1001-0302130003

BWXT of Ohio, Inc.

Miamisburg Environmental Management Project

Annual Site Environmental Report for Calendar Year 1999

September 2000

MOUND
is operated for the
U. S. Department of Energy
under contract No. DE-AC24-97OH20044

Fractions and Multiples of Units

Multiple	Decimal Equivalent	Prefix	Symbol
10^6	1,000,000	mega	M
10^3	1,000	kilo	k
10^2	100	hecto	h
10	10	deka	da
10^{-1}	0.1	deci	d
10^{-2}	0.01	centi	c
10^{-3}	0.001	milli	m
10^{-6}	0.000001	micro	μ
10^{-9}	0.000000001	nano	n
10^{-12}	0.000000000001	pico	p
10^{-15}	0.000000000000001	femto	f
10^{-18}	0.000000000000000001	atto	a

Conversion Table

Multiply	by	to Obtain	Multiply	by	to Obtain
in	2.54	cm	cm	0.394	in
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
qt (U.S.)	0.946	L	L	1.057	qt (U.S.)
ft^2	0.093	m^2	m^2	10.764	ft^2
ft^3	0.028	m^3	m^3	35.31	ft^3
L	1×10^{-3}	m^3	m^3	1000	L
Ci	3.7×10^{10}	Bq	Bq	2.7×10^{-11}	Ci
rad	0.01	Gy	Gy	100	rad
mrem	0.01	mSv	mSv	100	mrem

Ci = Curie, Bq = Becquerel = 1 disintegration/second, rad = radiation absorbed dose, mrem = millirem (radiation dose equivalent), 1 Gray = 100 Rad, 1 Sv = 100 rem

Miamisburg Environmental Management Project

Annual Site Environmental Report for Calendar Year 1999

September 2000

Prepared by the
Environmental Safeguards and Compliance Department
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for the
U. S. Department of Energy
under Contract No. DE-AC24-97OH20044

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LIST OF ACRONYMS

ALARA	As Low As Reasonably Achievable
APG	Analytical Products Group, Inc.
ATSDR	Agency for Toxic Substances and Disease Registry
ATD	Authorization to Discharge
BOD	Biochemical Oxygen Demand
BVA	Buried Valley Aquifer
BWXTO	BWXT of Ohio
CAA	Clean Air Act
CBOD	Carbonaceous Biochemical Oxygen Demand
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COD	Chemical Oxygen Demand
CRG	Cost Recovery Grant
CWA	Clean Water Act
CWPF	Consolidated Waste Processing Facility
DCF	Dose Conversion Factor
DCG	Derived Concentration Guide
DF&O	Director's Findings and Order
DMW	Dilute Mineral Water
DOE	U. S. Department of Energy
EDE	Effective Dose Equivalent
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ERS	Effluent Recovery System
ESA	Endangered Species Act
ESC	Environmental Safeguards and Compliance
ESD-LV	National Exposure Research Laboratory, Environmental Sciences Division, Las Vegas
FESOP	Federally Enforceable State Operating Permit
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FFCAct	Federal Facility Compliance Act
FWPCA	Federal Water Pollution Control Act
GAC	Granular Activated Carbon
HEPA	High Efficiency Particulate Air
HSWA	Hazardous and Solid Waste Amendments
HT	Tritium, elemental
HTO	Tritium, oxide
IC	Inhibiting Concentration
ICRP	International Commission on Radiological Protection
LC	Lethal Concentration
LDL	Lower Detection Limit
LSA	Low Specific Activity
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MEMP	Miamisburg Environmental Management Project
MGD	Million Gallons per Day

LIST OF ACRONYMS (continued)

MHSF	Moderately Hard Synthetic Freshwater
MMCIC	Miamisburg Mound Community Improvement Corporation
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NOEC	No-Observed-Effect Concentration
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTS	Nevada Test Site
NVO	Nevada Operations Office of the U. S. DOE
OAC	Ohio Administrative Code
Ohio EPA	Ohio Environmental Protection Agency
OHPO	Ohio Historic Preservation Office
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PRS	Potential Release Site
QA	Quality Assurance
RAPCA	Regional Air Pollution Control Agency
RCRA	Resource Conservation and Recovery Act
RMMA	Radioactive Material Management Area
RQ	Reportable Quantity
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
STP	Site Treatment Plan
SU	Standard Units (for pH measurements)
SWPPP	Storm Water Pollution Prevention Plan
TSCA	Toxic Substances Control Act
TU	Toxicity Units
U. S. EPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WM/PP	Waste Minimization/Pollution Prevention

CONTRIBUTORS

This report was prepared by B. M. Farmer, R. P. Paulick, J. K. Puckett and J. D. Guenther of the Environmental Safeguards & Compliance Department of BWXT of Ohio (BWXTO). The authors note with appreciation the support of the following personnel:

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EXECUTIVE SUMMARY

The purpose of this report is to characterize the environmental management performance of the Miamisburg Environmental Management Project (MEMP) in calendar year 1999. The MEMP is a government-owned site operated by Babcock & Wilcox Technologies of Ohio (BWXTO) for the U. S. Department of Energy (DOE). The site's historical mission included production, development, and research in support of DOE's weapon and energy related programs. The defense mission has been phased out. Current MEMP objectives include the nuclear energy program mission, environmental restoration and the transition of the site to the community for reuse as a commercial facility. As a result of economic development activities by the Miamisburg Mound Community Improvement Corporation (MMCIC), 21 private businesses are operating at the site.

MEMP is comprised of almost 100 buildings on nearly 122 hectares (300 acres) of land in Miamisburg, Ohio, approximately 16 km (10 mi) southwest of Dayton. The Great Miami River, which flows through the city of Miamisburg, dominates the landscape of the five-county region surrounding MEMP. The river valley is highly industrialized. The rest of the region is predominately farmland dotted with residential areas, small communities and light industry. Many city and township residences, five schools, the Miamisburg downtown area, and six of the city's 17 parks are located within one mile of the site. The climate is moderate. The geologic record preserved in the rocks underlying the site indicates that the area has been relatively stable since the beginning of the Paleozoic Era more than 500 million years ago. The southwestern portion of the site is located over the Buried Valley Aquifer which has been designated as a sole source aquifer by the U.S. Environmental Protection Agency (U. S. EPA).

ES.1 Perspective on Radiation

Radionuclides, radioactive species of atoms, emit ionizing radiation. Ionizing radiation is radiation possessing enough energy to remove electrons from the substances through which it passes. Most consequences to humans from exposure to radionuclides arise from the interactions of ionizing radiation with human tissue. These interactions are measured based on the amount of energy deposited in the tissue. This value is the absorbed dose. Since different types of ionizing radiation cause different degrees of biological harm, it is necessary to weight the doses to account for those differences. The unit used to make this comparison possible is the dose equivalent. The units used to report dose equivalents are the rem and the Sievert (Sv). Because doses associated with environmental exposures are typically only fractions of a rem or Sievert, it is common to report doses in terms of millirem (mrem) or millisievert (mSv). There are 1000 mrem per rem; 1000 mSv per Sv.

Our bodies are exposed to ionizing radiation each day. Most of this radiation comes from natural sources. The average dose to a resident of the United States from natural sources is about 300 mrem (3 mSv) per year. The primary contributors to this background dose are radon, cosmic and terrestrial sources, and medical sources such as x-rays or diagnostic exposures. A summary of the principles of radiation can be found in Appendix F of this Report.

ES.2 Radionuclide Releases from MEMP

Table ES-1 lists the quantities of radionuclides released by MEMP into the air and water during 1999. The unit used to report these quantities is the curie (Ci), a unit of radioactivity equal to 3.7×10^{10} disintegrations per second. The quantities, or activities, shown in Table ES-1 were measured at the point of release.

Table ES-1. Radiological Effluent Data for 1999

Radionuclide	Released to	Activity, Ci	MEMP Range[b], Ci
Tritium	Air	8.04×10^{2} [a]	$7.36 \times 10^{2} - 8.04 \times 10^{2}$
	Water	2.4	2.2 – 2.5
Plutonium-238	Air	1.1×10^{-5}	$6.9 \times 10^{-6} - 4.5 \times 10^{-5}$
	Water	2.3×10^{-4}	$2.3 \times 10^{-4} - 4.8 \times 10^{-4}$
Plutonium-239,240	Air	3.0×10^{-8}	$2 \times 10^{-8} - 1 \times 10^{-7}$
	Water	3.6×10^{-6}	$1.7 \times 10^{-6} - 7.7 \times 10^{-6}$
Radon-222	Air	1.01	0.55 – 2.4
Uranium-233,234	Air	8.0×10^{-9}	$3 \times 10^{-9} - 9.2 \times 10^{-8}$
	Water	3.8×10^{-4}	$3.5 \times 10^{-4} - 3.9 \times 10^{-4}$
Uranium-238	Air	7.0×10^{-9}	$1.7 \times 10^{-9} - 7 \times 10^{-9}$

[a] Tritium released to air consists of: Tritium oxide, 6.65×10^{2} Ci
Elemental tritium, 1.39×10^{2} Ci

[b] CY1995 -- CY1999

ES.3 Dose Limits

Dose limits, or more precisely, dose equivalent limits, for members of the public are presented in Table ES-2. These limits are expressed in terms of a committed effective dose equivalent (CEDE) and an effective dose equivalent (EDE) for the DOE and U. S. Environmental Protection Agency (EPA), respectively. Values shown in Table ES-2 represent annual limits on dose equivalents established by the DOE and EPA.

Table ES-2. Radiation Dose Limits for Protection of the Public from all Routine DOE Operations

Pathway	Regulatory Standard or Driver	Effective Dose Equivalent[a] mrem	mSv
All exposure media	DOE Order 5400.5	100	1
Air	40 CFR 61 (EPA)	10	0.1
Drinking water	40 CFR 141 (EPA)	4	0.04

[a] Annual Dose Limits

ES.4 Doses from MEMP Operations

In calculating the maximum dose received by a member of the public from MEMP activities, a committed effective dose equivalent is used. The CEDEs are the doses received by a hypothetical adult individual who remained at the site boundary 24 hours per day throughout 1999. This individual was assumed to have:

- breathed exclusively air with radionuclide concentrations corresponding to the location of the maximum offsite dose,
- drawn all of his drinking water from the Miamisburg water supply,
- consumed produce exhibiting the maximum average radionuclide concentrations in samples collected from the Miamisburg area.

The CEDEs from all of these pathways are added to obtain an estimate of the maximum CEDE received by this hypothetical individual. Table ES-3 shows the results for MEMP in 1999. CEDEs for tritium, plutonium-238, plutonium-239, 240, thorium-228, thorium-230, and thorium-232 were calculated. Concentrations of other radionuclides were below background levels or were too small to affect the overall dose. Most of the 1999 CEDE was due to one set of "foodstuffs" or vegetation samples (see Table ES-3). These samples had measurable, although very low, levels of Pu-238 that were greater than observed at other locations in previous years.

Table ES-3. Maximum Committed Effective Dose Equivalents to a Hypothetical Individual in 1999

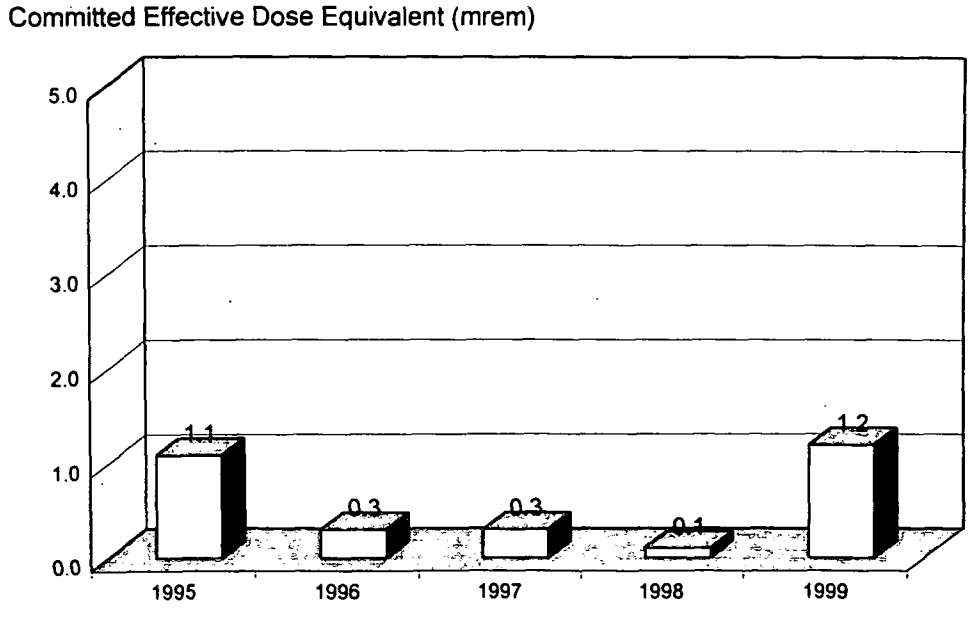
Radionuclide	Pathway	mrem	mSv
Tritium	Air	0.008	0.00008
	Drinking water	0.007	0.00007
	Foodstuffs	0.005	0.00005
	Total	0.02	0.0002
Plutonium-238	Air	0.004	0.00004
	Drinking water	ND	ND
	Foodstuffs	1.039	0.01039
	Total	1.043	0.01043
Plutonium-239,240	Air	0.0008	0.000008
	Drinking water	ND	ND
	Foodstuffs	0.011	0.00011
	Total	0.012	0.00012
Thorium-228	Air	0.015	0.00015
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.015	0.00015
Thorium-230	Air	0.016	0.00016
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.016	0.00016
Thorium-232	Air	0.062	0.00062
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.062	0.00062
Total		1.17	0.0117

ND indicates that concentrations were not detectable above the environmental level or reagent blanks.
NA = not applicable (not measured).

The data presented in Table ES-3 were calculated using environmental monitoring data measured at and near the site. MEMP also evaluates doses using the EPA's computer code CAP88-PC. CAP88-PC uses air effluent data as input to transport, dispersion, and dosimetry codes. By executing these codes, one generates an estimate of a maximum offsite dose from airborne releases. For 1999, the CAP88-PC-estimated maximum offsite dose was 0.05 mrem at a location 800 meters north-northeast of the HEFS stack. As reported in Table ES-2, the EPA's annual dose limit for airborne releases is 10 mrem. Therefore, MEMP releases in 1999 represented 0.5% of the dose limit set by the EPA.

Figure ES-1 shows the five year trend in CEDEs. The increase in CEDE from 1998 to 1999 is attributable to relatively low levels of Pu-238 observed in one set of vegetation samples. The doses from MEMP activities in 1995-1999 were small fractions of the 100 mrem per year DOE dose limit for members of the public. The increase in the CEDE value in 1995 was attributable to the decontamination and decommissioning (D&D) of SM Building. This project was completed in 1995.

Figure ES-1. Calculated CEDEs from MEMP Activities, 1995 - 1999



Population doses. CAP88-PC also has the capability of estimating regional population doses from airborne releases. The population, approximately 3,035,000 persons, within a radius of 80 km (50 mi) of MEMP received an estimated 2.22 person-rem from site activities in 1999. CAP88-PC arrived at that value by calculating doses at specific distances and in specific compass sectors relative to MEMP. The computer code then multiplied the average dose in a given area by the number of people living there. For example, an average dose of 0.001 rem x 10,000 persons in the area yields a 10 person-rem collective dose for that region. CAP88-PC then sums the collective doses for the 80-km radius region and reports a single value. Additional dose components from drinking water and radon emissions are added to obtain this result.

MEMP's dose contribution of 2.22 person-rem can be put in perspective by comparison with background doses. The average dose from background sources is 300 mrem (0.3 rem) per individual per year. A background collective dose can be estimated for the 80-km population by multiplying 0.3 rem x 3.035 million persons. The result, about one million person-rem, represents an estimate of the collective dose from all background sources of ionizing radiation. MEMP's contribution is approximately 0.00021% of that value.

ES.5 Environmental Monitoring Program Results

Besides setting limits on the CEDE to any member of the public, DOE has established Derived Concentration Guides (DCGs) for individual radionuclides. The DCG is defined as the concentration of a radionuclide in air or water that will result in a CEDE of 100 mrem (1 mSv) following continuous exposure for one year. The concentrations of radionuclides resulting from MEMP's 1999 releases were small fractions of the corresponding DCGs (see Chapter 4).

Radiological Monitoring of the Atmosphere

Ambient air is sampled for tritium and plutonium by an onsite network of eight perimeter stations and by an offsite network of 12 stations. Eleven of the offsite samplers are located in the Miamisburg area. One sampler is located far enough away to receive virtually no impact from MEMP activities. This sampler serves as a reference location to establish background or environmental levels of tritium, plutonium, and thorium. The amount by which a sample exceeds the background or environmental level is reported as an incremental concentration.

In 1999, average incremental concentrations measured at the onsite samplers were less than 0.03%, 0.006%, 0.002%, 0.02%, 0.02%, and 0.08%, respectively, of the DOE DCGs for tritium, plutonium-238, plutonium-239, thorium-228, thorium-230, and thorium-232.

Radiological Monitoring of Water

Water samples were collected from locations along the Great Miami River and were analyzed for tritium, plutonium-238, plutonium-239,240, uranium-233,234, uranium-238, thorium-228, thorium-230, and thorium-232. Other surface water locations were sampled for tritium and plutonium. Additionally, river sediment samples were analyzed for isotopes of plutonium and thorium.

River water. Average tritium concentrations in the river were less than 0.03% of the DOE DCG for tritium in water. The average incremental concentrations of plutonium-238 and plutonium-239,240 in water from the Great Miami River were less than 0.06% and 0.007%, respectively, of the DCGs. The average incremental concentrations of thorium-228, uranium-233,234 and uranium-238 were below the environmental level. Incremental thorium-230 and thorium-232 concentrations were less than 0.003% and 0.05%, respectively, of the DOE DCGs.

Pond Water. Samples from local ponds are sampled annually for tritium, plutonium-238, plutonium-239,240, and thorium-228, thorium-230, and thorium-232. Average incremental tritium concentrations in pond water were 0.09% of the DOE DCG. Incremental concentrations of plutonium and thorium-228 were not detectable above environmental levels. Concentrations of thorium-230 and thorium-232 were below 0.05% of the DCG.

Sediment. Plutonium and thorium results for river and pond sediments are listed in Appendix B, Tables B-14 through B-19. Maximum and average concentrations for 1999 are comparable to concentrations observed in previous years. Since isotopes of plutonium and thorium tend to accumulate in sediment, concentrations are affected by the movement of silt. This accounts for the variability in plutonium concentrations at the various river and pond locations.

Radiological Monitoring of Foodstuffs

Locally-grown produce was collected from the surrounding area. These samples were then analyzed for tritium and/or plutonium as appropriate. Average incremental concentrations of tritium, plutonium-238, and plutonium-239,240 were below 285×10^{-9}, 2.08×10^{-9}, and 0.03×10^{-9} μCi/g, respectively. Comparing 1999 results to 1998 results, average incremental concentrations of tritium, plutonium-238, and plutonium-239,240 were lower, higher, and lower, respectively.

Nonradiological Monitoring of Air

Particulate loadings are measured at all of the onsite and offsite air sampling locations. Particulate concentrations appeared to be independent of distance. This result suggests that MEMP exerts little or no influence on the levels of airborne particulates in the ambient environment.

Nonradiological Monitoring of Water

MEMP's nonradiological liquid discharges are regulated by an National Pollutant Discharge Elimination System (NPDES) permit and Authorization to Discharge (ATD). In 1999, over 1,300 samples were collected to demonstrate compliance with these permits. Of these, two results exceeded the permit limitations for total suspended solids (TSS). Additional information about NPDES and ATD results for 1999 can be found in Chapter 5.

ES.6 Groundwater Monitoring Program

MEMP maintains an extensive network of onsite and offsite monitoring wells. In addition, a number of onsite and offsite production wells and community water supplies are routinely sampled. Drinking water from the Miamisburg area is analyzed for tritium and isotopes of plutonium, uranium, and thorium. Other regional water supplies are sampled for tritium. Samples from monitoring and production wells are analyzed for various constituents including radionuclides, volatile organic compounds, metals, and inorganic cations and anions. As in previous years, monitoring data collected in 1999 indicated that volatile organic compounds and tritium, respectively, are the primary nonradiological and radiological contaminants of concern. Information about groundwater monitoring results for 1999 can be found in Chapter 6.

ES.7 Environmental Restoration

MEMP was designated a Superfund site, i.e., placed on the National Priorities List, in November of 1989. A Federal Facilities Agreement (FFA) between the DOE and the U. S. EPA followed in October of 1990. The FFA was expanded to a tri-party agreement in 1993 when the Ohio EPA became a signatory. The purpose of the FFA remains unchanged; it defines the responsibilities of each party for the completion of Superfund-related (CERCLA-related) activities. Highlights of the environmental restoration program during 1999 are described in Chapter 3 of this report.

ES.8 Quality Assurance for Environmental Data

To ensure the reliability of environmental data, MEMP maintains an internal quality assurance (QA) program that consists of running blanks, internal standards, and replicate samples. MEMP also participates in comparison exercises with external laboratories to further validate MEMP's environmental results. Comparisons of MEMP's performance with that of other laboratories are shown in Chapter 7 of this report. The close agreement between MEMP and the external labs provides confidence that MEMP's Environmental Monitoring Program generates reliable data.

CHAPTER 1

1.0 INTRODUCTION

1.1 Description of the Miamisburg Environmental Management Project

Location

The Miamisburg Environmental Management Project (MEMP) is comprised of almost 100 buildings on nearly 122 hectares (300 acres) of land in Miamisburg, Ohio, approximately 16 km (10 mi) southwest of Dayton (Figure 1-1). The Great Miami River flows southwest through the City of Miamisburg and dominates the geography of the region surrounding MEMP (Figure 1-2). The river valley is highly industrialized. The rest of the region is predominantly farmland dotted with residential areas, small communities and light industry. Many city and township residences, five schools, the Miamisburg downtown area, and six of the city's 17 parks are located within one mile of the site.

View of MEMP Looking East Across the Great Miami River

Figure 1-1. Locations of Miamisburg and Surrounding Communities

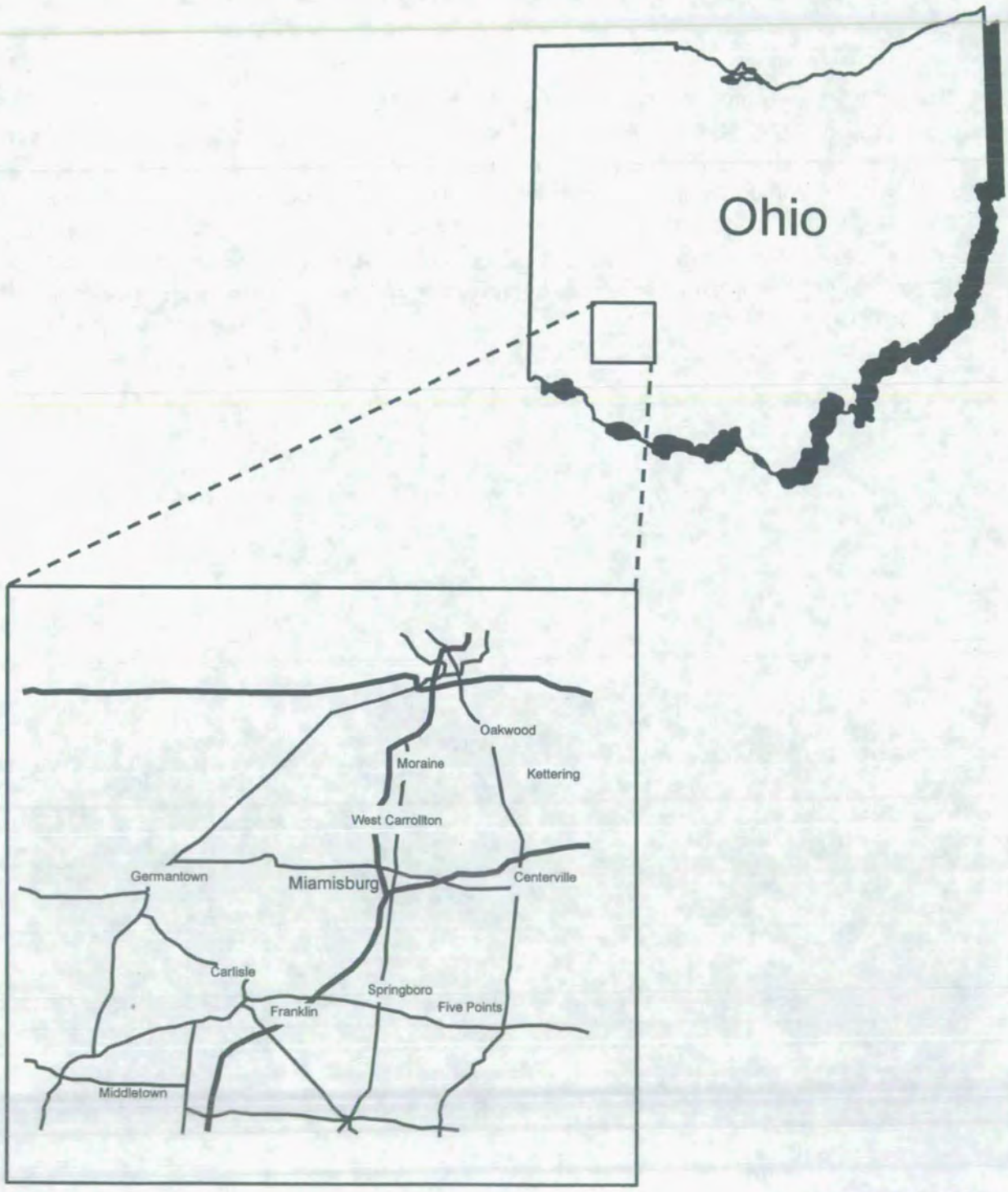
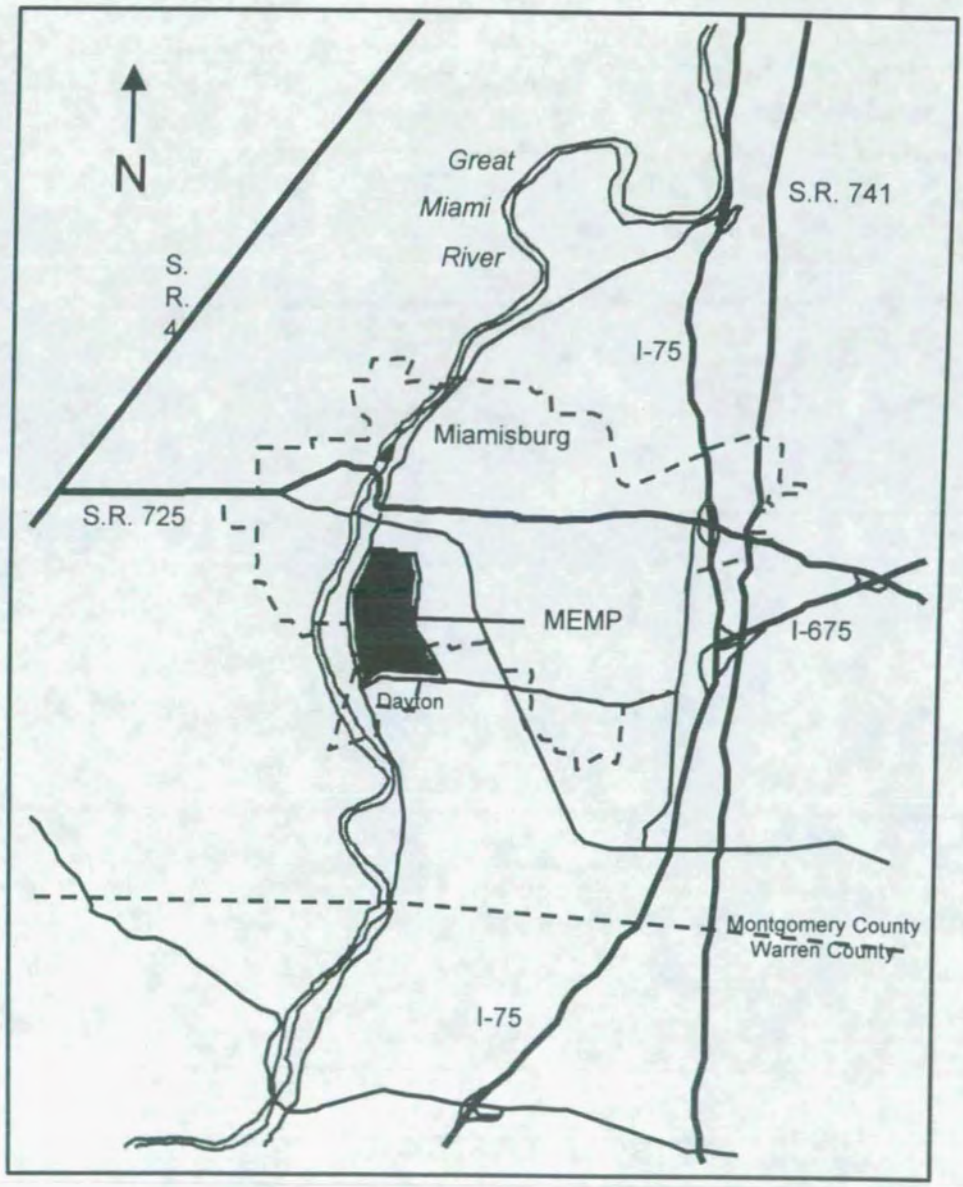


Figure 1-2. Location of MEMP



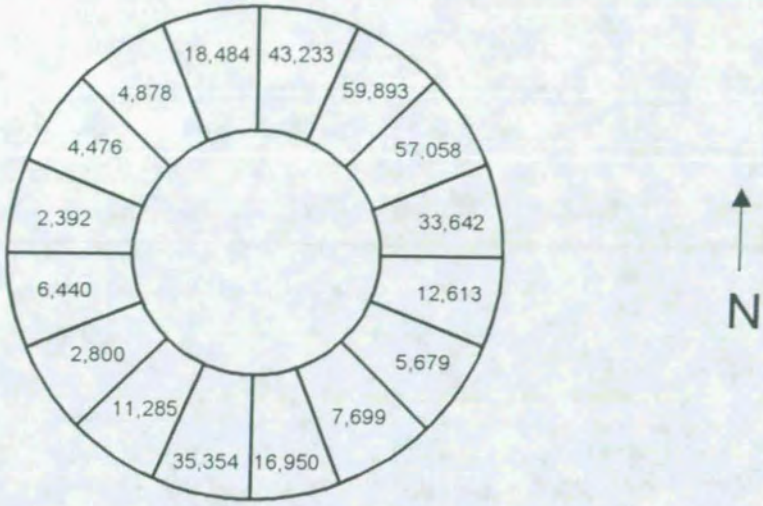
Population and Land Use

Figure 1-3 shows the population distribution within 50 miles (80 km) of the site. The population information was extracted from 1990 Census data by the Ohio Department of Development. The estimated number of individuals residing within the 50-mile radius is 3,034,679 (Table 1-1). The primary agricultural activity in the area is raising field crops such as corn and soybeans. Approximately 10% of the agricultural land is devoted to pasturing livestock.

