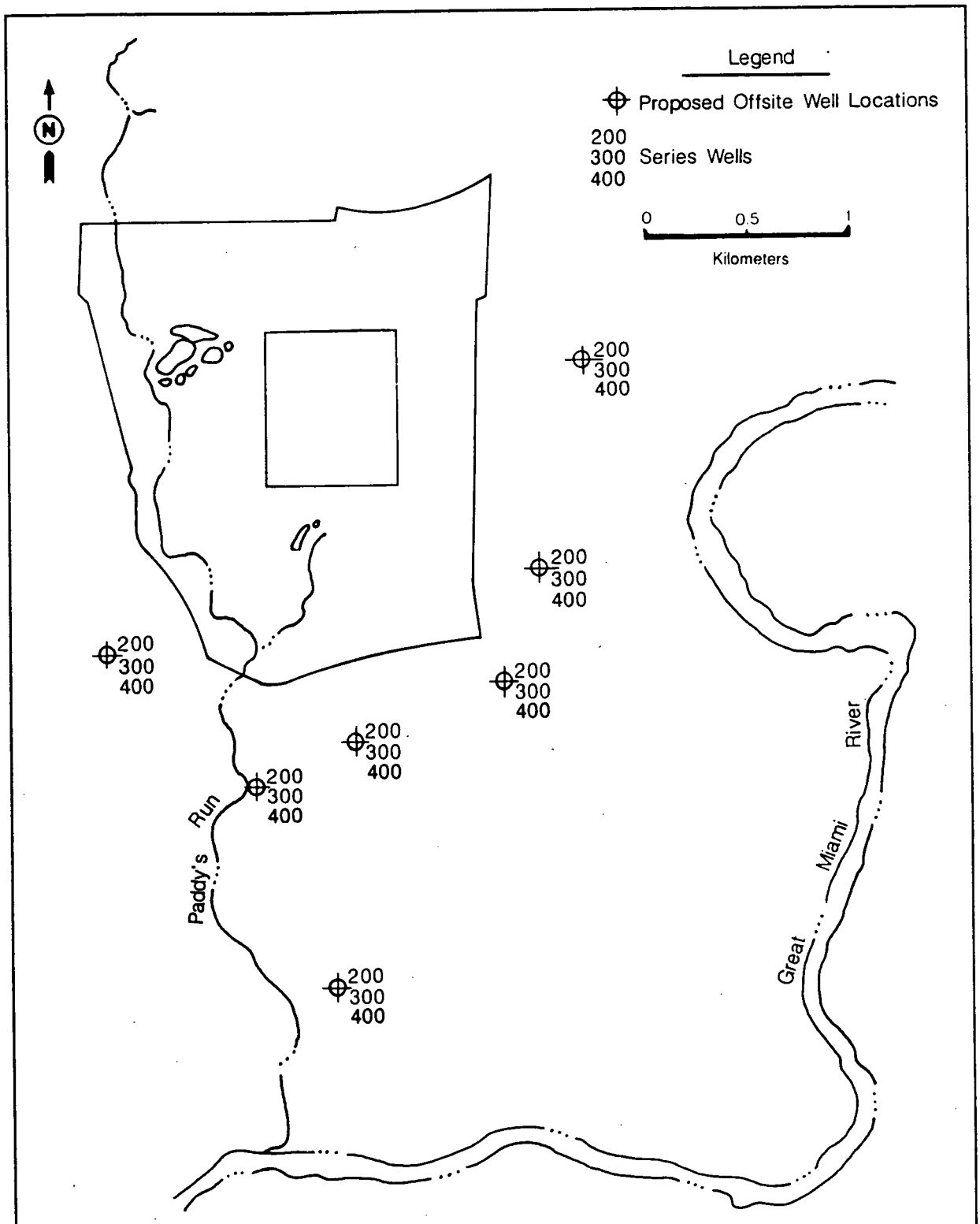

Figure 44. RI/FS Offsite Well Locations

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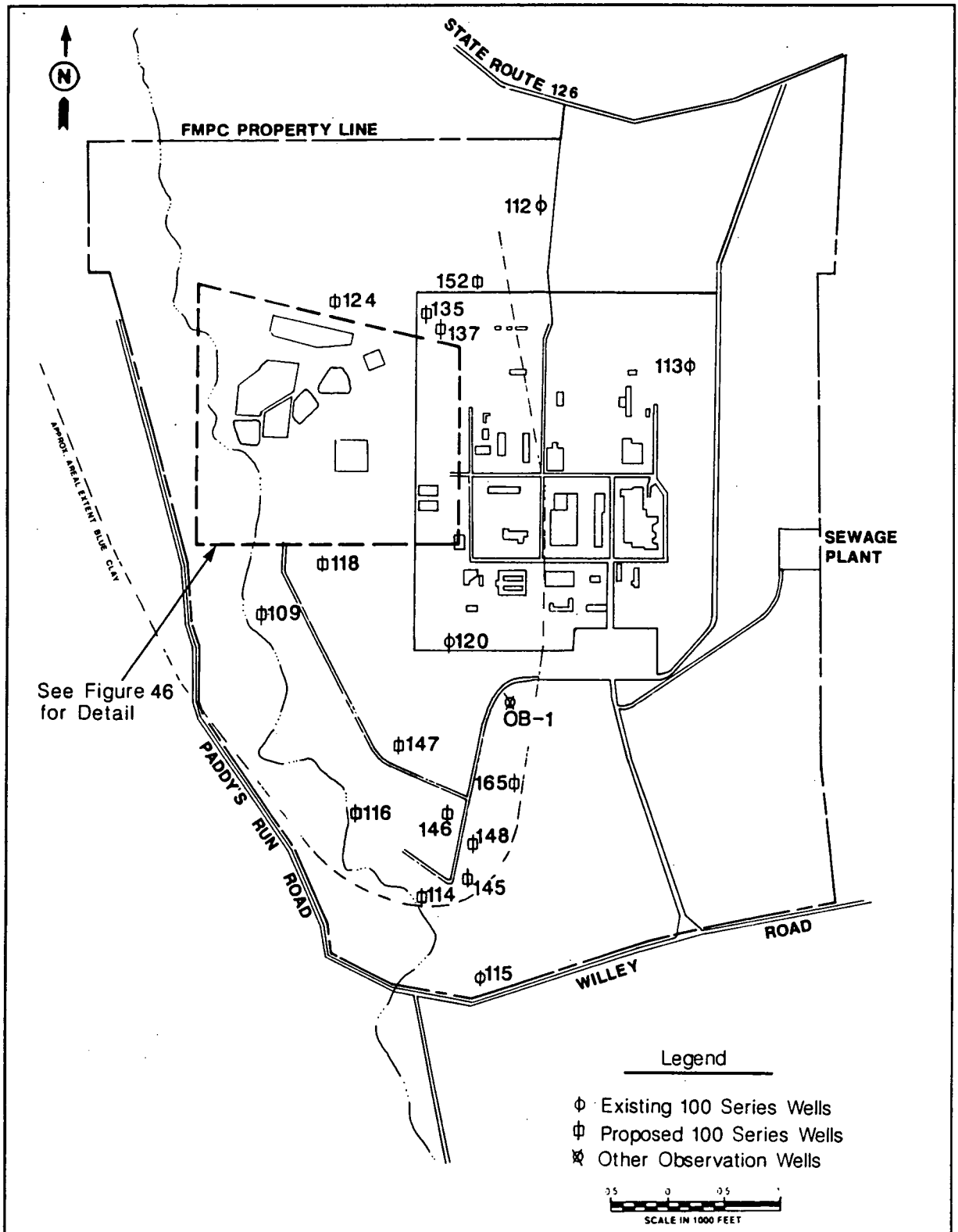

Figure 45. RI/FS 100 Series Wells – FMPC Site

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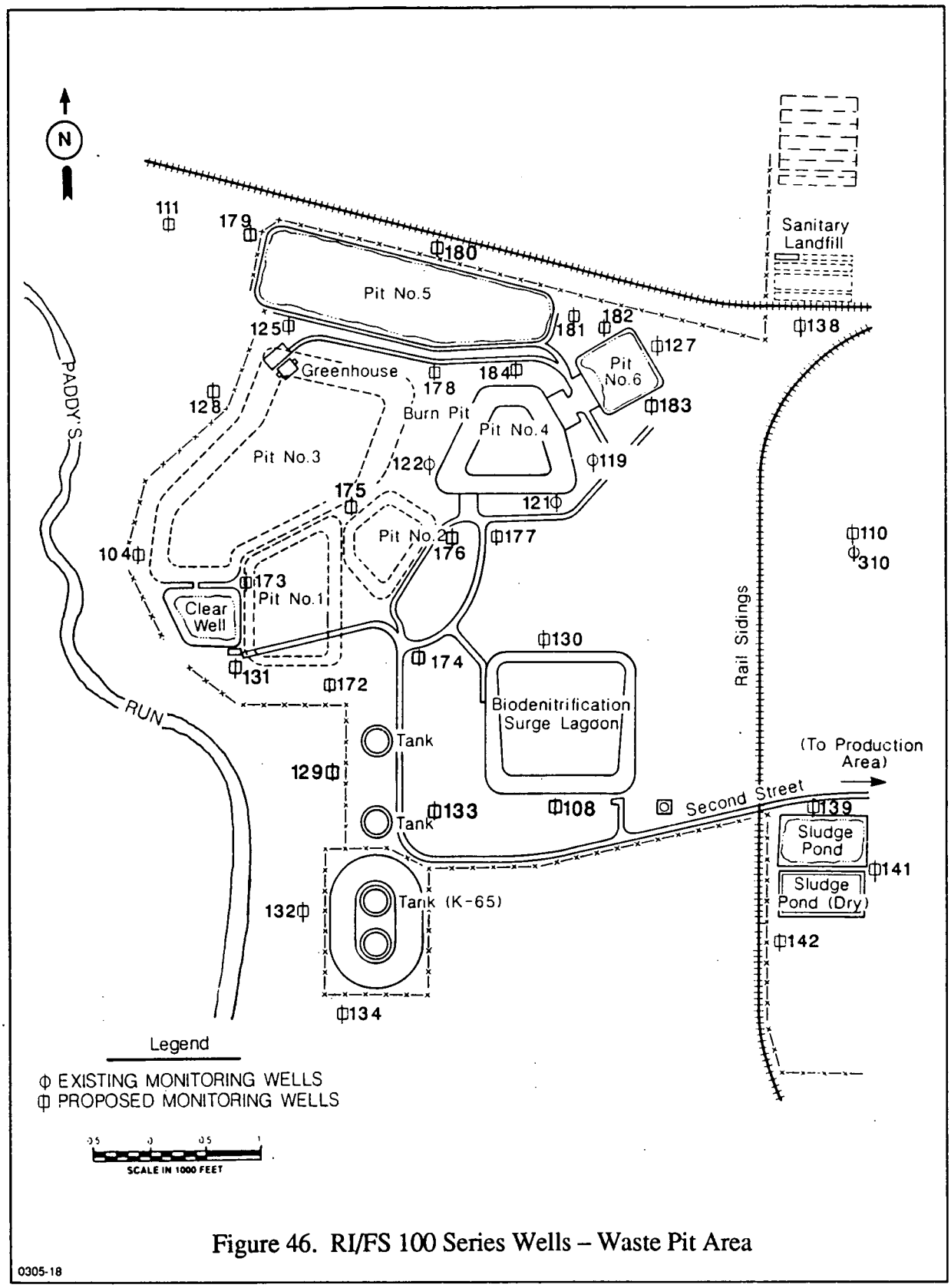

Figure 46. RI/FS 100 Series Wells – Waste Pit Area

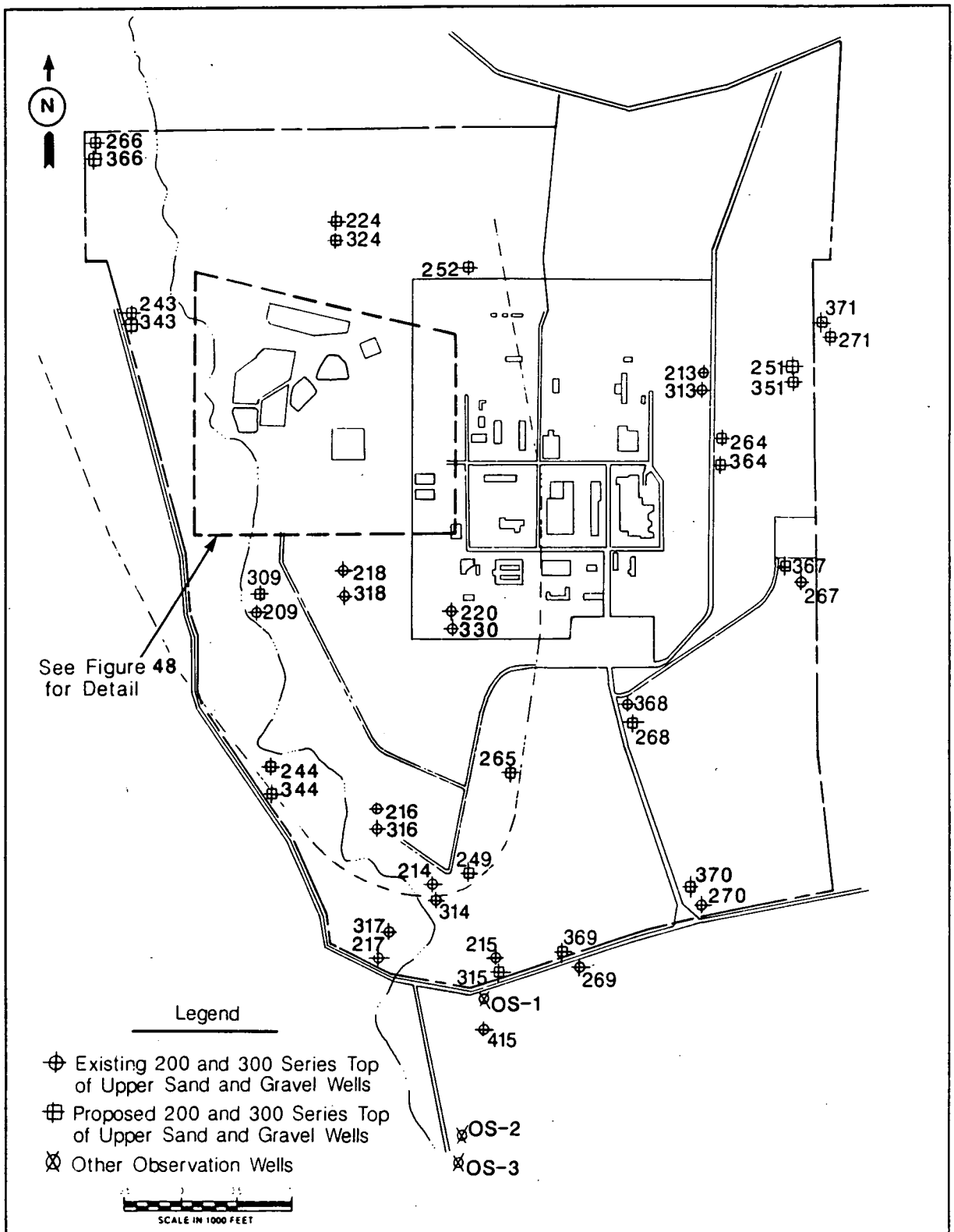

Figure 47. RI/FS 200 and 300 Series Wells – FMPC Site

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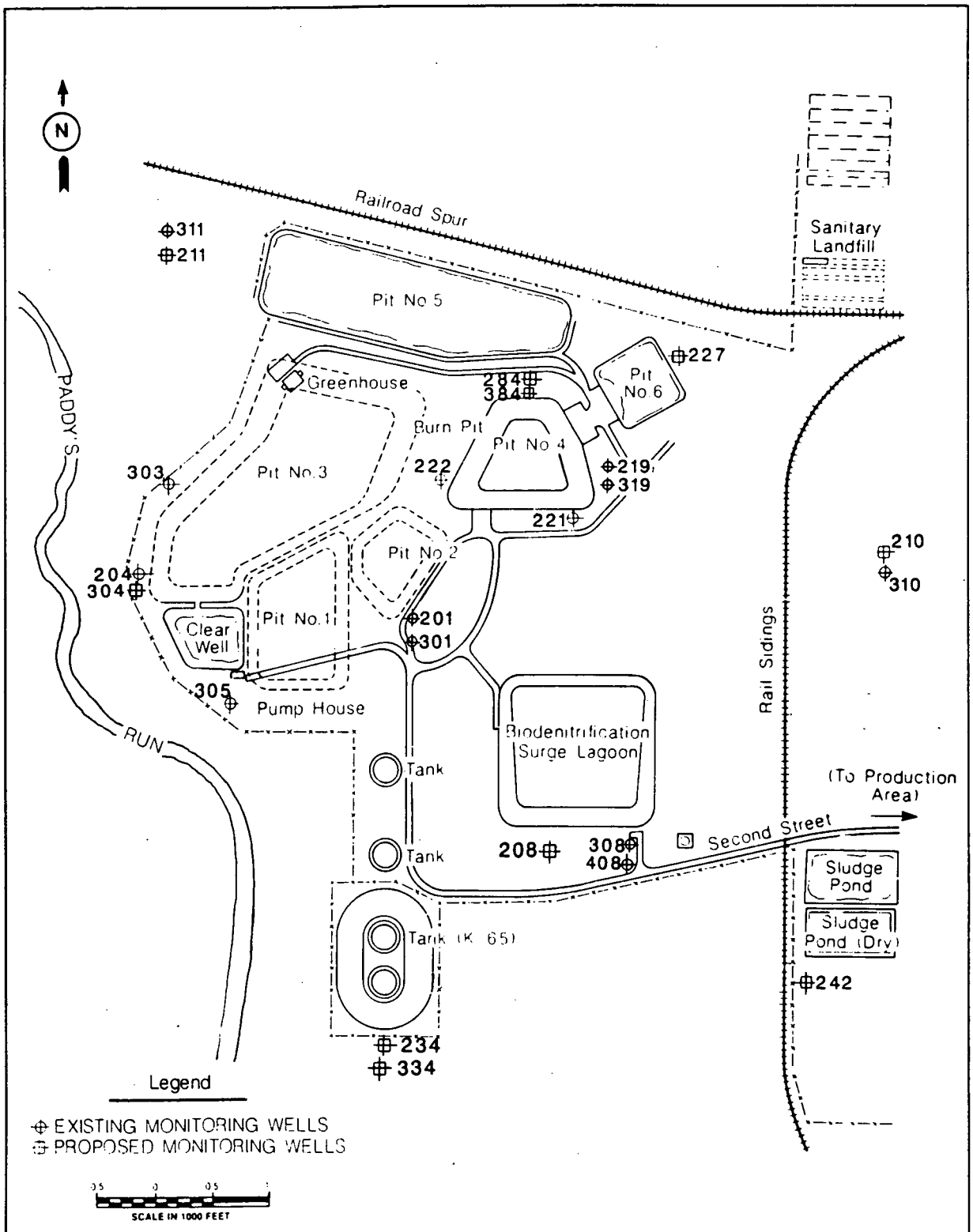

Figure 48. RI/FS 200 and 300 Series Wells – Waste Pit Area

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Sampling of subsurface soils is currently performed during the drilling of all wells. The completion of the subsurface soils sampling program will coincide with the final installation of the 92 new monitoring wells included in the groundwater sampling plan.

The *Surface Water and Sediment Sampling Plan* has the following objectives: characterize the radiological and hazardous chemical constituents along drainage pathways associated with Paddy's Run; determine the presence of radiological constituents and their given concentrations in the Great Miami River water and sediments; and determine if the FMPC is a significant source of organics and selected inorganics to the Great Miami River and Paddy's Run.

As of December 1987, no activity had been initiated on the Surface Water and Sediment Sampling Plan.

The objectives of the *Biological Resources Sampling Plan* are to determine: if contaminant substance releases to the FMPC and surrounding areas result in significant uptake, assimilation, and transfer through ecological habitats and in agricultural products and crops; the presence or absence of significant pathways to human receptors and the potential risk to humans from those pathways; if federal or state threatened or endangered species exist within the FMPC; and to identify any potential risk to those species from FMPC activities.

With the exception of samples of the highest-order mammals (i.e. rabbits and squirrels), all biological samples have been collected as of December 1987.

The objective of the *Facilities Testing Plan* is to determine if hazardous materials leakage has occurred or has the potential to occur from the underground storage tanks located in the production area and from the main effluent line. Underground tank testing will be conducted once during the sampling program. No actual testing or sampling had been initiated as of December 1987.

Characterization Investigation Study

On June 1, 1987, a ten-month Characterization Investigation Study (CIS) of the FMPC Waste Storage Area was completed. The CIS involved the gathering of technical data to characterize the location, volume, and nature of material in the Waste Storage Area at the FMPC. Data from the CIS is being used to enhance and modify sampling activities for the site-wide RI/FS.

The CIS was comprised of three tasks: Geophysical Survey; Chemical and Radiological Characterization of the Waste Storage Pits; and Radiological Characterization of Surface Soils in the Waste Storage Area. The results from the geophysical survey confirmed a substantial volume of buried ferrous metal, (e.g. steel drums) and the presence of nonferrous conductive materials (possibly graphite, nonferrous metal, and fly ash) in Pits 1, 2, and 4, the Burn Pit, and the Sanitary Landfill. Other buried solid waste materials (e.g., bricks and other construction debris) were indicated in Pits 1 and 4 and the Sanitary Landfill.

A total of 790 samples were obtained for the Chemical and Radiological Characterization of the FMPC Waste Storage Pits. Waste pit samples were analyzed for compounds contained in the USEPA Hazardous Substances List, RCRA parameters, and radioisotopes associated with FMPC operations. Most of the chemicals listed on the Hazardous Substance List of compounds were not detected in the more than 17,000 analyses performed. All of the pits except for the fly ash areas were tested for RCRA parameters and were found to be within the established limits or below the maximum allowable concentrations. The waste pits showed predominantly high concentrations of aluminum, calcium, iron, and magnesium. Trace concentrations of PCB's were pervasive throughout the areas tested with the exception of the south lime sludge pond. Trace levels of pesticides, including DDT and malathion, were seen in the results from Pits 1, 2, and 4 as well as the north lime sludge pond. Elevated concentrations of semi-volatile organic compounds were observed in Pit 2. Semi-volatile constituents were detected in Pit 4, the Burn Pit, Clear Well, and Sanitary Landfill.

Radioactivity concentrations in waste materials were principally associated with the isotopes of uranium. High values of uranium-238 were seen in Pits 2 and 6, with the highest activity concentration in Pit 4. The highest levels of thorium-230 and elevated radium-226 activity concentrations were in Pits 3 and 5. Overall, the upper and lower fly ash areas, the lime sludge ponds, and the Sanitary Landfill showed very low radionuclide activity concentrations.