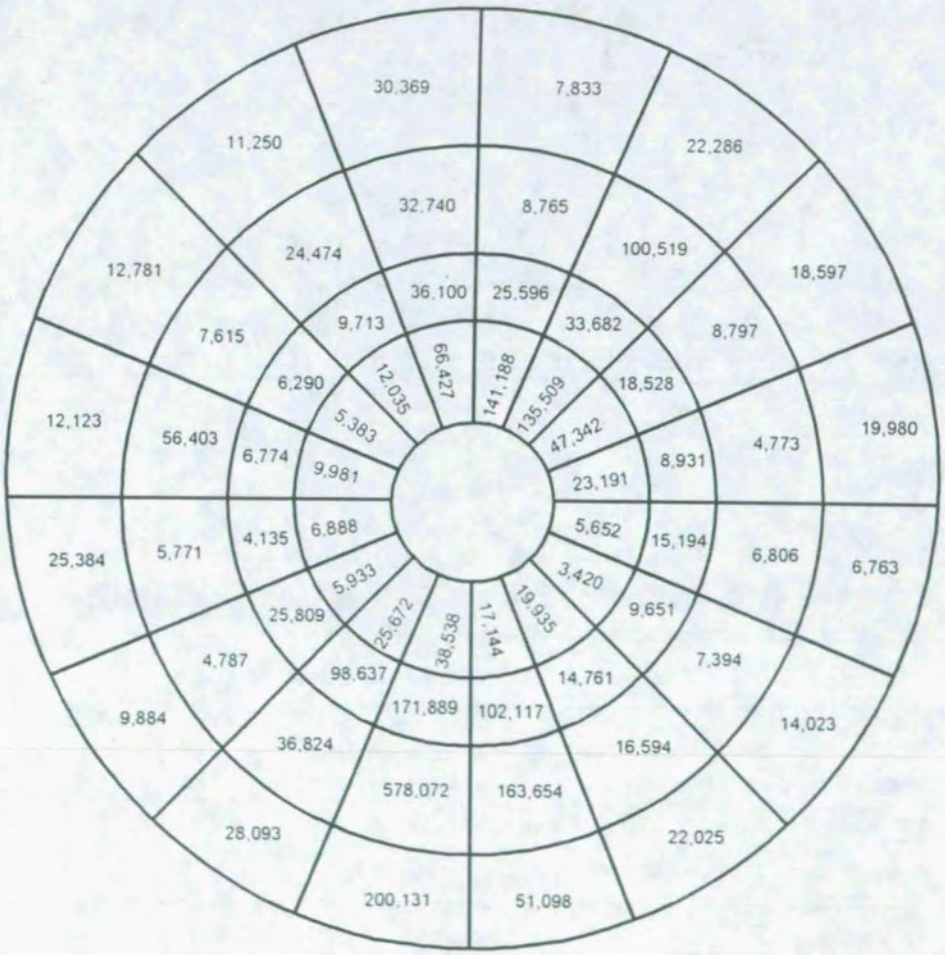
Table 1-1. Population Totals from the 1990 Census

Radius, miles	Total
0-10	322,876
0-20	887,114
0-30	1,477,621
0-40	2,541,609
0-50	3,034,679

Figure 1-3. Distribution of Population within 50 mi (80 km) of MEMP



0 - 10 Miles



10 - 50 Miles

Geology

The geologic record preserved in the rocks underlying the site indicates that the area has been relatively stable since the beginning of the Paleozoic era more than 500 million years ago. There is no evidence indicating subsurface structural folding, significant stratigraphic thinning, or subsurface faulting. Limestone strata, which are interbedded with shale layers at the site, show no evidence of solution activity. No evidence of solution cavities or cavern development has been observed in any borings or outcrops in the Miamisburg area.

Hydrogeology

The aquifer system of the site consists of two different hydrogeologic environments: groundwater flow through the bedrock beneath the hills and groundwater flow within the unconsolidated glacial deposits and alluvium associated with the Buried Valley Aquifer (BVA) in the Great Miami River valley. The bedrock flow system is dominated by fracture flow and is not considered a productive aquifer. The BVA is dominated by porous flow with interbedded gravel deposits providing the major pathway for water movement. The unconsolidated deposits are Quaternary Age sediments consisting of both glacial and fluvial deposits. The BVA is a highly productive aquifer capable of yielding a significant quantity of water. The BVA is considered a sole source aquifer.

Climate

The climate is moderate. The average annual precipitation rate is 94 cm (37 in) per year. As shown in Figure 1-4, the total precipitation measured at the site in 1999 was 58.1 cm (23 in). During 1999, winds were predominately out of the south-southwest (Figure 1-5). The annual average wind speed measured at MEMP for 1999 was 5.1 m/s (11.4 mi/hr) (Table 1-2).

Topography

The site topography is shown in Insert 1-1 (see 11 in x 17 in foldout at the end of this Chapter). MEMP site elevations vary from 216 m to 268 m (700 ft to 900 ft) above sea level; most of the site is above 244 m (800 ft). No building in which radioactive material is processed is located below an elevation of 241 m (790 ft). The typical nonflood stage of the Great Miami River is 208 m (682 ft). The highest flood-water levels that can be reasonably postulated for the Great Miami River basin (100-year storm event) would result in flooding to 213 m (700 ft). A narrow area along the southwest border of the site and a small triangular area in the extreme northeastern corner of the site lie within the 100-year floodplain.

Figure 1-4. Monthly Precipitation Measured at MEMP in 1999

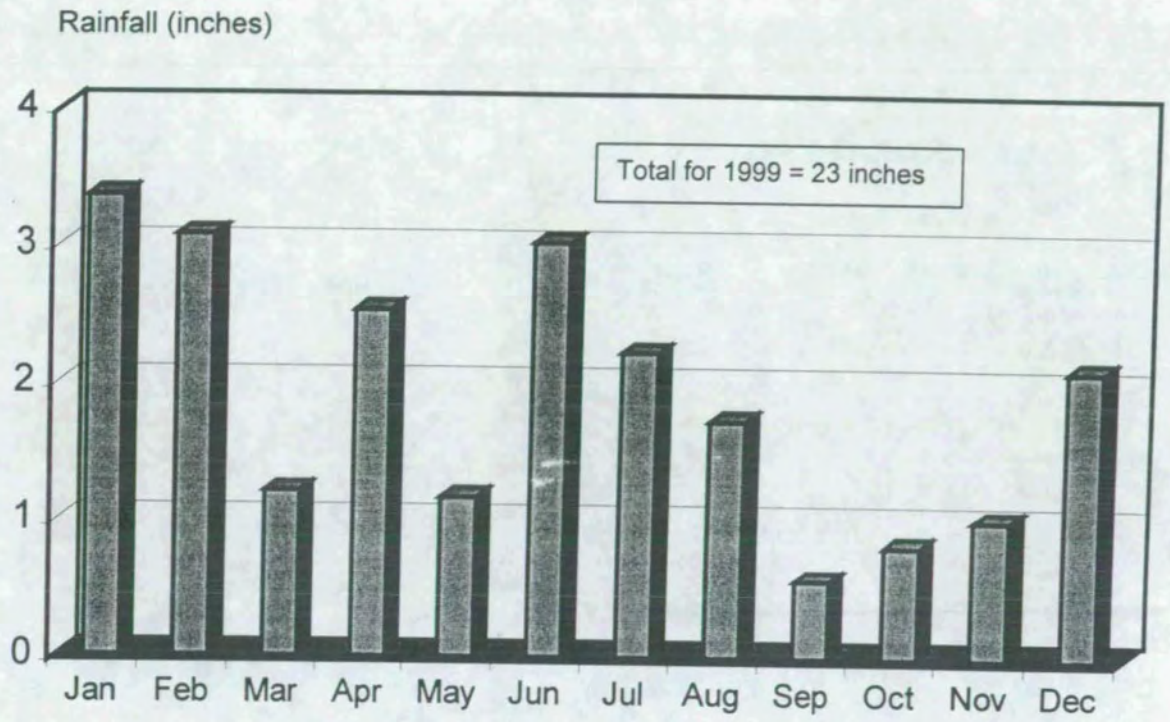


Figure 1-5. 1999 Wind Rose for MEMP

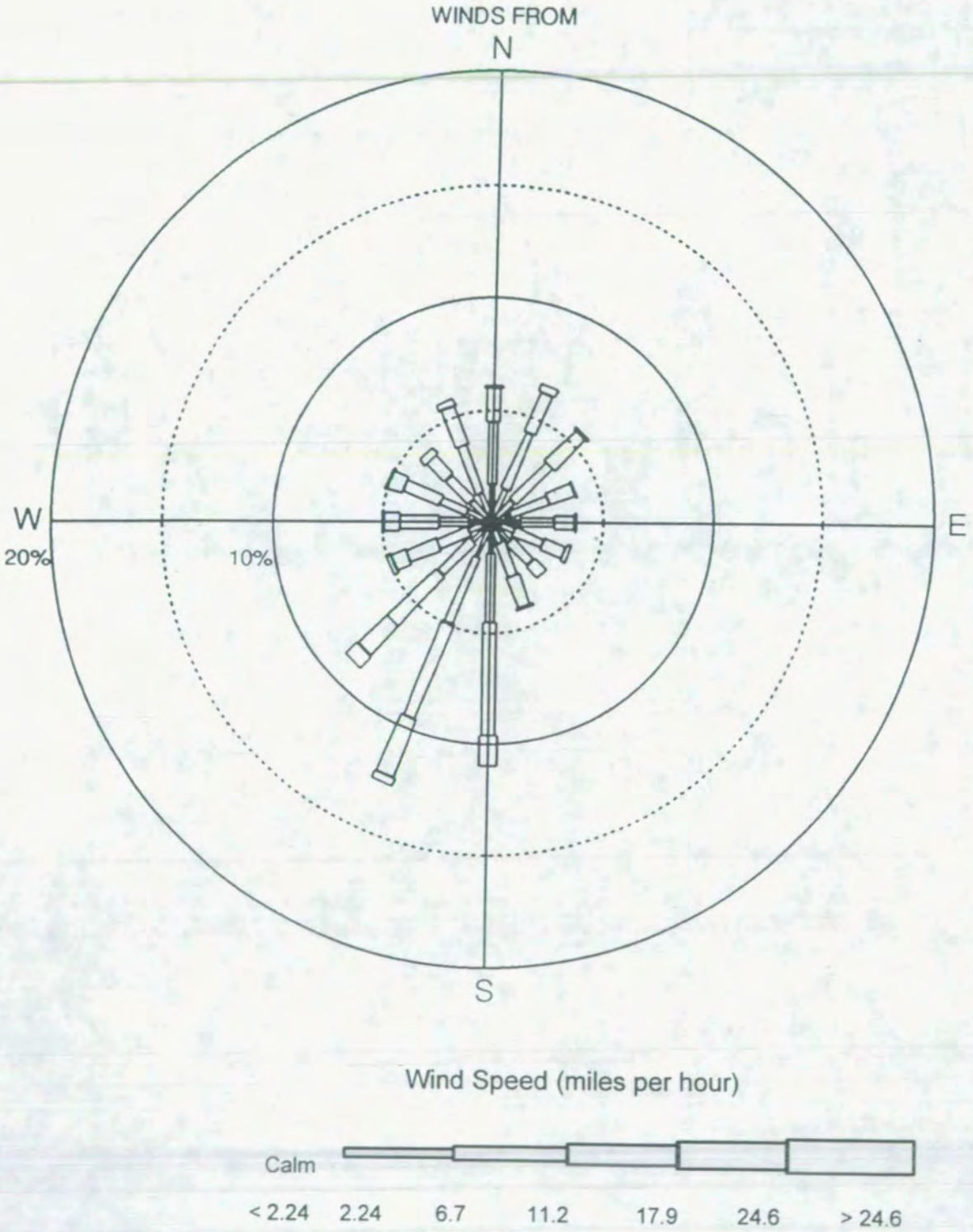


Table 1-2. Percent Frequency of Wind Direction and Wind Speed from MEMP 50-m Meteorological Tower for 1999

Direction	Percent of Time Winds From	Average Speed (m/s)[a]
N	6.3	4.1
NNE	7.0	4.4
NE	6.0	4.4
ENE	4.3	4.4
E	4.1	4.1
ESE	3.9	3.9
SE	3.4	3.9
SSE	4.4	4.5
S	11.4	5.5
SSW	13.1	6.1
SW	9.2	6.4
WSW	5.3	5.5
W	5.4	5.4
WNW	5.4	5.2
NW	4.7	4.4
NNW	6.1	4.5
		Average 5.1

[a] 1 m/s = 2.24 mi/hr.

Total relative frequency of calms distributed above is 1.1%.

Mission and Operations

In the past, MEMP served as an integrated research, development, and production facility in support of DOE weapon and nonweapon programs, especially in the areas of chemical explosives and nuclear technology. The principal mission of MEMP was research, development, and manufacture of non-nuclear explosive components for nuclear weapons that were assembled at another DOE site. Other major operations at MEMP included:

- Manufacture of stable (nonradioactive) nuclides for medical, industrial, and general research.
- Recovery and purification of tritium from scrap materials generated by MEMP and other DOE sites.
- Development and fabrication of radioisotopic thermoelectric generators fueled with plutonium-238 to provide power sources for such projects as lunar experiments, satellites, and spacecraft.
- Surveillance of explosive and radioactive weapons components received from other DOE sites.

As a result of the November 22, 1993, DOE decision to phase out the defense mission at MEMP, activities are currently underway to transfer MEMP's defense-related programs to other sites within the DOE complex. Current MEMP objectives include continuing the nuclear energy program mission, environmental restoration, and the transition of the site to the community for reuse as a commercial facility. As a result of recent economic development activities by MMCIC, 21 private businesses are operating at the site. Parcels D (Building 105 area) and H ("lower" parking lot area) were transferred to the Miamisburg Mound Community Improvement Corporation (MMCIC) on March 23, 1999, and August 12, 1999, respectively.

1.2 Perspective on Radiation

This section puts into perspective the potential consequences of the radionuclide releases described in subsequent sections of this report. Additional background information on radiation can be found in Appendix F, *Principles of Radiation.*

Most consequences to humans from radionuclides are caused by interactions between radiation emitted by the nuclides and human tissue. These interactions involve the transfer of energy from the radiation to the tissue, a process that may damage the tissue. The radiation may come from radionuclides located outside the body (i.e., in or on environmental media and man-made objects) and from radionuclides deposited inside the body via inhalation, ingestion, or absorption through the skin. Exposure to radiation from nuclides located outside the body is called external exposure and will last only as long as the exposed person is near the external source. Exposure to radiation from radionuclides deposited inside the body is called internal exposure and will last as long as the radionuclides remain in the body.

A number of specialized units are used to characterize exposure to ionizing radiation. Because the damage associated with such exposures is due primarily to the deposition of radiant energy in tissue, these units are described in terms of the amount of energy absorbed by the tissue and the biological consequences of the absorbed energy. Some of the key units are defined below:

- **Absorbed dose** indicates the amount of energy absorbed by a material (e.g., human tissue), divided by the mass of the material. The unit of absorbed dose is the gray (Gy) or the rad (100 rads = 1 Gy).

- **Dose equivalent** indicates the biological effect of an absorbed dose on a particular organ or tissue. It equals the absorbed dose multiplied by factors that relate the absorbed dose to biological effects on that particular organ. The unit of dose equivalent is the sievert (Sv) or the rem (100 rem = 1 Sv).

- **Effective dose equivalent** indicates an individual's cancer risk from an exposure to ionizing radiation. It is calculated from the weighted sum of the dose equivalents from the irradiated organs. It is also expressed in rem or Sieverts.

- **Committed effective dose equivalent** indicates the total dose over the individual's projected remaining lifetime (assumed to be 50 years) that results from an intake during one year. The committed effective dose equivalent (CEDE) expresses the dose of internal radiation received when an individual has ingested or inhaled a radionuclide that will remain inside the body for months or years. It is also expressed in rem, mrem (1000 mrem = 1 rem), or Sieverts.

- **Collective committed effective dose equivalent** indicates the sum of the committed effective dose equivalents to the individuals in a population. It gives an estimate of the expected health risk to the population from a dose of radiation. It can be used to calculate probable risks that might be too small to predict on the basis of a single individual. It is expressed in person-rem or person-Sieverts.

Sources of Radiation

Every day our bodies absorb ionizing radiation. Most of it comes from natural sources. Consumer products and medical procedures that use radiation are other common sources of ionizing radiation.

Natural Sources. Natural radiation comes from two sources, cosmic and terrestrial. Cosmic radiation results when energetic particles from outer space, traveling at nearly the speed of light, collide with nuclei in our atmosphere, creating showers of radioactive particles that fall to earth. The average annual dose equivalent received from cosmic radiation is 26 mrem (0.26 mSv) for an individual living at sea level. Because cosmic radiation dissipates as it travels through the atmosphere, individuals living at lower altitudes receive less dose from this source than those living at higher altitudes.

Terrestrial radiation results when radionuclides that are a natural part of the earth's rocks and soils emit ionizing radiation. Because the concentrations of these radionuclides vary

geographically, an individual's exposure depends on his location. The average annual dose equivalent from terrestrial radiation for an individual living in the U. S. is 28 mrem (0.28 mSv).

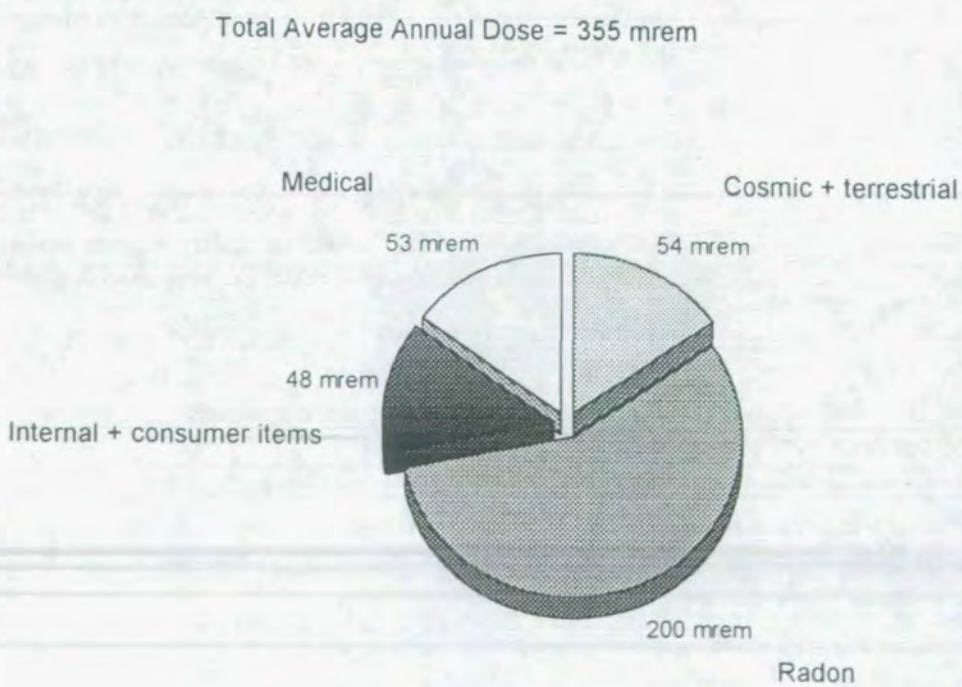
Besides absorbing radiation from external radionuclides, we can also absorb radiation internally when we ingest radionuclides along with the water, milk, and food we eat or along with the air we inhale. Once in our bodies, radionuclides follow the same metabolic paths as nonradioactive forms of the same elements. The length of time a particular radionuclide remains in the body and emits radiation depends on whether the body eliminates it quickly or stores it for a long period, and on how long it takes for the radionuclide to decay into a nonradioactive form. The principal source of internal exposure in the U. S. is believed to be radon. Inhalation of radon contributes about 200 mrem (2.0 mSv) to the average annual dose equivalent from internal radiation. Other radionuclides present in the body contribute approximately 39 mrem (0.39 mSv).

Consumer Products. Many familiar consumer products emit ionizing radiation. Some must emit radiation to perform their functions, e. g., smoke detectors and airport x-ray baggage inspection systems. Other products, e.g., TV sets, emit radiation only incidentally to performing their functions. The average annual effective dose equivalent to an individual from consumer products ranges from 6 to 12 mrem (0.06 to 0.12 mSv).

Medical Uses. Radiation is a tool for diagnosing and treating disease. The average annual dose equivalent for an individual in the U. S. from diagnostic radiation is 53 mrem (0.53 mSv). Individuals undergoing therapeutic radiation procedures may receive much higher doses.

Summary. The contributions to an average individual's annual radiation dose are shown in Figure 1-6. MEMP's maximum contribution for 1999, 1.17 mrem, is too small to be seen in the figure.

Figure 1-6. Average Annual Radiation Dose in the U.S. (NCRP, 1987)



CHAPTER 2

2.0 COMPLIANCE SUMMARY

BWXTO operates in compliance with environmental requirements established by federal, state, and local statutes and regulations. Additional requirements are imposed by Executive Orders, DOE Orders, and various compliance agreements. The site's status with respect to environmental requirements is summarized below.

2.1 Major Environmental Statutes, Regulations and Orders

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Federal Facilities Agreement (FFA)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, also known as Superfund, is the federal government's primary environmental restoration legislation. Through CERCLA, the U. S. EPA identifies sites where hazardous substance contamination may present a risk to human health and/or the environment. Those sites presenting a human health or environmental risk are then placed on the National Priorities List (NPL).

MEMP was added to the NPL in November of 1989 because of volatile organic compound (VOC) contamination in groundwater. A Federal Facilities Agreement (FFA) between the DOE and the U.S. EPA followed in October of 1990. The FFA defines the responsibilities of each party for the completion of CERCLA-related activities.

The FFA became a tri-party agreement on July 15, 1993, when the Ohio EPA became a signatory. The addition of the Ohio EPA did not change the purpose of the agreement, but rather provided a mechanism for the full participation of the Ohio EPA in the CERCLA process.

Preliminary CERCLA assessment of contamination at the site identified approximately 125 locations of actual or suspected releases. These locations were grouped into "Operable Units" (OUs) based on waste type and/or geographical proximity. Originally, nine OUs were established. As CERCLA activities progressed, changes to the number and composition of the OUs were warranted. In 1995, the CERCLA program was reorganized to increase the efficiency of the environmental restoration effort. The initiative, termed "MOUND 2000," has accelerated clean-up of the site so that the land can be released for economic development much sooner than originally planned. The MOUND 2000 process addresses buildings and potential release sites (PRSs) individually. More than 400 PRSs have been identified. A core team, comprised of U.S. EPA, Ohio EPA, and DOE representatives, reviews the status of each building and PRS based upon an information package that serves as the basis for decision-making. The core team reaches a consensus decision to categorize each PRS or building in one of the following ways: (1) no further assessment is required, i.e., the site is protective of human health and the environment, (2) a response action is warranted, or (3) there is insufficient information to make a determination (further assessment is needed). If there is consensus that the site is protective of human health and the environment, no further action is taken. If it is determined that

further assessment is needed, the additional data necessary to make a decision are collected and presented to the core team. If it is cost-prohibitive to obtain the necessary data, a decision to initiate a response action may be made. A response action is a clean-up action tailored to the PRS or building of interest. Core team decisions to initiate a response action or that no further assessment is required are presented to stakeholders. The MOUND 2000 process accelerates clean-up of the site by focusing on discrete areas and streamlining decision making. The end result is a multi-year and multi-million dollar savings that will allow DOE to exit the site and make the site available for economic development. A brief description of environmental restoration activities for 1999 can be found in Chapter 3.

In addition to the activities described above, the Superfund Act established a list of CERCLA-regulated materials. Release of these materials to the environment is subject to certain reporting requirements. No releases of reportable quantities of CERCLA-regulated materials occurred in 1999.

Clean Air Act (CAA)

Nonradiological emissions. The Clean Air Act (CAA) of 1970, as amended in 1977, gave the U. S. EPA authority to regulate two groups of airborne pollutants: criteria pollutants and hazardous air pollutants. The CAA was again amended in 1990. The major impact of the amendments was the requirement that major emitters of pollutants obtain comprehensive (Title V) air permits. As an alternative to Title V permits, MEMP applied for and received Federally Enforceable State Operating Permits (FESOPs). The FESOPs place limits on annual usage and thus limit potential air emissions.

MEMP is also subject to state air pollution regulations, including OAC 3745-31,-35,-15. Compliance with State of Ohio regulations requires that applicable MEMP activities be permitted or otherwise registered. The Ohio Environmental Protection Agency (Ohio EPA) has issued MEMP thirteen air permits (See Table 3-3). Ten other sources are registered with the Regional Air Pollution Control Agency (RAPCA). In order for a source to be considered for registration status, (1) the source owner must demonstrate compliance with all applicable laws including employment of best available technology, (2) maximum emissions of particulate matter, sulfur dioxide, nitrogen oxides, and organic compounds cannot exceed five tons per year, and (3) the source cannot be subject to U.S EPA new source performance standards or the National Emission Standards for Hazardous Air Pollutants (NESHAPs).

To ensure compliance with all state and local reporting requirements, chemical air emission data are collected. This information is maintained in a data base that is updated each calendar year. In addition to providing information on release levels for materials regulated by the CAA, the database is used to meet the reporting requirements of other statutes such as the Emergency Planning and Community Right-to-Know Act. All emissions were within required limits and no enforcement actions were initiated in 1999.

Radiological emissions. Ten stacks and ten building vents at the site discharge radioactive effluents to the atmosphere. These releases are subject to NESHAPs for radionuclides. These "radionuclide NESHAPs" regulations (40 CFR 61, Subpart H) are components of the Clean Air Act (CAA) and are enforced by the U. S. EPA.

The primary standard against which compliance with 40 CFR 61, Subpart H is measured is an annual effective dose equivalent (EDE). The regulations require that radionuclide air emissions from a given site do not exceed those amounts that would cause a member of the public to receive an annual EDE of 10 mrem (0.10 mSv). The regulations also state that each facility must determine this "maximum offsite dose" using an approved approach; the preferred approach is to use a computer code such as CAP88-PC.

Based on CAP88-PC calculations performed for MEMP emissions in 1999, the maximum EDE received by a member of the public was 0.05 mrem. This value represents 0.5% of the dose limit and demonstrates that MEMP releases for 1999 were well below allowable release levels.

The NESHAPs also define sampling and monitoring techniques which apply to stacks and vents that release radioactive materials. A Federal Facility Compliance Agreement (FFCA) to bring MEMP's effluent sampling and monitoring practices into full compliance with the requirements of 40 CFR 61, Subpart H was signed between DOE and Region 5 of the U. S. EPA in July of 1994. On December 22, 1998, MEMP received confirmation from U. S. EPA that the terms of the FFCA had been fully satisfied. MEMP was judged to be in full compliance with the requirements of 40 CFR 61, Subpart H and the FFCA was terminated.

Clean Water Act (CWA)

The Federal Water Pollution Control Act (FWPCA) of 1972 was established to limit the types and rates of liquid effluents that may be discharged to the nation's waters. The U. S. and/or state EPA using a National Pollutant Discharge Elimination System (NPDES) permit set these limits for a specific site. An NPDES permit is also used to maintain compliance with more recent legislation, the Clean Water Act (CWA) of 1987.

Ohio EPA renewed the site's NPDES permit on November 1, 1997. The permit was modified in March 1998. The permit defines discharge limits and monitoring frequencies for the site's water effluents. NPDES permit limitations were exceeded once during 1999 for total suspended solids (TSS). The exceedance was reported to the Ohio EPA and prompt corrective actions were taken following the incident. See Section 5.2. No enforcement actions were initiated in 1999.

In July 1997, the Ohio EPA issued an Authorization to Discharge (ATD) for the CERCLA OU 1 groundwater remediation process. One element of this process involves the continuous pumping of groundwater from a series of extraction wells to prevent migration of volatile organic compounds (VOCs) into the aquifer. The ATD serves as an NPDES permit for wastewater discharged as a result of this CERCLA action, specifying discharge limits and monitoring frequencies. During 1999, no exceedances of ATD discharge limitations occurred.

Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act (SDWA) of 1974 required the U. S. EPA to establish a program to protect drinking water sources. To meet this goal, the EPA developed National Primary and Secondary Drinking Water Standards. These standards are applied to drinking water supplies "at the tap." Since the site withdraws well water for use as drinking water, MEMP is subject to the requirements of the Act.