A systematic survey of the surface soils throughout the Waste Storage Area was conducted for the Radiological Characterization of Surface Soils. Approximately 24,400 locations were surveyed for radioactivity using various radiation detection instruments. Based on this survey, approximately 3,000 soil samples from the Waste Storage Area and fly ash areas were collected and analyzed for isotopes of uranium, radium, thorium, and other radionuclides. Results of the soil sample analysis indicate that uranium is the most prevalent radioactive element in surface soil, and that uranium-238 is the principal radionuclide in the general Waste Storage Area. The drainage area just south of Pit 5 had the highest value of uranium-238. The upper fly ash area had the highest radionuclide activity concentrations for uranium-234, -235, -238, technetium-99, radium-226, and thorium-230 in the surface soils. Elevated activity concentrations of thorium-230 were found along the K-65 slurry line along with thorium-232, technetium-99, radium-226 and lead-210.

Stabilization of the K-65 Silos

In response to the FFCA, the FMPC took action to stabilize the two K-65 waste storage silos located in the Waste Storage Area. The K-65 Silos are concrete storage structures containing radioactive radium-bearing residues from past DOE refinery operations at the FMPC and from other DOE facilities.

Based on a Feasibility Investigation which evaluated alternatives for the control of radon emissions from the K-65 Silos, an interim solution involving construction and operation of a radon treatment system and internal and external applications of polyurethane foam was recommended.

The radon treatment system was operated nine times between November 23 and December 5, 1987. It was designed to remove radon from the silos in order to reduce the whole body radiation dose to all personnel involved in the foaming application. The radon treatment system reduced penetrating radiation levels on the K-65 Silo domes by an average of 60 to 70% for the period of time involved in foaming operations.

The external foam operations were performed between November 25 and December 6, 1987, and included applying a 3-inch layer of rigid polyurethane foam to each dome surface and a 1.5-inch layer on each dome cap. A 45 mil waterproof, ultraviolet-resistant, urethane finish coating was then applied on top of the rigid foam. The purpose of the external foam application is threefold: to provide weather protection; to improve the structural integrity of the silos; and to reduce radon emissions from each silo. The final step in the K-65 Silos stabilization project involves the internal foaming of the silos, which is scheduled for Spring 1988.

RCRA Drummed Waste Characterization

As part of the FFCA, DOE must comply with interim status regulations in all areas subject to control under RCRA. To accomplish this goal, hazardous waste determinations for all current FMPC solid and liquid waste streams were performed.

Of the 57 identified waste streams at the FMPC, five were identified as RCRA hazardous wastes. The remaining waste streams were determined not to be hazardous wastes according to RCRA regulations. If new processes or modifications to existing processes generate new waste streams, hazardous waste determinations will be made immediately.

Of the approximately 37,000 drums of waste stored onsite, most are similar to the current waste streams; however, variations in processes and materials used since their generation require that additional sampling and analyses be performed before final hazardous waste determinations can be made. Of the 67 categories of stored waste, six were considered hazardous

waste. These six streams were identified as hazardous waste either by USEPA listing or toxicity characteristic testing, and are managed according to RCRA. For the remaining stored wastes, a sampling program has been implemented to assure compliance with RCRA requirements.

The RCRA sampling and analytical program will be completed during 1988. The sampling portion of the characterization program was completed in 1987, and analytical results are currently unavailable.

RCRA Groundwater Quality Assessment for Waste Pit 4

As a hazardous waste landfill facility, Pit 4 is subject to the RCRA regulations. To conform with these regulations, certain groundwater monitoring requirements (as outlined in 40 CFR 265, Subpart F) must be provided to the USEPA for review and approval.

A Groundwater Quality Assessment Program Outline was submitted in January 1987 in response to the RCRA section of the FFCA. The Program Outline presents a groundwater monitoring program for Pit 4 to identify whether hazardous waste or hazardous waste constituents have entered the groundwater, the rate and extent of migration of any hazardous waste or hazardous waste constituents in the groundwater, and the concentration of any hazardous waste or hazardous waste constituents in the groundwater.

Comparisons which were completed for the detection monitoring of designated wells around Pit 4 indicate that statistically significant changes in various indicator parameters such as pH, specific conductance, and TOC have occurred (Tables 44 through 47 of Appendix B). These changes required regulatory notification and preparation of a groundwater assessment plan (Figures 18 and 39; Appendix B). On November 13, 1987, USEPA was notified that Pit 4 may be affecting groundwater quality at the FMPC. A Groundwater Quality Assessment Program Plan submitted in November 1987 provides information on future RCRA groundwater monitoring activities at the FMPC. These activities will be coordinated and implemented as part of the current site-wide RI/FS at the FMPC.

Dispersion Modeling for Radon from the K-65 Silos and Structures Containing Thorium

Under the FFCA, dispersion modeling of the K-65 Silos and all FMPC structures that contain thorium is required. This effort is currently in progress, and is scheduled for completion in the spring of 1988.

The present scope of this effort is to perform AIRDOS-EPA/DARTAB modeling of radionuclide emissions from FMPC stacks, K-65 Silos, and from structures containing thorium. AIRDOS-EPA computer models will be used to calculate the doses to the maximally-exposed individual from each of these radionuclide emissions sources. The individual doses will then be added to determine the total dose to the maximally-exposed individual resulting from all FMPC radionuclide emissions.

Stack Sampling and Testing

During 1987, ten stacks at the FMPC site were tested. The tests consisted of sampling effluent air discharged from the stacks for particulate content, and were conducted according to methods specified by the USEPA.

The particulate catch was also analyzed for radionuclide content to satisfy the Clean Air Act Section of the FFCA. Particulate emissions from all the stacks tested in 1987 complied with OEPA regulations.

OEPA Director's Findings and Orders

In May 1987, the OEPA issued the amended Director's Findings and Orders (DFO) detailing certain scheduled compliance actions to be completed at the FMPC. The DFO consists of fifteen findings and eighteen orders which, by law, DOE and WMCO must address. DFO activities performed or initiated in 1987 and discussed in this section include:

- Best Management Practices Plan
- A Study of FMPC Effluent Discharge to the Great Miami River.

Best Management Practices Plan

During 1987, the development of a Best Management Practices (BMP) Plan for spill control was begun. The purpose of the BMP is to minimize the potential for releases of significant amounts of toxic or hazardous substances from the FMPC to surface waters. The plan will include a FMPC facilities description, a hazardous materials inventory/spill risk assessment, a description of the spill control committee and charter, spill reporting and recordkeeping procedures. Material storage and compatibility, good housekeeping practices and spill prevention, preventative maintenance and inspection, and security considerations will be detailed also. BMP training in spill prevention and control is scheduled to begin for all FMPC employees during the summer of 1988. The BMP Plan will be implemented at the FMPC following USEPA approval.

A Study of FMPC Discharge to the Great Miami River

In accordance with the DFO, an investigation of the FMPC discharge to the Great Miami River was required to determine the environmental impact associated with use of the FMPC effluent line (Figure 49). The investigation was to:

- Locate any leaks or holes in the FMPC discharge pipeline and to stop any leakage identified in the line as soon as possible

- Determine whether the FMPC discharge to the Great Miami River is located within the zone of influence of any major water production well field and to qualitatively and quantitatively determine any associated environmental impact

- Evaluate the gravel fill around the pipeline to determine if the fill is or has served as a conduit for sewage, industrial waste, or other wastes to the Great Miami River buried valley aquifer.

A revised workplan defining the scope of the investigation was submitted to OEPA on June 16, 1987. The FMPC was required to inspect (using a video camera), clean, pressure test, and chemically grout the pipeline from Manhole 175 to the Great Miami River. The overall condition of the buried line appeared satisfactory and no leaks, cracked sections, or faulty sewer joints were observed. However, due to extensive scaling of the effluent pipe along its entire length, the pressure testing and chemical grouting of the sewer line could not be performed. Also, activities associated with the evaluation of the gravel fill could not be completed due to the inability to pressure test the pipeline.

The FMPC conducted a hydrogeologic study of FMPC discharge to the Great Miami River. The study included such tasks as collecting and analyzing available information on the hydrologic and hydrogeologic environment in the vicinity of the FMPC outfall, computer modeling, river bed sediment and groundwater sampling, and piezometric (aquifer water level elevation) mapping. A draft interim report of the hydrogeologic study was submitted on September 24, 1987. This interim report concluded that the impact of the pipeline effluent on the quality of water pumped from the Great Miami River buried valley aquifer is insignificant under average conditions. The study will be completed as part of the ongoing site-wide RI/FS.

Water Compliance Activities

The following is an update on significant events or special studies which were performed or initiated in 1987 as part of the FMPC water compliance efforts:

- Biodenitrification Facility
- Status of Water Permits.

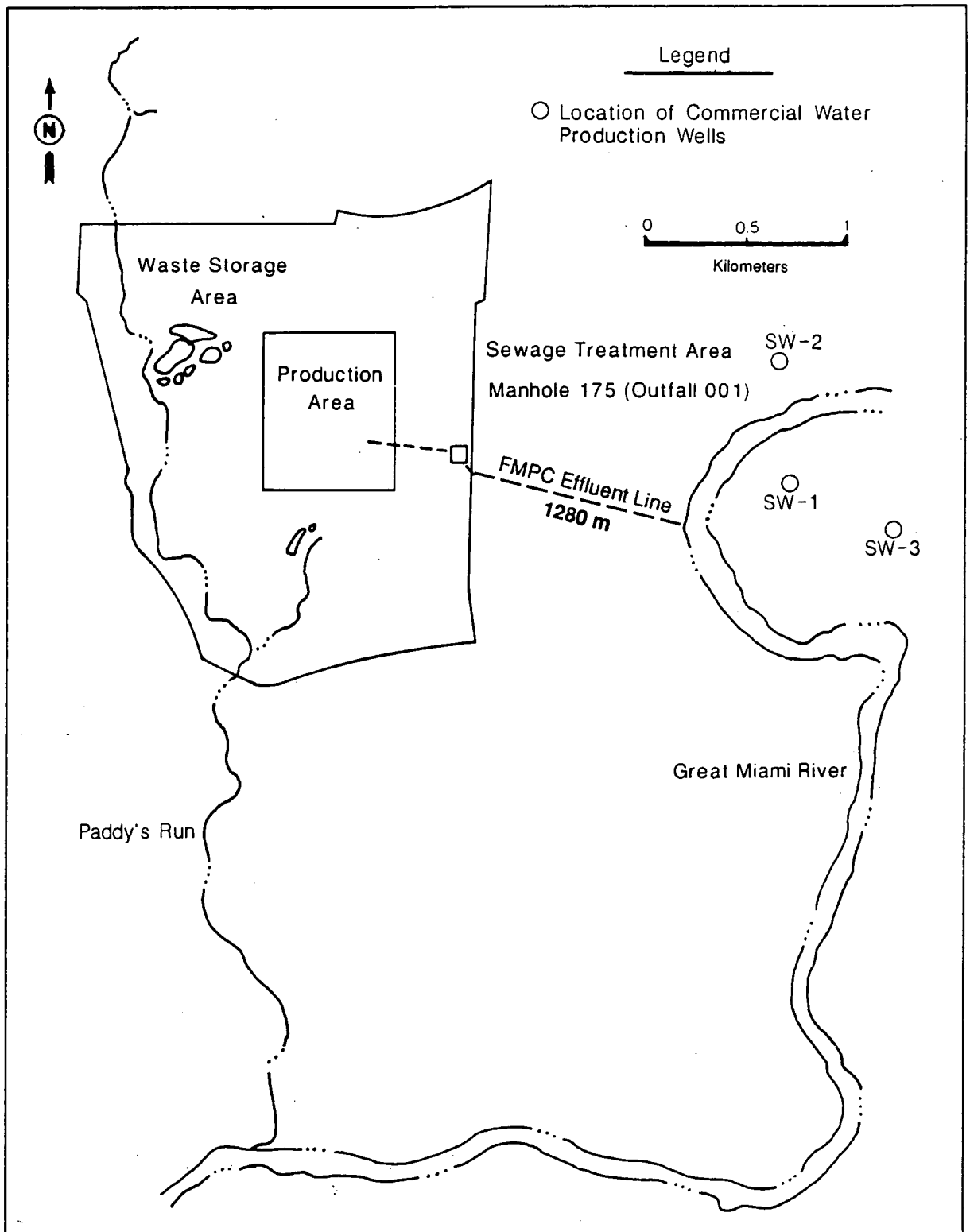

Figure 49. FMPC Discharge to the Great Miami River Study Area

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Biodenitrification Facility

The Biodenitrification Facility has been in continuous operation since May 19, 1987. The facility is designed to reduce nitrates in process effluents, enabling the FMPC to comply with the NPDES limits for nitrate discharge. Currently, the Biodenitrification Facility is operating as a two-tower demonstration facility, but plans are to complete it as a four-tower facility by adding permanent instrumentation and controls, influent nitrate concentration control, improving calcium removal on the feedstream, and separating effluent treatment.

In 1986, the average effluent nitrate mass loading to the river via Manhole 175 was approximately 150 kg/d. Since the Biodenitrification Facility has been operating, the average nitrate load to the river has been reduced to approximately 85 kg/d, allowing the FMPC to comply with NPDES nitrate limits. However, the facility has violated the NPDES limits for BOD_5, TSS, and fecal coliform. This noncompliance situation was created when increased flow and additional BOD_5 and TSS loading from the biodenitrification effluent overloaded the Sewage Treatment Plant. Several interim steps have been taken to minimize NPDES violations at the Sewage Treatment Plant, including: improving methanol feed control; increasing biodenitrification effluent aeration at tank 8; reducing flow of biodenitrification effluent to the Sewage Treatment Plant; and chlorinating Sewage Treatment Plant effluent (in addition to ultra-violet disinfection). Future interim actions include removing biodenitrification effluent suspended solids in another tank at the General Sump, and blending waste streams to provide more uniform feed. Long-term plans include constructing a separate biological treatment system to remove BOD_5 and TSS from biodenitrification effluent. Biodenitrification effluent will be discharged directly to the Great Miami River after treatment in this system.

Status of Water Permits

In 1987, four applications for wastewater Permits to Install (PTI's) for planned wastewater treatment facilities were transmitted to DOE for submittal to OEPA. In 1987, the OEPA issued PTI's for the Plant 6 Sump, the Stormwater Retention Basin Expansion and the Biosurge Lagoon Liner Upgrade. The OEPA issued the PTI for the Tank Farm Upgrade to DOE and FMPC in January 1988.

Air Compliance Activities

The following is an update on significant events or special studies which were performed or initiated in 1987 as part of the FMPC Air Compliance efforts:

- Meteorological Monitoring System
- NOAA Meteorological Tests
- NESHAP
- Status of Air Permits.

Meteorological Monitoring System

A meteorological monitoring system was installed at the FMPC site in August 1986. The system consists of a meteorological tower, instrumentation, a data logger, and a computer. The tower's instrumentation measures wind speed and direction, ambient air temperature, lapse rate (a measure of atmospheric stability), dewpoint temperature, relative humidity, barometric pressure, and precipitation. Data collected is used for emergency preparedness and to support engineering groups at FMPC.

In 1987, the monitoring system operated for 299 days. Lightning disrupted operation of the tower on three separate occasions: May 25 - June 19, July 9 - 29, and August 3 - 24. The FMPC will install additional surge protection devices in August and maintain a spare parts inventory on major system components to help eliminate downtime in 1988.

NOAA Meteorological Tests

In October and November 1987, the National Oceanic and Atmospheric Administration (NOAA) conducted a study of the meteorological conditions in the vicinity of the FMPC. The purpose of the month-long study was to examine weather conditions and make recommendations for the facility's environmental monitoring and emergency preparedness programs. The study included installing 12 temporary meteorological

towers offsite on private property rented for the study, encompassing a three-mile radius of the site. Temperature, relative humidity, precipitation, solar radiation, and wind speed and direction measurements were taken. Additional measurements were taken onsite to obtain wind profiles to a height of about 1,000 meters. NOAA is currently evaluating the results of the testing.

National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) program (Title 40 CFR Part 61) is administered by the USEPA Region V. Radionuclide emissions are among the several air pollutants classified as hazardous under the NESHAP program. FMPC is the first facility within Region V to attempt to demonstrate to OEPA and USEPA that it complies with the NESHAP regulations for radionuclide emissions.

Status of Air Permits

In 1987, nine Permit to Install (PTI) applications and four Permit to Operate (PTO) applications for FMPC sources were completed. The applications consist of responses to questions on emissions, process, and control equipment for each source to demonstrate compliance.

Solid Waste Compliance Activities

An important aspect of solid waste activities at the FMPC are the thorium disposition projects. Since 1972, the FMPC has served as DOE's storage site for thorium. Currently there are approximately 1,100 metric tons of thorium stored in silos, bins, and steel drums on the FMPC site. Approximately two-thirds of this thorium was processed onsite, while the remaining material originated from other DOE facilities.

The thorium at the FMPC consists of various thorium materials -- principally thorium oxides, processing residues, and a small quantity of thorium metal. The Plant 8 silo and bins contain approximately 175 metric tons of bulk thorium oxide materials plus inert materials like diatomaceous earth. Excluding the small quantity (nine metric tons as thorium) of thorium nitrate solution stored in the Pilot Plant Tank 2, the remainder of the thorium inventory (approximately 13,100 containers) is stored in drums and containers in warehouses and outside. This material is carefully managed in order to reduce the potential radiation hazard to employees, local residents, and the environment. The FMPC has developed a comprehensive three-part plan for the interim disposition of the stored thorium. All of the thorium materials will be identified, inventoried, and repackaged and/or overpacked for interim storage onsite until final disposition is determined.

The first project, which is required under the FFCA, addresses removing, sampling, and repackaging the thorium materials in bulk storage in the Plant 8 silo and bins. In September 1987, the design and construction of the handling system necessary to remove and package bulk thorium materials was begun. After this thorium is repackaged, the silo and bins where the material is currently stored will be decontaminated and demolished. Actual construction and thorium removal is scheduled to begin in Spring 1988.

Two other projects will address the 13,300 containers of thorium materials in the warehouse and outside storage. During 1987, the design of a remotely-operated system for handling, identifying, and overpacking the thorium material was initiated. Each container of the thorium materials in outside storage will be inventoried, weighed, and scanned to determine its radiation content. Once these procedures are complete, the warehoused thorium materials will be overpacked in larger containers suitable for interim storage until final disposition is determined.

Additional Activities

Two additional activities that were ongoing or initiated at the FMPC in 1987 include the Environmental Impact Statement and the Emergency Operations Center. They are described in the following paragraphs.

Environmental Impact Statement

DOE is preparing an Environmental Impact Statement (EIS) to address site-wide renovation and remedial activities at the FMPC. The planned renovation would enable the FMPC to meet production goals through the remainder of this century, while enhancing environment, health, and safety conditions.

Prior to implementing renovations, each construction project included in the EIS will be evaluated on the basis of potential environmental impacts versus reasonable alternative actions. High priority projects must be evaluated against criteria listed in 40 CFR 1506.1(a) to determine if they can proceed before implementation of the EIS. In cases such as this, it must be determined whether the project, when completed, would still comply with the regulations implementing the National Environmental Policy Act (NEPA).

In 1986, DOE initiated the scoping process for the EIS to address renovation and waste cleanup at the FMPC. A Notice of Intent to prepare an Environmental Impact Statement and to Conduct a Public Scoping Meeting was published and conducted in that year. Public scoping meetings for the FMPC EIS were held in September 1986. The following issues to be analyzed in the EIS were identified during the public scoping process: radiation doses; chemical exposure effects; exposure pathways; source terms; socioeconomic impacts; monitoring and mitigation; cumulative impacts; institutional issues; and potential costs. The implementation plan, which provides the workplan for the EIS, was written and approved by DOE in December 1987. A draft EIS is scheduled for completion on August 1, 1988, with issuance of the final EIS and the Record of Decision to follow.

Emergency Operations Center

The FMPC Emergency Operations Center (EOC) was constructed and put into operation during 1987. The EOC is an information management and communications center where technical support, communications, operations, public information, and policy-making personnel conduct business during emergency situations.

The EOC is functionally divided into an Operations Center (for onsite assessment and impact analysis) and a Policy Area (for offsite interaction and public affairs). A centrally-located group of wall-mounted information displays are visible to both groups and provide a common basis for decision-making at all levels.

More than 60 senior managers, scientists, and engineers have been trained for the task of EOC operations. A quarterly training program including lectures, drills, and exercises was conducted with DOE-ORO, the State of Ohio, and Butler and Hamilton County personnel, and resulted in an integrated response team capable of effectively dealing with any FMPC emergencies.

The EOC was activated once during an onsite release of anhydrous hydrogen fluoride on September 29, 1987 (discussed in the next section), and proved effective in dealing with the minor problems encountered.

Unusual Events

During 1987, 10 news releases that reported on operational events at the FMPC were issued. Six spills (two of magnesium fluoride, three of uranium tetrafluoride (UF_4) or UF_4/magnesium blends, and one of uranium oxide), one hydrogen fluoride release, one small uranium fire, one injury to a welder working on a fluid bed reactor, and one injury during a Pilot Plant shutdown were reported.

The following spills and releases are detailed in this section:

- Uranium Oxide Spill
- Anhydrous Hydrogen Fluoride Release.

Uranium Oxide Spill

At 12:35 p.m. on August 18, 1987, a spill of approximately 200 pounds of low-level radioactive uranium oxide occurred at the FMPC. In Plant 4, uranium tetrafluoride is produced by reacting uranium dioxide to anhydrous hydrogen fluoride. The material escaped from a processing feed hopper in Plant 4 when a gas seal failed as a routine nitrogen purge was introduced into the

fluid bed reactors. Immediately upon detecting the release, the nitrogen purge was valved off and ventilation systems were shut off to assure that no material was released from the building. The uranium oxide material was isolated and promptly cleaned up. Seven workers were sent to the plant's medical department for urinalysis to determine if they had inhaled any uranium. The FMPC notified state, local, and regulatory offices immediately after the incident. The uranium oxide spill was classified as an unusual event, the lowest category of emergencies. WMCO investigated the spill and published the results in a WMCO Unusual Occurrence Report.[20]

Anhydrous Hydrogen Fluoride Release

A maximum of 270 pounds of anhydrous hydrogen fluoride were released to the atmosphere at approximately 9:15 a.m. on September 29, 1987 at the FMPC. In the Pilot Plant, anhydrous hydrogen fluoride gas is a product of uranium hexafluoride conversion to uranium tetrafluoride. Anhydrous hydrogen fluoride is an extremely caustic gas and can cause serious burns or respiratory problems on contact. The release of the hazardous material occurred at the Pilot Plant when a rupture disc on an anhydrous hydrogen fluoride transfer line overpressure protection system was activated.

After the release occurred, the Pilot Plant was immediately evacuated and the EOC was activated. Two workers in acid suits closed an isolation valve and stopped the leak at approximately 9:25 a.m. The roof of the Pilot Plant was also flushed with water. Air monitoring readings taken immediately during and after the event indicated there was no offsite impact. State, local, and regulatory offices were notified immediately after the incident. This incident was classified as an unusual event, meaning there was a potential for reduced facility safety, but no potential for an offsite release. A number of FMPC employees reported to the plant's medical department complaining of eye and skin irritation, but no serious injuries were reported. DOE investigated the release and published the results in a DOE Incident Investigation Board Report.[21]

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Appendix A — 1987 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 1987. The results of this sampling are provided in the tables on the following pages.

TABLE 1
FMPC — OHIO DEPARTMENT OF HEALTH
SPLIT SAMPLING RESULTS, 1987

Parameter (Units)	Sampling Location[1]	Number of Samples	Uranium Concentration[2] FMPC Average[3]	ODH Average[3]	ODH/FMPC Ratio	Average Ratio
Surface Water (pCi/l)	W1	3	1.1 (0.039)	1.3 (0.048)	1.2	
	W3	3	2.1 (0.079)	2.7 (0.099)	1.3	
	W4	3	1.9 (0.072)	3.3 (0.12)	1.7	1.1
	W7	1	6.8 (0.25)	4.0 (0.15)	0.6	
	W8	1	1.7 (0.063)	2.0 (0.074)	1.2	
	W9	3	1.0 (0.038)	0.8 (0.031)	0.8	
Offsite Groundwater (pCi/l)	4	3	1.5 (0.054)	1.7 (0.062)	1.1	
	5	1	1.4 (0.052)	2.0 (0.074)	1.4	
	13	1	0.4 (0.01)	0.5 (0.02)	1.3	
	14	3	0.9 (0.03)	0.5 (0.02)	0.6	
	15	3	208 (7.68)	134 (4.96)	0.6	1.2
	16	1	0.3 (0.01)	0.8 (0.03)	2.7	
	17	1	33.2 (1.23)	30.0 (1.11)	0.9	
	19	3	0.8 (0.03)	0.3 (0.01)	0.3	
	21	1	0.3 (0.01)	0.6 (0.02)	2.0	
Sediments (pCi/g)	2	1	1.05 (0.0389)	1.7 (0.063)	1.6	
	3	1	1.08 (0.0400)	1.6 (0.059)	1.5	1.5
7	1	1.75	(0.0648)	1.7 (0.063)	1.0	
	24	1	1.05 (0.0389)	1.9 (0.070)	1.8	
Milk (pCi/l)	Dairy adjacent to the FMPC	1	< 0.7 (0.03)	...[4]	...[4]	...[4]

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1. See Figures 21, 30, and 40.
2. Any variance in sampling results for total uranium is most likely attributable to differences in analytical procedures between FMPC and ODH.
3. Bq/l or Bq/g in parentheses.
4. Data not available from ODH.

TABLE 2
1987 FMPC STACK EMISSIONS

Radionuclide	Curies
U-234	0.011
U-235	0.00054
U-238	0.012
Sr-90	0.000229
Tc-99	0.00131
Ru-106	0.000243
Cs-137	0.000169
Ba-137m	0.000169
Ra-226	0.00000991
Ra-228	0.0000109
Th-228	0.000243
Th-230	0.000808
Th-232	0.000175
Th-234	0.144
Pa-234m	0.0504
Np-237	0.0000173
Pu-238	0.0000092
Pu-239	0.000312
Pu-240	0.000312

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TABLE 3
SUMMARY OF RADIATION DOSE DUE TO 1987 EMISSIONS[1]

Type of Dose	Organ	Dose Equivalent (50-yr Committed) mrem	(mSv)	Standard[2] mrem	% of Standard
I. Inhalation[3]					
A. Maximum Individual Dose from all pathways, all nuclides[4]	Effective	1.2×10^{0}	(1.2×10^{-2})	1.0×10^{2}	1.2
	Whole Body[5]	2.8×10^{-0}	(2.8×10^{-4})	2.5×10^{1}	0.0011
	Bone Endosteum	1.8×10^{0}	(1.8×10^{-2})	7.5×10^{1}	2.4
	Pulmonary	8.9×10^{0}	(8.9×10^{-2})	7.5×10^{1}	12.
B. Ingestion[6]					
Vegetables (Potatoes)	Effective	3.0×10^{-8}	(3.0×10^{-10})	1.0×10^{2}	0.
Great Miami River Water (2 1/day)	Effective	6.4×10^{-2}	(6.4×10^{-4})	1.0×10^{2}	0.064
	Bone Endosteum	1.3×10^{0}	(1.3×10^{-2})	5.0×10^{3}	0.026
Offsite Well Water[7] Wells 12/15 (2 1/day)	Effective	3.5×10^{1}	(3.5×10^{-1})	1.0×10^{2}	36
	Bone Endosteum	5.4×10^{2}	(5.4×10^{0})	5.0×10^{3}	11
C. Direct External[8]	Whole Body	9.5×10^{0}	(9.5×10^{-2})	1.0×10^{2}	9.5
II. 80 km Population Dose[3]		person-rem	person-Sv		
Committed dose equivalent to 2.5×10^{6} people living within 80 km.	Effective	2.9×10^{1}	(2.9×10^{-1})	...[9]	
	Whole Body	8.0×10^{-3}	(8.0×10^{-5})	...[9]	
	Bone Endosteum	4.6×10^{1}	(4.6×10^{-1})	...[9]	
	Pulmonary	2.3×10^{2}	(2.3×10^{0})	...[9]	
III. Other Sources of Dose					
A. Natural Radioactivity[10]		mrem/yr	(mSv/yr)		
1. Radon in homes		2.0×10^{2}	(2.0×10^{0})		
2. Other natural background radiation Cosmic radiation plus natural terrestrial isotopes, both external and internal.		1.0×10^{2}	(1.0×10^{0})		
B. Medical Diagnosis[11]		5.0×10^{1}	(5.0×10^{-1})		
C. Consumer Products[10]		1.0×10^{1}	(1.0×10^{-1})		
D. Atmospheric Weapons Tests		4.6×10^{0}	(4.6×10^{-2})		

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FOOTNOTES FOR TABLE 3

1. Including dose due to Sr-90, Tc-99, Ru-106, Cs-137, Ba-137m, Ra-226, Ra-228, Th-228, Th-230, Th-232, Th-234, Pa-234m, Np-237, Pu-238, Pu-239, Pu-240 in addition to the uranium isotopes.
2. Standards are as included in DOE Draft Order 5480.XX, "Radiation Protection of the Public and the Environment," dated March 31, 1987. Also incorporated are the air emission dose standards of regulation 40 CFR 61, Subpart H (NESHAP).
3. See Table 4 for inhalation dose estimates at all air monitoring stations.
4. Dose estimates provided by ORNL using AIRDOS-EPA computer code; 80 km population dose expressed in units of person-rem.
5. Whole body dose equivalent provided by ORNL. It includes external dose from all nuclides listed in footnote 1 plus internal exposure from Cs-137, which is deposited uniformly throughout the body.
6. Dose equivalent based on environmental measurements according to ICRP 26/30 methodology. ICRP 26/30 based on 50-year commitment dose conversion factors.
7. Offsite wells 12 and 15 contained the highest concentration of uranium measured offsite in 1987. Dose calculations based on maximum hypothetical dose from offsite well water ingestion. The DOE Standard was applied because these wells are not a drinking water source.
8. Calculated from measured exposure rate at nearest residence west of the K-65 Silos, using a calibrated Pressurized Ionization Chamber.
9. There are no applicable standards.
10. From NCRP-93, "Ionizing Radiation Exposure of the Population of the United States."
11. Medical dose estimates are population averages and will not necessarily be applicable to each individual.

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TABLE 4
ESTIMATED COMMITTED EFFECTIVE DOSE EQUIVALENTS AND PULMONARY DOSE EQUIVALENTS AT AIR MONITORING STATIONS[1]

AMS	Organ	Dose Commitment[2] (mrem) 50 year	% of Standard[3]
1	Effective	1.9 (0.019)	1.9
	Pulmonary	16.0 (0.16)	21.0
2	Effective	1.9 (0.019)	1.9
	Pulmonary	16.0 (0.16)	21.0
3	Effective	4.9 (0.049)	4.9
	Pulmonary	41.0 (0.41)	55.0
4	Effective	1.2 (0.012)	1.2
	Pulmonary	10.0 (0.10)	13.0
5	Effective	1.2 (0.012)	1.2
	Pulmonary	9.8 (0.098)	13.0
6	Effective	1.6 (0.016)	1.6
	Pulmonary	13.0 (0.13)	17.0
7	Effective	0.88 (0.0088)	0.88
	Pulmonary	7.8 (0.078)	10.0
8	Effective	4.4 (0.044)	...[4]
	Pulmonary	37.0 (0.37)	...[4]
9	Effective	8.6 (0.086)	...[4]
	Pulmonary	72.0 (0.72)	...[4]
10	Effective	0.71 (0.0071)	0.71
	Pulmonary	5.9 (0.059)	7.9
11	Effective	0.60 (0.0060)	0.60
	Pulmonary	5.0 (0.050)	6.7
12	Effective	0.29 (0.0029)	0.29
	Pulmonary	2.4 (0.024)	3.2
13	Effective	1.3 (0.013)	1.3
	Pulmonary	11.0 (0.11)	15.0

0305-54

1. The effective dose equivalent is the weighted sum of dose equivalents delivered to the individual organs of the body.
2. mSv in parentheses.
3. See Table 3.
4. Onsite AMS; Standards for dose to public not applicable.

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TABLE 5 EXTERNAL RADIATION EXPOSURE, 1987			
Sampling Location[1]	Exposure Rate[2] in μR/hr		
	Annual Average	Maximum	Minimum
AMS 1	7.71	9.59	3.85
AMS 2	8.78	10.72	4.13
AMS 3	8.07	10.27	3.64
AMS 4	8.21	10.39	3.91
AMS 5	8.02	9.95	3.98
AMS 6	12.54	15.69	6.68
AMS 7	8.44	10.79	3.75
Background[3]	8.05	10.62	3.82
0305-55			

1. AMS 1 - AMS 7 are fenceline sampling locations. See Figure 5.
2. Environmental TLD's processed quarterly.
3. Background is average of measurements at two locations (AMS BK1 & AMS BK2) between 4 and 6 miles from the FMPC.

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TABLE 6
POPULATION DISTRIBUTION WITHIN 80 KM (50 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

0305-56

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 7
RADON IN AMBIENT AIR

Sampling Location[1]	1987 Average pCi/l	(Bq/l)	1986 Average pCi/l	(Bq/l)
AMS 1	0.54	(0.020)	0.64	(0.024)
AMS 2	0.46	(0.017)	0.84	(0.031)
AMS 3	1.12	(0.041)	0.68	(0.025)
AMS 4	1.02	(0.038)	0.55	(0.020)
AMS 5	0.60	(0.022)	0.58	(0.022)
AMS 6	1.26	(0.047)	0.65	(0.024)
AMS 7	0.66	(0.024)	0.96	(0.036)
AMS 8	0.52	(0.019)	0.60	(0.022)
AMS 9	0.40	(0.015)	0.50	(0.019)
AMS 10	0.74	(0.027)	0.80	(0.030)
AMS 11	0.72	(0.027)	0.90	(0.033)
AMS 12	0.47	(0.017)	...[2]	...[2]
AMS 13	0.66	(0.024)	0.70	(0.026)
AMS BK1	0.66	(0.024)	0.60	(0.022)
AMS BK2	0.80	(0.030)	0.57	(0.021)
FMPC-A	1.46	(0.054)	...[2]	...[2]
FMPC-B	1.31	(0.048)	...[2]	...[2]
FMPC-C	1.31	(0.048)	...[2]	...[2]
FMPC-D	1.07	(0.040)	...[2]	...[2]
FMPC-E	0.94	(0.035)	...[2]	...[2]
FMPC-F	1.25	(0.046)	...[2]	...[2]
FMPC-G	0.69	(0.026)	...[2]	...[2]
FMPC-H	0.87	(0.032)	...[2]	...[2]
FMPC-I	2.12	(0.078)	...[2]	...[2]
FMPC-J	1.03	(0.038)	...[2]	...[2]
FMPC-K	2.92	(0.11)	...[2]	...[2]
FMPC-L	0.69	(0.026)	...[2]	...[2]
FMPC-M	1.75	(0.065)	...[2]	...[2]
FMPC-N	0.87	(0.032)	...[2]	...[2]
FMPC-O	1.87	(0.069)	...[2]	...[2]
FMPC-P	0.71	(0.026)	...[2]	...[2]
RES 1	1.23	(0.046)	...[2]	...[2]
RES 2	0.92	(0.034)	...[2]	...[2]
RES 3	1.03	(0.038)	...[2]	...[2]
BKGD 1	0.43	(0.016)	...[2]	...[2]
BKGD 2	0.76	(0.028)	...[2]	...[2]

0305-57

1. See Figures 5 and 6.
2. Not sampled in 1986. These locations were added in 1987 as part of the FMPC expanded radon monitoring program.

TABLE 8 AIR MONITORING STATION NAME EQUIVALENTS, 1986-1987			
1986 Program		1987 Program[1]	Location[2]
AMS 1-9	=	AMS 1-9	onsite/FMPC fenceline
OS1	=	AMSBK1	background[3]
OS2	=	AMSBK2	background[3]
OS3	=	AMS 10	offsite
OS4	=	AMS 11	offsite
OS5	=	AMS 13	offsite
0305-58			

1. The 1987 Air Monitoring Program includes AMS 12, a new offsite station installed at Shandon.
2. See Figure 5.
3. Locations were used in 1986 radon monitoring program.

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TABLE 9 RADON CONCENTRATIONS AT FMPC FENCELINE		
Average Radon Concentration at FMPC Fenceline - 23 locations		
	pCi/l	1.15 ± 0.57
AMS 1-7 plus FMPC A-P	Bq/l	0.043 ± 0.021
Average Background Radon Concentration - 4 locations		
	pCi/l	0.66 ± 0.14
AMS BK 1 & 2 plus BKGD 1 & 2	Bq/l	0.024 ± 0.005
Net Radon Concentration at FMPC Fenceline		
	pCi/l	0.49 ± 0.59
(Not statistically distinguishable from background)	Bq/l	0.018 ± 0.022
0305-59		

TABLE 10
PARTICULATES, URANIUM AND GROSS BETA CONCENTRATION IN AIR

Sampling Location[1]	Particulates[2] µg/m³ Number of Samples	Minimum	Maximum	1987 AVG.	1986 AVG.	Uranium[2] µCi/ml x 10^{-15} Number of Samples	Minimum	Maximum	1987 AVG.	1986 AVG.	Beta[2] µCi/ml x 10^{-15} Number of Samples	Minimum	Maximum	1987 AVG.	1986 AVG.
AMS 1	52	10.6	54.3	29.0	33.3	52	0.24	22.0	1.88	2.52	52	11.5	71.1	23.7	28.5
AMS 2	51	14.2	100.1	31.9	33.6	51	0.09	16.0	1.92	2.31	51	9.8	67.8	24.5	29.7
AMS 3	52	12.6	76.9	31.9	37.1	52	0.49	28.3	4.94	5.17	52	12.2	76.9	28.7	35.5
AMS 4	52	16.5	68.0	34.7	38.6	52	0.18	10.2	1.22	1.43	52	10.3	54.3	24.5	28.8
AMS 5	52	15.1	71.8	30.7	32.4	52	0.20	9.4	1.18	1.28	52	9.0	102.3	26.7	27.9
AMS 6	52	16.6	72.5	33.5	36.2	52	0.22	15.2	1.55	1.51	52	13.0	98.0	27.4	29.6
AMS 7	52	14.6	68.8	34.8	31.9	52	0.09	10.1	0.94	0.88	52	11.0	95.9	29.6	28.5
AMS 8	52	16.5	64.8	34.5	33.5	52	0.24	47.2	4.40	3.72	52	11.5	70.0	28.6	35.3
AMS 9	52	13.6	127.7	37.8	36.5	52	0.48	75.5	8.61	6.49	52	13.2	75.8	30.4	39.9
AMS 10	52	12.4	95.0	47.2	...[3]	52	0.03	4.23	0.71	...[3]	52	2.87	27.9	11.3	...[3]
AMS 11	52	16.5	115.7	42.3	...[3]	52	0.03	4.98	0.60	...[3]	52	2.54	98.1	14.2	...[3]
AMS 12	45	16.5	72.5	35.2	...[3]	45	0.01	3.33	0.29	...[3]	45	0.0	29.2	9.88	...[3]
AMS 13	52	16.9	83.8	44.5	...[3]	52	0.06	10.2	1.26	...[3]	52	1.27	39.5	12.1	...[3]

0305-60

1. See Figure 5.
2. The following guidelines were used for comparison:
   a. Particulates = 60 µg/m³ (annual geometric mean) as stated in 40 CFR Part 50, National Ambient Air Standards.
   b. Uranium = 2,000 x 10^{-15} µCi/ml as stated in DOE Guideline.
   c. Gross Beta = 100,000 x 10^{-15} µCi/ml as stated in 10 CFR Part 20, Appendix B.
3. Not Sampled.

TABLE 11
RADIONUCLIDES IN AIR
(page 1 of 2)

Radionuclide	Derived Concentration Guides[4] $\mu Ci/m^3 \times 10^{-6}$	Concentration of Radionuclides at Air Monitoring Stations[1,2,3] in $\mu Ci/m^3 \times 10^{-12}$							
		AMS 1	AMS 2	AMS 3	AMS 4	AMS 5	AMS 6	AMS 7	AMS 8
Cs-137	400	< 18	< 19	< 20	< 18	< 15	< 20	< 22	< 21
Np-237	0.02	< 3.1	< 3.2	< 3.1	< 3.3	< 2.9	< 3.5	< 3.6	< 3.6
Pu-238	0.03	< 1.2	1.6 ± 0.79	< 1.2	1.2 ± 0.81	< 1.8	1.7 ± 1.3	< 1.4	2.7 ± 2.3
Pu-239/240	0.02	4.6 ± 2.3	2.8 ± 2.0	3.1 ± 2.0	< 1.2	< 1.8	< 1.3	< 1.4	5.0 ± 3.2
Pu-241	1	9.2 ± 0.13	7.6 ± 0.09	15 ± 0.18	3.5 ±0.09	4.0 ± 0.08	7.2 ±0.10	2.9 ±0.10	17 ±0.21
Ra-226	1	45 ± 12	57 ± 15	79 ± 20	63 ± 17	14 ± 6.1	64 ± 17	45 ± 13	47 ± 15
Ra-228	3	33 ± 12	28 ± 11	37 ± 12	< 13	53 ± 13	75 ± 17	40 ± 13	55 ± 16
Ru-106[5]	30	< 180	< 200	< 170	< 180	< 201	< 207	< 220	< 260
Sr-90	9	< 38	< 56	< 51	< 43	< 39	< 47	< 53	51 ± 24
Tc-99	2000	640 ± 99	580 ± 91	140 ± 31	220 ± 41	200 ± 38	540 ± 90	150 ± 37	280 ± 0.0
Th-228	0.04	76 ± 25	32 ± 14	23 ± 6.7	28 ± 7.3	13 ± 5	13 ± 4.8	37 ± 18	20 ± 9.6
Th-230	0.04	31 ± 15	31 ± 13	43 ± 10	35 ± 8.6	38 ± 9.3	34 ± 8.7	14 ± 11	16 ± 9.1
Th-232	0.007	16 ± 11	7.9 ± 6.7	14 ± 5.1	6.1 ± 2.9	6.8 ± 3.2	13 ± 4.8	9.9 ± 8.5	25 ± 11
U-234	0.09	970 ± 34	950 ± 50	2200 ± 130	610 ± 28	560 ± 28	750 ± 36	480 ± 20	2100 ± 110
U-235	0.1	45 ± 2.2	43 ± 1.8	110 ± 4.5	27 ± 1.1	26 ± 1.1	36 ± 1.4	22 ± 1.0	99 ± 4.1
U-236	0.1	61 ± 2.5	61 ± 2.7	150 ± 4.9	38 ± 1.6	35 ± 1.5	47 ± 1.8	29 ± 1.2	130 ± 4.3
U-238	0.1	800 ± 35	870 ± 29	2400 ± 95	550 ± 23	560 ± 20	720 ± 23	410 ± 16	2000 ± 84
U Total	. . .[6]	1900 ± 50	1900 ± 58	4900 ± 160	1200 ± 36	1200 ± 34	1600 ± 43	940 ± 26	4400 ± 140

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TABLE 11
RADIONUCLIDES IN AIR
(page 2 of 2)

Radionuclide	Derived Concentration Guides[4] $\mu Ci/m^3 \times 10^{-6}$	Concentration of Radionuclides at Air Monitoring Stations[1,2,3] in $\mu Ci/m^3 \times 10^{-12}$				
		AMS 9	AMS 10	AMS 11	AMS 12	AMS 13
Cs-137	400	< 25	44 ± 73	65 ± 76	< 47	< 37
Np-237	0.02	4.3 ± 3.0	< 85	< 93	< 100	< 100
Pu-238	0.03	7.3 ± 4.3	3.3 ± 5.6	3.5 ± 5.1	3.6 ± 5.5	2.9 ± 7.4
Pu-239/240	0.02	6.1 ± 3.5	3.8 ± 4.2	4.8 ± 4.5	7.4 ± 5.7	2.1 ± 6.6
Pu-241	1	27 ± 0.29	1200 ± 1100	570 ± 960	500 ± 601	150 ± 640
Ra-226	1	81 ± 20	< 750	< 900	<930	< 670
Ra-228	3	69 ± 17	< 200	< 180	< 200	< 170
Ru-106[5]	30	< 501	< 330	< 330	< 400	< 370
Sr-90	9	82 ± 25	< 58	< 150	780 ± 150	230 ± 150
Tc-99	2000	3900 ± 580	1100 ± 140	605 ± 140	410 ± 94	1100 ± 146
Th-228	0.04	16 ± 6.5	62 ± 22	60 ± 22	81 ± 17	44 ± 21
Th-230	0.04	17 ± 6.5	30 ± 13	28 ± 15	33 ± 8.6	31 ± 13
Th-232	0.007	13 ± 5.2	11 ± 6.0	17 ± 12	6.1 ± 4.4	13 ± 8.0
U-234	0.09	4100 ± 220	350 ± 55	290 ± 48	140 ± 27	620 ± 97
U-235	0.1	200 ± 8.0	16 ± 2.6	14 ± 2.2	6.6 ± 1.3	29 ± 4.5
U-236	0.1	230 ± 9.6	22 ± 3.4	18 ± 3.0	8.8 ± 1.7	38 ± 6.0
U-238	0.1	4100 ± 170	320 ± 51	270 ± 45	130 ± 26	580 ± 91
U Total	. . .[6]	8600 ± 280	710 ± 110	600 ± 99	290 ± 56	1300 ± 200

0305-61

1. See Figure 5.
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 51 weekly samples at AMS 2, 45 weekly samples at AMS 12, and 52 weekly samples at all other air monitoring stations.
4. Derived concentration guides from DOE Order 5480.xx, 4-23-87. Continuous inhalation of this concentration will result in an effective dose equivalent of 100 mrem/yr (1 mSv/yr).
5. Composite sample activity adjusted to midpoint of sampling.
6. Not Applicable.