In Ohio, the SDWA is administered by the Ohio EPA. In accordance with Ohio EPA requirements, the site's drinking water system is routinely tested for various compounds. These analyses must be performed by a state-certified laboratory. In 1999, National Environmental Testing, Inc. (NET) performed the following analyses: total coliform, lead, copper, nitrate, synthetic and volatile organic chemicals, radium, gross alpha and beta, and tritium. In 1999, the action level for lead was exceeded during semi-annual sampling events. Consequently, a corrosion control program designed to reduce copper and lead levels in drinking water continued.

Under the Ohio EPA's SDWA authority, MEMP is also required to maintain a minimum chlorination level of 0.2 mg/L free chlorine (or 1.0 mg/L combined chlorine) in the site's potable water system. This standard applies throughout the distribution system.

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act (RCRA) of 1976, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, established a "cradle to grave" tracking system for hazardous wastes. The Acts led to the implementation of registration and/or permit requirements for all facilities that transport, generate, treat, store, and/or dispose of hazardous wastes. The Ohio EPA administers this program for the State of Ohio.

BWXTO operates two hazardous waste storage units; one is used for hazardous wastes and the other is used for mixed wastes, i.e., radioactive wastes that are also regulated by RCRA. The storage units are operated in accordance with a RCRA Part B permit issued by the Ohio EPA in October 1996.

Hazardous wastes stored onsite are managed pursuant to RCRA requirements with respect to waste characterization, labeling, storage container integrity, facility performance criteria, and emergency response preparedness. These wastes are shipped offsite for approved treatment and/or disposal.

In April of 1998, the Ohio EPA issued DOE MEMP a Notice of Violation (NOV) for the accumulation of potentially RCRA-regulated chemicals and uncharacterized waste-like materials. In response to the NOV, a Chemical Disposition Plan was developed. This plan accelerated existing programs to identify, collect, characterize, and disposition excess legacy chemicals.

Waste disposition. In 1999, 62,444 pounds of hazardous and other regulated wastes were shipped offsite. Of that amount, 31,110 pounds were RCRA-regulated wastes, 20,098 pounds were asbestos and PCB wastes, and 11,236 pounds were other wastes not suitable for sanitary landfilling.

It is the policy of DOE that hazardous wastes originating in Radioactive Material Management Areas (RMMAs) be treated as "suspect" mixed wastes, (i.e., suspected of being radioactively contaminated). This precaution is necessary to ensure that hazardous waste management facilities do not receive radioactive wastes unless they are equipped and licensed to do so. As a result of this policy, BWXTO has implemented procedures to ensure that waste sent to commercial treatment/storage/disposal facilities is not radioactively contaminated.

Nonhazardous solid wastes generated by BWXTO are disposed of in a licensed, permitted sanitary landfill. The volume of materials requiring landfill disposal has been reduced as a result of recycling programs for paper, glass, and scrap metal. See Section 3.7.

Federal Facility Compliance Act (FFCAct)

The Federal Facility Compliance Act (FFCAct) was signed into law on October 6, 1992. The FFCAct requires that all DOE facilities prepare an inventory of mixed wastes and mixed waste treatment capabilities. In accordance with the Act, a Conceptual Site Treatment Plan was submitted to the Ohio EPA in October of 1993. Following discussions with the Ohio EPA and public stakeholders, the Conceptual Site Treatment Plan was revised and a *Draft Site Treatment Plan* was submitted to the Ohio EPA in August, 1994. The final *Site Treatment Plan* (STP) was submitted to DOE in March, 1995 and a Director's Findings and Orders (DF&O) was signed on October 4, 1995. The DF&O establishes schedules and treatment technologies for DOE's mixed waste. The STP is updated annually at a minimum.

BWXTO continues to reduce the volume of onsite legacy mixed waste. In 1999, five mixed waste streams were shipped off-site for treatment and disposal. BWXTO will continue to explore new treatment options as they become available to reduce the turnaround times associated with disposition of newly discovered mixed waste streams.

Toxic Substances Control Act (TSCA)

The goal of the Toxic Substances Control Act (TSCA) of 1976 is to protect human health and the environment from unreasonable risks associated with toxic chemical substances. The Act gave the U. S. EPA authority to govern the manufacture and use of chemicals deemed to present significant toxicity risks. Efforts continue to remove TSCA wastes associated with past practices. The two primary components of this category of waste are polychlorinated biphenyls (PCBs) and asbestos. In 1999, 20,098 pounds of asbestos and PCB wastes were shipped offsite for disposal.

Polychlorinated biphenyl (PCB)-contaminated materials that are not suspected of being radioactively contaminated are stored onsite pending their shipment to an EPA-approved facility

for disposal. "Suspect" asbestos and PCB wastes (those wastes originating in RMMAs) are retained onsite for waste characterization. Radioactively contaminated PCB wastes are also retained onsite. Disposal options are currently being explored for PCB-contaminated mixed waste.

The use of asbestos in pipes, panels, and as an additive to diallyl phthalate in parts production has been discontinued. Residual asbestos is handled, packaged, and shipped offsite to an approved disposal facility in compliance with TSCA regulations. In 1999, asbestos removal projects associated with building maintenance, and demolition activities continued. All such projects are carefully monitored by the Industrial Safety & Health Group to ensure compliance with TSCA and BWXTO's Safety and Hygiene Manual.

Emergency Planning and Community Right-to-Know Act (SARA Title III)

The reauthorization of CERCLA came in 1986 in the form of the Superfund Amendments and Reauthorization Act (SARA). The Emergency Planning and Community Right-to-Know (EPCRA) portion of that legislation is found in Title III of the Act. SARA Title III, Section 312, requires that sites handling "extremely hazardous" and "hazardous" substances notify regional emergency planning agencies. In compliance with the Act, MEMP annually reports hazardous chemical inventory data to the State Emergency Response Commission, the Montgomery/Greene County Information Coordinator, and the City of Miamisburg Fire Department. The inventory information is accompanied by maps showing the specific locations of the chemicals. In 1999, BWXTO used and/or stored two "extremely hazardous" and six "hazardous" chemicals in excess of EPCRA Section 312 reporting thresholds. See Section 5.3.

SARA Title III, or EPCRA, Section 313 mandates the annual submission of a Toxic Chemical Release Inventory report for sites which manufacture, process, or otherwise use listed toxic chemicals in quantities greater than specified thresholds. In 1999, BWXTO otherwise used ethylene glycol in excess of the EPCRA Section 313 reporting threshold.

National Environmental Policy Act (NEPA)

The National Environmental Policy Act (NEPA) of 1969 was established to ensure that consideration is given to the potential environmental impact of federal actions prior to the irretrievable commitment of resources. DOE has formalized its approach to NEPA by enacting regulations (10 CFR 1021). The Environmental Assessment (EA), *Disposition of Mound Plant's South Property* (DOE/EA-1239), and associated Finding of No Significant Impact (FONSI) was issued June 1999. In addition, NEPA reviews were performed for an additional seven projects: Relocation of Environmental Lab to Building 48, Spoils Area Stormwater Drainage Improvements, Consolidate IPS Operations in Building 50, Selentech Pilot Scale Treatability Study, LSA Waste Disposal, Suspect TRU Waste Blending, and Routine Maintenance Activities.

Endangered Species Act (ESA)

Provisions of the Endangered Species Act (ESA) of 1973, as amended, prohibit federal departments such as the DOE from carrying out projects that would destroy or modify a habitat deemed critical to the survival of an endangered or threatened species.

MEMP has performed a number of surveys for threatened or endangered species. Two potential ESA compliance issues have been noted. First, an endangered plant species, the Inland rush (*Juncus interior*), and an endangered bird species, the Dark-eyed junco (*Junco hyemalis*), have been observed onsite. Both species are listed on the State of Ohio Endangered Species list. Because only one individual of inland rush was located, it is not considered a viable breeding population at the site. The dark-eyed junco, despite being a common winter visitor to Ohio, is not known to breed in southwestern Ohio. Secondly, it has been determined that the site is in the habitat range of the federally endangered species of Indiana Bat (*Myotis sodalis*). Consultations with the U.S. Fish and Wildlife Service and the Dayton Museum of Natural History indicate that the site does not provide a suitable habitat for the Indiana bat and no Indiana bats have been observed onsite.

Neither the solitary sitings of the rush and the junco, nor the potential habitat for the Indiana bat, are expected to affect ongoing or future activities at the site.

National Historic Preservation Act (NHPA)

The National Historic Preservation Act (NHPA) of 1966, as amended, made the preservation of historic, architectural, and archeological resources a national policy. Consistent with this policy, the federal government requires that programs it funds or licenses in the State of Ohio be reviewed by the State Historic Preservation Office to determine what effects, if any, the activities will have upon such resources. Two studies were conducted to evaluate non-building archeological resources on the MEMP site. These studies concluded that no significant archeological resources are located on the site. The Ohio Historic Preservation Office (OHPO) concurred with these conclusions.

An evaluation of buildings and structures for architectural and cultural significance was submitted to the OHPO in June 1998. The OHPO concluded that the seventeen original structures are of historic significance because of their association with the early development of nuclear weapons (i.e., polonium research and fabrication). DOE initiated discussions with the OHPO to establish the terms of a Memorandum of Agreement (MOA) to mitigate adverse affects to these historic structures which will result from environmental restoration activities and transition of the site. According to the latest version of the draft MOA, which is in negotiation between the OHPO and DOE, mitigation will consist of documentation packages for the 17 original buildings and a documentation package for the site.

Executive Order 11988, "Floodplain Management"

A narrow area along the southwestern border of the site and a small triangular area in the extreme northeastern corner of the site lie within the 100-year floodplain. The southwestern area is primarily located within an undeveloped portion of the site and is not expected to affect project activities. The triangular area is located within Parcel H which was transferred to MMCIC on August 12, 1999. Floodplain Notices of Involvement were published in the Federal Register for the Parcel H and South Property transfers. A Floodplain Statement of Findings was published in the Federal Register for the Parcel H transfer.

Executive Order 11990, "Protection of Wetlands"

CERCLA ecological assessments have identified small wetland regions within and around the site. MEMP activities are planned to minimize adverse impacts to these regions. An evaluation must be conducted prior to any action taken within a floodplain or wetland. A public notice, including a Federal Register Notice publication, must be employed to notify stakeholders of the action. Authorization to backfill a wetland or discharge dredged or fill material into waterways designated as "waters of the United States" shall be secured from the U. S. Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act. A corresponding Section 401 Water Quality Certification shall be secured from OEPA, if applicable. The USACE concurred with the updated MEMP Wetlands Delineation.

Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements"

Executive Order 12856 mandates compliance with EPCRA (SARA Title III) reporting requirements for all federal facilities. In 1999, MEMP submitted an EPCRA Section 312 report for chemicals stored during calendar year 1998. A EPCRA Section 313 report was not required to be submitted for 1998 chemical usage. Data for 1999 will be reported in 2000 as specified by EPCRA.

The pollution prevention and waste minimization focus has shifted from routine operations to environmental restoration. Accomplishments in 1999 included collection of ferrous and non-ferrous metals, white paper, and toner cartridges for recycling.

2.2 Other Key Environmental Compliance Issues

Major External Environmental Audits in 1998

Ohio EPA RCRA inspection. The annual unannounced RCRA inspection by the Ohio EPA was conducted in February of 1999. The inspection focused on RCRA compliance issues. No noncompliances were identified.

Ohio EPA NPDES permit compliance inspection. The Ohio EPA conducted an NPDES permit compliance evaluation on June 21, 1999. All areas rated were judged to be satisfactory.

2.3 Summary of Permits

BWXTO operates in compliance with thirteen state air permits. Ten additional sources of air emissions are on registration status with the State of Ohio. An NPDES permit and an Authorization to Discharge govern water releases from the site. Hazardous waste activities are governed by a RCRA Part B permit.

CHAPTER 3

3.0 ENVIRONMENTAL PROGRAM INFORMATION

The principal objective of MEMP environmental monitoring programs is to ensure that any threat to human health or the environment is promptly detected and mitigated. It is MEMP policy that meeting this goal be viewed as a minimum standard of practice; better performance should always be pursued. The philosophy is evident in the extent and scope of MEMP's effluent and environmental monitoring programs. It is also supported by MEMP's commitment to successful programs in the areas of:

- ALARA (As Low As Reasonably Achievable),
- Regulatory compliance,
- Waste minimization and pollution prevention,
- Environmental restoration.

3.1 Environmental Monitoring Program

The MEMP environmental monitoring program (EG&G, 1997) generates data on surface water, groundwater, sediment, foodstuffs, and air. These media are pathways for migration of hazardous materials from the site to the public. The monitoring program includes effluent monitoring, environmental surveillance, and meteorological monitoring. Effluent monitoring focuses on releases from the site, i.e., stack and wastewater discharges. The environmental surveillance program focuses on environmental conditions in the area surrounding the site and in local communities.

3.2 Effluent Monitoring

Air Emissions

Stacks through which radioactive materials are potentially released are sampled continuously for tritium and/or particulate radionuclides. These samples are collected to demonstrate compliance with radionuclide NESHAPs regulations and to provide early warning of abnormal emissions so that timely corrective actions can be undertaken. An outline of the routine stack radionuclide sampling program is shown in Table 3-1. The stacks are also equipped with real-time monitors that operate continuously. Samples may be collected at any time if one of the real-time monitors should alarm. MEMP also releases very small quantities of nonradiological constituents into the atmosphere. Annual nonradiological emission rates are calculated using a material balance or emission factor approach. The releases are governed by State of Ohio EPA permits and regulations.

Table 3-1. Effluent Monitoring at MEMP

	Parameter Measured[a]	No. of Sampling Locations	Collection Frequency
Air Emissions			
	HT, HTO	10	Weekly
	^{238}Pu, $^{239,240}Pu$	7	Weekly
	$^{233,234}U$, ^{238}U	6	Weekly
Water Effluents			
	Flow rate	5	Daily
		1	When well is pumped
	HTO, gross alpha	4	Daily
	^{238}Pu, $^{239,240}Pu$	4	Daily
	$^{233,234}U$, ^{238}U	4	Daily
	^{228}Th, ^{230}Th, ^{232}Th	4	Daily
	pH	1	Daily
		3	Weekly
		1	1/2 Weeks
		1	When well is pumped
	Chlorine	1	Daily *
	Dissolved oxygen	1	Weekly
	Dissolved solids	1	1/2 Weeks
	Suspended solids	1	2/Week
		2	Weekly
		1	1/2 Weeks
	COD	1	Weekly
	$CBOD_5$	1	2/Week
		1	Monthly
	Fecal coliform	1	Weekly *
	Ammonia	1	1/2 Weeks
	Oil and grease	1	Monthly
		1	Quarterly

[a] HTO = Tritium oxide
HT = Elemental tritium
Pu = Plutonium
U = Uranium
Th = Thorium
$CBOD_5$ = Five day carbonaceous biochemical oxygen demand
COD = Chemical oxygen demand
* Summer Months: May 1 – October 31

Table 3-1. Effluent Monitoring at MEMP (continued)

	Parameter Measured[a]	No. of Sampling Locations	Collection Frequency
Water Effluents			
	Free cyanide	1	Monthly
	Cadmium	2	Monthly
	Chromium	1	Weekly
		2	Monthly
	Copper	1	Weekly
		2	Monthly
	Lead	1	1/2 Weeks
		2	Monthly
	Mercury	1	Weekly
	Nickel	1	1/2 Weeks
		2	Monthly
	Selenium	1	Monthly
	Silver	1	Monthly
	Zinc	1	1/2 Weeks
		2	Monthly
	VOCs	1	Monthly
		1	Quarterly
		1	When well is pumped
	Toxicity testing		
	Ceriodaphnia dubia		
	acute	1	Quarterly
	chronic	1	Quarterly
	Pimephales promelas		
	acute	1	Quarterly
	chronic	1	Quarterly

[a] VOC = Volatile organic compound

Water Releases

Water released from the site is also sampled continuously at the discharge points. Effluents include process wastewater, sewage water, and storm water. Extensive sampling and analysis are required to demonstrate compliance with the site's National Pollutant Discharge Elimination System (NPDES) permit and the Operable Unit 1 Authorization to Discharge (ATD). An outline of the effluent water sampling program is also shown in Table 3-1.

3.3 Environmental Surveillance

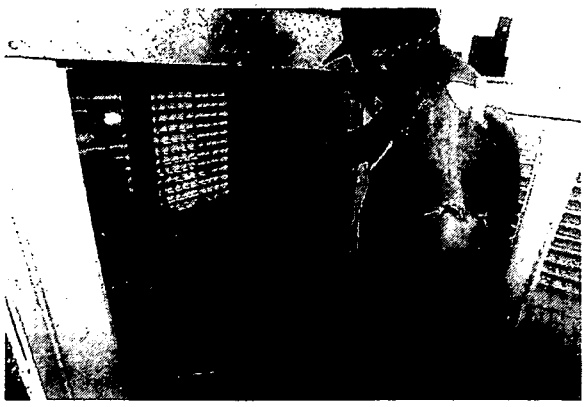
MEMP maintains an extensive environmental surveillance program designed to evaluate potential impacts from the site on human health and the environment. The environmental surveillance program involves sample collection and analysis of ambient air, regional water supplies, sediments, onsite and offsite groundwater, and foodstuffs. This program complements the effluent monitoring program which focuses on releases from the site, i.e., stack and water discharges. An outline of the environmental surveillance program is shown in Table 3-2.

Radionuclides of Concern

The principal radionuclides of concern at MEMP are tritium and plutonium-238; no other radionuclides contribute significantly to the dose estimates for the site (see Appendix E). Other radionuclides, however, have been used at the site. Where there is a strong probability of detecting such radionuclides in the environment, they have been added to the appropriate sampling schedule. The primary example is uranium. Because U-234 is a decay product of Pu-238, U-233,234 is a part of MEMP's routine environmental monitoring program. MEMP analyzes drinking water and river water samples to monitor the ingrowth of U-233,234. No significant concentrations have been encountered. Radioisotopes of thorium were also used historically in MEMP operations. To ensure that no significant dose impact from thorium is occurring, periodic monitoring is performed. These data show that thorium concentrations are at or very near environmental levels.

Ambient Air

MEMP maintains a network of ambient air surveillance stations to monitor the impact of airborne radiological emissions on the local and regional environments. The network includes both onsite and offsite stations. The number and placement of offsite stations is based on the population distribution and the prevailing winds.



Collection of Ambient Air Samples

Surface Water and Sediment

The Great Miami River and other regional surface water locations are sampled routinely for radionuclides. Since plutonium and thorium in river water tends to accumulate in sediments, sediment samples are collected from these locations and analyzed for isotopes of these radionuclides.

Table 3-2. Environmental Surveillance at MEMP

Environmental Medium	Parameter Measured[a]	No. of Sampling Locations[b]	Collection Frequency
Onsite			
Ambient air	HTO	8	Weekly
	^{238}Pu, $^{239,240}Pu$	8	Weekly
	^{228}Th, ^{230}Th, ^{232}Th	4	Weekly
	Particulates	8	Weekly
Drinking water	HTO	3	Weekly
	^{238}Pu, $^{239,240}Pu$	3	Monthly
	$^{233,234}U$, ^{238}U	3	Monthly
	^{228}Th, ^{230}Th, ^{232}Th	3	Monthly
	Radium	5	Annually
	Gross Alpha	5	Annually
	Gross Beta	5	Annually
	VOCs	5	Quarterly
	Nitrate	5	Annually
	Lead and Copper	20	Semi-annually
	Total coliform	2	Monthly
Groundwater	HTO	56 [c]	e
	^{238}Pu, $^{239,240}Pu$	7	e
	$^{233,234}U$, ^{238}U	7	e
	^{228}Th, ^{230}Th, ^{232}Th	7	e
	VOCs	56 [c,d]	e
	Inorganics	11 [c,d]	e

[a] HTO = Tritium oxide
Pu = Plutonium
U = Uranium
Th = Thorium
VOC = Volatile organic compound
[b] Includes background location when applicable
[c] Groundwater sampling includes wells, capture pits, and seeps
[d] Non-detects are not reported in App. D
[e] Sample collection frequency varies

Table 3-2. Environmental Surveillance at MEMP (continued)

Environmental Medium	Parameter Measured[a]	No. of Sampling Locations[b]	Collection Frequency
Offsite			
Ambient air	HTO	12	Weekly
	^{238}Pu, $^{239,240}Pu$	12	Weekly
	^{228}Th, ^{230}Th, ^{232}Th	2	Weekly
	Particulates	12	Weekly
River/stream water	HTO	7	Monthly
	^{238}Pu, $^{239,240}Pu$	6	Monthly
	$^{233,234}U$, ^{238}U	6	Monthly
	^{228}Th, ^{230}Th, ^{232}Th	6	Quarterly
River/stream sediment	^{238}Pu, $^{239,240}Pu$	7	Quarterly
	^{228}Th, ^{230}Th, ^{232}Th	7	Quarterly
Pond water	HTO	7	Annually
	^{238}Pu, $^{239,240}Pu$	7	Annually
Pond sediment	^{238}Pu, $^{239,240}Pu$	7	Annually
Drinking water	HTO	7	Monthly
	^{238}Pu, $^{239,240}Pu$	2	Monthly
	$^{233,234}U$, ^{238}U	2	Monthly
	^{228}Th, ^{230}Th, ^{232}Th	2	Semi-annually
Groundwater	HTO	15	e
	^{238}Pu, $^{239,240}Pu$	8	e
	$^{233,234}U$, ^{238}U	8	e
	^{228}Th, ^{230}Th, ^{232}Th	8	e
	VOCs	13	e
	Inorganics	12	e
Foodstuffs	HTO	8	Annually
	^{238}Pu, $^{239,240}Pu$	3	Annually

[a] HTO = Tritium oxide Pu = Plutonium U = Uranium Th = Thorium VOC = volatile organic compound
[b] Includes background location when applicable
[c] Groundwater sampling includes wells, capture pits, and seeps
[d] Non-detects are not reported in App. D
[e] Sample collection frequency varies

Foodstuffs

Various locally-grown vegetables are collected and analyzed to determine whether radionuclides of MEMP origin are contributing a dose via the ingestion exposure pathway. Root crops such as potatoes are analyzed since the roots may come into long-term contact with subsurface plutonium. Tomato samples, conversely, are of use due to their high water content making them excellent indicators of tritium uptake.

Groundwater

MEMP maintains an extensive groundwater monitoring network designed to provide information on the impact of site activities on local and regional groundwater. Groundwater samples are collected from onsite and offsite monitoring wells, onsite and offsite production wells, private wells, and regional community water supplies. Samples are analyzed for radionuclides, volatile organic compounds (VOCs), and inorganic parameters.

Environmental Levels

To evaluate MEMP's impact on the environment, it is necessary to establish background or baseline levels of contaminants in a variety of media. MEMP accomplishes this task by collecting samples at locations where the impact from site discharges is not observable. These locations are usually in a direction upwind and at a distance too great to be impacted by the site. Concentrations measured at these reference locations are referred to as "environmental levels" in this Report.

3.4 Meteorological Monitoring

Meteorological monitoring provides information on weather conditions that can be used to forecast atmospheric dispersion following planned or unplanned releases of airborne material. Atmospheric dispersion is a function of wind speed, wind direction and atmospheric stability. Atmospheric stability determinations are made by estimating the amount of atmospheric turbulence in the lateral wind direction using a bi-directional wind vane. The parameters which characterize dispersion (wind speed, wind direction and atmospheric stability) are closely monitored at the site with the aid of two meteorological towers.

50-meter meteorological tower

3.5 Effluent Treatment and Waste Management

Effluent Treatment

Air. High efficiency particulate air (HEPA) filters remove particulate radionuclides from process air emissions. Air effluents are filtered first at their point of origin (e.g., a glove box), and again just before reaching the release point (i.e., the stack or vent). The filtering system in place at each stack with particulate emissions is composed of two banks of HEPA filters connected in series. Each filter bank has a nominal collection efficiency of 99.95% for 0.2-micron particles. Tritium is not trapped by HEPA filters. A chemical process is used to recover tritium from waste gas streams.

Water. An onsite sanitary waste treatment plant manages all domestic wastewater generated at the site. Treatment is provided via an activated sludge process operated in the extended aeration mode. A continuous backwash sandfilter serves as tertiary treatment. The influent and effluent at the sewage treatment plant are monitored to ensure that radionuclides are not inadvertently discharged to the environment. All wastewater, after appropriate treatment and monitoring, is discharged to the Great Miami River. Digested sludge from the sanitary treatment plant is managed as Low Specific Activity (LSA) waste.

Waste Management

The waste management focus has shifted from support of routine operations to environmental restoration and disposition of legacy wastes. In 1999, 62,444 pounds of hazardous and other regulated wastes were shipped offsite. Of that amount, 31,110 pounds were RCRA-regulated wastes, 20,098 pounds were asbestos and PCB wastes, and 11,236 pounds were other wastes not suitable for sanitary landfilling.

Hazardous wastes. BWXT of Ohio (BWXTO) operates two hazardous waste storage units for the MEMP; one is used for hazardous wastes and the other is used for mixed wastes, i.e., radioactive wastes that are also regulated by RCRA. The storage units are operated in accordance with a RCRA Part B permit issued by the Ohio EPA in October 1996.

Radioactive Wastes. MEMP currently has two disposal options for low-level radioactive wastes. The waste can be shipped to the Nevada Test Site (NTS) or to Envirocare, a commercial disposal facility. In 1999, 209 truck shipments (166,601 ft^3) of low-level waste were shipped to NTS and 30 railroad shipments (66,143 ft^3) of low-level waste were shipped to Envirocare.

Mixed wastes. Hazardous wastes that are radioactively-contaminated are referred to as mixed wastes. These wastes are stored in a RCRA-permitted facility until treatment/disposal options have been evaluated. In 1999, five mixed waste streams were shipped off-site for treatment and disposal. BWXTO will continue to explore new treatment options as they become available to reduce turnaround times associated with the disposition of newly discovered mixed waste streams.

Nonhazardous solid wastes. Nonhazardous, nonradioactive solid wastes generated by BWXTO are disposed of in a licensed, permitted sanitary landfill. The volume of materials requiring landfill disposal has been reduced as a result of recycling programs for paper and scrap metal.

3.6 Environmental Permits

MEMP activities are routinely measured against the compliance requirements of state air and state water permits. Additionally, the hazardous waste program operates pursuant to a RCRA Part B permit. Table 3-3 lists permits applicable to MEMP and BWXTO activities.

3.7 Waste Minimization and Pollution Prevention

BWXTO has established programs to reduce the volume and toxicity of hazardous, radioactive, mixed, and solid waste streams. These goals are accomplished by preventing waste generation, recycling, and reclamation. Programs include recycling of expended vehicle batteries, scrap metals, white recyclable paper, and toner cartridges. Recycling bins are also provided for aluminum cans which are accumulated and recycled by employees. In 1999, MEMP recycled over 8 tons of white paper and 539 tons of scrap metal.

3.8 Environmental Restoration

MEMP's primary focus is environmental restoration of the site in preparation for transition of the property to the community for economic development. The site was added to the CERCLA National Priorities List (NPL) in 1989. DOE, U. S. EPA, and Ohio EPA administer CERCLA activities in accordance with the terms of a Federal Facilities Agreement (FFA). In 1995, the traditional CERCLA program at MEMP was reorganized to increase the efficiency of the environmental restoration effort. The resulting process, termed "MOUND 2000," has accelerated clean-up of the site so that the land can be released for economic development much more quickly than originally planned. The MOUND 2000 process is described in Section 2.1.

In 1999, several key environmental restoration projects and waste management initiatives were completed. Descriptions of key accomplishments are provided in the following sections.

Table 3-3. Environmental Permits

Operation	Permit Type	Permit No.	Valid Through	Issuing Agency
9 Standby Power Diesel Generators	air	B009 - B017[a]	permanent	Ohio EPA
SW/R Fumehoods	air	P012, P014, P015 (registration)	permanent	Ohio EPA
WDA Stack	air	P031	3/10/01	Ohio EPA
Wastewater Discharge (NPDES)	water	1IO00005*HD	3/31/02	Ohio EPA
Wastewater Discharge (OU1 ATD)	water	1IN90010*AD	permanent	Ohio EPA
Building 48	air	P008 (registration)	permanent	Ohio EPA
Crusher	air	F003	5/29/01	Ohio EPA
Roadways and Parking Lots	air	F001 (registration)	permanent	Ohio EPA
Underground Line Removal (diesel generator)	air	B008 (registration)	permanent	Ohio EPA
Gas Dispensing Facility	air	G001 (registration)	permanent	Ohio EPA
Open Burning (fire training)	air	Letter permit (registration)	permanent	RAPCA
Powerhouse Boiler 1 and Boiler 2	air	B001 B006 (registration)	permanent	Ohio EPA
Fuel Oil Storage	air	T005	2/17/01	Ohio EPA
R/SW HEFS Stack	air	P030	1/24/01	Ohio EPA
Hazardous Waste Storage	RCRA operation	05-57-0677	10/18/01	Ohio EPA

[a] Applied for registration status with Ohio EPA

OU 1 Treatment Systems. OU1 addresses volatile organic chemicals in the groundwater near the site's former solid waste landfill. Two treatment systems are operating there. A groundwater pump and treat system is used to create a hydraulic barrier to contain contaminated groundwater in the vicinity of the landfill. Groundwater is continuously pumped from a series of extraction wells and passed through an air stripper to reduce volatile organic compound (VOC) concentrations before the water is discharged. The water discharges are governed by an ATD issued by the Ohio EPA in July 1997. In 1999, approximately 45,700,000 gallons of water were treated, removing approximately 3 pounds of VOCs. Since its inception, the system has removed 21 pounds of contaminants.

An air sparge/vapor extraction system became operational in December 1997. It sparges (injects) air into the groundwater to volatize VOCs already in the groundwater. Recovery wells above the water table extract the VOC vapors liberated by air sparging as well as pulling in VOC vapors liberated from the soil above the water table. The captured vapors are passed through granular activated carbon (GAC) to absorb the VOCs before the air is vented to the atmosphere. Since start-up, the air sparge/soil vapor extraction system has recovered approximately 3,283 pounds of VOCs.

Miami-Erie Canal Project. The Miami-Erie Canal Project addressed contamination of a one-mile section of the abandoned canal within the City of Miamisburg. Clean-up of the canal to levels consistent with recreational use was completed in May 1998. Planting grass and trees and constructing a bike path has restored the site. The easement to perform remediation will be cancelled in May 2000 and no further environmental monitoring will be required. A CERCLA On-Scene Coordinator Report documenting the clean-up was issued in May 1999. A Human Health Residual Risk Evaluation and an Ecological Risk Evaluation will be performed in the Spring of 2000.

Building demolition projects. M Building, Buildings PS, 1, and 43, and Magazines 52 and 64 were demolished in 1999.

M Building

Demolition Project

Selentec Study. The objective of the Selentec pilot scale treatability study for transuranic (TRU) soil was to determine the ability of the ACT*DE*CON process to reduce radionuclide concentrations in soil. The process provides a highly selective dissolution of contaminants from the soil by the use of a chemical wash. The study evaluated process effectiveness on MEMP TRU soil.

TRU Waste Blending. Suspect transuranic (TRU) soil was moved to the Consolidated Waste Processing Facility (CWPF) and mixed with low-level waste (LLW) radioactive soil, packaged in approved containers and shipped to the Nevada Test Site (NTS) as LLW.

3.9 Cost Recovery Grant

The Cost Recovery Grant represents an added dimension to the environmental monitoring programs in place at MEMP. The Cost Recovery Grant (CRG) replaced the Agreement-in-Principle grant in July of 1998. These agreements establish a framework under which the State provides oversight and monitoring activities at MEMP.

Under the CRG, various state agencies review DOE environmental monitoring (Ohio EPA and Ohio Department of Health) and emergency management (Ohio Emergency Management Agency) programs. The agencies perform independent monitoring, data collection, and oversight of project activities.

3.10 Release of Property Containing Residual Radioactive Material

Real Property Management

Real Property Management is responsible for all real property issues arising at Mound. This includes the preparation of easements for utilities and other purposes on the site, and the disposal of modular and Butler buildings. Real Property Management oversees the Facility Information Management System (FIMS), which is a computerized database that provides DOE/HQ with a summary of real property data relating to Mound. Because of FIMS requirements, it is necessary to notify the Real Property Coordinator anytime a trailer or other structure is leased, purchased or demolished and when hazardous substances are moved into or out of a building or structure.

Personal Property Management

Excess personal property is dispositioned in accordance with the Code of Federal Regulations (CFR) Volume 41, Chapters 101 and 109 and Federal Property Management Regulations. Before excess property is made available to other government agencies through the reutilization process, the property is made available to the Miamisburg Mound Community Improvement Corporation (MMCIC). Depending on the type and condition of equipment, and the associated acquisition cost, excess property is also made available to U.S. Department of Energy facilities through the Energy Asset Disposal system (EADS), General Services Administration (GSA) database or gifted to educational institutions. Through access to either of these two databases, other State and Federal entities may acquire property. If other Federal or State entities do not acquire property within an allotted time, the property may then be donated to educational institutions or dispositioned through auctions. Net proceeds from these auctions are entered into a General Site Fund dedicated exclusively to Mound.

No equipment is accepted that has been: 1) exposed to radiological contamination, 2) located inside a Radioactive Materials Management Area (RMMA), Radiation Buffer Area (RBA), Contamination Area (CA) or High Contamination Area (HCA). See Table 3-4 for Radioactive Surface Contamination Limits for Unrestricted Release.

No equipment that has been exposed to heavy metals, beryllium, asbestos or energetic materials contamination is accepted into excess. The equipment must be evaluated and released by Industrial Hygiene/Safety to Waste Management.

Surplus Property Donations/Gifts

In accordance with governing documents, BWXTO "gifts" or "donates" equipment deemed appropriate for use in improving math and science curricula or activities for elementary and secondary school education, or for the conduct of technical and scientific education research activities. Eligible recipients are local (to MEMP) elementary and secondary schools (public and private), encompassing kindergarten through twelfth grade and non-profit organizations.

Excess property screened through the EADS system database is circulated for colleges and universities through the Energy-Related Laboratory Equipment (ERLE) program.

1999 Activities. Excess equipment was donated to the Ohio State University, the Village of West Alexandria, OH, the University of Cincinnati, and Sinclair Community College.

Table 3-4. Radioactive Surface Contamination Limits for Unrestricted Release

Radionuclide	Direct Total or Average Total (Fixed + Removable) (dpm/100 cm^2)	Maximum Total (Fixed + Removable) (dpm/100cm^2)	Removable (dpm/100cm^2)
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231	100	300	20
Th-natural, Sr-90, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
U-natural, U-235, U-238 and associated decay product, alpha emitters	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90	5,000	15,000	1,000
Tritium (surface and subsurface)	NA	NA	10,000

3.11 Protection of Biota

DOE Order 5400.5 requires that populations of aquatic organisms be protected at a dose limit of 1 rad/day (10 milliGray/day). The draft DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota (ENVR-0011)" and supporting software (RAD-BCG) were used in the evaluation and reporting of compliance with biota dose limits. The Technical Standard provides a graded approach for demonstrating compliance with the biota dose limit and for conducting ecological assessments of radiological impact. The Manual was developed by DOE through the Department's Biota Dose Assessment Committee (BDAC) , an approved committee organized through the DOE Technical Standards Program. The BDAC is sponsored and chaired by the Office of Environmental Policy and Guidance, Air, Water and Radiation Division.

The supporting software, or "RAD-BCG Calculator," provides a semi-automated tool for implementing screening and analysis methods contained in the DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota." This tool was also developed through the BDAC.

Because the biota protection standard is dose-based, a calculational method was developed to demonstrate compliance. Because of the inherent complexity of environmental systems and the vast array of biota that can be potentially exposed to any radionuclide contamination level, the DOE decided that a graded approach to evaluate compliance would be appropriate.

The graded approach consists of a three-step process which includes data assembly, general screening, and analysis. This three-tiered scheme helps to ensure that the magnitude of the evaluation effort is scaled to the likelihood and severity of potential environmental impacts.

In the general screening process, measured environmental concentrations are compared to very conservative Biota Concentration Guides (BCGs). The BCGs were set so that real biota exposed to such concentrations would not be expected to ever exceed the biota dose limits. Since the screening limits would be chosen to protect "all biota, everywhere" they would, by their nature be restrictive, and in many circumstances conservative with regards to specific environments.

BCGs that are considered to be conservatively protective of non-human biota were derived for twenty-three radionuclides. These radionuclides were selected because they are relatively common constituents in past radionuclide releases to the environment from DOE facilities. An additional set of BCGs will be derived for another set of approximately seventy radionuclides, for inclusion in the next version of the Technical Standard.

The results of MEMP's general screening are shown in Table 3-5. Using release results from calendar year 1999, MEMP "passed the site screen." Values used in the spreadsheet were obtained by averaging the maximum incremental concentrations of applicable radionuclides in the Great Miami River and river sediment. An additional measure of conservatism was added by including plutonium-238 release values in the input for plutonium-239 in the spreadsheet. MEMP's releases of Pu-238 were greater than Pu-239. The spreadsheet did not include a BCG for Pu-238.

Table 3-5. Aquatic System Data Entry/BCG Worksheet

Site Description: *MEMP CY1999*

Aquatic System Data Entry / BCG Worksheet

Limits for Water and Sediments in Std Units

Clear Site Data

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Nuclide	Nuclide data from single media or co-located samples?	Water Limit pCi/L	Site Data	Partial Fraction	Sediment Limit pCi/g	Site Data	Partial Fraction	Water & Sediment Sum of Fractions
Am-241	Water Sediment Both	4.E+02			5.E+03			
Ce-144	Water Sediment Both	2.E+03			3.E+03			
Cs-135	Water Sediment Both	5.E+02			4.E+04			
Cs-137	Water Sediment Both	4.E+01			3.E+03			
Co-60	Water Sediment Both	4.E+03			1.E+03			
Eu-154	Water Sediment Both	2.E+04			3.E+03			
Eu-155	Water Sediment Both	3.E+05			3.E+04			
H-3	Water Sediment Both	3.E+08	6.E+02	2.3E-06	4.E+05	6.E-04	1.60E-09	2.27E-06
I-129	Water Sediment Both	4.E+04			3.E+04			
I-131	Water Sediment Both	1.E+04			5.E+03			
Pu-239	Water Sediment Both	2.E+02	5.E-02	2.6E-04	6.E+03	1.E+00	1.71E-04	4.35E-04
Ra-226	Water Sediment Both	2.E-01			4.E+00			
Ra-228	Water Sediment Both	2.E-01			4.E+00			
Sb-125	Water Sediment Both	4.E+05			7.E+03			
Sr-90	Water Sediment Both	3.E+02			6.E+02			
Tc-99	Water Sediment Both	7.E+05			4.E+04			
Th-232	Water Sediment Both	3.E+02	4.E-02	1.3E-04	1.E+03	3.E-01	2.54E-04	3.80E-04
U-233	Water Sediment Both	2.E+02	1.E-01	5.7E-04	5.E+03	6.E-03	1.08E-06	5.72E-04
U-234	Water Sediment Both	2.E+02			5.E+03			
U-235	Water Sediment Both	2.E+02			4.E+03			
U-238	Water Sediment Both	2.E+02	1.E-01	5.9E-04	2.E+03	7.E-03	2.65E-06	5.94E-04
Zn-65	Water Sediment Both	1.E+01			1.E+03			
Zr-95	Water Sediment Both	7.E+03			2.E+03			
		Sum of fractions for radionuclides in water		1.55E-03	Sum of fractions for radionuclides in sediment		4.28E-04	1.98E-03

You have passed the site screen

CHAPTER 4

4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM INFORMATION

MEMP activities result in the discharge of radioactive effluents to the air and the Great Miami River. Release limits on these discharges have been established by DOE and the U. S. EPA. Releases are monitored using a network of stack and water sample collection devices. In addition, MEMP maintains an extensive environmental surveillance program to evaluate the impacts from site effluents on the environment. The environmental surveillance program involves the collection and analysis of air, water, sediment, groundwater, and foodstuff samples from locations onsite and in local communities. Data generated from those programs are presented in this Chapter.

4.1 Radionuclide Releases from MEMP

1999 Data

Table 4-1 lists the quantities of radionuclides released by MEMP into the air and water during 1999. The unit used to report these quantities is the curie (Ci), a unit of radioactivity equal to 3.7×10^{10} disintegrations per second. The quantities, or activities, shown in Table 4-1 were measured at the point of release. Information on effluent monitoring systems used to estimate release levels appears in Section 4.2 of this Chapter.

Table 4-1. Radiological Effluent Data for 1999

Radionuclide	Released to	Activity, Ci	MEMP Range[b], Ci
Tritium	Air	8.04×10^{2} [a]	$7.36 \times 10^{2} - 8.04 \times 10^{2}$
	Water	2.4	2.2 – 2.5
Plutonium-238	Air	1.1×10^{-5}	$6.9 \times 10^{-6} - 4.5 \times 10^{-5}$
	Water	2.3×10^{-4}	$2.3 \times 10^{-4} - 4.8 \times 10^{-4}$
Plutonium-239,240	Air	3.0×10^{-8}	$2 \times 10^{-8} - 1 \times 10^{-7}$
	Water	3.6×10^{-6}	$1.7 \times 10^{-6} - 7.7 \times 10^{-6}$
Radon-222	Air	1.01	0.55 – 2.4
Uranium-233,234	Air	8.0×10^{-9}	$3 \times 10^{-9} - 9.2 \times 10^{-8}$
	Water	3.8×10^{-4}	$3.5 \times 10^{-4} - 3.9 \times 10^{-4}$
Uranium-238	Air	7.0×10^{-9}	$1.7 \times 10^{-9} - 7 \times 10^{-9}$

[a] Tritium released to air consists of: Tritium oxide, 6.65×10^{2} Ci
Elemental tritium, 1.39×10^{2} Ci

[b] A range of annual release values from MEMP, 1995-1999.

4.2 Effluent Monitoring Program

Effluent monitoring focuses on releases from the site, i.e., stack and water discharges. It is MEMP policy and philosophy that all releases of effluents from the site are ALARA, that is, As Low As Reasonably Achievable. Release trends are monitored and unexpected increases trigger internal investigations. Effluent air and water sampling locations are shown in Figure 4-1.

Applicable Standards

Guidelines for concentrations of radionuclides in air are provided in DOE Order 5400.5 (DOE, 1993a). These guides are based on recommendations in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977, 1979). The guides for radionuclide concentrations are referred to as Derived Concentration Guides, or DCGs. The DCG for a radionuclide is defined as the concentration of that radionuclide in air or water which will result in a 50-year committed effective dose equivalent of 100 mrem (1 mSv) if taken into the body by inhalation or ingestion during one year of exposure. DCGs are included in Appendix A. In addition, the National Emission Standards for Hazardous Air Pollutants (NESHAPs) radionuclide regulations (40 CFR 61, Subpart H) limit offsite doses from airborne releases from DOE sites (excluding radon) to 10 mrem effective dose equivalent (EDE) per year.

Air Emissions

Stacks through which radionuclides are released are sampled continuously. MEMP monitors twelve stacks for radionuclides, including tritium and isotopes of plutonium and/or uranium. The average annual concentrations of radionuclide air emissions are shown in Appendix A, Table A-2. Figure 4-2 illustrates 5-year trends in releases of the radionuclides of primary interest, tritium and plutonium-238.

Tritium. In operational areas where a release potential exists, room air and exhaust stacks are continuously monitored for tritium using strategically placed ionization chambers. These monitoring systems incorporate alarms and have been placed to help to locate the source if a release should occur. In most situations, an effluent removal and containment system can be relied upon to prevent or reduce the release of tritium to the atmosphere.

Plutonium and Uranium. In operational areas where a release potential exists, ventilation air passes through a minimum of two HEPA filters before being discharged to the atmosphere. Fixed continuous air samplers and continuous air monitors with alarm systems are used throughout the operational areas to detect airborne plutonium and/or uranium. These monitoring systems have been designed to ensure that prompt corrective action can be taken to reduce the magnitude of releases to the atmosphere.

Radon. Though emission levels are negligible in comparison with natural radon emanation rates, a radon-222 release rate has been included in the 1999 effluent data (Table 4-1) in the interest of completeness. Radon-222 from natural sources, and from past operations involving radium-226 is

continually released to the atmosphere from SW Building via a small roof vent. The estimated dose contribution from radon, as predicted by CAP88-PC, was 0.001 mrem for 1999.

Tritium and plutonium-238 release rates to the atmosphere have remained relatively constant over the past five years and well below regulatory thresholds. Airborne emissions of plutonium-238 were elevated in 1997 because of construction activities associated with upgrades to the SM/PP stack monitoring system which were completed in December of 1997.

Water Releases

Sampling for radionuclides is not required by the NPDES permit; however flow-proportional samples collected from outfalls 601, 602, 002, and 003 (Figure 4-1) are analyzed for tritium and isotopes of plutonium, uranium, and thorium. Samples are collected daily during the work week. Three 24-hour samples are collected on Tuesdays, Wednesdays, and Thursdays. One 96-hour (weekend) sample is collected each Monday. Samples are analyzed four times a week for tritium. Two-week composite samples are analyzed for isotopes of plutonium and uranium. The two-week composite samples are also analyzed quarterly for isotopes of thorium. Average concentrations of radionuclides in effluent waters are shown in Appendix A, Table A-3. Figure 4-3 illustrates 5-year trends in releases of the radionuclides of primary interest, tritium and plutonium-238 to the Great Miami River. Radionuclide releases to water in 1999 were consistent with previous years. Radionuclide concentrations continue to be small percentages of the respective DCGs.

4.3 Environmental Occurrences

Under CERCLA and 40 CFR Part 302, reportable quantity (RQ) levels have been established for radionuclides and other designated hazardous substances. If a spill or other inadvertent release to the environment exceeds the RQ, immediate notification of the appropriate federal agencies (e.g., National Response Center, EPA, or Coast Guard) is required. No such releases occurred at MEMP during 1999.

Figure 4-1. Effluent Air and Water Sampling Locations

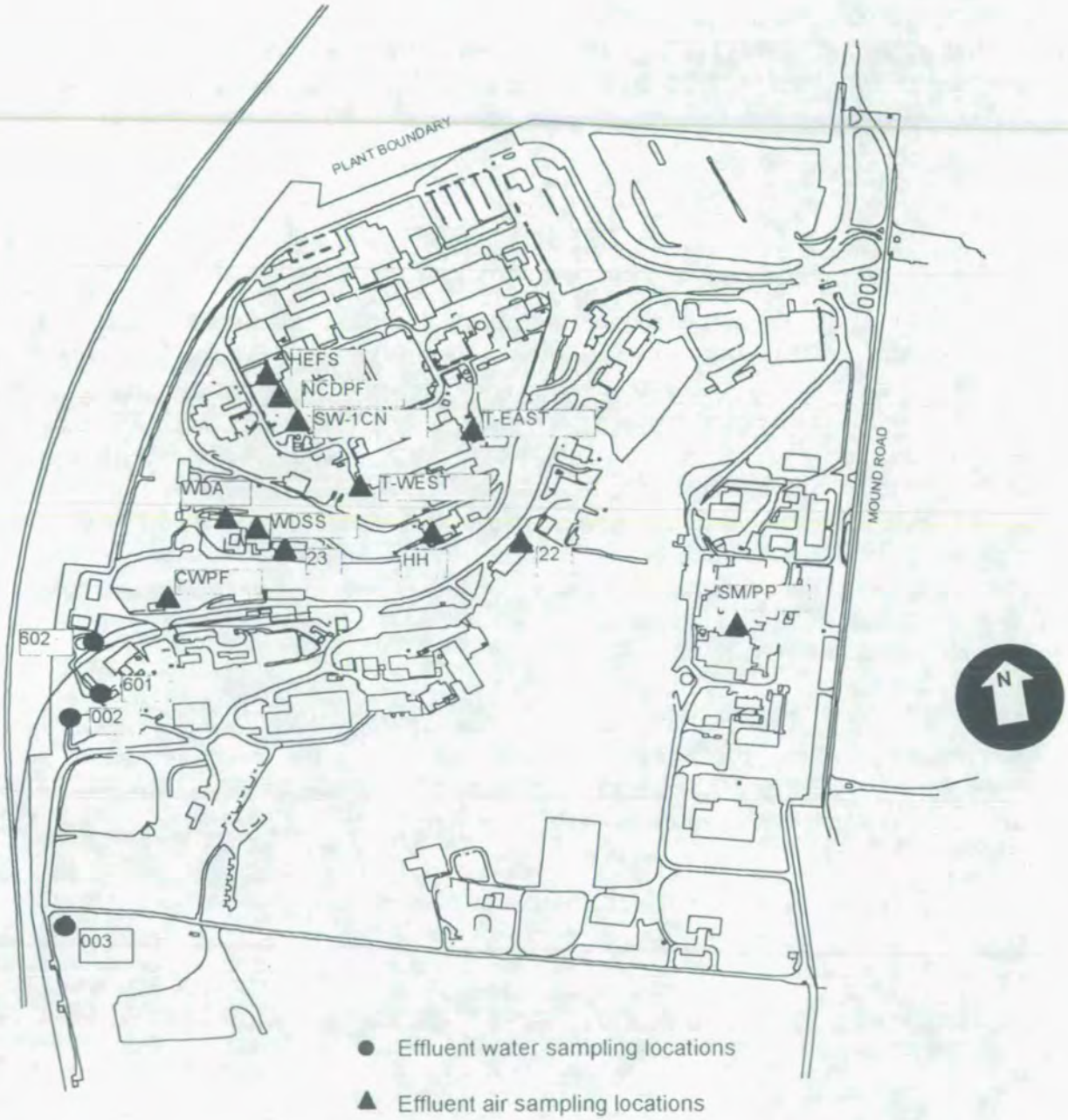
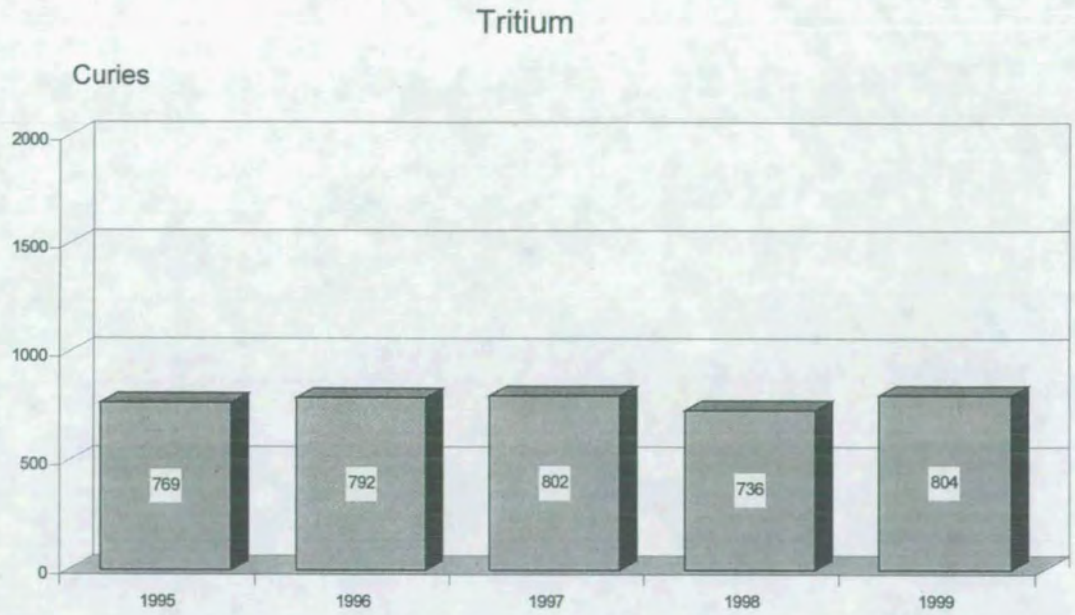


Figure 4-2. Tritium and Plutonium-238 Releases from MEMP to the Atmosphere, 1995 - 1999



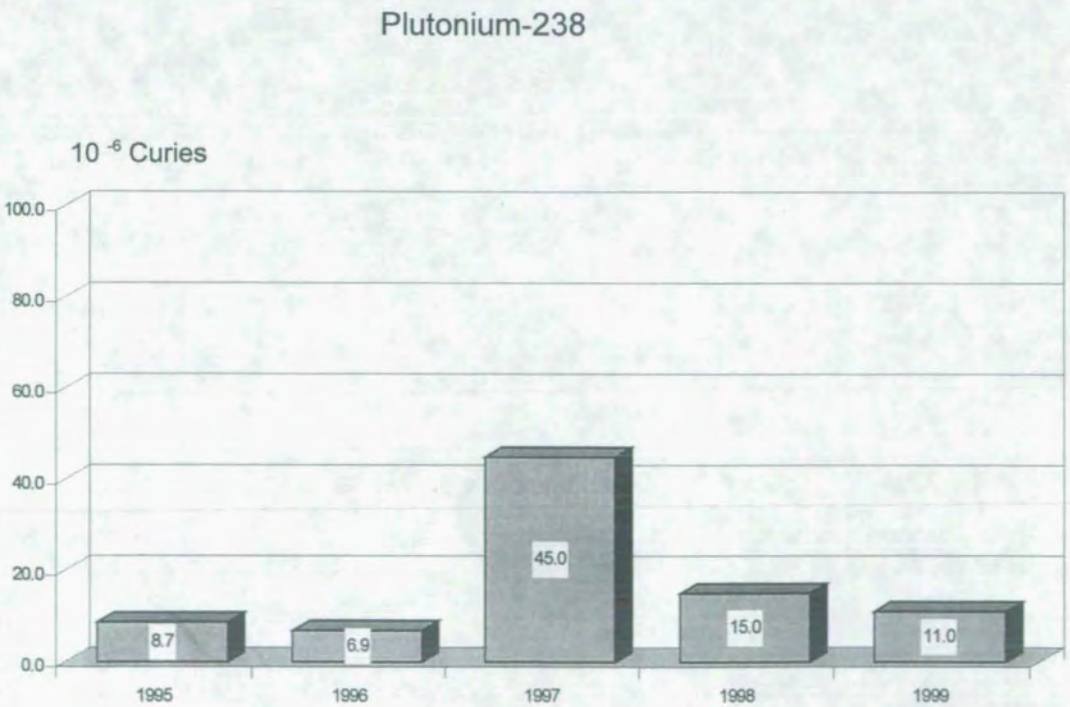
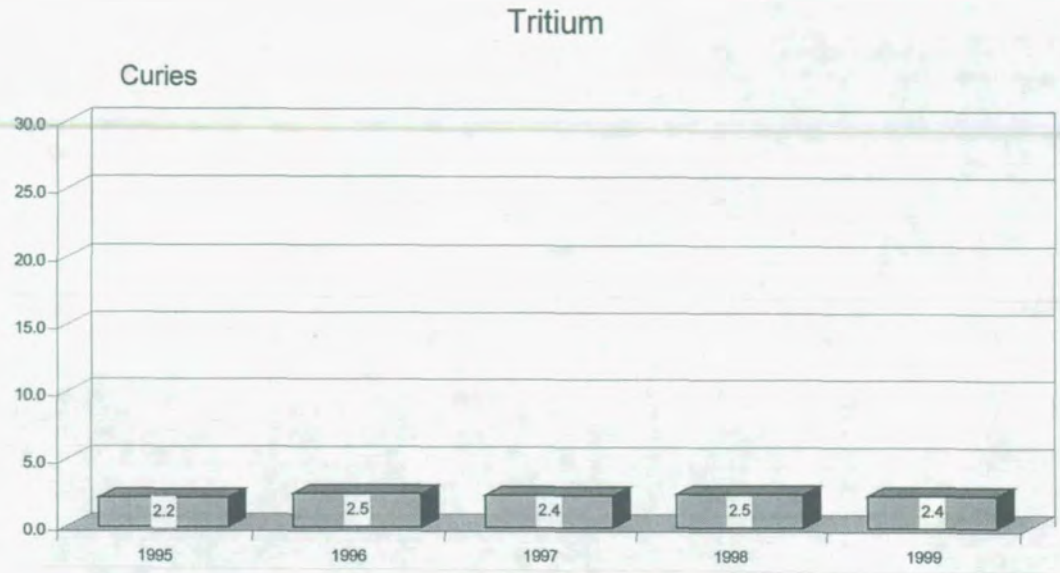
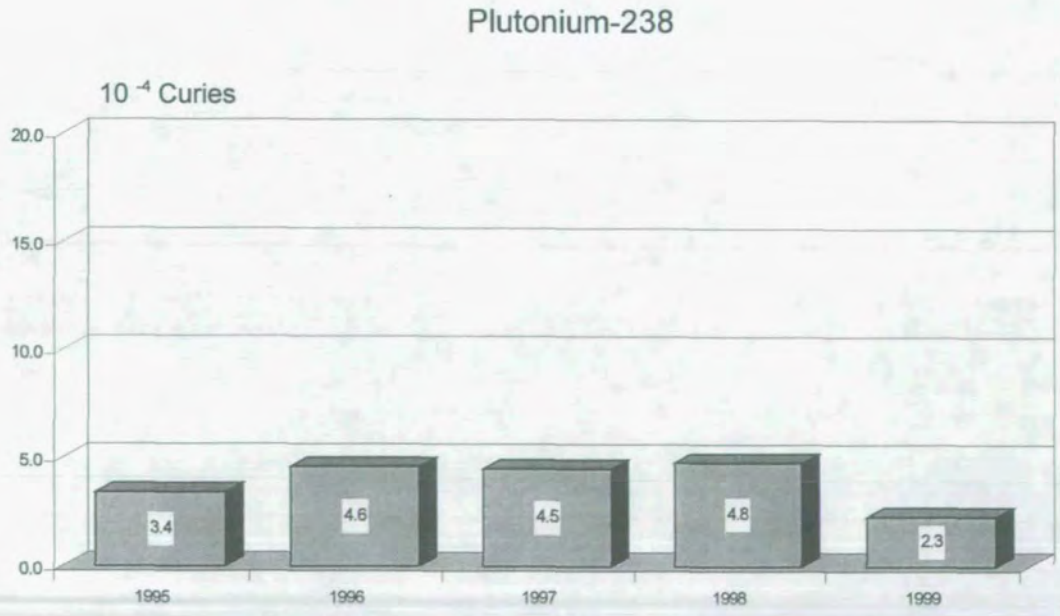


Figure 4-3. Tritium and Plutonium-238 Releases from MEMP to the Great Miami River, 1995 - 1999





4.4 Environmental Surveillance

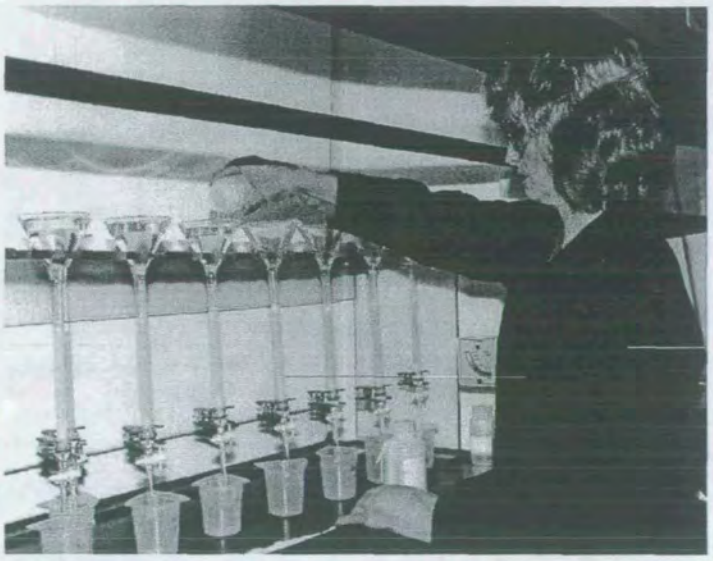
In the sections that follow, results of the Environmental Surveillance Program are summarized. The environmental surveillance program focuses on environmental conditions in the area surrounding the site and in local communities. Tables of monitoring results are presented in Appendix B.