TABLE 12
URANIUM CONCENTRATIONS IN ROUTINE SOIL SAMPLES, 1987
(page 1 of 2)

Sampling Location[1]	Depth Sampled	Concentration[2] pCi/g dry wt. 1986		1987	
1	0 - 5 cm	4.67	(0.17)	4.9	(0.18)
	5 - 10 cm	3.39	(0.13)	3.0	(0.11)
2	0 - 5 cm	10.16	(0.38)	11.0	(0.41)
	5 - 10 cm	6.03	(0.22)	7.0	(0.26)
3	0 - 5 cm	46.37	(1.72)	56.0	(2.07)
	5 - 10 cm	31.14	(1.15)	14.0	(0.52)
4	0 - 5 cm	5.42	(0.20)	5.2	(0.19)
	5 - 10 cm	6.36	(0.24)	3.0	(0.11)
5	0 - 5 cm	6.16	(0.23)	8.4	(0.31)
	5 - 10 cm	4.06	(0.15)	4.5	(0.17)
6	0 - 5 cm	6.79	(0.25)	10.4	(0.38)
	5 - 10 cm	3.99	(0.15)	6.9	(0.26)
7	0 - 5 cm	3.42	(0.13)	4.1	(0.15)
	5 - 10 cm	2.35	(0.09)	3.1	(0.12)
8	0 - 5 cm	2.30	(0.09)	2.7	(0.10)
	5 - 10 cm	1.90	(0.07)	1.6	(0.06)
9	0 - 5 cm	2.44	(0.09)	2.0	(0.07)
	5 - 10 cm	2.23	(0.08)	3.2	(0.12)
10	0 - 5 cm	1.42	(0.05)	2.2	(0.08)
	5 - 10 cm	1.35	(0.05)	1.6	(0.06)
11	0 - 5 cm	...[3]		7.7	(0.28)
	5 - 10 cm	...[3]		8.3	(0.31)
12	0 - 5 cm	1.56	(0.06)	...[3]	
	5 - 10 cm	1.83	(0.07)	...[3]	
13	0 - 5 cm	1.93	(0.07)	...[3]	
	5 - 10 cm	2.44	(0.09)	...[3]	
14	0 - 5 cm	2.50	(0.09)	...[3]	
	5 - 10 cm	3.39	(0.13)	...[3]	

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TABLE 12
URANIUM CONCENTRATIONS IN ROUTINE SOIL SAMPLES, 1987
(page 2 of 2)

Sampling Location[1]	Depth Sampled	Concentration[2] pCi/g dry wt. 1986		1987	
15	0 - 5 cm	2.03	(0.08)	...[3]	
	5 - 10 cm	1.96	(0.07)	...[3]	
16	0 - 5 cm	...[3]		2.3	(0.09)
	5 - 10 cm	...[3]		2.2	(0.08)
17	0 - 5 cm	...[3]		1.7	(0.06)
	5 - 10 cm	...[3]		1.4	(0.05)
18	0 - 5 cm	...[3]		1.4	(0.05)
	5 - 10 cm	...[3]		2.2	(0.08)

0305-62

1. See Figure 16.
2. < ± 20% uncertainty in results; Bq/g dry wt. in parentheses.
3. Not Sampled.

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TABLE 13
URANIUM AND FLUORIDE IN PARALLEL SOIL AND VEGETATION SAMPLES, 1987
(page 1 of 2)

Sampling Location[3]	Distance in km from FMPC[4]	Soil[1]			Vegetation[2]			
		Sample Depth	Total Uranium pCi/g dry[5]		Total Uranium pCi/g dry[5]		Fluoride (ppm)	% of Fluoride Standard [7]
1	6.5	0-5 cm	...[8]		0.20	(0.0075)	11.9	14.9
		5-10 cm	...[8]					
2	4.1	0-5 cm	1.2	(0.045)	0.23	(0.0085)	4.24	5.30
		5-10 cm	1.4	(0.050)				
3	6.2	0-5 cm	2.3	(0.085)	0.020	(0.00075)	4.79	5.99
		5-10 cm	2.1	(0.078)				
4	8.7	0-5 cm	3.3	(0.12)	0.11	(0.0040)	3.50	4.38
		5-10 cm	1.8	(0.068)				
5	2.7	0-5 cm	...[8]		0.12	(0.0043)	4.60	5.75
		5-10 cm	...[8]					
6	1.4	0-5 cm	3.2	(0.12)	0.33	(0.012)	3.42	4.28
		5-10 cm	1.9	(0.070)				
7	1.5	0-5 cm	6.1	(0.23)	0.081	(0.0030)	2.76	3.45
		5-10 cm	3.9	(0.14)				
8	1.3	0-5 cm	15.0	(0.554)	0.20	(0.0073)	4.79	5.99
		5-10 cm	9.34	(0.346)				
9	1.0	0-5 cm	23.8	(0.882)	0.39	(0.015)	3.41	4.26
		5-10 cm	12.7	(0.468)				
10	0.7	0-5 cm	14.2	(0.526)	0.961	(0.0356)	4.74	5.93
		5-10 cm	6.8	(0.25)				
11	0.8	0-5 cm	2.03	(0.0751)	0.32	(0.012)	3.25	4.06
		5-10 cm	1.76	(0.0651)				
12	1.9	0-5 cm	2.37	(0.0877)	1.03	(0.0381)	3.65	4.56
		5-10 cm	3.11	(0.115)				
13	0.7	0-5 cm	7.79	(0.288)	0.35	(0.013)	3.44	4.30
		5-10 cm	16.4	(0.606)				
14	0.8	0-5 cm	9.88	(0.366)	0.32	(0.012)	3.48	4.35
		5-10 cm	8.12	(0.301)				
15	0.7	0-5 cm	5.9	(0.22)	0.28	0.010	2.49	3.11
		5-10 cm	4.6	(0.17)				
16	0.7	0-5 cm	4.9	(0.18)	0.45	(0.017)	3.64	4.55
		5-10 cm	3.5	(0.13)				

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TABLE 13
URANIUM AND FLUORIDE IN PARALLEL SOIL AND VEGETATION SAMPLES, 1987
(page 2 of 2)

Sampling Location[3]	Distance in km from FMPC[4]	Soil[1]			Vegetation[2]			
		Sample Depth	Total Uranium pCi/g dry[5]		Total Uranium pCi/g dry[5]		Fluoride (ppm)	% of Fluoride Standard [7]
17	2.3	0-5 cm	4.3	(0.16)	0.22	(0.0080)	5.76	7.20
		5-10 cm	2.5	(0.09)				
18	1.9	0-5 cm	6.5	(0.24)	0.28	(0.010)	3.39	4.24
		5-10 cm	3.1	(0.12)				
19	4.0	0-5 cm	3.0	(0.11)	0.14	(0.0050)	4.13	5.16
		5-10 cm	2.5	(0.09)				
20	1.4	0-5 cm	4.5	(0.17)	0.27	(0.010)	7.18	8.98
		5-10 cm	2.4	(0.09)				

0305-63

1. Parallel soil samples taken at depth intervals of 0-5 cm and 5-10 cm.
2. Plant material primarily brome grass (Bromus sp.), but other genera represented: Allium, Daucus, Hordeum, Medicago, Melilotus, Poa, Secale and Triticum.
3. See Figure 18.
4. For the purpose of this table, the center of the production area was used for distance measurements.
5. Bq/g in parentheses.
6. CL = ± 2 sigma.
7. No Ohio standard established; Kentucky standard of 80 ppm used.
8. Not Sampled.

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TABLE 14
AVERAGE URANIUM CONCENTRATION IN SOIL, FERTILIZER AND FARM AND GARDEN PRODUCE WITHIN 63 KM (39 MI) OF THE FMPC, 1987
(Page 1 of 2)

Location[1] Garden Number	1	2	3	4	5	6	7	8	9
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9	2.0	6.2
Soil/Fertilizer[2]									
Soil	1.9	2.0	5.5	...[3]	7.65	3.6	2.6	...[3]	3.2
Fertilizer	2.5	...[3]	...[3]	...[3]	...[3]	...[3]	5.0	...[3]	...[3]
Leafy Vegetables[2]									
Cabbage	0.00088 ± 0.0005	...[3]	...[3]	...[3]	< 0.0007	...[3]	...[3]	...[3]	...[3]
Roots & Stems[2]									
Carrots	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	0.0018 ±0.0005	...[3]
Onions	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	0.0024 ±0.0003	< 0.0007	...[3]
Potatoes	< 0.0007	...[3]	0.0051 ±0.0013	...[3]	< 0.0007	...[3]	0.0023 ±0.0005	...[3]	< 0.0007
Potatoes, Sweet	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	< 0.0007	0.0035 ±0.00081
Turnip	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	0.0018 ±0.0007	...[3]

0305-64

1. Garden numbers shown correspond to locations shown in Figure 19. Locations 10, 11, 12, and 13 were not sampled.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037
3. Not sampled.

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TABLE 14
AVERAGE URANIUM CONCENTRATION IN SOIL, FERTILIZER AND FARM AND GARDEN PRODUCE WITHIN 63 KM (39 MI) OF THE FMPC, 1987
(Page 2 of 2)

Location[1] Garden Number	1	2	3	4	5	6	7	8	9
Approx. Dist. (km)	3.6	1.6	1.9	62.8	1.9	2.7	1.9	2.0	6.2
Fruit[2]									
Beans, Green	0.0015 ±0.0002	...[3]	...[3]	...[3]	0.0012 ±0.0002	...[3]	...[3]	...[3]	0.0056 ±0.00088
Beans, Lima	0.0020 ±0.0003	...[3]	...[3]	...[3]	< 0.0007	...[3]	...[3]	...[3]	0.0115 ±0.0020
Beans Soy	...[3]	...[3]	...[3]	...[3]	...[3]	0.0041 ±0.00081	...[3]	...[3]	...[3]
Broccoli	0.00068 ±0.0001	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]
Corn	...[3]	...[3]	...[3]	...[3]	0.0052 ±0.0011	...[3]	...[3]	...[3]	...[3]
Cucumber	0.0011 ±0.0002	...[3]	...[3]	...[3]	...[3]	...[3]	...[3]	0.0010 ±0.0001	...[3]
Peppers, Green	0.0016 ±0.0002	...[3]	...[3]	...[3]	0.00088 ±0.0001	0.00095 ±0.0001	...[3]	< 0.0007	0.0012 ±0.0002
Pumpkin	< 0.0007	...[3]	...[3]	...[3]	0.0016 ±0.0003	...[3]	< 0.0007	...[3]	...[3]
Squash, Butter	< 0.0007	...[3]	...[3]	...[3]	...[3]	...[3]	< 0.0007	...[3]	0.0030 ±0.00074
Tomato	0.0007 ± 0.0003	0.0074 ±0.0020	0.0020 ± 0.0005	...[3]	0.0028 ±0.0003	0.00081 ±0.0001	0.0011 ±0.0002	< 0.0007	0.0012 ±0.0002

0305-64

1. Garden numbers shown correspond to locations shown in Figure 19. Locations 10, 11, 12, and 13 were not sampled.
2. pCi/g dry weight. Bq/g = pCi/g x 0.037.
3. Not sampled.

TABLE 15
ONSITE WELL NAME EQUIVALENTS, 1986 - 87

1986 Onsite Well Name	1987 Onsite Well Name
P1	P1
P2	P2
P3	P3
T1s	301
T1d	401
T3	303
T4	204
T5	305
T8s	308
T8d	408
T9	309
T10	310
T11	211

0305-65

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TABLE 16
URANIUM IN ONSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	Concentration pCi/l				
		Minimum	Maximum	Average[2]	95% C.L.[3]	% of Standard[4]
204	12	3.7	7.4	5.4 (0.20)	0.70	...[5]
211	12	0.07	0.5	0.2 (0.007)	0.1	...[5]
301	11	6.8	12	9.4 (0.35)	1.1	...[5]
303	12	1.5	677	65 (2.4)	118	...[5]
305	10	2.4	11	4.2 (0.16)	1.6	...[5]
308	12	0.20	26	3.4 (0.13)	4.4	...[5]
309	12	0.74	1.4	1.1 (0.041)	0.12	...[5]
310	12	10	17	14 (0.52)	1.3	...[5]
401	12	0.1	0.7	0.3 (0.01)	0.1	...[5]
408	12	0.1	0.8	0.3 (0.01)	0.1	...[5]
P1	11	0.07	2	0.3 (0.01)	0.3	0.8
P2	11	0.07	0.7	0.2 (0.007)	0.1	0.5
P3	12	0.1	0.3	0.2 (0.007)	0.03	0.5

0305-66

1. See Figure 20.
2. Bq/l in parentheses.
3. C.L. = confidence level; ± value applicable to the average concentration.
4. Standard used is 40 pCi/l (1.5 Bq/l). This value is the median value in the range of values (30 to 50 pCi/l) which DOE has directed WMCO to use as interim drinking water limits for natural uranium. (DOE letter 288-88). Percent of Standard relates to the average value.
5. Not applicable.

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TABLE 17
GROSS ALPHA CONCENTRATIONS IN ONSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	Concentration pCi/l				
		Minimum	Maximum	Average[2]	95% C.L.[3]	% of Standard[4]
204	4	2.7	4.1	4.0 (0.1)	1.0	...[5]
211	4	< 0.9	1	< 1 (0.04)	0.3	...[5]
301	3	14	18	15 (0.55)	4.7	...[5]
303	4	2.3	54	16 (0.59)	35	...[5]
305	3	2	4	3 (0.1)	1	...[5]
308	4	0.5	3	1 (0.04)	2	...[5]
309	4	1	3	2 (0.07)	0.8	...[5]
310	4	8.6	14	11 (0.41)	3.8	...[5]
401	4	< 0.5	1	< 1 (0.04)	0.6	...[5]
408	4	< 0.9	3	< 1 (0.04)	1	...[5]
P1	3	2	4	3 (0.1)	2	6
P2	3	0.9	3	2 (0.07)	2	4
P3	4	< 0.9	1	< 1 (0.04)	0.3	7

0305-67

1. See Figure 20.
2. Bq/l in parentheses.
3. C.L. = confidence level; ± value applicable to the average concentration.
4. DOE has directed WMCO to use the USEPA standard for gross alpha activity in drinking water which is 15 pCi/l (0.6 Bq/l). This standard applies only to water sampled from the FMPC production wells. There is currently no gross alpha standard which can be applied to surface water or monitoring wells which are not drinking water sources. Percent of Standard relates to the average value.
5. Not Applicable.

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TABLE 18
GROSS BETA CONCENTRATIONS IN ONSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	Concentration pCi/l				
		Minimum	Maximum	Average[2]	95% C.L.[3]	% of Standard[4]
204	4	6.3	8.1	7.1 (0.26)	1.1	...[5]
211	4	1.4	3.2	2.1 (0.078)	1.1	...[5]
301	3	6.3	9.5	8.1 (0.30)	3.2	...[5]
303	4	5.4	52	18 (0.67)	32	...[5]
305	3	5.0	5.9	5.4 (0.20)	0.92	...[5]
308	4	1.4	12	5.3 (0.19)	6.2	...[5]
309	4	13	16	15 (0.55)	2.1	...[5]
310	4	24	31	27 (1.0)	5.3	...[5]
401	4	< 0.45	2.7	< 1.5 (0.056)	1.4	...[5]
408	4	1.4	2.3	1.7 (0.063)	0.64	...[5]
P1	3	4.5	5.4	5.1 (0.19)	1.0	10
P2	3	2.3	4.1	3.0 (0.11)	1.9	6.0
P3	4	1.8	2.7	2.3 (0.085)	0.51	4.6

0305-68

1. See Figure 20.
2. Bq/l in parentheses.
3. C.L. = confidence level; ± value applicable to the average concentration.
4. DOE has directed WMCO to use the USEPA standard for gross beta activity in drinking water which is 50 pCi/l (1.9 Bq/l). This standard applies only to water sampled from the FMPC production wells. There is currently no gross beta standard which can be applied to surface water or monitoring wells which are not drinking water sources. Percent of Standard relates to the average value.
5. Not Applicable.

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TABLE 19
NITRATE-NITROGEN IN ONSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	Concentration mg/l				
		Minimum	Maximum	Average	95% C.L.[2]	% of Standard[3]
204	4	0.30	2.0	1.3	1.1	13
211	4	< 0.1	0.3	< 0.2	0.1	2
301	3	< 0.1	0.1	< 0.1	...[4]	1
303	4	< 0.1	0.1	< 0.1	...[4]	1
305	3	< 0.1	0.1	< 0.1	...[4]	1
308	4	< 0.1	0.1	< 0.1	...[4]	1
309	4	1.1	2.2	1.4	0.71	14
310	4	67	155	118	54.8	1178
401	4	< 0.1	0.1	< 0.1	...[4]	1
408	4	< 0.1	0.1	< 0.1	...[4]	1
P1	3	0.2	0.6	0.4	0.4	4
P2	3	0.1	0.4	0.2	0.3	2
P3	4	< 0.1	0.2	< 0.1	0.1	1

0305-69

1. See Figure 20.
2. C.L. = confidence level; ± value applicable to the average concentration.
3. 10 mg/l per 40 CFR Part 141, National Interim Primary Drinking Water Standard. Percent of Standard relates to the average value.
4. Not Applicable

TABLE 20
SULFATE IN ONSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	Concentration mg/l				
		Minimum	Maximum	Average	95% C.L.[2]	% of Standard[3]
204	4	49	74	61	14	24
211	3	77	80	78	3.1	31
301	3	66	76	71	10	29
303	4	77	82	79	3.3	31
305	3	60	74	67	14	27
308	4	2.0	26	17	15	6.7
309	4	64	71	67	4.6	27
310	4	641	721	671	48.5	268
401	3	2.0	11	6.0	9.9	2.4
408	4	7.0	26	12	13	4.9
P1	3	105	126	112	24.6	44.8
P2	3	23.0	182	78.3	182	31.3
P3	4	37	42	40	3.0	16

0305-70

1. See Figure 20.
2. C.L. = confidence level; ± value applicable to the average concentration.
3. 250 mg/l per 40 CFR Part 143, National Interim Secondary Drinking Water Standard. Percent of Standard relates to the average value.

TABLE 21
CHLORIDE IN ONSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	Concentration mg/l				
		Minimum	Maximum	Average	95% C.L.[2]	% of Standard[3]
204	4	22	25	24	2.1	9.5
211	4	19	21	20	1.1	8.0
301	3	17	20	19	3.1	7.5
303	4	19	21	20.5	1.4	8.2
305	3	16	19	17	3.1	6.9
308	4	13	19	17	4.0	6.9
309	4	18	23	21	3.0	8.4
310	4	63	90	79	16	32
401	4	18	22	20.3	2.4	8.1
408	4	12	13	12.3	0.69	4.9
P1	3	29	40	35	11	14
P2	3	23	41	29	21	12
P3	4	10	30	16	13	6.2

0305-71

1. See Figure 20.
2. C.L. = confidence level; ± value applicable to the average concentration.
3. 250 mg/l per 40 CFR Part 143, National Interim Secondary Drinking Water Standard. Percent of Standard relates to the average value.

4

TABLE 22
pH IN ONSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	pH Range		
204	4	7.4	to	7.5
211	4	7.4	to	7.6
301	3	7.4	to	7.5
303	4	7.5	to	7.5
305	3	7.4	to	7.6
308	4	7.5	to	8.2
309	4	7.5	to	7.6
310	4	6.9	to	7.0
401	4	7.4	to	7.6
408	4	7.4	to	7.5
P1	3	7.4	to	7.5
P2	3	7.4	to	7.5
P3	4	7.4	to	7.5

0305-72

1. See Figure 20.

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TABLE 23
URANIUM IN OFFSITE WELL WATER, 1987

Sampling Point[1]	Number of Samples	Concentration pCi/l					
		Minimum	Maximum	Average[2]		95% C.L.[3]	% of Standard[4]
1	9	0.1	0.3	0.2	(0.007)	0.06	0.5
2	...[5]	...[5]	...[5]	...[5]	...[5]	...[6]	...[6]
3	12	0.07	0.3	0.2	(0.007)	0.04	0.5
4	12	0.81	2.0	1.4	(0.052)	0.17	3.5
5	12	1.1	1.8	1.4	(0.052)	0.11	3.5
6	3	1.0	1.4	1.2	(0.044)	0.35	3.0
7	12	0.68	1.4	1.1	(0.041)	0.12	2.8
8	12	0.47	1.2	0.66	(0.024)	0.13	1.7
9	12	0.74	1.2	0.97	(0.036)	0.064	2.4
10	12	0.34	0.81	0.47	(0.017)	0.076	1.2
11	12	0.81	1.2	1.0	(0.039)	0.070	2.5
12	12	88.0	278	201	(7.44)	32.4	...[6]
13	12	0.3	0.61	0.5	(0.02)	0.06	1
14	12	0.61	1.2	0.89	(0.033)	0.10	2.2
15	12	169	223	201	(7.44)	9.98	...[6]
16	12	0.34	0.68	0.48	(0.018)	0.057	1.2
17	11	29	75	40	(1.5)	8.1	...[6]
18	11	0.07	0.6	0.4	(0.01)	0.07	1
19	12	0.1	0.4	0.2	(0.007)	0.05	0.5
20	10	0.07	0.5	0.2	(0.007)	0.07	0.5
21	12	0.2	0.5	0.3	(0.01)	0.05	0.8
22	12	0.54	1.1	0.80	(0.030)	0.10	2.0
23	12	0.41	0.74	0.56	(0.021)	0.064	1.4
24	1	0.4	0.4	0.4	(0.01)	...[6]	1
25	11	0.4	0.6	0.5	(0.02)	0.04	1
26	12	0.20	1.6	0.39	(0.014)	0.26	0.98
27	12	0.34	1.2	0.69	(0.026)	0.20	1.7
28	0	...[5]	...[5]	...[5]	...[5]	...[6]	...[6]
29	12	1.2	1.7	1.4	(0.052)	0.11	3.5
30	7	0.3	0.4	0.4	(0.01)	0.02	1

0305-73

1. See Figure 21.
2. Bq/l in parentheses.
3. C.L. = confidence level; ± value applicable to the average concentration.
4. Percent of Standard relates to the average value reported. Standard used is 40 pCi/l (1.5 Bq/l). This value is the median value in the range of values (30 to 50 pCi/l) which WMCO has been directed to use as an interim drinking water limit for natural uranium in drinking water. See letter DOE-288-88.
5. Not Sampled.
6. Not Applicable.