Applicable Standards

Guidelines for concentrations of radionuclides in air and water are provided in DOE Order 5400.5 (DOE, 1993a). These guides are based on recommendations in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977, 1979). The guides for radionuclide concentrations are referred to as Derived Concentration Guides, or DCGs. The DCG for a radionuclide is defined as the concentration of that radionuclide in air or water which will result in a 50-year committed effective dose equivalent of 100 mrem (1 mSv) if taken into the body by inhalation or ingestion following continuous exposure for one year. DCGs are included in Appendix B.

Environmental Concentrations

In a number of the tables, results are presented as "incremental concentrations." The designation indicates that an average background concentration, or "environmental" concentration, has been subtracted from those values. Therefore, incremental concentrations represent estimates of MEMP's contribution to the radionuclide content of an environmental sample.



Chemist analyzing samples for radionuclides

Environmental or reference locations were positioned at sites where virtually no impact from the site could be measured. The sites are in the least prevalent wind direction and/or are at substantial distances relative to the site. Environmental levels for radionuclides in different environment media are shown in Appendix B, Table B-1.

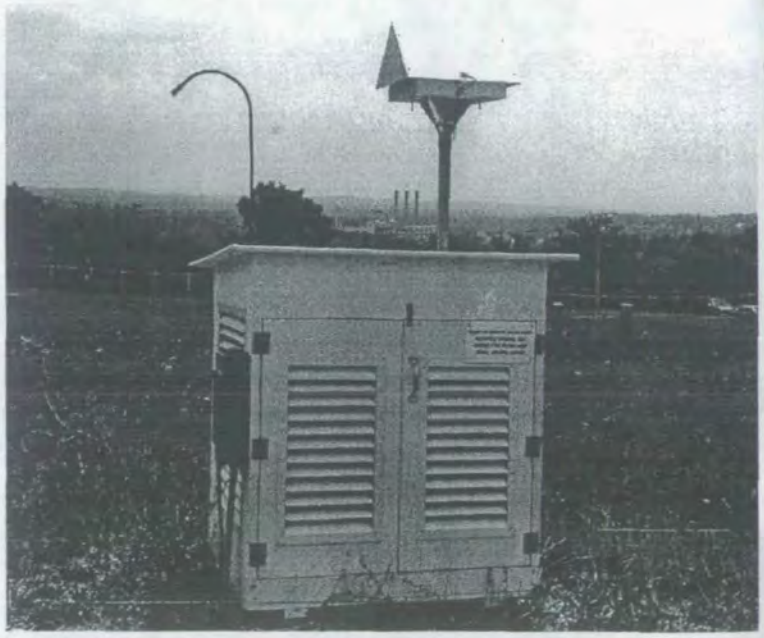
With decreasing release rates of radionuclides, it has become increasingly difficult to observe MEMP's contribution to radionuclide concentrations in the environment. For this reason, many of the tables in Appendix B report data as "below environmental levels." In those cases, it is not possible to observe an incremental concentration. In other words, the radionuclide concentration in the sample was equal to or less than the background sample.

Lower Detection Limit

All concentrations of radionuclides are determined by subtracting the instrument background and/or reagent blank from the sample count. The lower detection limit (LDL) is shown for each set of data in this Chapter. The LDL is the value at which the presence of a contaminant can be inferred at the 95% confidence level. An LDL is calculated from the instrument background or reagent blank results. Much of the radionuclide data in this report show concentrations that are below the LDL. Most of these data are incremental concentrations, i.e., the average environmental concentration has been subtracted from the result. Most of these data lie between true zero and the LDL level and are included for comparative purposes. (The measured concentration may have exceeded the LDL but, when the environmental concentration was subtracted, it fell below the LDL.) Data are reported if the concentration is below the LDL but exceeds the reagent blank or the instrument background level.

4.5 Ambient Air Sampling Program

Two types of air samples are collected at each sampling location. A particulate air sample is analyzed for plutonium-238 and plutonium-239,240. Samples from selected locations are also analyzed for thorium-228, thorium-230, and thorium-232. A second air sample, collected in a bubbler apparatus, is analyzed for tritium oxide. In 1999, 20 sampling stations were in operation: eight onsite and 12 offsite. The locations of the stations are shown in Figures 4-4 and 4-5, respectively.



Air Sampling Station

Figure 4-4. Onsite Ambient Air Sampling Locations

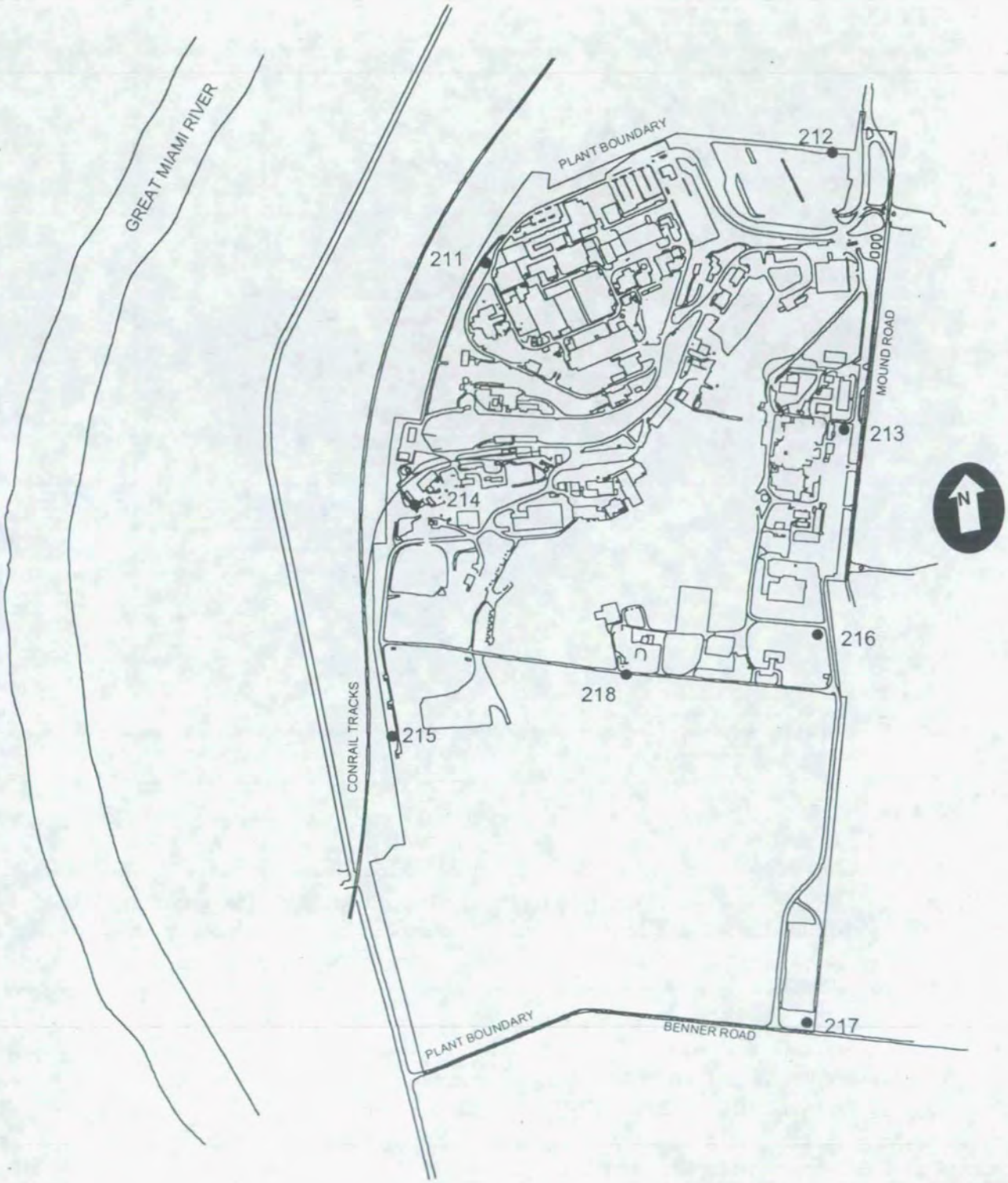
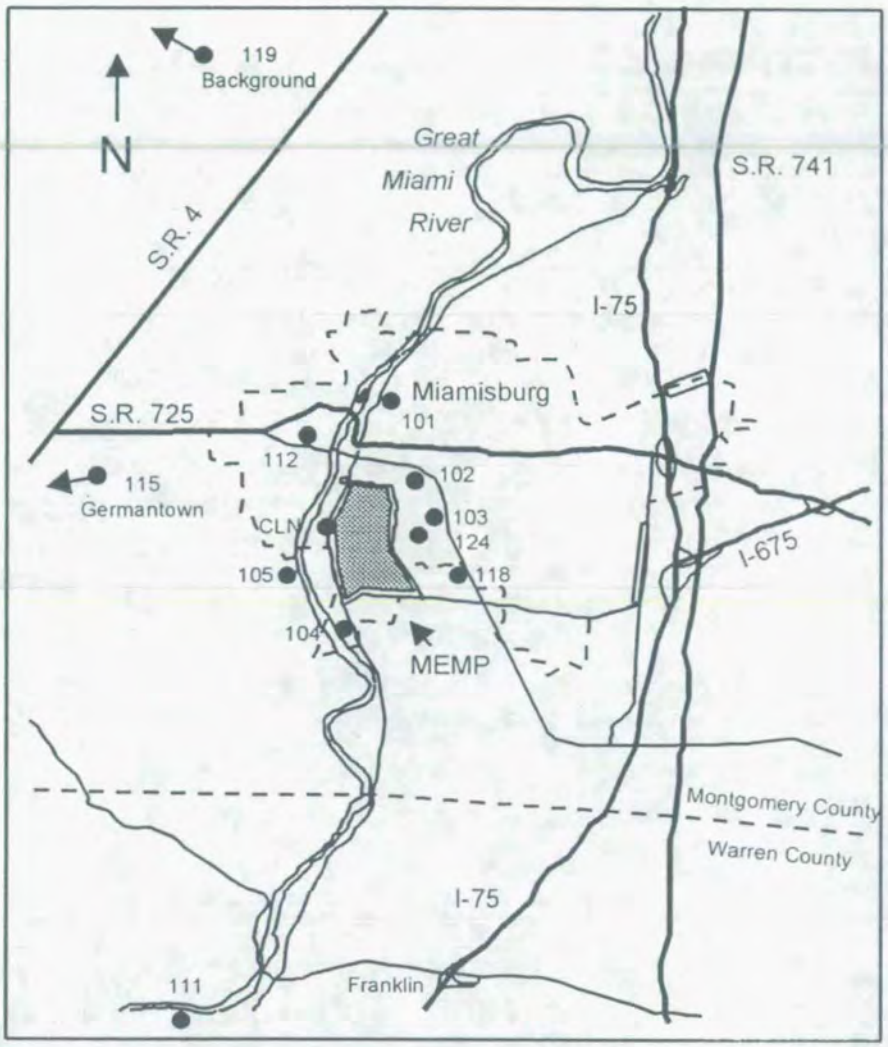


Figure 4-5. Offsite Ambient Air Sampling Locations



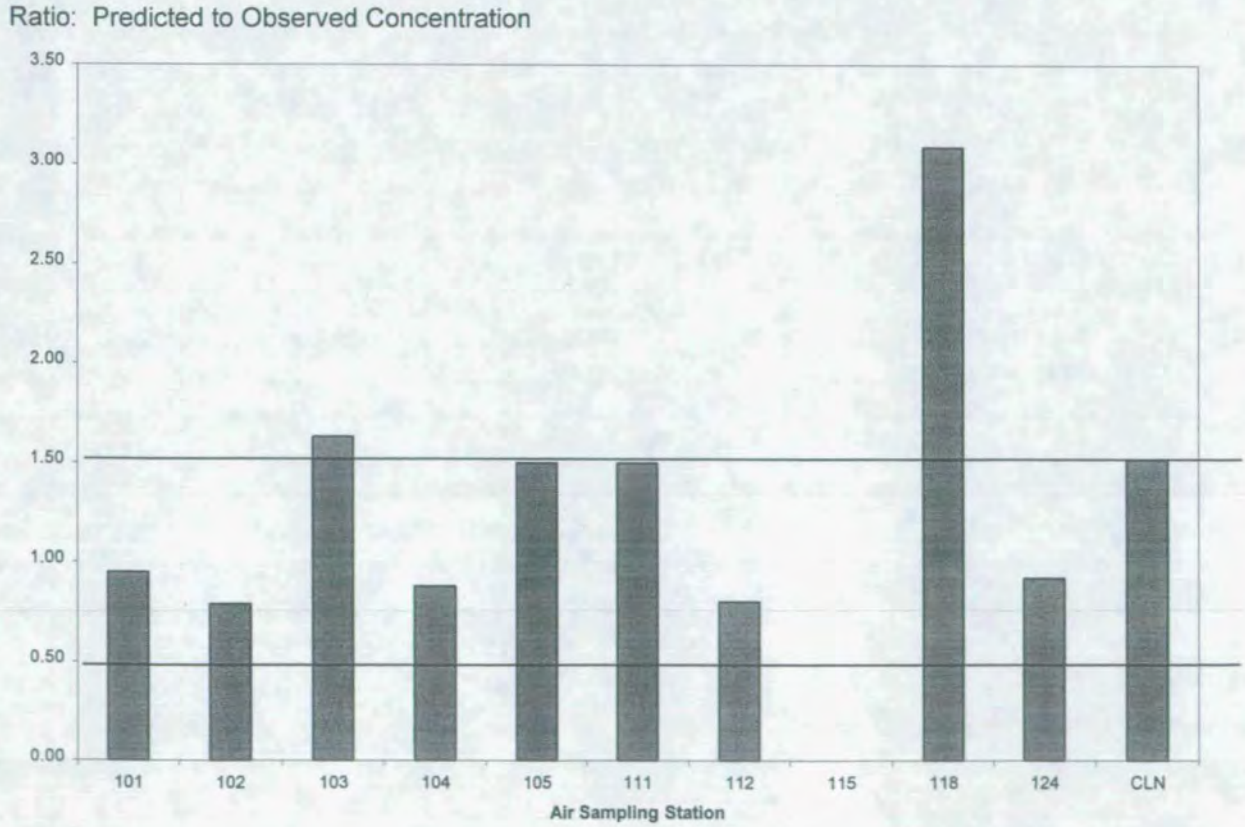
Tritium. Air samples for tritium analyses are collected on a continuous basis. Air is bubbled through 200 mL of ethylene glycol at a flow rate of approximately 1000 cm^3/min. Ethylene glycol is used as a trapping solution because it is not subject to loss by evaporation and will not freeze when exposed to winter sampling conditions. The glycol solutions are changed weekly and represent a sample volume of approximately 10 m^3 of air. An aliquot of each glycol solution is then analyzed weekly in a liquid scintillation counter.

With this technique, tritium oxide rather than elemental tritium is collected. This approach is appropriate because tritium oxide is the more radiotoxic form of tritium. The dose that would result from a given release of tritium oxide would be 25,000 times greater than the dose from the same number of curies of elemental tritium.

Comparisons of Predicted and Measured Tritium Concentrations

For 1999, tritium air concentrations predicted from modeling stack emissions with the EPA CAP88-PC dispersion model were compared to air concentrations observed during routine monitoring. Since essentially all of the impact from plutonium has been observed to be from resuspension of soil, and essentially all the impact from tritium has been observed to be from stack emissions, the air concentration comparison was performed for tritium (oxide) only. The predicted average concentration at offsite air sampling locations was compared with the observed incremental average concentration for 1999. Figure 4-6 shows the results of the comparison. Successful correlation is generally viewed as the ratio of predicted to observed concentration between 0.5 and 1.5. Ratios greater than 1.5 indicate that estimates of predicted dose impact from site activities were conservative at this location. In 1999, all values but one were greater than 0.5. Therefore, the ratios show successful correlation between predicted and observed results or that observed results are much lower than those predicted by the model. There is no ratio for sampling location 115, located in Germantown, because the observed result was below the environmental level. This sampling station is one of those located the greatest distance from the site where tritium concentrations were close to environmental levels.

Figure 4-6. Predicted and Observed Concentrations of Airborne Tritium in 1999



Plutonium. The particulate sample for isotopic plutonium analysis is collected on a 200-mm diameter fiberglass disc by a continuously operating high-volume air sampler. The air is sampled at an average rate of 1.3 x 10^6 cm^3/min (45 ft^3/min). The disc is changed weekly and represents a sample volume of approximately 13,000 m^3 of air. Each sampler is equipped with a flow meter so location-specific flow rates can be calculated.

Plutonium analysis is performed on monthly composite samples for each onsite location and for offsite stations closest to the site. The remaining samples are composited for quarterly analysis. The analytical process for plutonium includes the following basic steps: use of an internal tracer, chemical treatment, separation of plutonium with anion exchange resin, and alpha spectroscopy.

Thorium. Particulate samples from selected air sampling locations are also analyzed for thorium. The release of thorium from ground surfaces (resuspension) is possible due to remediation activities at the site. The analytical process for thorium follows the same principles as the plutonium analysis.

Uranium. As seen in Table 4-1, MEMP includes isotopes of uranium in the release data for air. However, because the stack emissions of uranium-233,234 and uranium-238 are so low and their dose contributions are negligible, ambient air monitoring for uranium is not performed in the environment.

Results for 1999

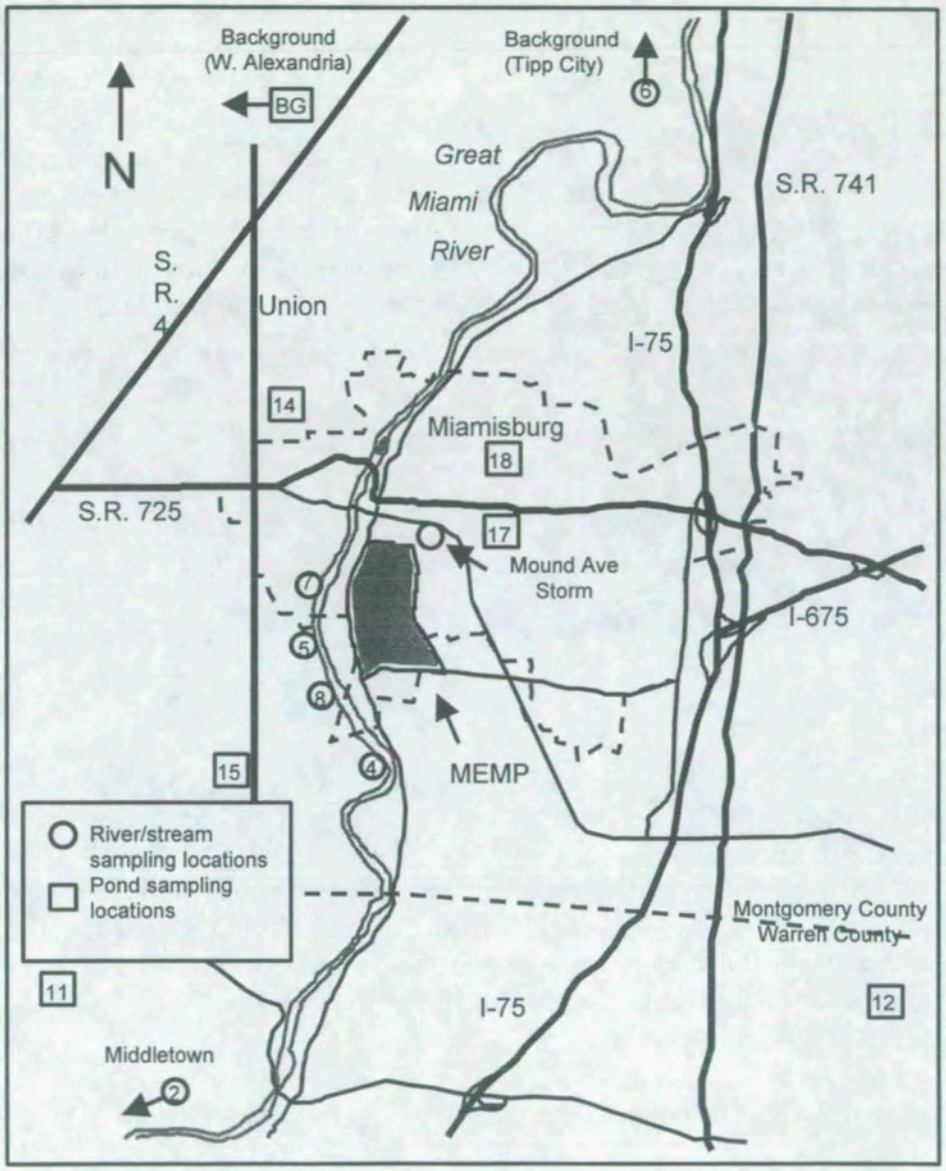
Radionuclide concentrations measured at environmental air sampling stations in 1999 are shown in Appendix B, Tables B-2 through B-5. The results are also presented in terms of the percentage DCG they represent. The tables show that air concentrations of tritium and plutonium consistently averaged less than 0.03% of the DCGs established for those radionuclides. In 1999, concentrations of thorium isotopes averaged less than 0.08% of the respective DCGs.

4.6 Surface Water and Sediment Sampling Program

The Great Miami River and other regional surface waters are sampled routinely for tritium, isotopes of plutonium, and isotopes of uranium. Sediment samples are also collected from these locations and analyzed for plutonium and thorium isotopes. Sampling locations are shown in Figure 4-7.

Great Miami River and Local Stream. River sampling locations have been selected according to guidelines published by the DOE (DOE, 1991). These locations provide samples that are representative of river water after considerable mixing with MEMP effluents has occurred. Tritium, plutonium-238, plutonium-239,240, uranium-233,234, and uranium-238 samples are collected and analyzed monthly. Great Miami River samples are analyzed for thorium-228, thorium-230, and thorium-232 quarterly. A local stream just northeast of the site is also sampled monthly for tritium.

Figure 4-7. Sampling Locations for the Great Miami River, Stream, Ponds, and Sediment



Local surface waters. Ponds in various compass sectors relative to MEMP are sampled annually. These samples are analyzed for tritium, plutonium-238, and plutonium-239,240.

Collection of Surface Water Samples

River and pond sediments. Many plutonium and thorium solutions, including those used at MEMP, are relatively insoluble in water. For this reason, they are more likely to be found in sediment than in surface water. Additionally, because of the relatively long half-lives of these isotopes, they may accumulate in sediments. Therefore, MEMP samples river and stream sediments on a quarterly basis and pond sediments on an annual basis. The river samples are then analyzed for plutonium-238, plutonium-239, 240, thorium-228, thorium-230, and thorium-232. The samples collected in the ponds are analyzed for plutonium-238 and plutonium-239,240.

Results for 1999

River and local stream water. Tritium, plutonium, uranium, and thorium concentrations in the Great Miami River are shown in Appendix B, Tables B-6 through B-10. Many measurements were below their respective environmental levels. Tritium concentrations were less than 0.03% of the DOE DCG. Average concentrations of plutonium and uranium isotopes were less than 0.06% of the respective DCG values. In 1999, river samples were also analyzed for isotopes of thorium quarterly. Average thorium concentrations were less than 0.05% of the DOE DCGs.

Pond water. Radionuclide concentrations measured in pond water are shown in Appendix B, Tables B-11 through B-13. The pond results were less than 0.004% of the DOE DCGs.

Sediment. Plutonium and thorium results for river sediments and plutonium results for pond sediments are listed in Appendix B, Tables B-14 through B-19. Maximum and average measurements for 1999 are comparable to those observed in previous years. Since isotopes of plutonium and thorium accumulate in sediment, concentrations are affected by the movement of silt in water bodies. This accounts for the variability in plutonium concentrations at the various river and pond locations.

4.7 Foodstuffs

Various locally grown produce samples and vegetation are collected during the growing season. The objective of this aspect of the Environmental Monitoring Program is to determine whether significant concentrations of radionuclides are present in plant and animal life. In 1999, samples of root crops and leafy and non-leafy vegetables were collected from a number of regional communities.

Plutonium concentrations are determined by ashing the samples, then analyzing the sample using chemical treatment, separation with anion exchange resin, and alpha spectroscopy. Tritium concentrations are determined by distilling the water from the sample, then analyzing the distillate using liquid scintillation spectrometry.

Results for 1999

The results for foodstuff analyses are shown in Appendix B, Tables B-20 through B-22. Average incremental concentrations of tritium, plutonium-238, and plutonium-239,240 were below 285×10^{-9}, 2.08×10^{-9}, and 0.03×10^{-9} μCi/g, respectively. Comparing 1999 results to 1998 results, average incremental concentrations of tritium, plutonium-238, and plutonium-239,240 were lower, higher, and lower, respectively.

4.8 Offsite Dose Impacts

Dose Estimates Based on Measured Concentrations

MEMP used the data presented in this report to estimate maximum doses to an offsite individual. The figure-of-merit used to calculate those doses was the committed effective dose equivalent (CEDE). CEDE calculations are required of DOE facilities. These calculations are also useful in evaluating the success of ALARA (As Low As Reasonable Achievable) policies. It is the philosophy of DOE to ensure that all doses from radiation exposure remain ALARA.

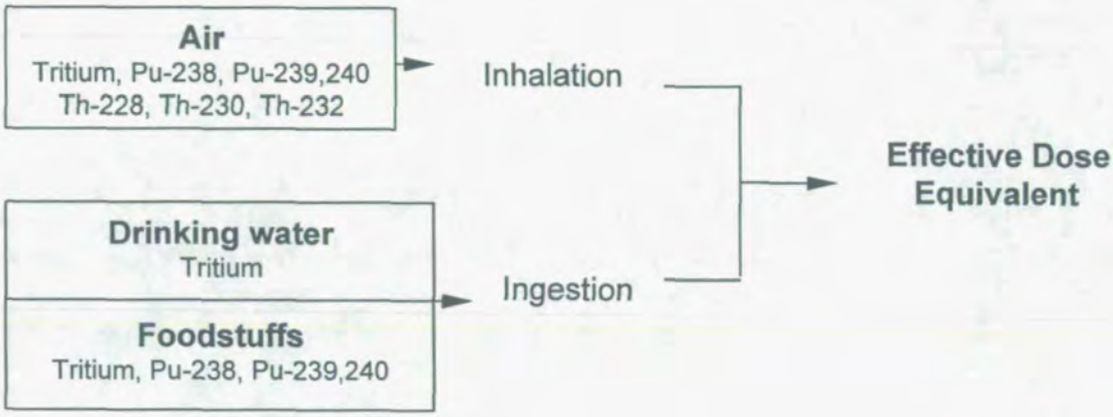
To provide an extra degree of conservatism, dose estimates are often calculated based on maximum exposure conditions. This "maximum individual," as defined for purposes of calculating CEDEs, is a hypothetical person who remained at the site boundary 24 hours per day throughout 1999. This individual was assumed to have:

- breathed exclusively air with radionuclide concentrations corresponding to the location of the maximum offsite dose,
- drawn all of his drinking water from the Miamisburg water supply, and
- consumed produce exhibiting the maximum average radionuclide concentrations in samples collected from the Miamisburg/Miami Township area.

The radionuclides and the exposure pathways which contributed to the maximum individual's CEDEs in 1999 are shown in Figure 4-8. Values for the CEDEs are shown in Table 4-2. More

detailed information on the CEDE calculations, including the concentration values used, is presented in Appendix E.

Figure 4-8. Exposure Pathways for Dose Calculations Based on Measured Data for 1999



Dose Estimates for NESHAPs Compliance

NESHAPs radionuclide regulations limit offsite doses from airborne releases from DOE sites (excluding radon) to 10 mrem EDE per year. As specified by the EPA, the preferred technique for demonstrating compliance with this dose standard is a modeled approach. A comparison between measured and modeled doses can be found on page 4-11.

Maximum individual. MEMP uses the EPA computer code CAP88-PC to evaluate doses for NESHAPs compliance. The 1999 input data for the CAP88-PC calculations are listed in Appendix E. Based on the CAP88-PC output, the maximum EDE from all airborne releases was 0.05 mrem. This estimate represents 0.5% of the dose standard.

Table 4-2. Maximum Committed Effective Dose Equivalents to a Hypothetical Individual in 1999

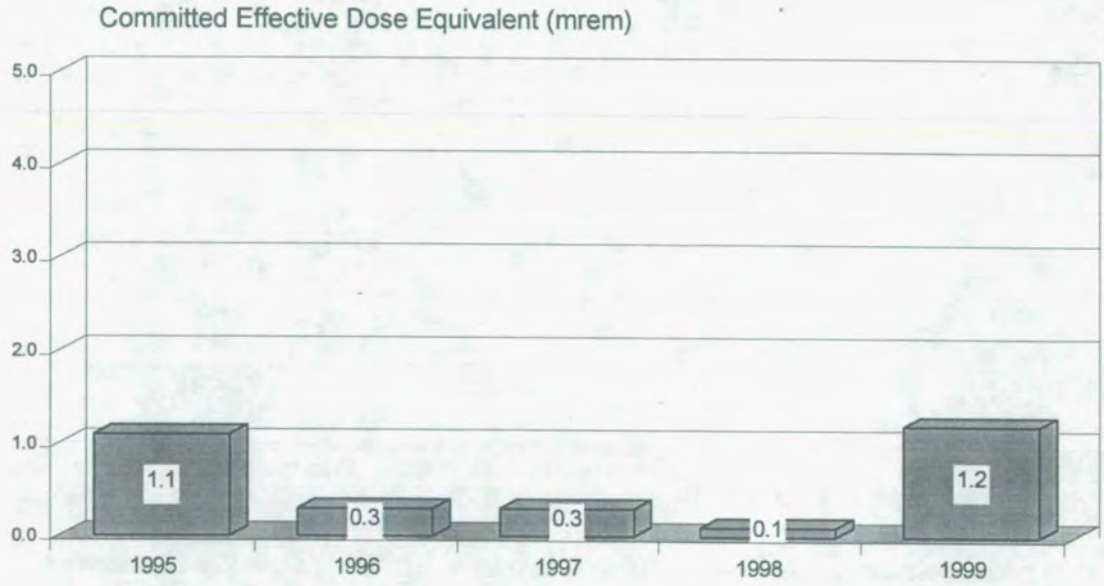
Radionuclide	Pathway	mrem	mSv
Tritium	Air	0.008	0.00008
	Drinking water	0.007	0.00007
	Foodstuffs	0.005	0.00005
	Total	0.02	0.0002
Plutonium-238	Air	0.004	0.00004
	Drinking water	ND	ND
	Foodstuffs	1.039	0.01039
	Total	1.043	0.01043
Plutonium-239,240	Air	0.0008	0.000008
	Drinking water	ND	ND
	Foodstuffs	0.011	0.00011
	Total	0.012	0.00012
Thorium-228	Air	0.015	0.00015
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.015	0.00015
Thorium-230	Air	0.016	0.00016
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.016	0.00016
Thorium-232	Air	0.062	0.00062
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.062	0.00062
Total		1.17	0.017

ND indicates that concentrations were not detectable above the environmental level or reagent blanks.
NA = not applicable (not measured).

Five-Year Trend in Committed Effective Dose Equivalents to a Hypothetical Individual

Figure 4-9 presents a plot showing the 5-year trend in committed effective dose equivalent to a hypothetical individual. The dose from MEMP activities in 1999 was a small fraction of the 100 mrem DOE dose limit for members of the public.

Figure 4-9. Committed Effective Dose Equivalents to a Hypothetical Individual, 1995 - 1999



Population doses. CAP88-PC also has the capability of estimating regional population doses from airborne releases. The population, approximately 3,035,000 persons, within a radius of 80 km (50 mi) of MEMP received an estimated 2.22 person-rem from site activities in 1999. CAP88-PC arrived at that value by calculating doses at specific distances and in specific compass sectors relative to MEMP. The computer code then multiplied the average dose in a given area by the number of people living there. For example, an average dose of 0.001 rem x 10,000 persons in the area yields a 10 person-rem collective dose for that region. CAP88-PC then sums the collective doses for the 80-km radium region and reports a single value. Additional dose components from drinking water and radon emissions are added to obtain this result.

MEMP's dose contribution of 2.22 person-rem can be put in perspective by comparison with background doses. The average dose from background sources is 300 mrem (0.3 rem) per individual per year. A background collective dose can be estimated for the 80-km population by multiplying 0.3 rem x 3.035 million persons. The result, about one million person-rem, represents an estimate of the collective dose from all background sources of ionizing radiation. MEMP's contribution, 2.22 person-rem, is approximately 0.00022% of that value.

CHAPTER 5

5.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAM INFORMATION

MEMP releases minor quantities of nonradiological constituents to the environment. These releases are governed by State of Ohio permits. MEMP monitors the impact of nonradiological airborne releases by measuring airborne particulates at eight onsite and 12 offsite locations. Nonradiological releases to water are also subject to extensive sampling protocols. In 1999, MEMP collected over 1,300 water samples to demonstrate compliance with the site's National Pollutant Discharge Elimination System (NPDES) permit and Authorization to Discharge (ATD).

5.1 Air Monitoring Program

Airborne Effluent

The primary source of nonradiological airborne emissions at MEMP is the steam power plant. The plant is normally fueled with natural gas but under certain circumstances fuel oil is used. Fuel oil with a 0.1% sulfur content is burned during unusually cold weather or if the natural gas supply to the site is interrupted. Approximately 13,250 liters (3500 gallons) of fuel oil and 5,447,500 m^3 (192,377,000 ft^3) of natural gas were burned during 1999. Powerhouse emissions are comprised primarily of sulfur oxides, nitrogen oxides, VOCs, carbon monoxide, lead, and particulates. Airborne effluent rates are calculated using a mass balance approach or AP-42 (EPA, 1985) emission factors. Annual emission rates are presented in Appendix C, Table C-1.

Ambient Air Monitoring

MEMP evaluates particulate concentrations at eight onsite and 12 offsite locations. Sampling locations are shown in Figures 4-4 and 4-5. High-volume particulate air samples are collected weekly by flowing air through a 200-mm diameter fiberglass filter. The system operates at about 1.3×10^6 cm^3/min which represents a sample volume of 13,000 m^3 of air per week. By weighing the filter paper before and after use, it is possible to determine the mass of particulates retained by the filter. The mass loading and known air volume can then be used to generate concentration values. Results for 1999 are presented in Appendix C, Table C-2.

Results for 1999

Nonradioactive air emissions from MEMP in 1999 did not significantly affect ambient air quality. All regulated releases were below permit limits, and comparisons of particulate concentrations measured onsite versus offsite suggest little or no influence by MEMP. The Ohio ambient air quality standard (50 $\mu g/m^3$) is provided as a reference value for particulate measurements. This value is the state goal for average ambient air quality over a three-year period. In 1999, average particulate concentrations measured at onsite sampling locations were below this standard.

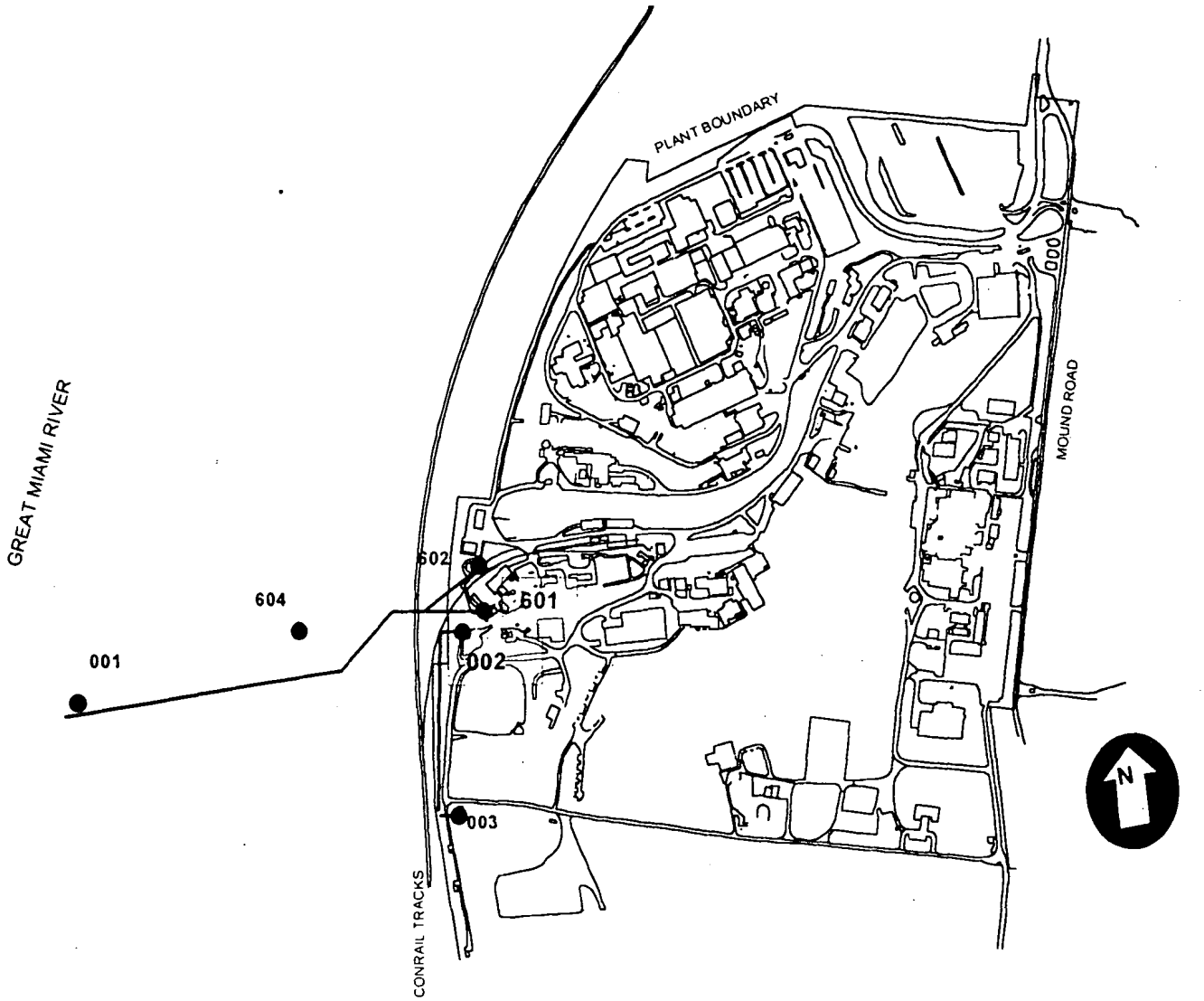
5.2 Water Monitoring Program

MEMP releases wastewater to offsite surface waters via three discharge systems. In 1999, MEMP discharged an average of 0.87 million gallons (3.30 million liters) of water per day to the Great Miami River. U. S. Geological Survey data indicate that the 1999 flow rate in the river averaged 1,909 million gallons per day (MGD), with minimum and maximum flow rates of 250 MGD and 28,100 MGD, respectively. The average magnitude of the river flow rate is significantly greater than that of MEMP's effluents. Therefore, releases from the site can be expected to have a minimal effect on river water quality outside of the mixing zone.

The site's wastewater discharges are regulated by the NPDES permit and ATD. The NPDES permit was most recently modified by the Ohio EPA in March of 1998; it is effective until March 2002. The ATD governs discharges from the CERCLA Operable Unit 1 groundwater pump and treat system. The ATD was issued July 11, 1997, and will remain in effect for the duration of the project. The NPDES permit and ATD define discharge limits and monitoring frequencies for the site's water effluents.

The site's NPDES permit requires scheduled collection and analysis of site effluents at three onsite locations (Outfalls 601, 602, and 002). Flow-weighted effluent limitations are further imposed for the combined discharges from Outfalls 601 and 602 (calculated Outfall 001). Additional samples are required for one offsite outfall (604) when operating. The ATD specifies monitoring requirements for the OU1 pump and treat system. This sampling location is designated Outfall 003. NPDES permit and ATD sampling locations are shown in Figure 5-1. A brief description of each outfall follows Figure 5-1.

Figure 5-1. NPDES Permit and ATD Sampling Locations



Outfall 601. Outfall 601 contains the effluent from the sanitary waste treatment plant. Flow-proportional, 24-hour composite samples and periodic grab samples are collected at this outfall. Monitoring requirements for this location focus on conventional pollutants and heavy metals. The effluent is also sampled quarterly for ten specific volatile organic compounds.

Outfall 602. Outfall 602 includes stormwater runoff, single-pass cooling water, zeolite softener backwash, and effluent from the radioactive waste disposal facility. Flow-proportional, 24-hour composite samples and periodic grab samples are collected at this outfall. Monitoring requirements for this location include oil and grease, chemical oxygen demand, and suspended solids.

Outfall 002. Outfall 002 contains softener backwash, cooling tower blowdown, single-pass cooling water, and most of the site's stormwater runoff. Flow-proportional, 24-hour composite samples and periodic grab samples are collected at this outfall. Monitoring requirements for this location focus on pH and suspended solids.

Outfall 001. Outfall 001 represents the combined effluents of 601 and 602. These discharges are combined and released to the Great Miami River via a closed pipe. Since sampling is not practical, additional limits for this outfall are imposed based on flow-weighted calculations. A composite sample is generated from samples collected from Outfalls 601 and 602. The concentrations of materials present in the composite sample represents an estimate of concentrations actually present in the effluent discharged through the pipe.

Outfall 604. Outfall 604 is a groundwater well, also known as Miamisburg Well 2, located west of the site. In the past, the well was purged to reduce tritium concentrations. The purged water was directed through a closed pipe to the Great Miami River. Monitoring of flow rate, pH, and VOCs is required for discharges from this outfall. The well was last pumped in 1991. In 1998, the closed pipe was removed and the electricity was disconnected.

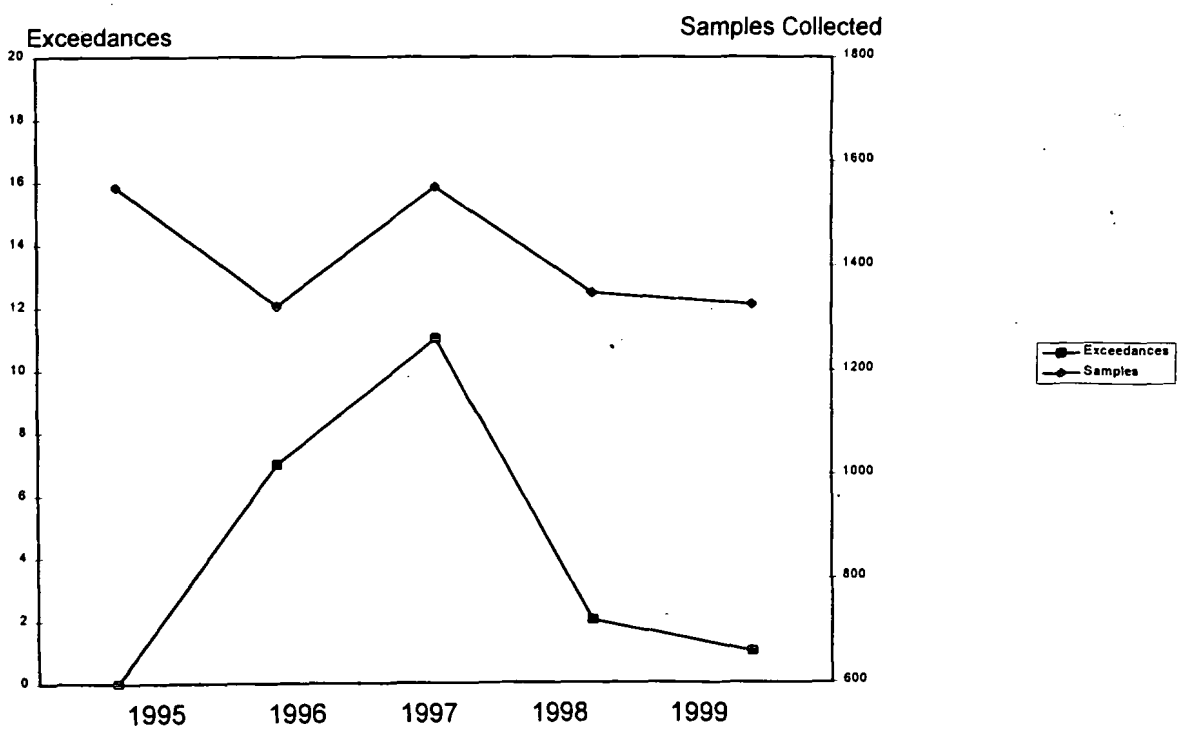
Outfall 003. Outfall 003 is the discharge from the CERCLA Operable Unit 1 groundwater pump and treat system. Time-proportional, 24-hour composite samples and periodic grab samples are collected at this outfall. Monitoring requirements for this location focus on VOCs and heavy metals. Biotoxicity tests are also performed quarterly each year at this outfall.

Results for 1999

More than 1,300 samples were analyzed for NPDES and ATD parameters in 1999. Key results are summarized in Appendix C, Table C-3. Analytical procedures were consistent with the methods specified in regulations of the Clean Water Act, 40 CFR 136. Sampling and analytical services were provided by BWXTO's Environmental Monitoring laboratory and by outside contractors. All such procedures meet EPA and BWXTO standards for quality assurance and quality control.

A review of NPDES and ATD performance over the past five years is shown in Figure 5-2. In 1999, two NPDES total suspended solids (TSS) permit exceedances were recorded. In April, a TSS exceedance occurred at Outfall 002 as a result of low flow, stagnant conditions causing the sampler to collect bio-material. Grab samples indicated that the effluent was within TSS limits. Corrective action was taken to reposition the sampler tube to collect a more representative effluent sample. In December, the TSS limit was exceeded again at Outfall 002. This exceedance was exempted, as the TSS was a result of storm water conditions. No ATD exceedances occurred in 1999.

Figure 5-2. NPDES and ATD Sampling Profile, 1995 - 1999



5.3 Submissions under SARA Title III

Title III of the Superfund Amendments and Reauthorization Act (SARA) addresses the emergency planning and community right-to-know responsibilities of facilities handling hazardous substances. Sections 311 and 312 of Title III specify reporting requirements for the use and/or storage of "extremely hazardous" and "hazardous" substances. For facilities subject to Section 311 and 312, chemical usage, storage, and location information must be submitted to regional emergency response agencies before March 1 each year. In 1999, BWXTO used and/or stored two extremely hazardous substances and six hazardous substances in excess of reporting thresholds. This information, along with site maps showing usage and storage locations, is reported to the State Emergency Response Commission, the Miami Valley Regional Planning Commission, and the City of Miamisburg Fire Department each year. The eight regulated substances handled by BWXTO are listed in Table 5-1.

Table 5-1. 1999 SARA Title III Emergency and Hazardous Chemical Data

Hazardous Substances

Diesel fuel	Gasoline, unleaded	Ethylene glycol
No. 2 fuel oil	Nitrogen	Argon

Extremely Hazardous Substances

Sulfuric acid	Nitric acid

Section 313 of Title III specifies reporting requirements associated with the release of toxic chemicals. For facilities that exceed the reporting threshold, toxic chemical release data must be submitted to the U. S. EPA before July 1 each year. In 1999, BWXTO used ethylene glycol in excess of the reporting threshold and will submit a "Form R" to the Ohio EPA and USEPA in 2000.

5.4 Environmental Occurrences

Under CERCLA and the Clean Water Act, reportable quantity (RQ) levels have been established for designated hazardous substances. If a spill or other inadvertent release to the environment exceeds the RQ, immediate notification of the appropriate federal agencies (e.g., National Response Center, EPA, or Coast Guard) is required. No such releases occurred at MEMP during 1999.

CHAPTER 6

6.0 GROUNDWATER MONITORING PROGRAM

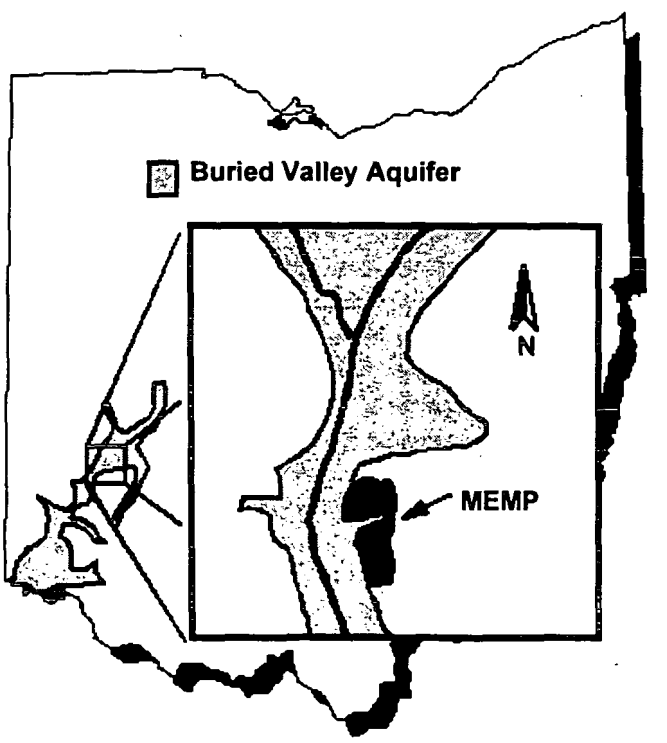
The MEMP site lies atop the largest of Ohio's sole-source aquifers, the Buried Valley Aquifer (BVA). The City of Miamisburg and a number of other communities in the area draw drinking water from the BVA. MEMP also relies on the BVA for drinking and process water.

MEMP maintains approximately 175 active groundwater monitoring points onsite and offsite to characterize the impact operations may have on the BVA. Included in these sites are three onsite production wells, 117 monitoring wells, 38 piezometers, five capture pits, and 13 community water supplies and private wells. The groundwater monitoring program has been developed to meet Safe Drinking Water Act (SDWA) monitoring requirements, CERCLA program objectives, and DOE-mandated practices. This chapter serves as a general summary of the groundwater activities that have occurred in 1999. Additional information can be found in the *"Annual Groundwater Monitoring Report, Calendar Year 1999,"* and the *"OU-1 Annual Report, Volumes 1 and 2, 1999."*

6.1 Regional Hydrogeology

The BVA was designated a sole-source aquifer by the U.S. EPA in May 1988. This distinction indicates that the aquifer supplies all of the drinking water to the communities above it. The approximate aerial extent of the BVA is shown in Figure 6-1.

Figure 6-1. Location and Extent of the Buried Valley Aquifer



The aquifer has a north-south orientation and reaches a maximum thickness of about 46 m (150 ft) near the Great Miami River channel. Groundwater in the area generally flows south, following the downstream course of the River. Limited recharge by induced stream infiltration occurs due to the extensive layers of clayish till in the region, which impede infiltration. The BVA flow system is characterized by glacial outwash deposits with very high hydraulic conductivity, consequently, the aquifer is capable of transmitting large quantities of groundwater. The BVA west of the site is estimated to have calculated transmissivity values ranging from 200,000 to 430,000 gallons per day per foot. The transmissivity values are based upon hydraulic characterization data obtained from a May 1993 aquifer pump test.

The BVA is somewhat overdrawn between the cities of West Carrollton and Dayton. Practices involving relocation of well fields and artificial recharge via infiltration lagoons are in use to reduce the magnitude of the reversal. There is no evidence that the gradient reversal affects regions south of West Carrollton such as Miamisburg. In Miamisburg, pumping does not influence the natural groundwater gradient except in the immediate vicinity of the well fields.

Uses of Groundwater in the Vicinity

There are seven municipal water supplies and numerous industrial users within an 8 km (5 mi) radius of the site. The locations of public and private water supply and monitoring wells are shown in Figure 6-2. The only industrial user within 8 km (5 mi) downgradient is the O. H. Hutchings Power Generation Station. Industrial groundwater users located north (upgradient) of the site are isolated from MEMP by hydraulic barriers.

The communities of Franklin and Carlisle are the first downgradient water supplies. Monitoring efforts are concentrated in the Miamisburg area due to the relatively slow movement of groundwater. The City of Miamisburg operates four production wells to the west of the Great Miami River. These wells are upgradient and are not expected to be impacted by MEMP. All community production wells in use are separated from the site by a minimum straight-line distance of 0.8 km (0.5 mi).

In 1992, a residential well and cistern study (DOE, 1993b) was conducted. A total of 216 residential wells and 14 cisterns were identified within a two-mile radius of the site. Results of this study are in the CERCLA Public Reading Room.

6.2 Site Hydrology

As seen in Figure 6-1, a "tongue" of the BVA underlies the site. Within the limits of the property, the maximum known thickness of the aquifer is about 21 m (70 ft) at the extreme southwest corner of the site. Present usage of the BVA by MEMP ranges approximately from 1.5 to 2.0 million liters per day (400,000 to 528,500 gallons per day). Recharge to the portion of the BVA underlying the site primarily arises from infiltration of river water, precipitation, and leakage from valley walls. These sources of recharge provide sufficient volumes of water to balance MEMP's withdrawals.

As a result of the dramatic changes in elevations associated with site topography, the site has a variety of groundwater regimes. Typical groundwater elevation contour maps, shown in Figures 6-3 and 6-4, reflect the two sources of groundwater that are of concern to MEMP, perched water in the bedrock and the BVA. Groundwater levels vary from elevations near 204 m (670 ft) to approximately 267 m (875 ft). Onsite groundwater levels generally increase with increasing ground surface elevations. (Ground surface elevations are shown on Insert 1-1.) At the lowest site elevations overlying the BVA, groundwater is typically present at depths between 20 ft (6 m) and 25 ft (7 m) below the surface. The maximum groundwater level for the perched water in the bedrock beneath the main hill is approximately 255 m (835 ft). The ground surface elevation for the main hill is approximately 268 m (880 ft).

Bedrock permeability. The bedrock flow system is comprised of thick sequences of interbedded shales and limestones that make-up the topographic bedrock highs known as the Main Hill and SM/PP Hill. The bedrock is not capable of transmitting large quantities of water due to its low hydraulic conductivity. Groundwater flow in the bedrock system occurs primarily within an upper fracture carapace that extends from the ground surface to a depth of approximately 50 ft. The fracture carapace is characterized by bedrock that contains sufficient interconnected secondary porosity to allow transmission of small quantities of groundwater. Permeability of this carapace is estimated to range from 40 to 400 L/day/m^2 (1 to 10 gal/day/ft^2). Below it, bedrock permeability generally ranges from 0 to 8 L/day/m^2. Bedrock groundwater typically discharges as either surface seeps or into onlapping portions of glacial deposits.

Glacial till and outwash permeability. Hydraulic properties of the glacial tills that form a veneer over the site vary depending on the proportions of fine and course-grained materials at a given location. Values of permeability normally range from 0.0041 to 0.041 L/day/m^2 (0.0001 to 0.001 gal/day/ft^2), although values up to 2.8 L/day/m^2 (0.07 gal/day/ft^2) have been measured in upper weathered zones. Below the glacial till in the lower valley is a zone of glacial outwash composed of sand and gravel. The permeability of this zone is estimated to range from 40,700 to 81,000 L/day/m^2 (1,000 to 2,000 gal/day /ft^2). Additional information concerning the site's hydrology can be found in *"Operable Unit 9, Hydrologic Investigation, 1994"* (Bedrock and Buried Valley Aquifer Reports).

Seeps

At points along the north hillside, bedrock is exposed and seep lines exist. A generalized cutaway depicting this phenomenon is shown in Figure 6-5. Seeps serve as escape routes for groundwater in the upper elevations of the groundwater regime.

Surface Water Features

There are no perennial streams on the site. A natural drainage area exists in the deep valley separating the two main hills, but water in this area generally has a short residence time. The basin is relatively small and the slopes are relatively steep. Therefore, runoff through site drainage features is rapid.