TABLE 24
METALS IN OFFSITE WELL WATER, 1987

Sampling Point[1]	Concentration 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	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]
2	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]
3	< 0.001	0.018	0.480	85.3	< 0.001	< 0.001	0.004	2.950	1.140	29.1	0.020	30.8	< 0.001	0.002	0.001	0.010
4	< 0.001	0.002	< 0.050	141	< 0.001	< 0.001	0.012	0.110	2.040	72.2	< 0.010	49.2	0.002	0.003	0.011	0.020
5	0.039	0.003	0.050	150	< 0.001	< 0.001	0.003	0.290	2.430	67.3	0.050	37.4	< 0.001	0.003	0.010	0.020
6	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]
7	< 0.001	0.016	0.070	116	< 0.001	< 0.001	0.003	0.690	1.840	37.5	0.180	8.5	< 0.001	0.003	0.005	0.050
8	< 0.001	0.002	0.060	96.4	< 0.001	< 0.001	0.003	0.120	2.340	33.3	0.160	14.2	0.002	< 0.001	0.004	0.020
9	< 0.001	0.002	0.080	83.6	< 0.001	< 0.001	0.003	0.120	3.140	32.0	0.300	25.2	0.002	< 0.001	0.005	< 0.010
10	< 0.001	0.004	0.050	98	< 0.001	< 0.001	0.002	1.850	1.720	29.3	0.270	10.1	< 0.001	0.001	0.004	< 0.010
11	< 0.001	0.005	0.050	87.5	< 0.001	< 0.001	0.037	0.150	2.020	28.9	< 0.010	19.8	0.002	0.004	0.004	0.160
12	< 0.001	0.004	0.050	96.2	0.001	< 0.001	0.007	0.150	3.020	28.6	0.080	17.8	< 0.001	0.003	0.004	0.170
13	< 0.001	0.002	< 0.050	101	< 0.001	< 0.001	0.015	0.140	2.450	33.7	0.070	10.4	< 0.001	0.002	0.004	0.020
14	< 0.001	0.004	0.100	11.7	< 0.001	< 0.001	0.003	0.800	4.400	38.9	0.350	17.0	0.002	0.002	0.005	0.010
15	< 0.001	0.004	< 0.050	89.9	< 0.001	< 0.001	0.036	0.310	2.900	26.6	0.085	12.2	0.001	0.002	0.004	0.060
16	< 0.001	0.004	0.080	103	< 0.001	< 0.001	0.002	0.160	2.250	32.8	0.070	24.5	0.002	< 0.001	0.004	< 0.010
17	< 0.001	0.003	0.060	95.3	< 0.001	< 0.001	< 0.001	1.110	2.400	26.9	0.450	11.6	< 0.001	< 0.001	0.003	< 0.010
18	< 0.001	0.006	0.070	104	< 0.001	< 0.001	0.002	2.220	2.070	32.0	0.280	9.22	0.001	< 0.001	0.005	< 0.010
19	< 0.001	0.048	< 0.050	96.6	< 0.001	< 0.001	0.002	1.100	24.040	34.8	0.240	20.4	0.002	0.001	0.008	< 0.010
20	0.005	0.038	< 0.050	< 1.0	0.002	0.004	0.003	0.120	401.0	0.6	< 0.010	231	0.002	0.052	0.034	< 0.010
21	< 0.001	0.006	0.080	106	< 0.001	< 0.001	0.002	1.830	2.140	31.4	0.320	9.5	0.001	< 0.001	0.005	0.020
22	< 0.001	0.001	< 0.050	89	< 0.001	< 0.001	0.003	0.200	2.450	26.1	0.090	10.8	0.001	< 0.001	0.005	< 0.010
23	0.001	0.002	< 0.050	1.0	0.001	< 0.001	< 0.055	0.120	0.750	< 0.10	< 0.010	147	0.001	0.002	0.007	< 0.010
24	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]
25	< 0.001	0.002	0.050	114	< 0.001	< 0.001	0.006	0.120	1.830	38.8	0.100	7.02	0.002	0.001	0.005	0.040
26	< 0.001	0.007	0.070	101	< 0.001	< 0.001	0.001	2.100	1.430	29.0	0.390	6.28	< 0.001	0.002	0.004	0.090
27	< 0.001	0.002	0.060	105	< 0.001	< 0.001	0.036	0.120	2.110	26.6	< 0.010	17.1	0.002	0.001	0.003	0.060
28	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]	...[4]
29	< 0.001	0.005	0.080	111	< 0.001	< 0.001	0.002	1.960	2.400	37.0	0.260	9.88	0.002	< 0.001	0.005	0.040
30	< 0.001	0.002	< 0.050	85.0	< 0.001	< 0.001	0.015	0.150	2.120	25.8	< 0.010	10.9	0.001	0.004	0.003	< 0.010

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FOOTNOTES FOR TABLE 24

1. See Figure 21. Samples were not taken at sampling points 1, 2, 6, 24, and 28.
2. USEPA Drinking Water Guidelines: (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. USEPA Drinking Water Guidelines: (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.
4. Not Sampled.

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TABLE 25
RADIONUCLIDES IN SURFACE WATER, 1987
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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]	pCi/l[6]
Gross Alpha	W1	52	< 0.9	< 4	< 2	(< 0.07)	0.2	...[8]	...[7]
	W3	52	1.4	5.9	3.0	(0.11)	0.27	...[8]	
	W4	52	0.90	8.1	3.1	(0.11)	0.36	...[8]	
	W5	52	< 0.9	< 4	< 2	(< 0.07)	0.2	...[8]	
	W7	20	1.8	16	6.1	(0.23)	1.5	...[8]	
	W8	32	0.90	5.4	2.5	(0.093)	0.43	...[8]	
	W9	49	< 0.90	< 6.3	< 2.3	(< 0.085)	0.32	...[8]	
	W10	32	< 0.90	< 59	< 5.6	(< 0.21)	3.6	...[8]	
	W11	18	0.90	9.0	5.9	(0.22)	0.94	...[8]	
Gross Beta	W1	52	2.7	8.6	5.2	(0.19)	0.39	...[8]	...[7]
	W3	52	2.7	41	12	(0.44)	2.6	...[8]	
	W4	52	2.7	108	16	(0.59)	4.7	...[8]	
	W5	52	2.7	17	5.3	(0.20)	0.70	...[8]	
	W7	20	1.8	18	5.9	(0.22)	1.5	...[8]	
	W8	32	1.4	32	4.1	(0.15)	1.8	...[8]	
	W9	49	2.7	17	5.3	(0.20)	0.69	...[8]	
	W10	32	3.2	27	5.5	(0.20)	1.5	...[8]	
	W11	18	3.6	9.5	5.6	(0.21)	0.80	...[8]	
Cs-137	W1	2	< 3.62	< 4.16	< 3.89	(< 0.14)	...[8]	< 0.13	3000
	W3	2	< 3.46	< 3.49	< 3.48	(< 0.13)	...[8]	< 0.12	
	W4	2	< 2.00	< 2.51	< 2.26	(< 0.08)	...[8]	< 0.075	
Ra-226	W1	12	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	100
	W3	12	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	
	W4	12	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	
	W5	6	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	
	W7	9	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	
	W8	3	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	
Ra-228	W1	12	< 0.5	< 0.9	< 0.5	(< 0.02)	...[8]	< 0.5	100
	W3	12	< 0.5	< 0.9	< 0.5	(< 0.02)	...[8]	< 0.5	
	W4	12	< 0.5	< 0.9	< 0.6	(< 0.02)	...[8]	< 0.5	
	W5	6	< 0.5	< 0.9	< 0.6	(< 0.02)	...[8]	< 0.5	
	W7	9	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	
	W8	3	< 0.5	< 0.5	< 0.5	(< 0.02)	...[8]	< 0.5	
Sr-90	W1	2	< 0.6	< 0.6	< 0.6	(< 0.02)	...[8]	< 0.060	1000
	W3	2	< 0.6	< 0.7	< 0.7	(< 0.03)	...[8]	< 0.070	
	W4	2	< 0.6	< 0.6	< 0.6	(< 0.02)	...[8]	< 0.060	

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TABLE 25
RADIONUCLIDES IN SURFACE WATER, 1987
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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]	pCi/l[6]
Tc-99	W1	2	< 13.5	< 13.5	< 13.5	(< 0.50)	. . .[8]	< 0.01	100,000
	W3	2	< 11.9	< 20.9	< 16.4	(< 0.61)	. . .[8]	< 0.02	
	W4	2	< 12.5	< 15.7	< 14.1	(< 0.52)	. . .[8]	< 0.01	
U-234	W1	2	1.1	1.3	1.2	(0.04)	0.90	0.24	500
	W3	2	1.0	1.1	1.1	(0.04)	0.45	0.22	
	W4	2	1.1	1.3	1.2	(0.04)	0.90	0.24	
U-235/U-236	W1	2	0.2	0.2	0.2	(0.007)	. . .[8]	0.04	550
	W3	2	< 0.2	< 0.2	< 0.2	(< 0.007)	. . .[8]	< 0.04	
	W4	2	< 0.2	< 0.2	< 0.2	(< 0.007)	. . .[8]	< 0.04	
U-238	W1	2	0.8	1.2	1.0	(0.037)	1.80	0.17	600
	W3	2	1.1	1.2	1.2	(0.044)	0.45	0.20	
	W4	2	1.0	1.1	1.1	(0.041)	0.45	0.18	
Uranium	W1	52	0.74	2.2	1.2	(0.044)	0.089	0.22	550
	W3	52	0.88	3.9	1.6	(0.059)	0.14	0.29	
	W4	52	1.0	3.0	1.7	(0.063)	0.14	0.31	
	W5	52	0.47	3.6	1.0	(0.037)	0.11	0.18	
	W7	20	1.5	16	5.8	(0.21)	1.5	1.05	
	W8	32	0.74	4.7	1.9	(0.070)	0.32	0.35	
	W9	49	0.68	5.9	1.7	(0.063)	0.32	0.31	
	W10	32	1.1	88	6.8	(0.25)	5.4	1.24	
	W11	18	1.8	15	5.8	(0.21)	1.4	1.05	

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1. See Figure 30.
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. = confidence level; ± value applicable to the average concentration.
5. Percent of Standard is calculated from average value. Neither the Great Miami nor Paddy's Run is used as a source of public drinking water downstream from the FMPC, but DOE effluent discharge standards have been used in these calculations.
6. Drinking Water Guidelines from DOE Draft Order 5480.XX.
7. No applicable DOE Standard.
8. Not applicable.

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TABLE 26
ION AND pH LEVELS IN SURFACE WATER, 1987

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	0.9	0.5	0.06	28	1.8 mg/l
	W3	52	0.3	0.8	0.5	0.6	28	
	W4	52	0.2	0.8	0.5	0.6	28	
	W5	13	0.1	0.3	0.2	0.03	11	
	W7	10	0.1	1	0.3	0.2	17	
	W8	11	0.1	0.2	0.1	0.03	6	
	W9	12	0.2	2	0.4	0.3	22	
	W10	9	0.2	0.6	0.3	0.08	17	
	W11	8	0.2	0.9	0.3	0.2	17	
Nitrate (as N)	W1	52	0.90	6.1	3.4	0.31	34	10 mg/l
	W3	52	1.0	6.3	3.3	0.33	33	
	W4	52	0.70	5.8	3.2	0.33	32	
	W5	12	0.20	2.8	1.3	0.56	13	
	W7	10	0.10	5.4	1.9	1.0	19	
	W8	11	0.1	0.4	0.2	0.07	2	
	W9	12	0.10	2.9	1.2	0.59	12	
	W10	9	0.20	2.3	1.4	0.54	14	
	W11	8	0.70	5.4	2.3	1.1	23	
Chloride	W1	52	24.0	118	71.5	7.53	28.6	250 mg/l
	W3	52	22.0	116	71.8	7.41	28.7	
	W4	52	22.0	116	71.9	7.44	28.8	
	W5	12	16	50	32	6.4	13	
	W7	10	4.0	28	19	5.6	7.6	
	W8	10	5.0	57	18	11	7.2	
	W9	12	18	38	29	3.8	12	
	W10	9	14	35	25	4.3	10	
	W11	8	11	28	22	4.3	8.8	
pH[4]	W1	52	8.0	9.0	8.4	0.067	...[5]	6.5 - 9.0
	W3	52	8.1	9.0	8.4	0.070	...[5]	
	W4	52	8.0	9.1	8.5	0.078	...[5]	
	W5	52	7.7	8.3	8.0	0.045	...[5]	
	W7	20	7.6	8.4	8.2	0.10	...[5]	
	W8	32	7.3	8.3	7.7	0.069	...[5]	
	W9	49	7.9	8.6	8.2	0.035	...[5]	
	W10	32	7.8	8.4	8.2	0.040	...[5]	
	W11	18	8.0	8.4	8.3	0.050	...[5]	

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1. See Figure 30.
2. C.L. = confidence level; ± value applicable to the average concentration.
3. OEPA Water Quality Standards, Administrative Code Chapter 3745-1 (Public Water Supply Use Designation).
4. pH is reported in standard units.
5. Average pH value is within the acceptable standard range.

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TABLE 27
RADIONUCLIDES RELEASED AT DISCHARGE 001, 1987

Radionuclide[1]	Total Curies 1986	Total Curies 1987[2]	Average Concentration[3] pCi/l	Standard[4] pCi/l	% of Standard[5]
Cs-137	$< 1.0 \times 10^{-3}$	$< 7.5 \times 10^{-3}$ (2.8×10^{8})	$< 9.3 \times 10^{0}$ (3.4×10^{-1})	3,000	< 0.3
Np-237	$< 1.0 \times 10^{-5}$	$< 2.4 \times 10^{-4}$ (8.9×10^{6})	$< 3.0 \times 10^{-1}$ (1.1×10^{-2})	30	< 1.0
Pu-238	$< 1.0 \times 10^{-5}$	$< 5.6 \times 10^{-5}$ (2.1×10^{6})	$< 7.0 \times 10^{-2}$ (2.6×10^{-3})	40	< 0.2
Pu-239/240	$< 1.0 \times 10^{-5}$	$< 5.6 \times 10^{-5}$ (2.1×10^{6})	$< 7.0 \times 10^{-2}$ (2.6×10^{-3})	30	< 0.2
Ra-226	$< 4.6 \times 10^{-3}$	$< 4.0 \times 10^{-3}$ (1.5×10^{8})	$< 5.0 \times 10^{0}$ (1.9×10^{-1})	100	< 5.0
Ra-228	$< 4.1 \times 10^{-3}$	$< 3.9 \times 10^{-3}$ (1.4×10^{8})	$< 4.9 \times 10^{0}$ (1.8×10^{-1})	100	< 4.9
Ru-106	$< 1.0 \times 10^{-2}$	$< 3.3 \times 10^{-2}$ (1.2×10^{9})	$< 4.1 \times 10^{1}$ (1.5×10^{0})	6000	< 0.7
Sr-90	9.0×10^{-4}	2.2×10^{-3} (8.2×10^{7})	2.8×10^{0} (1.0×10^{-1})	1000	0.3
Tc-99	1.5×10^{0}	2.7×10^{0} (1.0×10^{11})	3.3×10^{3} (1.2×10^{2})	100,000	3.3
Th-228	...[6]	$< 4.0 \times 10^{-4}$ (1.5×10^{7})	$< 5.0 \times 10^{-1}$ (1.8×10^{-2})	400	< 0.1
Th-230	...[6]	$< 4.8 \times 10^{-4}$ (1.8×10^{7})	$< 6.0 \times 10^{-1}$ (2.2×10^{-2})	300	< 0.2
Th-232	5.4×10^{-4}	$< 3.6 \times 10^{-4}$ (1.3×10^{7})	$< 4.5 \times 10^{-1}$ (1.7×10^{-2})	50	< 0.9
U-234	1.1×10^{-1}	2.4×10^{-1} (8.9×10^{9})	3.0×10^{2} (1.1×10^{1})	500	60.6
U-235	5.9×10^{-3}	1.2×10^{-2} (4.3×10^{8})	1.5×10^{1} (5.4×10^{-1})	600	2.4
U-236	2.0×10^{-2}	1.0×10^{-2} (3.8×10^{8})	1.3×10^{1} (4.8×10^{-1})	500	2.6
U-238	1.8×10^{-1}	2.6×10^{-1} (9.5×10^{9})	3.2×10^{2} (1.2×10^{1})	600	54.1
Uranium	3.1×10^{-1}	5.2×10^{-1} (1.9×10^{10})	6.6×10^{2} (2.4×10^{1})	550	119.6

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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) are determined from two 6-month composites.
2. Bq in parentheses.
3. Bq/l in parentheses.
4. As stated in DOE Draft Order 5480.XX, April 23, 1987.
5. Percent of Standard relates to the average value reported.
6. Not analyzed in 1986.

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TABLE 28
NPDES DATA, 1987

Sampling Location[1]/ 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	0.248	1.134	0.576	...[7]	...[7]	...[7]
pH	pH Units	Daily Grab	7.2	9.0	...[7]	Range = 6.5 to 10.0		100
Suspended Solids	mg/l[2]	53	2	88	13	40	20	94
Ammonia (as N)	mg/l	53	0.08	3.35	0.69	...[7]	...[7]	...[7]
Oil & Grease	mg/l	53	<5	<5	<5	15	...[7]	100
Residual Chlorine	mg/l	26[3]	< 0.02	< 0.09	< 0.06	0.1	...[7]	100
Nitrate (as N)	mg/l	53	0.2	202	36	...[7]	...[7]	...[7]
Discharge 002 (Storm Sewer Outfall)								
Flow Rate	MG/Event	Continuous	...[7]	...[7]	0.076	...[7]	...[7]	....[7]
pH	pH Units	Grab/Event	...[7]	...[7]	8.5	Range = 6.5 to 9.0		100
Suspended Solids	mg/l[2]	1[4]	...[7]	...[7]	50	100	30	100
Oil & Grease	mg/l	1[4]	...[7]	...[7]	5	15	...[7]	100
Sampling Location 001A (Sewage Treatment Plant)								
Flow Rate	MGD	Continuous	0.035	0.274	0.398	...[7]	...[7]	...[7]
pH	pH Units	Daily Grab	7.2	8.9	...[7]	Range = 6.5 to 9.0		100
BOD_5	mg/l	53	3	183	23	40	20	79
Suspended Solids	mg/l	53	1	82	26	40	20	60
Fecal Coliform	MPN/100ml[2]	26[3]	9	11000	2595[4]	2000	1000	96
BOD_5	kg/day	52	0.2	197.4	24.3	10	5	38
Suspended Solids	kg/day	52	0.2	111.4	26.9	10	5	27
Sampling Locations 001B & C (Combined General Sump & Clearwell)								
Flow Rate	MGD	Continuous	0.000	0.348	0.069	...[7]	...[7]	...[7]
Suspended Solids	kg/day	52	0.3	21.9	3.2	12.8	6.2	88
Chromium (+6)	kg/day	52	0.0001	0.006	0.0006	0.008	0.004	100
Chromium (total)	kg/day	52	0.0001	0.010	0.0012	0.102	0.050	100
Iron	kg/day	52	0.0030	0.743	0.0270	0.85	0.41	100
Nickel	kg/day	52	0.0001	0.017	0.0024	0.256	0.124	100
Copper	kg/day	52	0.0001	0.023	0.0028	0.051	0.025	100
Sampling Location 001D (Lift Station)								
Flow Rate	MGD	Continuous	0.114	0.703	0.227	...[7]	...[7]	...[7]
Suspended Solids	mg/l	52	<2	64	< 6.7	100	30	100
Oil & Grease	mg/l	52	<5	<5	<5	15	...[7]	100
Sampling Location 001E (Bioreactor)								
Flow Rate	MGD	Continuous	0	0.240	0.069	...[7]	...[7]	...[7]
Nitrate-Nitrogen	kg/day	29[6]	0.1	261.4	18.0	124	62	90
Ammonia-Nitrogen	kg/day	24[6]	0.01	2.09	0.32	18	12	100

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FOOTNOTES FOR TABLE 28

1. See Figure 37.
2. Flow-weighted averages.
3. Monitoring not required during winter months.
4. Geometric mean.
5. One overflow event, July 13, 1987. Flow value is total flow.
6. Unit began continuous external discharge in June, 1987.
7. Not Applicable.

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TABLE 29
RADIOISOTOPES IN GREAT MIAMI RIVER, PADDY'S RUN, AND STORM SEWER OUTFALL DITCH SEDIMENTS, 1987

		Isotope Concentration pCi/g (dry weight)											
Location[1]	Statistics	PU-238	Pu-239/ 240	Ra-224	Ra-226	Ra-228	Tc-99	Th-228	Th-230	Th-232	U-234	U-235/ 236	U-238
Paddy's Run Above Storm-sewer Outfall[2]													
	minimum	< 0.02	< 0.02	< 0.0792	< 0.217	< 0.154	< 1.0	0.18	0.34	0.17	0.24	< 0.02	0.2
	maximum	< 0.04	< 0.03	< 0.511	< 1.55	< 0.523	< 1.3	0.74	1.1	0.54	0.69	< 0.14	0.82
	average	< 0.02	< 0.02	< 0.213	< 0.673	< 0.322	< 1.1	0.35	0.63	0.33	0.41	< 0.051	0.43
	95% CL[3]	. . . [4]	. . . [4]	. . . [4]	. . . [4]	. . . [4]	. . . [4]	0.060	0.073	0.041	0.048	. . . [4]	0.053
Storm-sewer Outfall[2]													
	minimum	< 0.02	< 0.02	< 0.110	0.549	0.342	< 1.1	0.29	0.34	0.30	0.34	0.04	0.44
	maximum	< 0.02	< 0.03	< 2.96	1.92	2.86	< 1.3	2.81	1.1	2.19	10.6	0.59	10.3
	average	< 0.02	< 0.02	< 0.763	0.806	0.901	< 1.2	0.80	0.63	0.75	2.76	0.22	3.33
	95% CL[3]	. . . [4]	. . . [4]	. . . [4]	0.280	0.577	. . . [4]	0.520	0.073	0.42	2.14	0.13	2.28
Paddy's Run Below Storm-sewer Outfall[2]													
	minimum	< 0.02	< 0.02	< 0.10	< 0.25	< 0.11	< 1.1	0.13	0.44	0.16	0.34	0.02	0.04
	maximum	< 0.04	< 0.02	< 0.403	< 0.817	< 0.486	< 1.3	0.45	0.9	0.43	0.59	0.08	0.59
	average	< 0.02	< 0.02	< 0.23	< 0.56	< 0.28	< 1.2	0.32	0.64	0.31	0.45	0.05	0.22
	95% CL[3]	. . . [4]	. . . [4]	. . . [4]	. . . [4]	. . . [4]	. . . [4]	0.048	0.056	0.047	0.038	0.01	0.055
Great Miami River													
	minimum	< 0.01	0.01	< 0.0739	0.116	< 0.147	< 1.1	0.41	0.63	0.33	0.38	< 0.02	< 0.31
	maximum	< 0.05	0.04	< 0.892	1.01	< 0.764	< 1.4	1.07	1.16	1.08	0.75	< 0.1	< 0.84
	average	< 0.03	0.03	< 0.502	0.688	< 0.515	< 1.3	0.71	0.92	0.72	0.57	< 0.06	< 0.59
	95% CL[3]	. . . [4]	0.007	. . . [4]	0.211	. . . [4]	. . . [4]	0.14	0.14	0.16	0.088	. . . [4]	. . . [4]

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1. See Figure 40.
2. Statistical data are calculated using sediments collected in the middle of the stream bed.
3. C.L.= Confidence Level; ± value applicable to the average concentration.
4. Not applicable.

TABLE 30
URANIUM CONCENTRATION IN FISH, 1987

Sampling Point[1]	Family[2]	Number of Samples	Concentration[3] pCi/g Minimum	Maximum	Average[4]		95% CL[5]
1	1	5	0.0021	0.0494	0.0120	(0.00044)	0.0232
	2	1	0.0025	0.0025	0.0025	(0.00009)	...[6]
	3	3	0.0004	0.0019	0.0011	(0.00004)	0.0011
	4	8	0.0006	0.0041	0.0024	(0.00009)	0.0009
	5	0	...[6]	...[6]	...[6]	...[6]	...[6]
	Total	17	0.0004	0.0494	0.0050	(0.00018)	0.0057
2	1	3	0.0027	0.0106	0.0056	(0.00021)	0.0089
	2	6	0.0009	0.0047	0.0029	(0.00011)	0.0013
	3	6	0.0034	0.0053	0.0041	(0.00015)	0.0007
	4	4	0.0044	0.0181	0.0087	(0.00032)	0.0077
	5	2	0.0044	0.0042	0.0030	(0.00011)	0.0108
	Total	21	0.0009	0.0181	0.0047	(0.00018)	0.0016
3	1	0	...[6]	...[6]	...[6]	...[6]	...[6]
	2	1	0.0021	0.0021	0.0021	(0.00008)	...[6]
	3	2	0.0007	0.0040	0.0023	(0.00009)	0.0146
	4	19	0.0020	0.0214	0.0067	(0.00025)	0.0019
	5	1	0.0016	0.0016	0.0016	(0.00006)	...[6]
	Total	23	0.0007	0.0214	0.0059	(0.00022)	0.0018

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1. See Figure 41.
2. Family: 1 = Cyprinidae (carp)
   2 = Catastomidae (carpsucker, redhorse, hogsucker)
   3 = Centrarchidae, Sciaenidae (bass, sunfish, drum, sauger)
   4 = Clupeidae (gizzard shad)
   5 = Ictaluridae (catfish)
3. All concentrations in dry weight.
4. Bq/g in parentheses.
5. C.L. = confidence level; ± value applicable to the average concentration.
6. Not Applicable.

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TABLE 31 WASTE SHIPMENT DATA, 1987	
Material Description	Cubic Feet
Wooden pallets	120,243
Other wood	111,262
Magnesium	44,002
Baled trash	41,040
Filter and sump cake	26,455
Clothing and plastic	23,199
Contaminated metal	17,619
Furnace salts	11,419
Dust collector residues	11,099
Contaminated burnables	8,525
Unrecoverable residues	8,415
Roofing materials	8,258
Contaminated oil	5,668
Asbestos	1,776
Dust collector bags	1,228
Contaminated soil and rocks	1,117
TOTAL	441,325

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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. All onsite wells and offsite wells 8, 12, 15, 17, and 26 were sampled quarterly in 1986 and semiannually in 1987. In many instances, cross comparisons between three laboratories were used to verify data. Identification letters and numbers of offsite 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. In this report, RCRA monitoring wells have been assigned names according to the system used in the RI/FS and in this report (see Figure 23 and Table 32).

This appendix lists the parameters analyzed for the RCRA groundwater sampling program, and also includes the results of sampling rounds four and five.[7,8] Sampling rounds one through three were reported in the 1986 FMPC Environmental Monitoring Report, and results of round six will be reported in next year's report.

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. Toluene
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 32
RCRA WELL NAME EQUIVALENTS, 1986-87

1986 RCRA Well Name	1987 RCRA Well Name	1986 RCRA Well Name	1987 RCRA Well Name
P1	P1	17d	317
P2	P2	18s	218
P3	P3	18d	318
1s	301	19TP	119
1d	401	19s	219
3	303	19d	319
4	204	20TP	120
5	305	20s	220
8s	308	20d	320
8d	408	21TP	121
9	309	21s	221
10	310	22TP	122
11	211	22s	222
12	112	IT-1	268
13s	213	IT-2	267
13d	313	IT-5A	270
14s	214	IT-6	369
14d	314	OS-1	OS-1
15s	215	OS-1A	OS-1A
15d	415	OS-2	OS-2
16s	216	OS-3	OS-3
16d	316	SW-2	SW-2
17s	217		

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TABLE 33
FOURTH ROUND WATER LEVEL ELEVATION, 1987

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
301	60.00	585.55	583.47	525.55
401	63.66	585.31	583.81	521.65
303	38.00	560.86	559.30	522.86
204	33.45	556.85	556.15	523.40
305	35.00	557.09	555.53	522.09
308	54.71	576.60	574.90	520.19
408	56.75	576.62	574.82	519.87
309	33.93	557.23	555.31	523.30
310	67.72	588.39	586.56	520.67
211	63.15	585.78	583.64	522.63
112	34.17	639.67	637.48	605.50
213	70.96	590.37	588.71	519.41
313	70.94	590.36	588.72	519.42
214	14.97	535.79	533.76	520.87
314	14.81	535.81	533.71	521.00
215	59.64	579.65	577.80	520.01
415	61.64	579.41	577.80	517.77
216	20.70	542.28	540.47	521.58
316	20.59	542.13	540.50	521.54
217	15.17	536.19	534.43	520.92
317	15.43	536.35	534.28	520.92
218	51.00	573.36	571.31	522.36
318	51.14	573.88	571.56	522.74
219	63.40	585.38	583.26	521.98
319	63.23	585.25	583.20	522.02
119	8.62	584.96	582.98	576.34
220	54.14	574.44	573.42	520.30
320	55.50	574.71	573.31	519.20
120	5.10	574.73	573.21	569.63
221	63.90	586.02	594.42	522.12
121	4.13	585.61	584.06	581.48
222	68.17	587.95	587.93	519.78
122	7.35	588.91	587.93	581.56
SW-2	32.67	NA	NA	NA
OS-1	61.64	581.83	581.35	520.19
OS-2	NA	NA	NA	NA
OS-3	NA	NA	NA	NA
OS-1A	14.23	581.83	581.83	567.60
*268	59.79	579.93	577.93	520.14
*267	76.33	595.58	593.22	519.25
*270	74.64	594.22	592.17	519.58
*369	55.77	576.02	574.07	520.25

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

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TABLE 34
SHALLOW (TILL) FMPC GROUNDWATER SAMPLING RESULTS, FOURTH ROUND, 1987
(All results in ppm except as noted)

Well location	112	119	120	121	122	OS-1A
Chloride	91.0	744.0	< 1.0	13.0	14.0	32.0
Iron	2.200	3.930	7.530	3.450	7.050	0.069
Manganese	0.044	1.970	1.670	2.010	1.250	< 0.020
Phenols	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	236.000	171.000	5.370	11.600	16.200	272.000
Sulfate	< 1.0	375.0	42.0	435.0	1,320	100.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	0.007	0.006	< 0.005	< 0.005
Barium	< 0.200	< 0.200	< 0.200	0.277	< 0.200	< 0.200
Calcium	97.900	489.000	119.000	164.000	524.000	149.000
Cadmium	< 0.002	< 0.002	< 0.002	0.003	< 0.002	< 0.002
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium						
-Total	< 0.005	0.006	0.006	< 0.005	0.012	< 0.005
-Hexavalent	< 0.005	< 0.006	< 0.006	< 0.005	< 0.010	< 0.005
Copper	< 0.025	< 0.025	< 0.025	< 0.025	0.025	< 0.025
Fluoride	1.00	0.40	0.29	0.46	1.07	0.28
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	11.500	2.010	1.890	1.820	6.700	24.300
Magnesium	6.200	137.000	33.000	58.000	144.000	43.000
Nickel	< 0.005	0.009	0.010	0.007	0.015	< 0.005
Nitrates	0.02	0.13	0.04	0.07	0.24	8.80
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	< 0.02	0.09	0.13	0.13	0.38	0.04
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	0.033	0.025	0.056	0.046
T.D.S.	716	2,830	320	761	2,560	668
C.O.D.	< 10	20	< 10	< 10	25	< 10
pH-lab[1,2]	7.66	6.82	7.07	7.37	7.01	7.25
Conductivity-lab[1,3]	1,030	3,500	675	988	2,510	921
T.O.C.[1]	< 1	4	< 1	3	5.75	< 1
T.O.X.[1,4]	< 10.0	163.0	< 10	< 10	21.5	< 10
Coliform[10]	3	13	130	260	13	2600
Alachlor[LASSO]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
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]	< 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
VOC's[4]	ND	...	ND	ND	...	...
1.1 Dichloro-ethane	...	...	1.0	...	...	...
Acetone	...	...	...	...	4,770.0	4,480.0
2-Propanol	...	...	...	...	8,500.0	1,420.0
Trichloro-ethene	...	0.5	...	...	...	...
Tetrachloro-ethene	...	...	8.2	...	...	...
Bromoform	...	7.0	...	...	...	...
Gross Alpha[5]	21	13	2	251	330	< 1
Gross Beta[5]	7	50	3	251	625	33
Uranium[13]	0.0002	0.74	0.018	4.48	4.40	0.0011

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TABLE 35
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS INSIDE PRODUCTION AREA, FOURTH ROUND, 1987

(All results in ppm except as noted) page 1 of 2

Well location	301	401	303	204	305	308	408	310	213	313	219	319	221	222
Chloride	17.0	18.0	21.0	24.0	17.0	18.0	12.0	86.0	27.0	63.0	42.0	49.0	44.0	68.0
Iron	1.150	5.160	1.060	1.565	2.200	1.230	2.610	0.393	2.630	7.260	0.112	0.314	0.295	8.910
Manganese	0.547	0.383	0.418	0.031	0.553	0.243	0.390	5.190	0.211	0.393	0.031	3.190	0.038	0.391
Phenols	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.066	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	10.200	11.700	15.100	15.900	5.900	9.300	9.000	188.000	255.000	54.200	28.100	68.700	44.700	35.700
Sulfate	80.0	8.0	100.0	58.0	72.0	73.0	14.0	680.0	105.0	240.0	90.0	330.0	90.0	< 1.0
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	0.007
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	103.000	96.000	96.300	86.800	119.000	91.200	84.700	421.000	130.000	207.000	153.000	204.000	149.000	218.000
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	< 0.002	< 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	0.035
-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	0.020
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	0.20	0.24	0.20	0.21	0.24	0.17	0.22	0.14	0.24	0.16	0.29	49.0	0.24	0.63
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	2.290	0.885	2.590	2.940	2.460	2.660	1.100	18.400	2.760	4.190	4.010	7.270	8.850	5.970
Magnesium	24.500	24.100	24.200	20.200	28.900	23.900	22.000	73.000	28.000	44.100	32.500	26.600	25.500	65.000
Nickel	< 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	0.009
Nitrates	0.04	0.04	< 0.02	0.27	0.04	0.06	0.07	142.00	0.08	0.07	45.30	0.11	87.70	49.60
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006
Phosphorus, total	< 0.02	0.09	0.04	0.04	0.50	0.04	0.36	0.04	< 0.02	< 0.02	0.04	0.04	0.39	0.02

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TABLE 35
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS INSIDE PRODUCTION AREA, FOURTH ROUND, 1987

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

Well location	301	401	303	204	305	308	408	310	213	313	219	319	221	222
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	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.041
T.D.S.	423	363	404	332	473	350	377	2,320	503	972	652	962	1,046	1,090
C.O.D.	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	10	< 10
pH-lab[1,2]	7.38	7.56	7.53	7.41	7.37	7.54	7.40	7.08	7.20	6.93	7.45	7.09	7.23	7.22
Conductivity-lab[1,3]	600	600	566	531	700	600	550	2,600	690	1,280	1,000	1,200	1,260	1,100
T.O.C.[1]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
T.O.X.[1,4]	31.0	< 10	67.8	7.3	24.0	< 10	21.0	10	< 10	< 10	13.0	< 10	21.3	< 10
Coliform[10]	28	70	12	13	< 2	3	< 2	13	< 2	6	< 2	6	9	< 2
Alachlor[LASSO]	< 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	NA
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	NA
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	NA
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	NA
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	NA
2,4-D[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	NA
2,4,5-TP,Silvex[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	NA
VOCs[4]	NA	ND	NA	ND	NA	NA	NA	ND	ND	...	ND	(15)	...	ND
Acetone	...	...	...	...	...	...	...	...	...	1,030.0	...	...	...	...
Tetrachloro-ethene	...	...	...	...	...	...	...	...	...	...	...	...	11.9	...
Gross Alpha[5]	5	13	< 1	< 1	< 1	5	10	5	< 1	< 1	4	2	15	< 1
Gros Beta[5]	5	7	2	4	3	18	18	11	3	4	209	8	627	42
Uranium[13]	0.083	0.0001	0.0022	0.0080	0.0034	NA	0.0003	0.016	0.0011	0.021	0.0041	0.027	0.0047	0.0032

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TABLE 36
GROUNDWATER SAMPLING RESULTS
FMPC PLANT PRODUCTION WELLS,
FOURTH ROUND, 1987

(All results in ppm except as noted)

Well Location	P-1	P-2	P-3*
Chloride	35.0	20.0	NA
Iron	5.850	2.940	NA
Manganese	0.455	0.379	NA
Phenols	< 0.005	< 0.005	NA
Sodium	39.100	15.600	NA
Sulfate	125.0	42.0	NA
Silver	< 0.030	< 0.030	NA
Arsenic	< 0.005	< 0.005	NA
Barium	< 0.200	< 0.200	NA
Calcium	138.000	96.400	NA
Cadmium	< 0.002	< 0.002	NA
Cyanide	< 0.005	< 0.005	NA
Chromium			
-Total	< 0.005	< 0.005	NA
-Hexavalent	< 0.005	< 0.005	NA
Copper	< 0.025	< 0.025	NA
Fluoride	0.20	0.25	NA
Mercury	< 0.002	< 0.002	NA
Potassium	3.720	1.340	NA
Magnesium	35.500	25.100	NA
Nickel	< 0.005	< 0.005	NA
Nitrate	0.03	0.02	NA
Lead	< 0.005	< 0.005	NA
Phosphorus, total	0.08	0.08	NA
Selenium	< 0.0025	< 0.0025	NA
Zinc	< 0.025	< 0.025	NA
T.D.S.	582	404	NA
C.O.D.	< 10	< 10	NA
pH-lab[1,2]	7.48	7.35	NA
Conductivity-lab[1,3]	893	598	NA
T.O.C.[1]	< 1	< 1	NA
T.O.X.[1,4]	61.8	< 10	NA
Coliform[10]	< 2	< 2	NA
Alachlor[LASSO]	< 0.2	< 0.2	NA
Lindane[4]	< 0.2	< 0.2	NA
Endrin[4]	< 0.2	< 0.2	NA
Methoxychlor[4]	< 0.2	< 0.2	NA
Toxaphene[4]	< 0.5	< 0.5	NA
2,4-D[4]	< 0.2	< 0.2	NA
2,4,5-TP,Silvex[4]	< 0.2	< 0.2	NA
VOC's[4]	NA	NA	NA
Gross Alpha[5]	< 1	< 1	NA
Gross Beta[5]	1	< 1	NA
Uranium[13]	0.0002	0.0002	NA

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* Well was not sampled due to pump repair work.

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TABLE 37
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FOURTH ROUND, 1987

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

Well location	309	211	214	314	215	216	316	217	317
Chloride	23.0	19.0	19.0	20.0	21.0	17.0	17.0	27.0	20.0
Iron	0.198	3.060	26.500	< 0.050	0.289	0.690	< 0.050	0.107	1.470
Manganese	0.074	0.187	0.342	< 0.020	< 0.020	0.025	< 0.020	0.154	0.321
Phenols	< 0.005	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	12.500	7.800	11.900	11.800	14.900	8.900	9.040	12.300	13.000
Sulfate	70.0	78.0	60.0	60.0	60.0	60.0	70.0	100.0	72.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.005	< 0.005	0.008	< 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	84.400	105.000	197.000	83.600	82.900	87.900	82.800	149.000	100.000
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	0.084	< 0.005	0.009	0.011	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.01	< 0.005	< 0.009	< 0.010	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	0.127	< 0.025	0.027	< 0.025	< 0.025	< 0.025	< 0.025
Fluoride	0.18	0.23	0.38	0.19	0.40	0.24	0.20	0.23	0.18
Mercury	< 0.0002	< 0.0002	< 0.0002	0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.0002
Potassium	2.130	1.060	4.480	2.130	2.650	2.390	2.120	2.060	2.180
Magnesium	21.700	26.100	37.100	19.300	20.600	21.300	19.900	30.200	19.300
Nickel	< 0.005	< 0.005	0.017	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nitrate	2.60	< 0.04	1.53	1.68	2.96	2.03	2.43	0.03	< 0.03
Lead	< 0.005	< 0.005	0.048	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	< 0.02	0.02	0.39	< 0.02	0.09	< 0.02	< 0.02	0.04	0.04

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TABLE 37
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FOURTH ROUND 1987

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

Well location	218	318	220	320	SW-2	OS-1	415	OS-2	OS-3
Chloride	16.0	3.0	22.0	19.0	32.0	23.0	23.0	23.0	24.0
Iron	10.500	0.725	0.086	1.410	< 0.050	< 0.050	3.080	< 0.050	1.100
Manganese	0.379	0.078	0.032	0.230	0.144	< 0.020	0.351	< 0.020	0.395
Phenols	< 0.005	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sodium	6.160	4.650	10.400	8.500	270.000	10.500	7.970	251.000	10.700
Sulfate	68.0	68.0	78.0	100.0	70.0	60.0	85.0	60.0	75.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	0.010	< 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	155.000	91.600	88.600	97.700	104.000	90.900	117.000	99.500	94.500
Cadmium	< 0.004	< 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	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	0.051	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Fluoride	0.40	0.35	0.24	0.20	0.20	0.35	0.17	0.21	0.23
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.0002
Potassium	2.740	0.582	2.540	1.900	2.660	2.570	1.480	3.120	2.390
Magnesium	40.700	33.700	19.500	27.900	28.100	20.100	24.800	22.800	21.300
Nickel	0.011	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nitrate	0.80	0.05	4.08	0.08	2.39	3.04	0.03	3.04	0.02
Lead	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus, total	0.22	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02

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TABLE 37
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FOURTH ROUND, 1987

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

Well location	309	211	214	314	215	216	316	217	317
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.025	< 0.025	0.070	< 0.025	0.026	< 0.025	< 0.025	< 0.025	< 0.025
T.D.S.	472	580	188	540	388	423	322	533	376
C.O.D.	< 10	< 10	21	< 10	49	< 10	< 10	< 10	< 10
pH-lab[1,2]	7.31	7.43	8.29	7.52	7.41	7.41	7.54	7.24	7.45
Conductivity-lab[1,3]	570	625	504	551	521	521	481	908	550
T.O.C.[1]	< 1	< 1	1	< 1	8.75	< 1	< 1	< 1	< 1
T.O.X.[1,4]	10.5	122.0	199.0	< 10	< 10	< 10	< 10	25.5	19.5
Coliform[10]	67,000	< 2	20	3	19	540	< 2	< 2	< 2
Alachlor[LASSO]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
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	...	...
Bromoform	...	...	...	2.4	...	...	...	...	...
Acetone	12.0	...	...	...	120.0	...	...	17,700	...
2-Propanol	4,000.0	...	...	...	...	...	...	45,000	578.0
1,1,1 Trichloro-ethane	...	...	...	...	7.0	...	...	...	...
Trichloro-ethene	...	...	...	1.0	...	...	...	...	...
1,1 Dichloro-ethane	...	...	...	...	1.1	...	...	...	...
Gross Alpha[5]	< 1	< 1	12	9	18	8	3	< 1	< 1
Gross Beta[5]	6	2	57	7	42	10	2	2	< 1
Uranium[13]	0.0011	0.0002	0.028	0.025	0.18	0.018	0.0088	0.0026	0.0006

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TABLE 37
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FOURTH ROUND, 1987

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

Well location	218	318	220	320	SW-2	OS-1	415	OS-2	OS-3
Selenium	0.003	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	0.055	< 0.025	< 0.025	< 0.025	< 0.025	0.202	0.200	0.078	< 0.025
T.D.S.	410	440	372	411	426	369	456	403	408
C.O.D.	< 10	< 10	< 10	< 10	< 10	< 10	< 10	40	< 10
pH-lab[1,2]	7.33	7.34	7.38	7.45	7.24	7.40	7.31	7.47	7.40
Conductivity-lab[1,3]	568	565	551	560	666	541	629	568	589
T.O.C.[1]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
T.O.X.[1,4]	< 10	< 10	< 10	12.6	< 10	< 10	< 10	15.3	< 10
Coliform[10]	25	6	< 2	65	< 2	480	< 2	< 2	< 2
Alachlor[LASSO]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
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]	NA	ND	ND	ND	ND	...	NA	NA	NA
Bromoform	...	...	...	...	...	...	...	...	...
Acetone	...	...	...	...	...	...	...	...	...
2-Propanol	...	...	...	...	...	...	...	...	...
1,1,1-Trichloro-ethane	...	...	...	...	8.7	...	...	...	...
Trichloro-ethene	...	...	...	...	...	...	...	...	...
1,1 Dichloro-ethane	...	...	...	...	...	...	...	...	...
Gross Alpha[5]	< 1	22	< 1	< 1	< 1	20	< 1	16	8
Gross Beta[5]	< 1	12	3	4	4	43	1	60	2
Uranium[13]	0.0014	0.0020	0.0005	0.0008	0.0006	0.20	0.0002	0.28	0.031