Figure 6-2. Production and Monitoring Well Locations

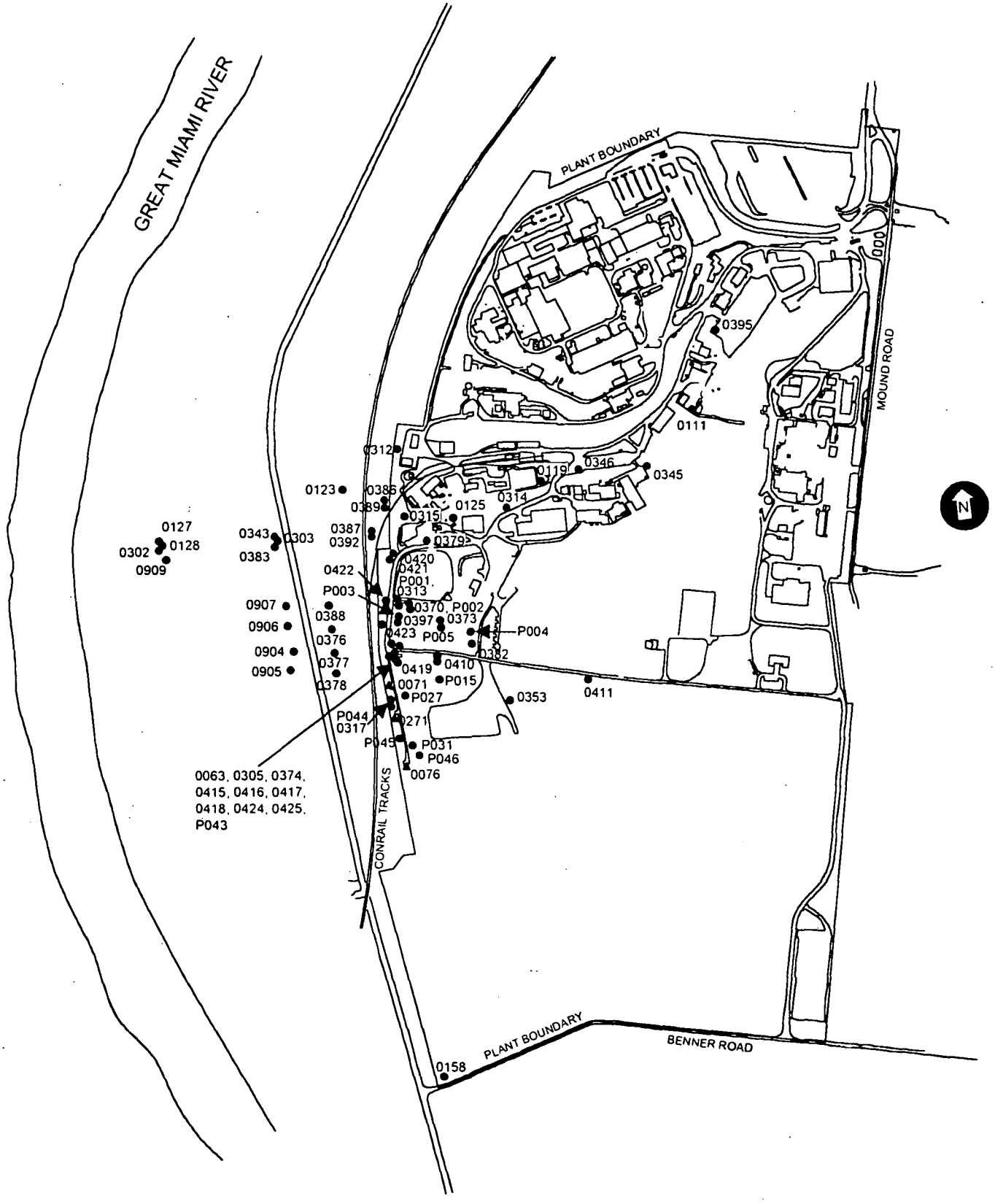


Figure 6-3. Groundwater Elevations for Perched Water in the Bedrock

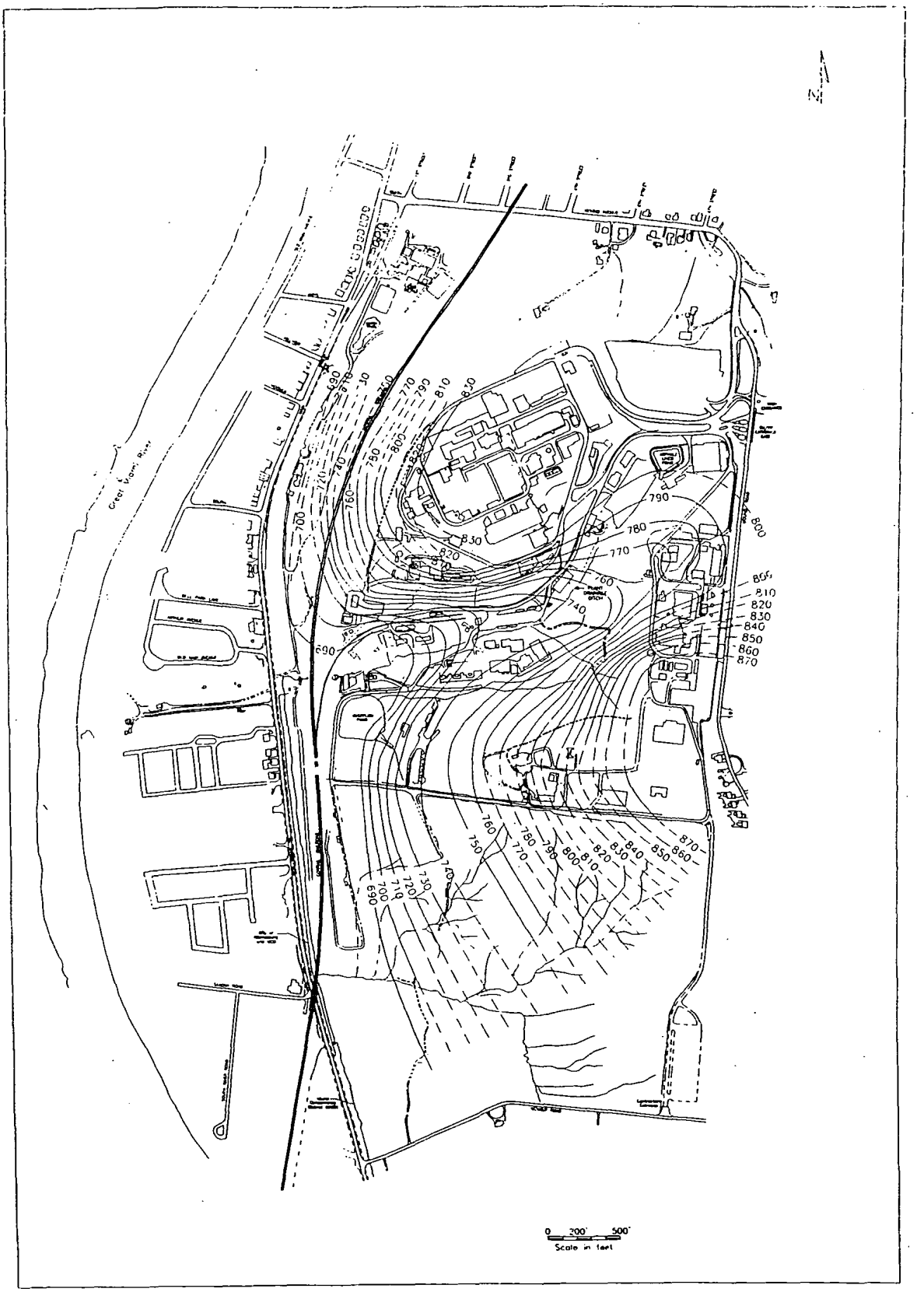


Figure 6-4. Groundwater Elevations for the Buried Valley Aquifer

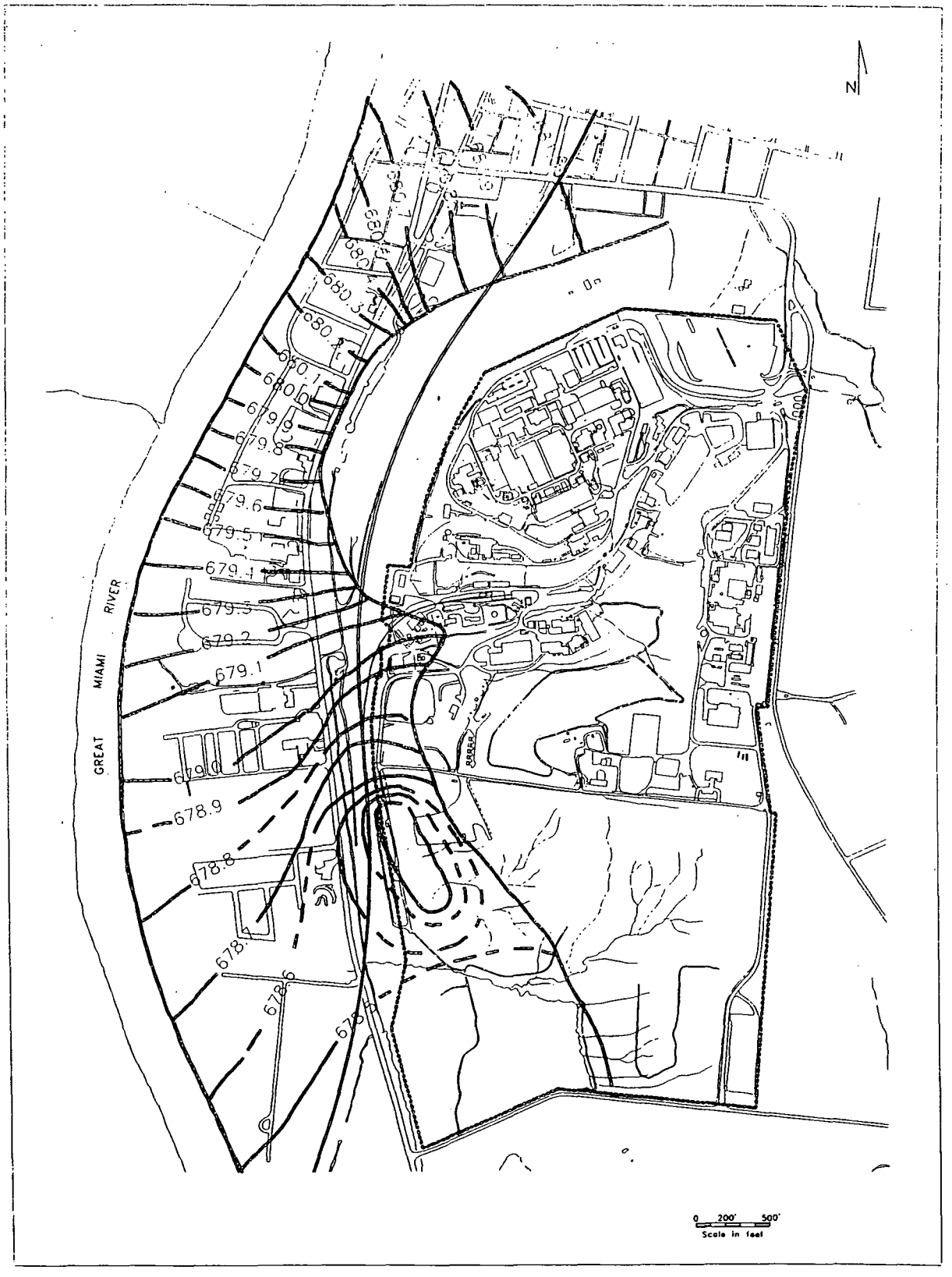
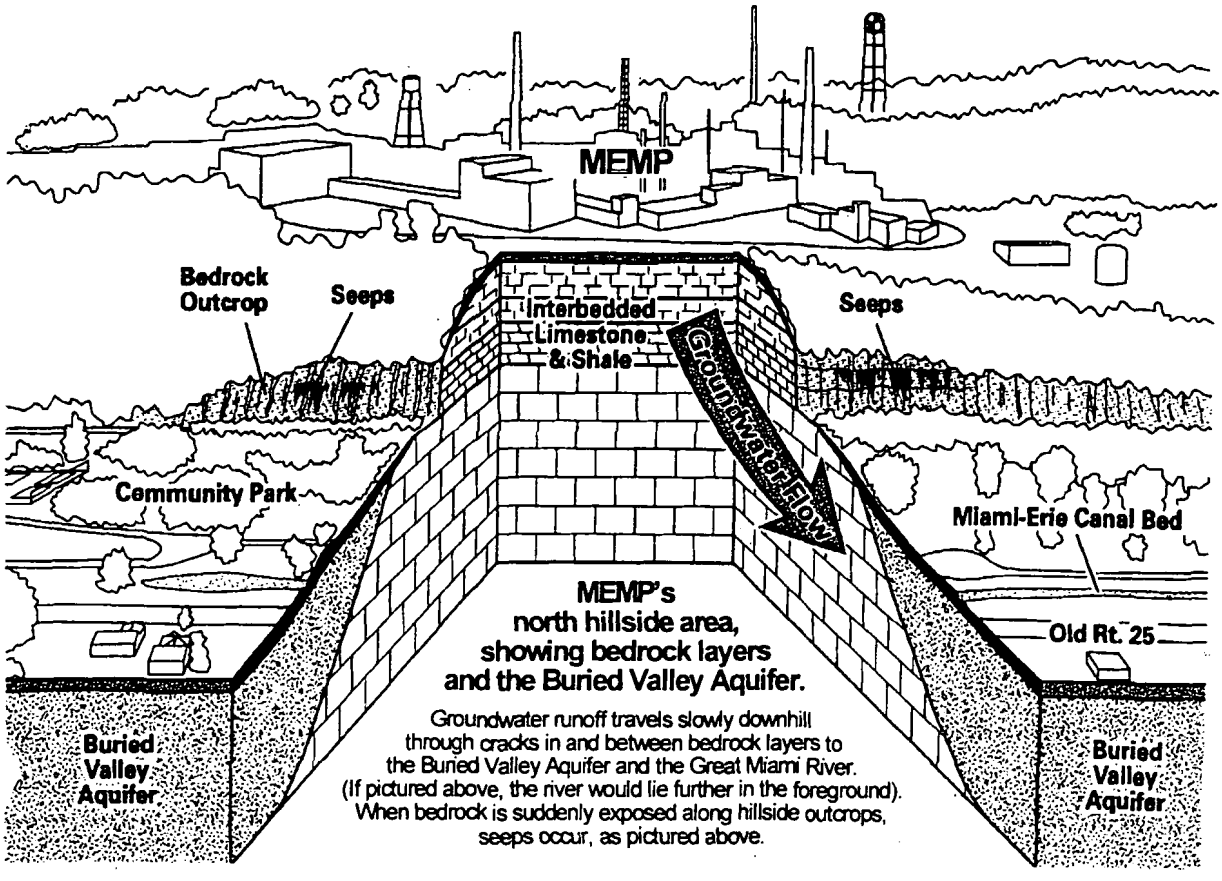


Figure 6-5. Geologic Cutaway



6.3 Applicable Standards

Guidelines for concentrations of radionuclides in drinking water are provided in DOE Order 5400.5 (DOE, 1993). These guides are based on recommendations in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977, 1979). The guides for radionuclide concentrations are referred to as Derived Concentration Guides, or DCGs. The DCG for a radionuclide is defined as the concentration of that radionuclide which will result in a 50-year committed effective dose equivalent of 100 mrem (1 mSv) following continuous exposure for one year. EPA has also established a drinking water dose standard of 4 mrem/year for specific combinations of radionuclides and concentration standards, or maximum contaminant levels (MCLs), for tritium, radium, and gross alpha.

The National Primary and Secondary Drinking Water Standards also provide MCLs for nonradiological parameters. Primary MCLs have been established for a variety of parameters, including volatile organic compounds (VOCs) and inorganic substances such as metals. Primary MCLs are the maximum concentrations allowed under the SDWA. Secondary MCLs are guidelines for maximum advisable concentrations for other contaminants. Maximum concentrations of lead and copper are expressed as "action levels." DCGs, MCLs, and action levels are included with the groundwater results presented in Appendix D.

6.4 Environmental Concentrations

Each year, samples are collected from a community water supply that is not affected by MEMP operations. These samples represent background, or "environmental," levels for radionuclides. For drinking water, the environmental reference location is Tipp City, approximately 40 km (25 mi) north of MEMP. Environmental concentrations for 1999 can be found in Appendix D, Table D-1.

6.5 Offsite Groundwater Monitoring Program

The objectives of the offsite groundwater monitoring program are to assure local residents and communities that their drinking water has not been adversely impacted by plant activities and to provide an early warning of impacts due to continuing decontamination and decommissioning activities and environmental restoration activities. This program consists of the collection and analysis of samples from production wells, private wells, regional drinking water supplies, and BVA monitoring wells. Samples are analyzed for radionuclides, inorganic substances, and VOCs. A description of the analytical procedures used to generate these results can be found in the Environmental Monitoring Plan (EG&G, 1997) and the Groundwater Protection Management Program Plan (DOE, 1997).

Community Water Supplies and Private Wells

Tritium is the most mobile of the radionuclides released from the site. Therefore, private wells immediately downgradient of MEMP and regional groundwater supplies are closely monitored for tritium. Monthly samples are collected from seven community water supplies and six private wells. Results for 1999 are shown in Appendix D, Table D-2. Average tritium concentrations ranged from 0.05 nCi/L to 0.53 nCi/L, or 0.3% to 2.7% of the MCL, respectively. The results reflect the pattern of tritium concentrations one would expect: higher averages near the site (e.g., Miamisburg) and lower averages at greater distances (e.g., Middletown).

The Miamisburg community water supply is also analyzed for plutonium-238, plutonium-239,240, uranium-233,234, uranium-238, thorium-228, thorium-230, and thorium-232. Plutonium and uranium samples are collected monthly, while thorium samples are collected quarterly. Results for 1999 are shown in Appendix D, Tables D-3 through D-5. Many results for 1999 were comparable to background levels for these radionuclides; average concentrations were less than 2.9% of the respective EPA dose standard.

Offsite Monitoring Wells

Radionuclides. To provide additional information on the extent of offsite tritium migration, MEMP also collects groundwater samples from offsite monitoring wells. The results for 1999 are shown in Appendix D, Table D-6. Average tritium concentrations ranged from 0.08 nCi/L to 8.67 nCi/L, or 0.4% to 43.4% of the MCL, respectively.

Monitoring wells along the western boundary of the site are also analyzed for plutonium-238, plutonium-239,240, uranium-233,234, uranium-238, thorium-227, thorium-228, thorium-230, and thorium-232. The results are shown in Appendix D, Tables D-7 through D-9. Average concentrations ranged from non-detectable to 1.3% of the respective EPA dose standard.

VOCs and Inorganics. Thirteen offsite monitoring wells were also used to evaluate concentrations of VOCs in the BVA. The wells sampled were analyzed for over 50 organic compounds. Results are presented in Appendix D, Table D-10. In 1999, tetrachloroethene, trichloroethene, 1,1,1-trichloroethane were observed offsite in five wells. No MCLs were exceeded except for trichloroethene in monitoring well 0386. This well is located in the transition zone between the tributary valley onsite and the BVA. A field investigation identified a small-localized area of subsurface VOC soil contamination in the vicinity of Building 19. Potential release site 417 has been generated as a result of the investigation.

Inorganic substances are also evaluated in offsite monitoring wells. The metals and other inorganics of interest are those regulated under the SDWA. In 1999, only those parameters with MCL detectable concentrations are presented in Appendix D, Table D-11. In 1999, concentrations above primary MCLs were observed for chromium and nickel. Secondary MCLs were exceeded for aluminum, iron, and manganese. In 1999, a field investigation was initiated to study the nature and variability of the elevated levels of metals. The study results suggested that turbidity induced by the sampling methodology was the primary factor for the variability in metal concentrations. Results and sampling recommendations from the field investigation can be found in *"Metals Investigation Assessment Report, US Department of Energy, October, 1999."*

6.6 Onsite Groundwater Monitoring Program

The objectives of the onsite groundwater monitoring program are to assure site workers that drinking water is safe for consumption, to assure containment of known groundwater contamination, and to monitor progress and effectiveness of ongoing groundwater remediation efforts. This program consists of routine collection and analysis of samples from production wells and BVA monitoring wells. Samples are analyzed for radionuclides, inorganic substances, and VOCs. A description of the analytical procedures used to generate these results can be found in the Environmental Monitoring Plan (EG&G, 1997) and the Groundwater Protection Management Program Plan (DOE, 1997).

MEMP Production Wells

Three onsite production wells provide drinking and process water for the site. Samples from the production wells are analyzed for tritium, plutonium-238, plutonium-239,240, uranium-233,234, uranium-238, thorium-228, thorium-230, and thorium-232. Tritium samples are collected and analyzed weekly, plutonium and uranium samples monthly, and thorium quarterly. Results for 1999 are summarized in Appendix D, Tables D-12 through D-15. Average tritium

concentrations observed in 1999 were less than 0.5 nCi/L. This value represents less than 2.5% of the MCL. Average concentrations of other radionuclides measured in 1999 represented less than 1.5% of the respective EPA dose standard.

MEMP's production wells are also analyzed for over 50 organic compounds quarterly each year. The three halogenated solvents typically present in trace concentrations are 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene. Results for 1999 are shown Appendix D, Table D-16. The data confirm that the production wells are consistently below MCLs for organic compounds.

SDWA Compliance Summary

Results in this Chapter have been summarized in terms of average concentrations for the year. SDWA compliance for drinking water supplies, however, is evaluated by comparing individual sample results with applicable MCL values. Because the three onsite production wells serve as a drinking water source for the site, SDWA compliance is determined by an annual running average. Table 6-1 shows the maximum concentrations of parameters measured in the production wells during 1999. In 1999, no MCL exceedances were observed in the production wells.

Table 6-1. SDWA Compliance Summary

Parameter	Maximum Concentration	MCL
Tritium	0.8 nCi/L	20 nCi/L
1,1,1-Trichloroethane	3.0 µg/L	200 µg/L
Trichloroethene	1.2 µg/L	5 µg/L
Tetrachloroethene	1.0 µg/L	5 µg/L

MCL = Maximum Contaminant Level (based on EPA Drinking Water Standards)

The SDWA does not limit the concentrations of most radionuclides individually (tritium is an exception). Instead, the dose from specific combinations of radionuclides is limited to 4 mrem/year. In 1999, the dose from plutonium, uranium, and thorium measured in the onsite production wells was 0.09 mrem. This represents 2.3% of the dose standard.

To demonstrate compliance with the SDWA, samples are collected from the distribution system. These samples are analyzed for total coliform, lead, copper, nitrate, volatile and synthetic organic compounds, gross alpha and beta, radium, and tritium. The action level for lead was exceeded

during semi-annual sampling. As a result, MEMP has implemented a corrosion control program to reduce corrosion of distribution system piping, a significant contributor to lead levels in drinking water. No other exceedances were observed in 1999.

Onsite Monitoring Wells

Radionuclides. MEMP maintains an extensive network of onsite BVA monitoring wells (Figure 6-2). Samples from these wells are analyzed for tritium. The results for 1999 are shown in Appendix D, Table D-17. The maximum concentration observed in 1999 was 6.06 nCi/L. This value represents 30.3% of the MCL.

Samples from onsite monitoring wells located in the tributary valley are also analyzed for plutonium-238, plutonium-239,240, uranium-233,234, uranium-235, uranium-238, thorium-227, thorium-228, thorium-230, thorium-232, radium-226, and radium-228. Monitoring for these constituents are part of the PRS 66 field investigation. Results for 1999 are shown in Appendix D, Tables D-18 through D-21. In 1999, average values ranged from non-detectable to 12.8% of the respective EPA dose standard.

VOCs and Inorganics. Onsite monitoring wells in the upper and lower units of the BVA have been sampled since 1988. Results confirm the presence of VOC contamination in the aquifer. The contamination appears to be greatest in the upper unit of the BVA along the western boundary, immediately southwest of the Main Hill. Generally, within the site boundaries, contamination tends to decrease from west to east and from south to north.

The CERCLA Operable Unit 1 project addresses VOC contamination in groundwater near the site's former solid waste landfill. The project is comprised of two elements: a groundwater pump and treat system designed to prevent the migration of VOCs into the aquifer and an air sparge/soil vapor extraction system to accelerate the removal of VOCs from the soil.

Onsite monitoring wells are sampled for over 50 organic compounds. Many of the wells are sampled to evaluate containment of the plume and the effectiveness of the Operable Unit 1 treatment process. A declining trend in VOC concentrations has been observed. Results for 1999 are presented in Appendix D, Table D-22. In 1999, carbon tetrachloride, cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene exceeded drinking water MCLs. Additional information can be found in the *"OU-1 Annual Report, Volumes 1 and 2, 1999."*

Inorganic substances in onsite monitoring wells are also evaluated. The metals and other inorganics of interest are those regulated under the SDWA. The results are presented in Appendix D, Table D-23. In 1999, concentrations above primary MCLs were observed for arsenic, antimony, chromium, lead, and nickel. Secondary MCLs were exceeded for aluminum, iron, manganese, and zinc. In 1999, a field investigation was initiated to study the nature and variability of the elevated levels of metals. The study results suggested that turbidity induced by the sampling methodology was the primary factor for the variability in metal concentrations. Results and sampling recommendations from the field investigation can be found in *"Metals Investigation Assessment Report, US Department of Energy, October, 1999."*

6.7 Seeps and Capture Pits

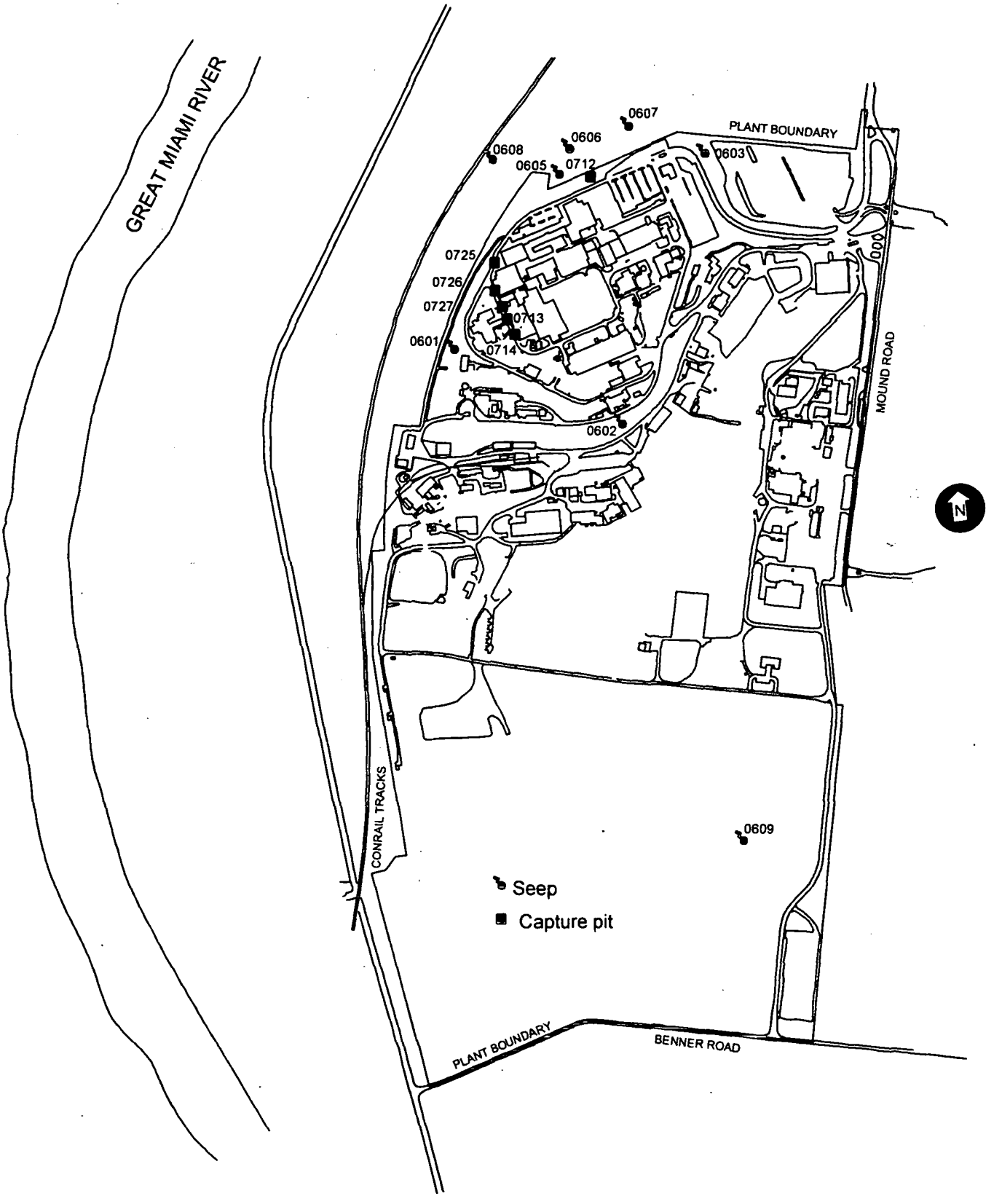
Seeps. Tritium has been recognized as a contaminant in the seeps located along the northwest border of the site since 1986. Since then, tritium has been the focus of extensive sampling activities in that area. Appendix D, Table D-24 shows concentrations of tritium in seep samples in 1999. In 1999, the highest tritium concentrations were associated with Seep 601, consistent with observations in previous years. The sampling locations are shown on Figure 6-6.

Samples collected in 1988 first confirmed the presence of VOCs in Seeps 0601, 0602, 0605, and 0607 (EG&G, 1991). VOC monitoring results for the seeps in 1999 are presented in Appendix D, Table D-25. In 1999, trichloroethene and tetrachloroethene were observed at concentrations greater than the drinking water MCL.

Capture Pits. A number of groundwater collection devices, or "capture pits," are used on the Main Hill to isolate and monitor contamination in perched groundwater. These devices have been designed to collect pockets of shallow groundwater which may have been contaminated as a result of past operational practices. In 1999, samples were collected from the capture pits and analyzed for tritium. The results are shown in Appendix D, Table D-26. The sampling locations are shown on Figure 6-6.

Monitoring in previous years has indicated that the VOC contamination exists in the capture pits. The results are shown in Appendix D, Table D-27. In 1999, trichloroethene was the only compound to exceed the MCL value.

Figure 6-6. Seep and Capture Pit Locations



6.8 Five-Year Trends for Wells of Interest

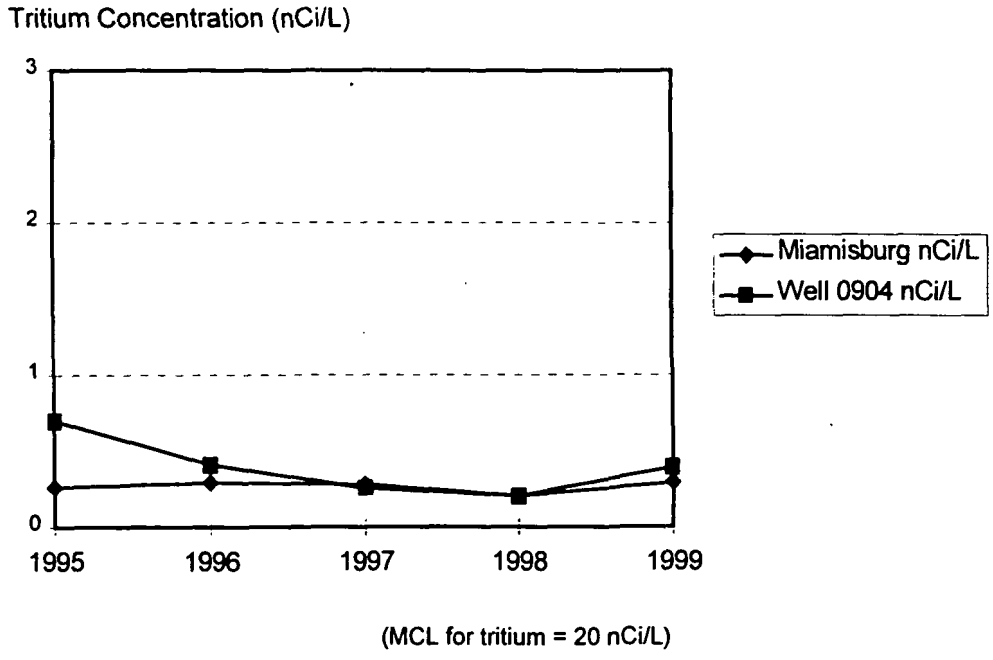
As seen in the preceding sections of this Chapter, a large volume of groundwater monitoring data is generated each year. It is important that the data be reviewed for evidence of long-term trends, especially in cases where there is some history of elevated concentrations of contaminants. In this section, five-year trends are presented for certain indicator parameters measured in wells of interest.