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FOOTNOTES FOR TABLES 33 - 37

ND Not Detected.
NA Not Analyzed
1. Average of four tests.
2. pH results in standard units.
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Results in pCi/l.
6. Taken from 40 CFR Part 141 National Interim Primary Drinking Water Regulations - Subpart B - Maximum Contaminant Levels, July 1, 1984.
7. Taken from 40 CFR Part 143 National Secondary Drinking Water Regulations - Section 143.3 - Secondary Maximum Contaminant Levels.
8. High counts did not yield any individual elements using a 4096 channel analyzer. These levels are due to solids only in the samples.
9. Standard is for Radium -226 Plus Radium -228.
10. Reported in per 100 ml.
11. Maximum Permissible Activity taken from World Health Organization, 1970 European Standards. National Primary Drinking Water Regulation for gross beta is 4 mR/year.
12. 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.
13. WMCO Split Sample - Analyzed for Uranium at the FMPC; Results in Mg/l.
14. Taken from World Health Organization European Standards, 1970.
15. VOC's detected in 319:

COMPOUND	RESULT
Acetone	104.0 µg/l
2-Propanol	2,200.0 µg/l

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TABLE 38
FIFTH ROUND WATER LEVEL ELEVATION, 1987

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
301	NA	585.55	583.47	NA
401	63.17	585.31	583.81	522.14
303	NA	560.86	559.30	NA
204	NA	556.85	556.15	NA
305	NA	557.09	555.53	NA
308	54.33	576.60	574.90	522.27
408	54.83	576.62	574.82	521.79
309	33.10	557.23	555.31	524.13
310	66.92	588.39	586.56	521.47
211	62.69	585.78	583.64	523.09
112	31.83	639.67	637.48	607.84
213	70.06	590.37	588.71	520.31
313	70.08	590.36	588.72	520.28
214	14.04	535.79	533.76	521.75
314	14.06	535.99	533.71	521.93
215	58.85	579.53	577.80	520.68
415	NA	579.41	577.80	NA
216	20.15	542.28	540.47	522.13
316	20.13	542.13	540.50	522.00
217	14.42	536.19	534.43	521.77
317	14.54	536.35	534.83	521.81
218	50.50	573.36	571.31	522.86
318	NA	573.88	571.56	NA
219	63.17	585.38	583.26	522.21
319	63.08	585.25	583.20	522.17
119	7.00	584.96	582.98	577.96
220	53.81	574.44	573.42	520.63
320	53.10	574.71	573.31	521.61
120	4.69	574.73	573.21	570.04
221	63.58	586.02	594.42	522.44
121	4.58	585.61	584.06	581.03
222	65.29	587.95	587.93	522.66
122	6.83	588.91	587.93	582.08
SW-2	NA	NA	NA	NA
OS-1	NA	581.33	581.35	NA
OS-2	NA	NA	NA	NA
OS-3	NA	NA	NA	NA
OS-1A	NA	581.83	581.83	NA
*268	63.38	579.93	577.93	516.55
*267	75.00	595.58	593.22	520.58
*270	74.23	594.22	592.17	519.99
*369	55.50	576.02	574.07	520.52

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

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TABLE 39
SHALLOW (TILL) FMPC GROUNDWATER SAMPLING RESULTS, FIFTH ROUND, 1987
(All results in ppm except as noted)

Well location	112	112DUP	119	120	121	122	OS-1A
Chloride	93.0	104.0	562.0	3.0	14.0	13.0	30.0
Iron	6.070	11.600	2.550	7.060	0.948	1.970	< 0.050
Manganese	0.158	0.228	1.230	0.872	2.090	< 0.690	0.033
Phenols	0.016	< 0.005	< 0.005	0.018	0.006	< 0.005	0.008
Sodium	226.000	255.000	135.000	4.510	13.600	14.800	33.300
Sulfate	9.0	5.0	480.0	60.0	250.0	1050	120.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.0025	< 0.005	0.003	0.004	0.004	< 0.0025	< 0.0025
Barium	< 0.200	< 0.200	< 0.200	< 0.200	0.235	< 0.200	< 0.200
Calcium	34.200	48.700	379.000	110.000	154.000	391.000	149.000
Cadmium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cyanide	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005
Chromium							
-Total	0.006	0.011	0.005	0.007	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.006	< 0.010	< 0.005	< 0.007	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	< 0.025	0.032	< 0.025	< 0.025	< 0.025
Fluoride	1.18	1.04	0.24	0.21	0.50	0.52	0.30
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Potassium	15.800	16.700	1.610	2.200	1.490	5.770	32.600
Magnesium	8.900	10.900	121.000	36.900	70.000	118.000	48.000
Nickel	< 0.005	0.010	< 0.005	< 0.005	< 0.005	0.008	< 0.005
Nitrates	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	1.24	4.40
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus	< 0.02	< 0.02	0.07	0.13	0.04	0.07	0.03
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Zinc	0.056	0.032	< 0.020	0.123	< 0.020	0.030	0.034
T.D.S.	592	672	2,736	448	928	2,390	662
C.O.D.	17	15	17	12	11	13	< 10
pH[1,2]	7.81	7.81	6.73	7.08	7.18	7.02	7.12
Conductivity[1,3]	877	974	2520	596	969	2020	1040
T.O.C.[1]	< 1	2.50	5.5	2	3	3.75	1.75
T.O.X.[1]	< 10	< 10	< 10	< 10	< 10	37.5	16.08
Coliform[7]	< 2	< 2	< 2	1,400	< 2	8	16
Alachlor[4]	< 2.0	< 2.0	< 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
Endrin[4]	< 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
Toxaphene[4]	< 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
2,4,5-TP,Silvex[4]	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
VOC's							
Acetone[4]	84.4	694.0		...	...	...	...
Cloroethene[4]	...	...	0.8	...	...	...	...
Cyclohexane[4]	15.0	10.2	...	...	...	...	...
Cis-1,2-Dichloro-ethene[4]	...	25.8	...	...	...	...	
1,1 Dichloro-ethane[4]	...	...	15.5	...	...	...	
Gross Alpha[5]	< 1	< 1	27	2	100	296	< 1
Gross Beta[5]	11	7	102	8	640	998	28
Radium[5]	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Uranium[11]	0.0005		0.9	0.019	3.76	5.42	0.0019

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TABLE 40
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS INSIDE PRODUCTION AREA, FIFTH ROUND, 1987

(All results in ppm except as noted) page 1 of 2

Well location	301	401	303	204	305	308	408	310	213	313	219	319	221	222
Chloride	14.0	19.0	23.0	30.0	15.0	18.0	10.0	83.0	25	65.0	58.0	43.0	46.0	70.0
Iron	4.710	2.150	1.420	1.620	2.510	5.810	2.220	0.289	2.57	6.710	< 0.050	< 0.050	0.119	0.163
Manganese	0.345	0.552	0.405	0.023	0.487	0.547	0.357	4.000	0.194	0.380	< 0.015	1.850	0.016	< 0.015
Phenols	0.011	0.015	0.009	< 0.005	< 0.005	< 0.005	0.011	0.023	< 0.005	0.007	0.027	0.041	0.015	0.022
Sodium	15.100	10.600	10.800	12.200	8.340	10.600	9.900	129.000	12.8	47.600	33.900	51.200	51.000	29.400
Sulfate	76.0	10.0	88.0	84.0	76.0	20.0	9.0	52.0	112.000	310.0	116.0	290.0	88.0	96.0
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	< 0.0025	< 0.0025	< 0.0025	< 0.005	< 0.013	< 0.005	< 0.005	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 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	88.500	96.600	85.000	86.900	106.000	24.200	82.500	354.000	108.000	202.000	146.000	187.000	189.000	134.000
Cadmium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
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	0.24	0.21	0.21	0.19	0.26	0.05	0.21	0.19	0.340	0.42	0.23	0.14	0.20	0.58
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	0.936	2.680	2.560	2.990	3.000	2.660	1.170	21.200	2.190	4.560	6.660	7.020	10.000	4.860
Magnesium	25.000	26.500	25.000	22.600	28.400	24.800	21.700	65.000	27.900	65.000	34.400	23.300	23.900	41.400
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005
Nitrates	< 0.02	< 0.02	< 0.02	1.42	< 0.02	< 0.02	< 0.02	118.00	0.510	< 0.02	44.40	3.22	63.00	40.00
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

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TABLE 40
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS INSIDE PRODUCTION AREA, FIFTH ROUND, 1987

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

Well location	301	401	303	204	305	308	408	310	213	313	219	319	221	222
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	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	0.040	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
T.D.S.	468	384	420	415	532	233	372.	2488	488	916	900	968	1,040	904
C.O.D.	< 10	< 10	< 10	< 10	< 10	12	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
pH[1,2]	7.48	7.37	7.49	7.49	7.36	7.71	7.42	6.97	7.36	7.13	7.33	7.05	7.29	7.31
Conductivity[1,3]	577	549	524	535	614	300	463	2,280	636	1,130	1,040	1,090	1,100	1,060
T.O.C.[1]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	0.50	< 1	< 1	< 1	< 1
T.O.X.[1]	< 10	< 10	< 10	< 10	12	< 10	< 10	< 10	< 10	< 10	12.25	< 10	< 10	< 10.0
Coliform[7]	< 2	< 2	46	12	19	< 2	< 2	< 2	< 2.0	< 2	< 2	< 2	< 2	< 2
Alachlor[4]	< 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	< 2.0
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]	< 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	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Acetone[4]	...	15.6	...	580.0	...	40.0	21.3	10,000	1800	34.2	...	...	...	...
Cyclohexane[4]	...	20.0	...	600.0	...	22.0	12.0	5,000.0	300	...	...	...	...	...
Gross Alpha[5]	< 1	3	< 1	1	< 1	< 1	< 1	3	< 1	2	16	4	51	3
Gross Beta[5]	4	< 3	4	3	3	< 3	29	24	3	6	559	17	1,560	72
Uranium[11]	0.013	0.0001	0.0043	0.0074	0.0062	0.0011	0.0011	0.019	0.0013	0.017	0.0018	0.067	0.0018	0.0042
Radium[5]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1

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TABLE 41
GROUNDWATER SAMPLING RESULTS FMPC PLANT PRODUCTION WELLS, FIFTH ROUND, 1987
(All results in ppm except as noted)

Well Location	P-1	P-2	P-3
Chloride	36.0	23.0	14.0
Iron	5.870	3.520	2.590
Manganese	0.422	0.378	0.392
Phenols	0.006	0.013	0.019
Sodium	38.900	16.000	7.100
Sulfate	120.0	28.0	48.0
Silver	< 0.030	< 0.030	< 0.030
Arsenic	< 0.0025	0.003	0.003
Barium	< 0.200	< 0.200	< 0.200
Calcium	130.000	99.400	92.400
Cadmium	< 0.001	< 0.001	< 0.001
Cyanide	< 0.005	< 0.005	< 0.005
Chromium			
-Total	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.005	< 0.005
Copper	< 0.025	< 0.025	< 0.002
Fluoride	0.16	0.20	0.17
Mercury	< 0.0002	< 0.0002	< 0.0002
Potassium	4.610	1.800	1.750
Magnesium	35.700	27.700	21.600
Nickel	< 0.005	< 0.005	< 0.005
Nitrate	< 0.02	< 0.02	< 0.02
Lead	< 0.005	< 0.005	< 0.005
Phosphorus	0.09	0.11	0.06
Selenium	< 0.0025	< 0.0025	< 0.0025
Zinc	< 0.020	< 0.020	< 0.020
T.D.S.	677	504	376
C.O.D.	< 10	< 10	< 10
pH[1,2]	7.38	7.51	7.38
Conductivity[1,3]	907	635	536
T.O.C.[1]	< 1	< 1	< 1
T.O.X.[1]	< 10	< 10	< 10
Coliform[7]	< 2	< 2	< 2
Alachlor[4]	< 2.0	< 2.0	< 2.0
Lindane[4]	< 0.2	< 0.2	< 0.2
Endrin[4]	< 0.2	< 0.2	< 0.2
Methoxychlor[4]	< 0.2	< 0.2	< 0.2
Toxaphene[4]	< 0.5	< 0.5	< 0.5
2,4-D[4]	< 1.0	< 1.0	< 1.0
2,4,5-TP,Silvex[4]	< 0.5	< 0.5	< 0.5
Gross Alpha[5]	< 1	< 1	< 1
Gross Beta[5]	5	4	< 3
Radium[5]	< 1	< 1	< 1
Uranium[11]	0.0023	0.0011	0.003

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TABLE 42
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FIFTH ROUND, 1987

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

Well location	309	211	214	314	215	415	216	316	217
Chloride	20.0	18.0	19.0	21.0	20.0	24.0	23.0	25.0	34.0
Iron	0.188	2.280	0.813	< 0.050	2.120	2.570	6.180	< 0.050	13.900
Manganese	0.070	0.179	< 0.015	< 0.015	0.060	0.326	0.214	< 0.015	0.635
Phenols	< 0.005	< 0.005	0.016	0.011	< 0.005	0.016	< 0.005	< 0.005	0.005
Sodium	11.800	9.800	11.400	12.700	11.200	7.090	14.200	10.900	9.000
Sulfate	80.0	88.0	72.0	72.0	56.0	92.0	76.0	64.0	112.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	0.003	0.003	< 0.025	0.006
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	81.800	97.200	83.500	79.300	89.300	98.000	114.000	83.600	207.000
Cadmium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
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	0.008	< 0.005	< 0.005	< 0.005	0.009	< 0.005	0.024
-Hexavalent	< 0.005	< 0.005	< 0.008	< 0.005	< 0.005	< 0.005	< 0.009	< 0.005	< 0.010
Copper	< 0.025	< 0.025	0.065	< 0.025	< 0.025	< 0.025	0.044	< 0.025	0.080
Fluoride	0.22	0.24	0.32	0.21	0.46	0.26	0.43	0.21	0.18
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0003	< 0.0002	< 0.0002
Potassium	2.230	1.080	3.490	2.540	3.610	1.700	4.070	2.300	4.290
Magnesium	23.300	27.900	22.300	21.000	24.000	26.900	34.900	24.200	64.000
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	0.009
Nitrate	1.54	< 0.02	1.56	1.53	1.79	< 0.02	1.90	2.42	< 0.02
Lead	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008
Phosphorus	< 0.020	< 0.02	0.09	0.03	0.24	< 0.02	0.08	< 0.02	< 0.02

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TABLE 42
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FIFTH ROUND, 1987

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

Well location	317	218	318	220	320	SW-2	OS-1	OS-2	OS-2DUP	OS-3
Chloride	22.0	15.0	4.0	22.0	21.0	31.0	31.0	24.0	23.0	26.0
Iron	1.430	34.700	22.900	0.166	1.230	0.110	< 0.050	< 0.050	< 0.050	1.280
Manganese	0.305	1.090	0.783	0.034	0.187	< 0.167	< 0.015	< 0.015	< 0.015	0.348
Phenols	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	0.008	0.016	0.019	< 0.005
Sodium	8.900	4.280	5.060	9.400	9.200	15.300	19.700	11.800	12.200	10.900
Sulfate	84.0	52.0	68.0	72.0	88.0	72.0	60.0	64.0	60.0	64.0
Silver	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Arsenic	< 0.0025	0.023	0.010	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	0.003
Barium	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Calcium	94.600	141.000	98.700	82.600	93.100	93.600	94.200	95.500	88.600	89.300
Cadmium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cyanide	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium										
-Total	< 0.005	0.011	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
-Hexavalent	< 0.005	< 0.010	< 0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Copper	< 0.025	0.039	0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Fluoride	0.14	0.26	0.29	0.36	0.22	0.21	0.59	0.24	0.27	0.26
Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0008	< 0.0002	< 0.0002
Potassium	2.100	1.750	0.764	3.090	2.300	2.630	3.170	3.620	3.640	2.930
Magnesium	21.100	35.500	37.600	21.500	23.400	28.700	27.000	22.200	22.800	22.800
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nitrate	< 0.02	2.53	< 0.02	2.51	< 0.02	2.36	2.83	2.40	2.32	< 0.02
Lead	< 0.005	0.009	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phosphorus	< 0.02	< 0.02	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

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TABLE 42
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FIFTH ROUND, 1987

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

Well location	309	211	214	314	215	415	216	316	217
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.013	< 0.0025
Zinc	< 0.020	< 0.020	0.049	< 0.020	< 0.020	0.073	0.074	< 0.020	0.068
T.D.S.	344	376	423	404	392	398	400	380	556
C.O.D.	< 10	< 10	< 10	< 10	14	< 10	< 10	< 10	< 10
pH[1,2]	7.60	7.50	7.59	7.69	7.60	7.46	7.58	7.58	7.31
Conductivity[1,3]	493	579	493	493	487	524	528	493	699
T.O.C.[1]	< 1	< 1	2	1.25	< 1	< 1	< 1	< 1	< 1
T.O.X.[1]	< 10	< 10	< 10	13.0	19.30	< 10	< 10	< 10	< 10
Coliform[7]	4,200	8	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Alachlor[4]	< 2.0	< 2.0	< 2.0	< 2.0	< 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
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	< 0.5	< 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	...	...	...	...	...	...	...	...	...
Acetone[4]	29.8	...	...	...	104.0	...	930.0	40.8	...
Cyclohexane[4]	10.2	...	...	...	20.0	...	...	60.0	...
1,1,1 Trichloro-ethane[4]	...	...	...	18.9	...	...	...	...	...
1,1 Dichloro-ethane[4]	...	...	...	...	2.3		...	...	...
Gross Alpha[5]	2	< 1	10	5	27	< 1	4	< 1	< 1
Gross Beta[5]	9	3	19	14	50	3	6	7	6
Radium[5]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Uranium[11]	0.0021	0.0006	0.085	0.038	0.2	0.0003	0.02	0.01	0.0051

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TABLE 42
SAND AND GRAVEL AQUIFER FMPC GROUNDWATER SAMPLING RESULTS OUTSIDE PRODUCTION AREA, FIFTH ROUND, 1987

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

Well location	317	218	318	220	320	SW-2	OS-1	OS-2	OS-2[DUP]	OS-3
Selenium	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.013
Zinc	< 0.020	0.052	0.074	< 0.020	< 0.020	< 0.020	0.148	0.051	< 0.045	< 0.020
T.D.S.	428	444	423	388	454	400	408	396	419	431
C.O.D.	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
pH[1,2]	7.33	7.39	7.31	7.41	7.37	7.39	7.46	7.47	7.45	7.42
Conductivity[1,3]	524	588	585	547	553	597	570	529	526	575
T.O.C.[1]	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
T.O.X.[1]	< 10	< 10	< 50	< 10	< 10	26.50	< 10	< 10	< 10	< 10
Coliform[7]	< 2	< 2	< 2	3	< 2	< 2	37	< 2	< 2	< 2
Alachlor[4]	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 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
Endrin[4]	< 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
Toxaphene[4]	< 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
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
VOC's										
Acetone[4]	1,040	24,500.0	...	...	...	30.8	34.2	...	40.5	...
Cyclohexane[4]	5,000	900.0	...	...	...	12.0	...	42	12.5	...
1,1,1 Trichloro-ethane[4]	...	...	...	...	...	...	87	...	...	...
1,1 Dichloro-ethane[4]	...	...	...	...	...	...	...	...	...	...
Gross Alpha[5]	< 1	< 1	< 1	< 1	< 1	< 1	29	42	43	3
Gross Beta[5]	3	< 3	4	16	4	4	30	87	69	18
Radium[5]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Uranium[11]	0.0008	0.001	0.0029	0.0008	0.0013	0.0	0.37	0.33	551	0.054

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Footnotes for 38-42

NA = Not Analyzed
ND = Not Detected
(DUP) = Results from replicate sample

1. Average of four tests.
2. pH results in standard units
3. Conductivity results in µmhos/cm.
4. Concentrations reported in ppb.
5. Results in pCi/l
6. Standard is for Radium-226 plus Radium-228.
7. Reported in per 100 ml.
8. Maximum Permissible Activity taken from World Health Organization, 1970 European Standards. National Primary Drinking Water Regulation for gross beta is 4 mrem/year.
9. Taken from 40 CFR Part 141 National Interim Primary Drinking Water Regulations - Subpart B - Maximum Contaminant Levels, July 1, 1984.
10. Taken from 40 CFR Part 143 National Interim Secondary Drinking Water Regulations - Section 143.3 - Secondary Maximum Contaminant Levels.
11. Uranium values measured by FMPC in mg/l.

TABLE 43
FMPC RADIONUCLIDE SCAN RESULTS, FIFTH ROUND, 1987

(All results in pCi/ml except as noted) page 1 of 5

Location	301			401			204		
Parameters	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab
Potassium 40	$< 1 \times 10^{-3}$	$< 2.087 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	22.061×10^{-1}	...	$< 1 \times 10^{-3}$	$< 1.206 \times 10^{-1}$	...
Total Uranium[1,3]	$< 1.5 \times 10^{-3}$	1.2×10^{-2}	8.3×10^{-3}	$< 1.5 \times 10^{-3}$	1.31×10^{-3}	1×10^{-4}	$< 1.5 \times 10^{-3}$	9.2×10^{-3}	8.0×10^{-3}
Radium 226	$< 1 \times 10^{-3}$	$< 4.336 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 4.030 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 4.192 \times 10^{-2}$	...
Radium 228	$< 1 \times 10^{-3}$	$< 6.077 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 6.641 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 8.600 \times 10^{-2}$	...
Technetium 99	$< 1 \times 10^{-3}$	6.25×10^{-3}	...	$< 1 \times 10^{-3}$	$< 1.4 \times 10^{-3}$	...	$< 1 \times 10^{-3}$	$< 3.0 \times 10^{-3}$	...
Thorium 228	$< 1 \times 10^{-3}$	$< 1.1 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 6 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 7.3 \times 10^{-5}$	...
Thorium 230	$< 1 \times 10^{-3}$	$< 1.3 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 2 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	4.6×10^{-5}	...
Thorium 232	$< 1 \times 10^{-3}$	$< 8 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 1.614 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 4.0 \times 10^{-5}$	...
Cesium 137	$< 1 \times 10^{-3}$	$< 1.696 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.9 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 1.960 \times 10^{-2}$	...
Strontium 90	$< 1 \times 10^{-3}$	$< 6 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 1.427 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 2.7 \times 10^{-4}$	...
Ruthenium 106	$< 1 \times 10^{-3}$	$< 1.180 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.1 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 1.563 \times 10^{-1}$	...
Neptunium 237	$< 1 \times 10^{-3}$	6.6×10^{-5}	...	$< 1 \times 10^{-3}$	$< 4 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 1.1 \times 10^{-4}$	...
Plutonium 238	$< 1 \times 10^{-3}$	1.3×10^{-5}	...	$< 1 \times 10^{-3}$	1.5×10^{-5}	...	$< 1 \times 10^{-3}$	1.7×10^{-5}	...
Plutonium 239[2]	$< 1 \times 10^{-3}$	$< 1.5 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 1 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 1.4 \times 10^{-5}$	...
Plutonium 240[2]	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...

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TABLE 43
FMPC RADIONUCLIDE SCAN RESULTS, FIFTH ROUND, 1987

(All results in pCi/ml except as noted) page 2 of 5

Location	310			314			219		
Parameters	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab
Potassium 40	$< 1 \times 10^{-3}$	$< 1.869 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.837 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.901 \times 10^{-1}$	...
Total Uranium[1,3]	$< 1.5 \times 10^{-3}$	4.6×10^{-2}	1.6×10^{-2}	$< 1.5 \times 10^{-3}$	2.9×10^{-2}	2.5×10^{-2}	$< 1.5 \times 10^{-3}$	7.5×10^{-3}	4.1×10^{-3}
Radium 226	$< 1 \times 10^{-3}$	$< 3.47 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	8.464×10^{-2}	...	$< 1 \times 10^{-3}$	$< 2.699 \times 10^{-2}$	...
Radium 228	$< 1 \times 10^{-3}$	$< 7.127 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 7.290 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 9.122 \times 10^{-2}$	...
Technetium 99	$< 1 \times 10^{-3}$	5.41×10^{-3}	...	$< 1 \times 10^{-3}$	$< 1.4 \times 10^{-3}$	...	$< 1 \times 10^{-3}$	1.47 + 5	...
Thorium 228	$< 1 \times 10^{-3}$	3.9×10^{-4}	...	$< 1 \times 10^{-3}$	2.7×10^{-4}	...	$< 1 \times 10^{-3}$	1.4×10^{-4}	...
Thorium 230	$< 1 \times 10^{-3}$	2.3×10^{-4}	...	$< 1 \times 10^{-3}$	1.4×10^{-4}	...	$< 1 \times 10^{-3}$	2.2×10^{-4}	...
Thorium 232	$< 1 \times 10^{-3}$	$< 8.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	2.3×10^{-5}	...	$< 1 \times 10^{-3}$	$< 7.0 \times 10^{-5}$	...
Cesium 137	$< 1 \times 10^{-3}$	$< 2.009 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.554 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.339 \times 10^{-2}$	...
Strontium 90	$< 1 \times 10^{-3}$	1.08×10^{-3}	...	$< 1 \times 10^{-3}$	1.25×10^{-3}	...	$< 1 \times 10^{-3}$	6.85×10^{-4}	...
Ruthenium 106	$< 1 \times 10^{-3}$	$< 1.212 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.328 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.151 \times 10^{-1}$	...
Neptunium 237	$< 1 \times 10^{-3}$	7.06×10^{-3}	...	$< 1 \times 10^{-3}$	$< 1.7 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 2.0 \times 10^{-4}$	...
Plutonium 238	$< 1 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	2.9×10^{-5}	...	$< 1 \times 10^{-3}$	$< 4.0 \times 10^{-5}$	...
Plutonium 239[2]	$< 1 \times 10^{-3}$	1.9×10^{-5}	...	$< 1 \times 10^{-3}$	2.4×10^{-5}	...	$< 1 \times 10^{-3}$	$< 4.0 \times 10^{-5}$	...
Plutonium 240[2]	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...

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TABLE 43
FMPC RADIONUCLIDE SCAN RESULTS, FIFTH ROUND, 1987

(All results in pCi/ml except as noted) page 3 of 5

Location	319			119			221		
Parameters	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab
Potassium 40	$< 1 \times 10^{-3}$	$< 2.491 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.950 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 2.150 \times 10^{-1}$	...
Total Uranium[1,4]	$< 1.5 \times 10^{-3}$	3.5×10^{-2}	2.7×10^{-2}	$< 1.5 \times 10^{-3}$	7.7×10^{-1}	7.4×10^{-1}	NS	5.1×10^{-3}	4.7×10^{-3}
Radium 226	$< 1 \times 10^{-3}$	$< 4.532 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 2.339 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 2.643 \times 10^{-2}$	...
Radium 228	$< 1 \times 10^{-3}$	$< 7.755 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 5.677 \times 10^{-2}$	...	4×10^{-3}	$< 6.798 \times 10^{-2}$	...
Technetium 99	$< 1 \times 10^{-3}$	5.38×10^{-2}	...	$< 1 \times 10^{-3}$	2.07×10^{-2}	...	$< 1 \times 10^{-3}$	5.35 + 3	...
Thorium 228	$< 1 \times 10^{-3}$	1.2×10^{-4}	...	$< 1 \times 10^{-3}$	1.7×10^{-4}	...	$< 1 \times 10^{-3}$	2.0×10^{-4}	...
Thorium 230	$< 1 \times 10^{-3}$	$< 1.3 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	3.2×10^{-4}	...	$< 1 \times 10^{-3}$	$< 8.0 \times 10^{-5}$	...
Thorium 232	$< 1 \times 10^{-3}$	3.9×10^{-5}	...	$< 1 \times 10^{-3}$	$< 4.0 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 1.1 \times 10^{-4}$	...
Cesium 137	$< 1 \times 10^{-3}$	$< 1.307 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.712 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.382 \times 10^{-2}$	...
Strontium 90	NS	4.7×10^{-4}	...	$< 1 \times 10^{-3}$	1.6×10^{-4}	...	15.2×10^{-3}	2.03×10^{-2}	...
Ruthenium 106	$< 1 \times 10^{-3}$	$< 9.990 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.305 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.303 \times 10^{-1}$	...
Neptunium 237	$< 1 \times 10^{-3}$	1.7×10^{-4}	...	$< 1 \times 10^{-3}$	$< 1.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	7.9×10^{-5}	...
Plutonium 238	$< 1 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	2.5×10^{-5}	...	$< 1 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...
Plutonium 239[2]	$< 1 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	1.5×10^{-5}	...	$< 1 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...
Plutonium 240[2]	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...

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TABLE 43
FMPC RADIONUCLIDE SCAN RESULTS, FIFTH ROUND, 1987

(All results in pCi/ml except as noted) page 4 of 5

Location	121			222			122		
Parameters	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab
Potassium 40	$< 1 \times 10^{-3}$	$< 1.571 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.886 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.705 \times 10^{-1}$	...
Total Uranium[1,3]	1.80	4.06	4.48	$< 1.5 \times 10^{-3}$	1.0×10^{-2}	3.2×10^{-3}	6.12	4.95	4.40
Radium 226	$< 1 \times 10^{-3}$	$< 3.863 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 3.135 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 3.544 \times 10^{-2}$	...
Radium 228	$< 1 \times 10^{-3}$	$< 8.426 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 6.016 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 7.270 \times 10^{-2}$	...
Technetium 99	$< 1 \times 10^{-3}$	5.19×10^{-3}	...	$< 1 \times 10^{-3}$	2.25×10^{-1}	...	$< 1 \times 10^{-3}$	1.22×10^{-2}	...
Thorium 228	$< 1 \times 10^{-3}$	$< 3 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	1.1×10^{-4}	...	$< 1 \times 10^{-3}$	4.1×10^{-4}	...
Thorium 230	$< 1 \times 10^{-3}$	3.6×10^{-3}	...	$< 1 \times 10^{-3}$	$< 9.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 1.4 \times 10^{-3}$	...
Thorium 232	$< 1 \times 10^{-3}$	2.4×10^{-3}	...	$< 1 \times 10^{-3}$	$< 6.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	2.1×10^{-4}	...
Cesium 137	$< 1 \times 10^{-3}$	$< 1.862 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.939 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.201 \times 10^{-2}$	...
Strontium 90	NS	$< 4.5 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	7.72×10^{-4}	...	$< 3.94 \times 10^{-3}$	3.64×10^{-3}	...
Ruthenium 106	$< 1 \times 10^{-3}$	$< 1.505 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.727 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.523 \times 10^{-1}$	...
Neptunium 237	$< 1 \times 10^{-3}$	5.6×10^{-4}	...	$< 1 \times 10^{-3}$	$< 1.1 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 1.0 \times 10^{-4}$	...
Plutonium 238	$< 1 \times 10^{-3}$	$< 4.0 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 1.3 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	2.6×10^{-5}	...
Plutonium 239[2]	$< 1 \times 10^{-3}$	$< 1.7 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	$< 1.3 \times 10^{-5}$	...	$< 1 \times 10^{-3}$	4.2×10^{-5}	...
Plutonium 240[2]	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...

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TABLE 43
FMPC RADIONUCLIDE SCAN RESULTS, FIFTH ROUND, 1987

(All results in pCi/ml except as noted) page 5 of 5

Location	OS 1			OS 2			OS 3		
Parameters	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab	Howard Lab	TMA/Norcal Lab	WMCO Lab
Potassium 40	$< 1 \times 10^{-3}$	$< 1.933 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.283 \times 10^{-1}$	...	$< 1 \times 10^{-3}$	$< 1.066 \times 10^{-1}$	...
Total Uranium[1,4]	0.47	2.40×10^{-1}	0.200	NS	0.34	0.28	$< 1.5 \times 10^{-3}$	4.6×10^{-2}	3.1×10^{-2}
Radium 226	$< 1 \times 10^{-3}$	$< 2.164 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 2.980 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 1.525 \times 10^{-2}$	...
Radium 228	$< 1 \times 10^{-3}$	$< 5.091 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 5.991 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	$< 3.410 \times 10^{-2}$	...
Technetium 99	$< 1 \times 10^{-3}$	1.24×10^{-2}	...	$< 1 \times 10^{-3}$	4.8×10^{-3}	...	$< 1 \times 10^{-3}$	1.2×10^{-3}	...
Thorium 228	$< 1 \times 10^{-3}$	1.1×10^{-4}	...	$< 1 \times 10^{-3}$	$< 1.5 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 1.0 \times 10^{-4}$	...
Thorium 230	$< 1 \times 10^{-3}$	$< 3.0 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	2.1×10^{-4}	...	$< 1 \times 10^{-3}$	$< 8.0 \times 10^{-5}$	...
Thorium 232	$< 1 \times 10^{-3}$	8.8×10^{-5}	...	$< 1 \times 10^{-3}$	$< 1.5 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	$< 2.0 \times 10^{-5}$	...
Cesium 137	$< 1 \times 10^{-3}$	$< 1.234 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	1.554×10^{-2}	...	$< 1 \times 10^{-3}$	6.672×10^{-3}	...
Strontium 90	$< 1 \times 10^{-3}$	5.00×10^{-4}	...	$< 1 \times 10^{-3}$	9.68×10^{-4}	...	$< 1 \times 10^{-3}$	4.55×10^{-4}	...
Ruthenium 106	$< 1 \times 10^{-3}$	$< 9.186 \times 10^{-2}$	...	$< 1 \times 10^{-3}$	21.425×10^{-1}	...	$< 1 \times 10^{-3}$	$< 6.839 \times 10^{-2}$	...
Neptunium 237	$< 1 \times 10^{-3}$	$< 1.8 \times 10^{-4}$	...	$< 1 \times 10^{-3}$	8.0×10^{-4}	...	$< 1 \times 10^{-3}$	4.4×10^{-4}	...
Plutonium 238	$< 1 \times 10^{-3}$	4.6×10^{-5}	...	$< 1 \times 10^{-3}$	1.3×10^{-4}	...	$< 1 \times 10^{-3}$	$< 3.0 \times 10^{-5}$	...
Plutonium 239[2]	$< 1 \times 10^{-3}$	3.9×10^{-5}	...	$< 1 \times 10^{-3}$	5.9×10^{-5}	...	$< 1 \times 10^{-3}$	$< 1.7 \times 10^{-5}$	...
Plutonium 240[2]	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...	$< 1 \times 10^{-3}$	...	...

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FOOTNOTES FOR TABLE 43

1. Total U for TMA/Norcal and WMCO results in mg/l.
2. Total Pu 239, 240.
3. Total U for Howard Laboratory in mg/l calculated from activity measurements.
   Conversion from pCi/l to mg/l assumes total U calculated as natural U. Use 0.100 mg/l = 67 pCi/l for equilibrium total α activity of U-234 and U-238 (Wrenn, et. al., HP Vol. 48 No. 5 (May, 1985), pp. 601-633).
4. "NS" denotes that analysis could not be performed due to insufficient sample.

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 112

(Background Well for Glacial Till Water-Bearing Zone)
(page 1 of 9)

Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.68	1,001.5	1	1,672.3	0.013	5,072.75	0	10,957,057

Round 1 Phase 1				Round 1 Phase 3			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.42	880	< 1	< 10	7.79	990	< 1	65.0
7.47	880	< 1	< 10	7.79	1,000	< 1	63.0
7.49	880	< 1	< 10	7.79	1,000	< 1	64.0
7.52	880	< 1	< 10	7.79	1,000	< 1	64.0

Round 2				Round 3			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.74	1,000	< 1	<10	7.72	1,100	1	9,220
7.75	1,000	< 1	<10	7.74	1,100	1	7,560
7.75	1,000	< 1	<10	7.75	1,100	1	8,470
7.75	1,000	< 1	<10	7.75	1,100	1	7,820

Round 4			
pH	SC	TOC	TOX
7.65	1,020	< 1	<10
7.65	1,030	< 1	<10
7.66	1,040	< 1	<10
7.66	1,030	< 1	<10

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 119
(page 2 of 9)

Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.66	2,812.5	4.38	139.8	0.015	422,968.8	0.48	1,808.6

Round 1 Phase 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.49	2,350	4	77	6.73	2,000	4	NA
6.49	2,350	4	79	6.72	2,000	4	NA
6.52	2,350	4	82	6.72	2,000	4	NA
6.52	2,350	4	83	6.72	2,000	4	NA

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.58	3,400	5	178	6.81	3,500	4	163
6.58	3,400	6	176	6.82	3,500	4	165
6.58	3,400	6	180	6.81	3,500	4	165
6.57	3,400	5	169	6.82	3,500	4	161

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 121
(page 3 of 9)

Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.20	971.6	3	10.33	0.020	1,849.1	0.5	0.72

Round 1 Phase 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.98	1,000	4	< 10	7.35	995	2	NA
7	1,000	4	< 10	7.25	1,000	2	NA
7	1,000	4	< 10	7.25	1,000	2	NA
6.99	1,000	4	< 10	7.26	1,000	2	NA

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.17	900	3	< 10	7.37	900	3	13
7.15	900	3	< 10	7.37	1,000	3	11
7.15	900	3	< 10	7.37	1,000	3	10
7.17	900	3	< 10	7.37	1,000	3	10

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 122
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Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.91	2,357.5	5.81	21.25	0.016	59,718.8	0.40	67.94

Round 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.75	1,950	7	< 10	7.06	2,400	5	31
6.74	1,950	6	< 10	7.07	2,400	5	30
6.75	1,950	6	< 10	7.07	2,400	5	28
6.76	1,950	7	< 10	7.07	2,400	5	34

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.81	2,500	6	18	7.01	2,500	5	24
6.82	2,600	6	33	7.01	2,500	6	20
6.82	2,600	6	24	7.01	2,500	6	19
6.85	2,600	6	16	7.01	2,520	6	23

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 219
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Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.27	1,075	1.5	298.3	0.019	6,975	0.75	161,146

Round 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.03	1,000	3	NA	7.28	1,200	< 1	19
7.05	1,000	3	NA	7.29	1,200	< 1	19
7.08	1,000	3	NA	7.30	1,200	< 1	19
7.09	1,000	3	NA	7.31	1,200	< 1	17

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.28	1,100	< 1	838	7.45	1,000	< 1	18
7.29	1,100	< 1	803	7.45	1,000	< 1	12
7.29	1,100	< 1	832	7.45	1,000	< 1	13
7.30	1,100	< 1	980	7.44	1,000	< 1	10

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 221
(page 6 of 9)

Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.30	1,175.6	1	15.88	0.003	24,087.1	0	36.11

Round 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.25	900	1	< 10	7.36	1,240	< 1	24
7.33	910	1	< 10	7.37	1,260	< 1	23
7.36	910	1	< 10	7.37	1,260	< 1	23
7.36	910	1	< 10	7.38	1,260	< 1	19

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.26	1,280	1	< 10	7.20	1,260	< 1	23
7.28	1,280	1	< 10	7.23	1,260	< 1	22
7.28	1,280	1	< 10	7.24	1,250	< 1	21
7.28	1,280	1	< 10	7.25	1,270	< 1	19

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 222
(page 7 of 9)

Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.37	1,012.5	1.25	17.63	0.013	3,956.25	0.1875	66.6

Round 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.30	980	2	28	7.45	920	< 1	< 20
7.30	980	2	29	7.45	930	< 1	< 22
7.30	980	2	25	7.46	940	< 1	< 22
7.30	980	2	33	7.46	940	< 1	< 23

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.49	1,030	1	< 10	7.23	1,100	< 1	< 10
7.49	1,040	1	< 10	7.22	1,100	< 1	< 10
7.49	1,040	1	< 10	7.21	1,100	< 1	< 10
7.51	1,040	1	< 10	7.21	1,100	< 1	< 10

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION 319
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Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.97	1,431	1	19.8	0.009	27,773	0	289

Round 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
6.81	1,600	1	< 10	6.96	1,500	< 1	< 10
6.84	1,600	1	< 10	6.96	1,600	< 1	< 10
6.83	1,600	1	< 10	6.96	1,600	< 1	< 10
6.84	1,600	1	< 10	6.96	1,600	< 1	< 10

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.03	1,350	1	48	7.10	1,200	< 1	10
6.98	1,350	1	50	7.08	1,700	< 1	10
7.03	1,350	1	49	7.08	1,200	< 1	10
7.02	1,350	1	50	7.09	1,200	< 1	10

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TABLE 44
RCRA STATISTICAL ANALYSIS
WELL LOCATION SW-2
(Background Well for Sand and Gravel Aquifer)
(page 9 of 9)

Mean				Variance			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.34	659	1	1,631.7	0.007	294.6	0	8,085,130.5

Round 1				Round 2			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.35	650	< 1	61	7.47	630	< 1	< 10
7.36	660	< 1	61	7.46	640	< 1	< 10
7.36	620	< 1	61	7.46	623	< 1	< 10
7.36	660	< 1	63	7.45	640	< 1	< 10

Round 3				Round 4			
pH	SC	TOC	TOX	pH	SC	TOC	TOX
7.25	670	< 1	5,340	7.25	660	< 1	< 10
7.28	680	< 1	7,560	7.24	670	< 1	10
7.28	680	< 1	5,150	7.24	665	< 1	11
7.31	680	< 1	7,730	7.24	666	< 1	< 10

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FOOTNOTES FOR TABLE 44

1. Total U for TMA/Norcal and WMCO results in mg/l.
2. Total Pu 239, 240.
3. Total U for Howard Laboratory in mg/l calculated from activity measurements. Conversion from pCi/l to mg/l assumes total U calculated as natural U. Use 0.100 mg/l = 67 pCi/l for equilibrium total α activity of U-234 and U-238 (Wrenn, et. al., HP Vol. 48 No. 5 (May, 1985), pp. 601-633).
4. "NS" denotes that analysis could not be performed due to insufficient sample.

TABLE 45
RCRA STATISTICAL ANALYSIS CALCULATED T*/TC STATISTICS

Parameter	Well Number[1]				Well Number[2]				
TOX	112	119	121	122	219	319	221	222	SW-2
Mean	10	10	10	37.5	12.25	10	10	10	26.5
Variance	0.0	0.0	0	27.67	13.58	0	0	0	1.67
T*	-2.19	-2.19	-2.19	-2.15	-2.21	-2.21	-2.21	-2.21	-2.19
Tc	1.73	1.73	1.73	1.73	1.75	1.75	1.75	1.75	1.75
Increase	No	No	No	No	No	No	No	No	No

Parameter	Well Number[1]				Well Number[2]				
TOC	112	119	121	122	219	319	221	222	SW-2
Mean	1	5.5	3	3.75	1	1	1	1	1
Variance	0	0.33	0	0.25	0	0	0	0	0
T*	NA	15.59	NA	11.00	NA	NA	NA	NA	NA
Tc	NA	2.35	NA	2.36	NA	NA	NA	NA	NA
Increase	No	Yes	Yes	Yes	No	No	No	No	No

Parameter	Well Number[1]				Well Number[2]				
Sp. Cond.	112	119	121	122	219	319	221	222	SW-2
Mean	877	2522.5	970	2020	1037.5	1090	1105	1062.5	597.25
Variance	0	34425	3654	19000	1091.7	0	4300	91.67	6.25
T*	-7.62	16.15	-0.92	14.38	22.12	87.132	13.54	58.85	-11.41
Tc	1.73	2.33	2.21	2.32	2.3	1.75	2.34	2.04	1.79
Increase	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No

Parameter	Well Number[1]				Well Number[2]				
pH	112	119	121	122	219	319	221	222	SW-2
Mean	7.81	6.73	7.18	7.01	7.33	7.05	7.29	7.31	7.38
Variance	3.3E-05	0.000292	0.000467	0.000158	6.7E-05	6.67E-05	0.000467	0.000292	0.0003
T*	4.71	-34.63	-17.79	-24.79	-0.23	-12.91	-1.86	-0.96	214
Tc	2.11	2.20	2.25	2.15	2.17	2.17	2.34	2.27	2.28
Change	Incr.	Decr.	Decr.	Decr.	None	Decr.	None	None	None

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1. Each well compared to W-12 background values.
2. Each well compared to SW-2 background values.

TABLE 46
RCRA
BACKGROUND MEANS AND VARIANCES FOR UPGRADIENT WELLS

	112 Glacial Till Well	SW-2 Sand and Gravel Well
pH		
Mean	7.68	7.33
Variance	1.36×10^{-2}	7.53×10^{-3}
S.C.		
Mean	1001.5	655.9
Variance	5339.7	397.2
TOX		
Mean	1672.3	1631.7
Variance	1.15×10^{7}	8.62×10^{6}
TOC		
Mean	(<) 1	(<) 1
Variance	0.0	0.0

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TABLE 47
RCRA
STATISTICAL COMPARISON SUMMARY

Glacial Till Wells	Parameters pH	Specific Cond.	TOC	TOX
112	Increase	No Change	No Change	No Change
119	Decrease	Increase	Increase	No Change
121	Decrease	No Change	Increase	No Change
122	Decrease	Increase	Increase	No Change

Sand and Gravel Wells	Parameters pH	Specific Cond.	TOC	TOX
SW-2	No Change	No Change	No Change	No Change
219	No Change	Increase	No Change	No Change
319	Decrease	Increase	No Change	No Change
221	No Change	Increase	No Change	No Change
222	No Change	Increase	No Change	No Change

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Appendix C
1987 Environmental Monitoring Annual Report Distribution Lists

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