Trend Data for Offsite Drinking Water

A primary consideration of the MEMP environmental monitoring program is to ensure that area drinking water supplies are not adversely affected by activities at the site. The most mobile of the constituents released to groundwater is tritium. For this reason, tritium is an excellent indicator of offsite migration. Two drinking water sources can be considered key receptor wells. First, the drinking water supply of the City of Miamisburg is of interest due to the proximity of the City's well fields. And second, Well 0904, a private well, is useful as an indicator because it reflects potential impact to small drinking water systems.

Five-year trends for tritium concentrations in the two wells described above are shown in Figure 6-7. As seen in the figure, tritium levels in the wells have exhibited little change over the past five years. All of the values are significantly below the MCL for tritium of 20 nCi/L.

Figure 6-7. Annual Average Tritium Concentrations in Offsite Drinking Water, 1995 - 1999



Trend Data for Onsite Production Wells and Seeps

As previously described in this chapter, tritium and certain VOCs have been observed in groundwater underlying the site. The seven halogenated solvents typically present in trace concentrations are carbon tetrachloride, chloroform, cis-1,2-dichloroethene, freon, tetrachloroethene, trichloroethene, and 1,1,1-trichloroethane. Trichloroethene has been the most prevalent contaminant and, therefore, serves as an "indicator" VOC.

An appropriate onsite indicator well is Production Well 0076 (also referred to as Well 3) because it serves as the primary source of drinking water for the site. Other important monitoring points for the evaluation of groundwater conditions are the seeps. Data suggest that Seep 0601 is an appropriate location for the observation of long-term trends.

Five-year trend data for Production Well 0076 are shown in Figures 6-8 and 6-9 for tritium and trichloroethene, respectively. Similarly, Figures 6-10 and 6-11 present five-year trend data for tritium and trichloroethene at Seep 0601.

Figure 6-8 indicates that tritium levels in Well 0076 have consistently averaged near 1 nCi/L. This value is well below the applicable MCL (20 nCi/L). Trace concentrations of trichloroethene have also been observed in Well 0076 (Figure 6-9). However, measured concentrations have steadily decreased and remained well below the applicable MCL (5 μg/L).

Figure 6-10 presents tritium concentration data for Seep 0601. Data for the period 1994-1998 show the yearly average for tritium concentrations ranging from approximately 75 nCi/L to 115 nCi/L. Although the average concentrations have varied over the five-year period shown, tritium values have been consistently near or below the 100 nCi/L level the last four years. Seep 0601 is also characterized by elevated levels of trichloroethene. Additionally, though not shown in the figure, tetrachloroethene has also emerged as a contributor to VOC contamination in this seep.

The risks associated with contamination in the seeps will be evaluated under CERCLA and appropriate remediation actions taken if indicated.

Figure 6-8. Annual Average Tritium Concentration in Production Well 0076, 1995 - 1999

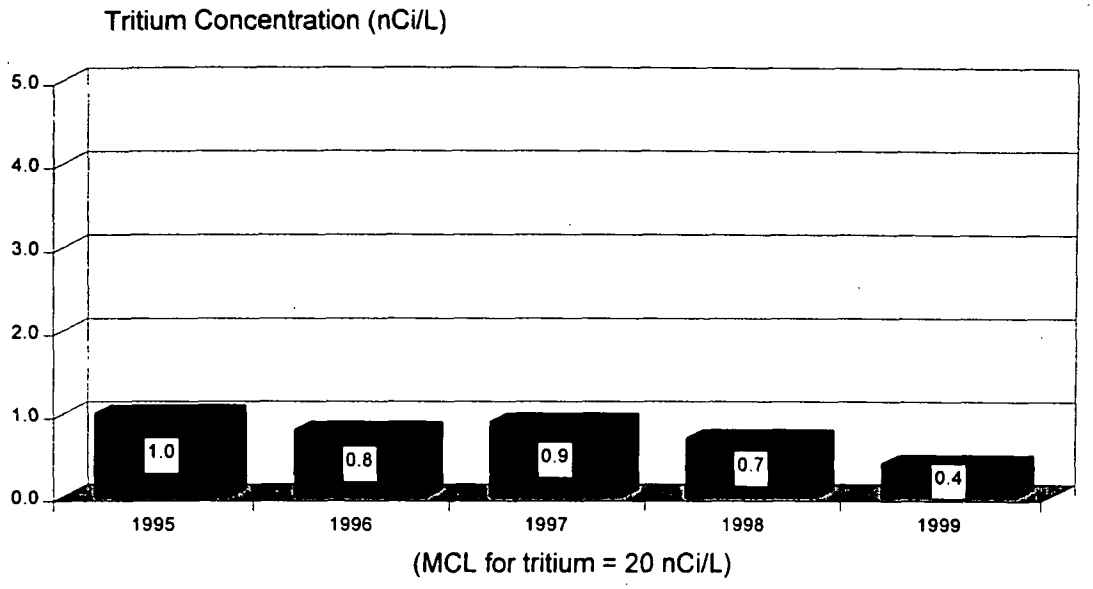


Figure 6-9. Annual Average Indicator VOC Concentration in Production Well 0076, 1995 - 1999

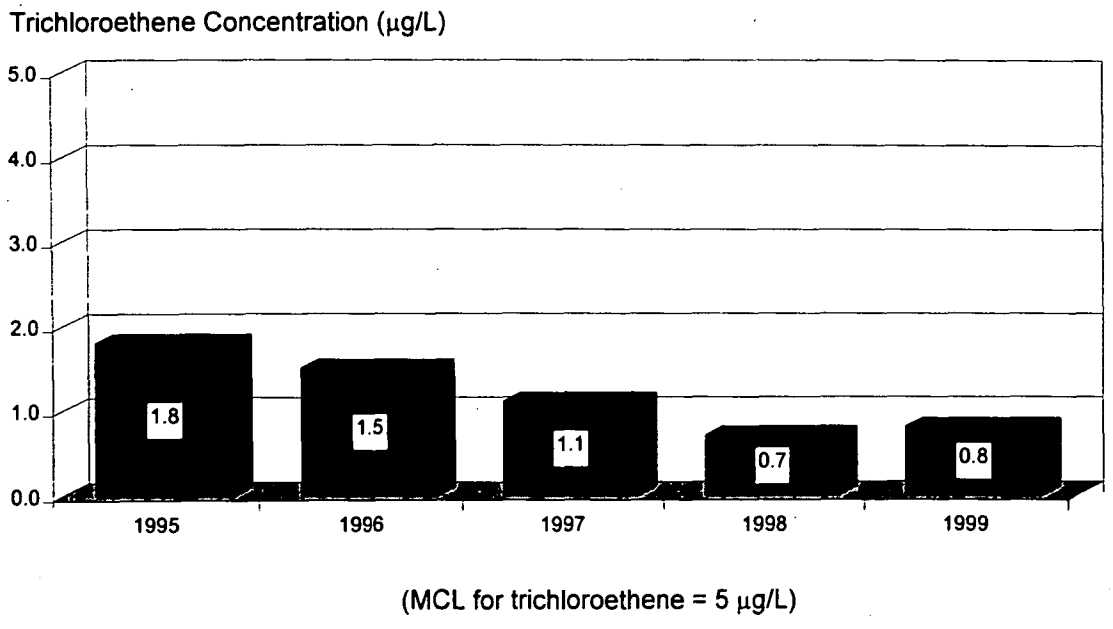


Figure 6-10. Annual Average Tritium Concentration for Seep 0601, 1995 - 1999

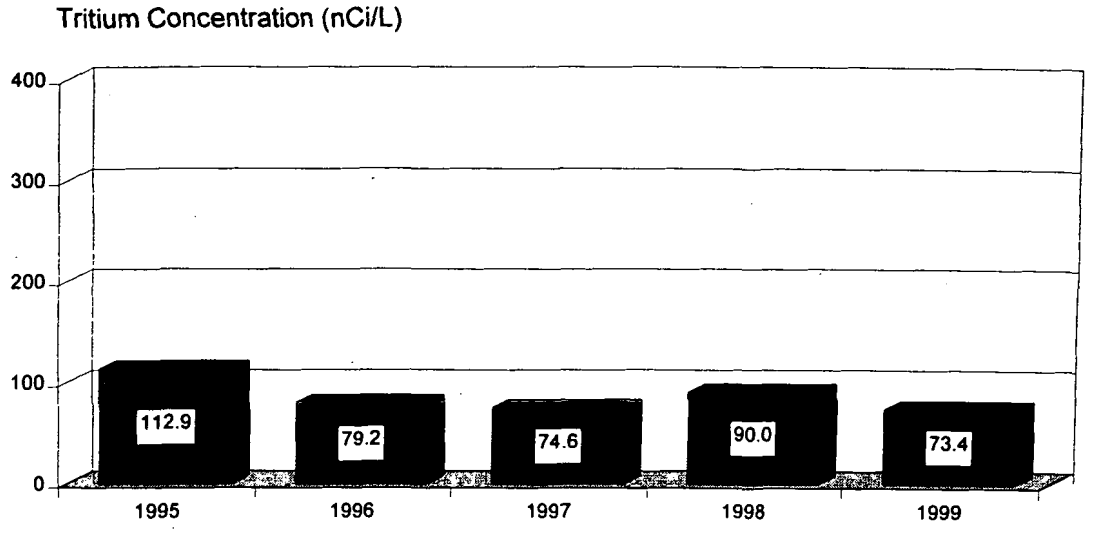
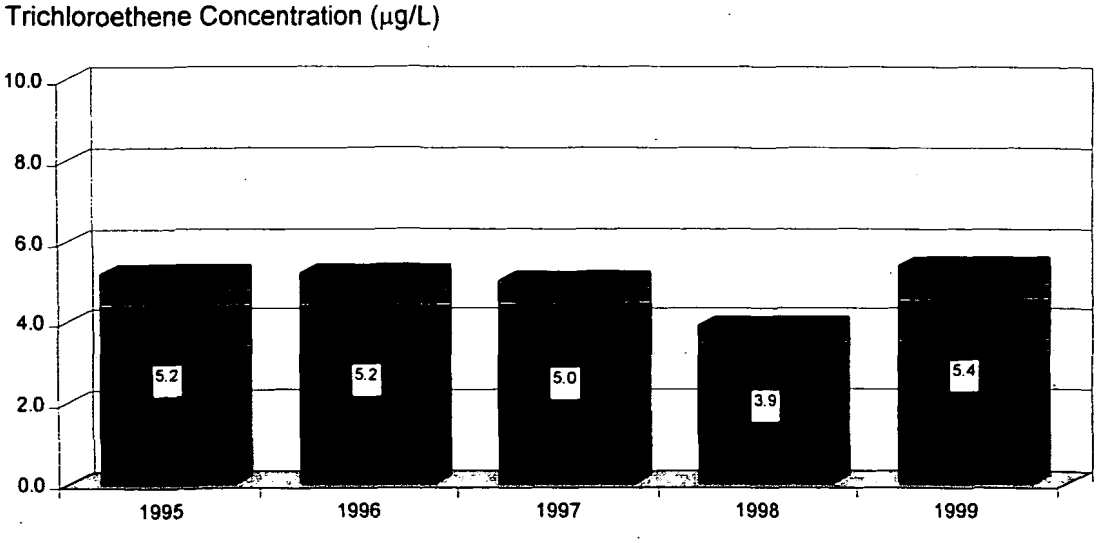


Figure 6-11. Annual Average Indicator VOC Concentration for Seep 0601, 1995 - 1999



CHAPTER 7

7.0 QUALITY ASSURANCE PROGRAMS FOR ENVIRONMENTAL DATA

MEMP participates in quality assurance (QA) exercises sponsored and/or recognized by the DOE. Such exercises provide objective evaluations of the validity of the environmental data generated by MEMP. In this Chapter, QA programs involving radiological and nonradiological analyses of a variety of environmental media are described. In addition to these external QA programs, MEMP performs internal QA studies that make use of reagent blanks, internal standards, and replicate samples.

Internal QA Program

MEMP employs a quality-based approach to environmental data. Such an approach is imperative because many sample results are at or below the lower detection limit. QA samples, including blanks, standards, and replicates, are routinely analyzed to evaluate analytical bias and precision. Blank samples are analyzed to verify the absence of excessive instrument contamination or background levels. The standard deviation of the blanks is used to calculate the lower limit of detection. Standards and replicates are used to evaluate analytical bias and precision, respectively. QA parameters are closely monitored and tracked. Deviations from expected values result in a review of analytical protocol.

External QA Activities

DOE EML Quality Assessment Program. Twice each year MEMP participates in DOE's Office of Environmental Management, Quality Assessment Program conducted by Environmental Measurements Laboratory (EML). EML supplies samples containing specific quantities of radionuclides to each participating lab for radiological analysis. The radionuclides are present as contaminants on air filters, soil, vegetation, or water. The radionuclide activity present in the sample is not disclosed to the participating laboratory. A laboratory's performance is evaluated by comparing their results with the EML reference values.

In the 1999 EML Performance Evaluation, four environmental media were analyzed. The results reported by MEMP are shown in Table 7-1. EML reference values are also shown. A useful method of evaluating MEMP's performance is to examine the ratio of MEMP's result to the EML reference concentration for each environmental medium. This is shown graphically in Figure 7-1. MEMP's results compared favorably with DOE (EML) reference values with an overall average ratio of 0.99.

DOE MAPEP Quality Assessment Program. In 1999, MEMP also participated in the DOE Radiological and Environmental Sciences Laboratory Mixed Analyte Performance Evaluation Program (MAPEP). The primary objective of the MAPEP is to foster reliability and credibility for the analytical results used in the decision making process, particularly as it relates to the environment and public health and safety. Participation in MAPEP requires analysis of samples (one water and one soil sample each year) that contain known concentrations of plutonium and uranium isotopes. The results reported by MEMP in 1999 and the corresponding MAPEP reference values are shown in Table 7-2. The figure-of-merit used to evaluate a laboratory is the bias, or the difference between the MAPEP reference value and MEMP result for each analysis, expressed as a percent. MAPEP has established "acceptable," "warning," and "not acceptable" limits of acceptability for these studies. These limits have been set at 20 percent and 30 percent bias, respectively. In 1999, MEMP results in all categories, but one, were within acceptability limits. The results for each environmental medium are shown graphically in Figure 7-2.

NPDES QA Program

National Pollutant Discharge Elimination System (NPDES) permits are used by the EPA to regulate discharges of water effluents. The permits limit the concentrations of certain wastewater constituents to protect the receiving body of water. To ensure that effluent limits are not exceeded, NPDES permits impose strict requirements for effluent characterization. EPA has required that laboratories performing analyses for NPDES parameters participate in QA exercises. These exercises ensure EPA that the laboratories are producing reliable and accurate data.

Discharge Monitoring Report (DMR) Quality Assessment Program. In 1999, the USEPA suspended the NPDES DMR QA exercise due to privatization of the program. The USEPA plans to reinstitute the exercise in 2000.

Table 7-1. DOE EML Quality Assessment Program Results for 1999: Radionuclides in Environmental Samples

Sample Type [a]	Date	Radionuclide	MEMP Result	EML [b] Reference	Ratio [c] MEMP/EML
Air filters, Bq/filter	March	Pu-238	0.27	0.27	0.99
		Pu-239	0.12	0.12	0.97
		U-234	0.06	0.06	1.00
		U-238	0.07	0.06	1.14
	September	Pu-238	0.09	0.10	0.96
		Pu-239	0.13	0.14	0.96
		U-234	0.07	0.07	1.00
		U-238	0.06	0.06	0.98
Vegetation, Bq/kg	March	Pu-239	5.96	5.20	1.15
	September	Pu-239	4.13	4.30	0.96
Soil, Bq/kg	March	Pu-239	7.12	8.11	0.88
		U-234	136.01	140.67	0.97
		U-238	142.55	145.00	0.98
	September	Pu-239	2.67	3.20	0.83
		U-234	188.67	190.00	0.99
		U-238	198.93	202.00	0.99
Water, Bq/L	March	Tritium	122.5	121.08	1.01
		Pu-238	0.84	0.77	1.09
		Pu-239	1.03	1.01	1.02
		U-234	0.27	0.27	1.01
		U-238	0.25	0.26	0.96
	September	Tritium	77.79	80.70	0.96
		Pu-238	0.74	0.79	0.94
		Pu-239	0.83	0.87	0.95
		U-234	0.38	0.37	1.03
		U-238	0.37	0.36	1.03

[a] 1 Bq = 2.7×10^{-11} Ci
[b] DOE Environmental Measurements Laboratory (EML)
[c] Data have been rounded.

Figure 7-1. MEMP Performance in the DOE EML Quality Assessment Program in 1999

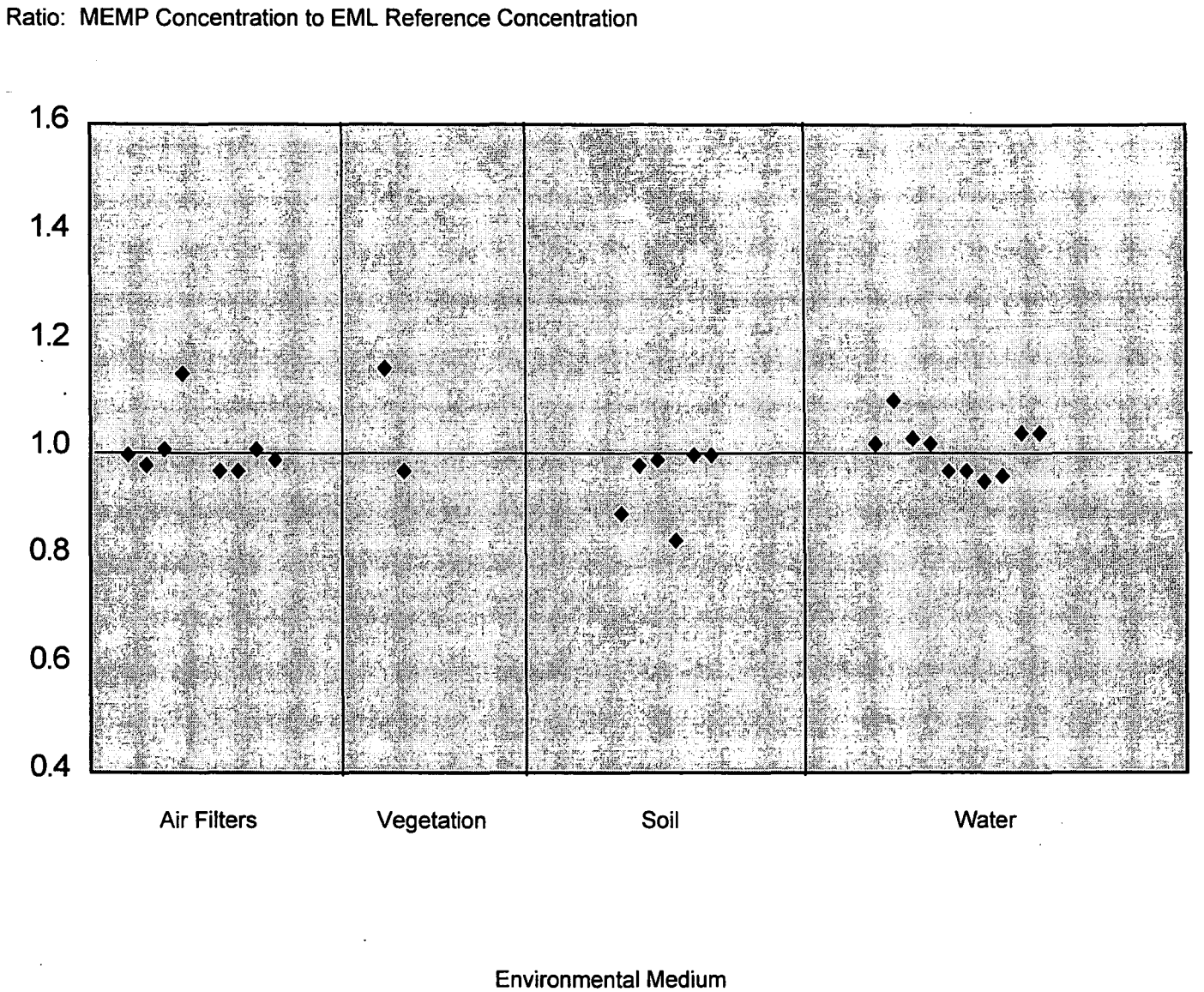
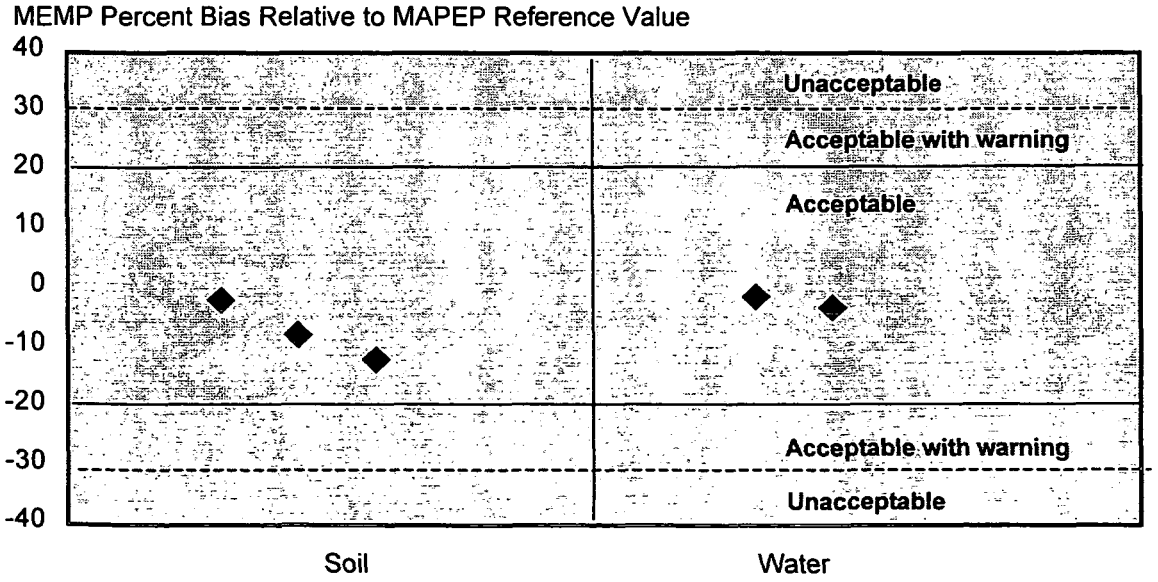


Table 7-2. DOE MAPEP Quality Assessment Results for 1999: Radionuclides in Environmental Samples

Sample Type [a]	Radionuclide	MEMP Result	MAPEP[b, c] Reference Concentration	Bias (percent)
Soil (Bq/kg)	Pu-238	49.64	50.60	-1.90
	Pu-239/240	0.064	0.00	--
	U-233,234	45.259	51.40	-11.95
	U-238	110.648	120.00	-7.79
Water (Bq/L)	Pu-238	1.43	1.45	-1.38
	Pu-239,240	3.91	4.04	-3.22

[a] 1 Bq = 2.7 x 10^{-11} Ci
[b] DOE Mixed Analyte Performance Evaluation Program.
[c] The bias for the Pu-239/240 result is not included due to a zero reference concentration. The MEMP result for this value was "Not Acceptable."

Figure 7-2. MEMP Performance in the MAPEP Quality Assessment Program in 1999



CHAPTER 8

8.0 REFERENCES

DOE, 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance,* DOE/EH-0173T, U. S. Department of Energy, Washington, D. C.

DOE, 1993a. *Radiation Protection of the Public and the Environment,* DOE Order 5400.5, U. S. Department of Energy, Washington, D. C.

DOE, 1993b. OU-9 *Residential Well/Cistern Survey Task Summary,* Mound Plant, Miamisburg, OH.

DOE, 1997. *Groundwater Monitoring Program and Groundwater Protection Management Program Plan,* Mound Plant, Miamisburg, OH.

EG&G, 1991. *Hydrogeologic/Groundwater Contamination, Operable Unit 1, Area B Technical Memorandum,* Mound Plant, Miamisburg, OH.

EG&G, 1997. *Mound Plant Environmental Monitoring Plan,* Mound Plant, Miamisburg, OH.

EPA, 1985. AP-42: *Compilation of Air Pollutant Emission Factors,* 4th ed., U. S. Environmental Protection Agency, Research Triangle Park, NC.

ICRP, 1977. *Recommendations of the International Commission on Radiological Protection,* ICRP Publication No. 26.

ICRP, 1979. *Limits for Intakes by Workers,* ICRP Publication No. 30.

NCRP, 1987. *Ionizing Radiation Exposure of the Population of the U. S.,* NCRP Report No. 93, Bethesda, MD.

10 CFR 1021. *Compliance with the National Environmental Policy Act.*

40 CFR 61, Subpart H. *National Emission Standards for Emissions of Radionuclides Other than Radon From Department of Energy Facilities.*

40 CFR 122. *The National Pollutant Discharge Elimination System.*

40 CFR 136. *Guidelines Establishing Test Procedures for the Analysis of Pollutants.*

40 CFR 141-143. *National Primary Drinking Water Regulations Implementation and National Secondary Drinking Water Regulations.*

40 CFR 300. *Oil and Hazardous Substances Pollution Contingency Plan.*

40 CFR 302. *Designation, Reportable Quantities, and Notification.*

50 CFR 17. *Endangered and Threatened Wildlife and Plants.*

50 CFR 222. *Endangered Fish or Wildlife.*

OAC 3745-15. *General Provisions on Air Pollution Control.*

OAC 3745-17. *Particulate Matter Standards.*

OAC 3750-30. *Hazardous Chemical Reporting.*

OAC 3745-31. *Permits to Install New Sources of Pollution.*

OAC 3745-33. *Ohio National Pollutant Discharge Elimination System Program.*

OAC 3745-35. *Air Permits to Install and Variances.*

OAC 3745-77. *Title V Permits.*

OAC 3745-81. *Primary Drinking Water Rules.*

OAC 3745-82. *Secondary Maximum Contaminant Levels.*

OAC-3745-83. *Operational Requirements.*

OAC 3745-84. *Public Water System Licenses.*

OAC 3745-100. *Toxic Chemical Release Reporting.*

APPENDIX A

APPENDIX A

RADIOLOGICAL RELEASE RESULTS

Effluent monitoring focuses on releases from the site, i.e., stack and liquid (wastewater) discharges. Tables summarizing monitoring results from 1999 are presented in this Appendix. The tables show the average concentration and a comparison to a DOE standard. It should be noted that DOE Derived Concentration Guide (DCG) values are not directly applicable to airborne (stack) releases as it is not credible for a receptor to be present at the point of release. For such releases, DCG values are provided for comparative purposes.

Table A-1. Radiological Effluent Data for 1999

Radionuclide	Released to	Activity, Ci	MEMP Range[b], Ci
Tritium	Air	8.04×10^{2} [a]	$7.36 \times 10^{2} - 8.04 \times 10^{2}$
	Water	2.4	2.2 – 2.5
Plutonium-238	Air	1.1×10^{-5}	$6.9 \times 10^{-6} - 4.5 \times 10^{-5}$
	Water	2.3×10^{-4}	$2.3 \times 10^{-4} - 4.8 \times 10^{-4}$
Plutonium-239,240	Air	3.0×10^{-8}	$2 \times 10^{-8} - 1 \times 10^{-7}$
	Water	3.6×10^{-6}	$1.7 \times 10^{-6} - 7.7 \times 10^{-6}$
Radon-222	Air	1.01	0.55 – 2.4
Uranium-233,234	Air	8.0×10^{-9}	$3 \times 10^{-9} - 9.2 \times 10^{-8}$
	Water	3.8×10^{-4}	$3.5 \times 10^{-4} - 3.9 \times 10^{-4}$
Uranium-238	Air	7.0×10^{-9}	$1.7 \times 10^{-9} - 7 \times 10^{-9}$

[a] Tritium released to air consists of: Tritium oxide, 6.65×10^{2} Ci
Elemental tritium, 1.39×10^{2} Ci

[b] A range of annual release values from MEMP, 1995-1999.

Table A-2. Average Annual Concentration of Radionuclide Air Emissions in 1999

Stack*	Radionuclide	Average Concentration (μCi/mL)	Average as a Percent of DOE DCG[a]
HH	Tritium	3.26×10^{-8}	32.6
NCDPF	Tritium	1.13×10^{-7}	112.9
SM/PP	Pu-238	2.24×10^{-14}	74.6
	Pu-239,240	4.73×10^{-17}	0.2
	U-233,234	3.26×10^{-18}	0.004
	U-238	1.59×10^{-18}	0.002
SW-1CN	Tritium	3.28×10^{-08}	32.8
	Pu-238	1.28×10^{-17}	0.043
	Pu-239	1.29×10^{-18}	0.006
	U-233,234	1.96×10^{-18}	0.002
	U-238	2.96×10^{-18}	0.002
T-West	Tritium	1.07×10^{-07}	107.4
	Pu-238	3.15×10^{-16}	1.05
	Pu-239	5.14×10^{-18}	0.026
	U-233,234	2.17×10^{-18}	0.002
	U-238	1.75×10^{-18}	0.002
T-East	Tritium	1.35×10^{-10}	0.1
HEFS	Tritium	6.03×10^{-7}	603.2
	Pu-238	5.72×10^{-18}	0.019
	Pu-239,240	1.08×10^{-18}	0.005
	U-233,234	1.73×10^{-18}	0.002
	U-238	1.26×10^{-19}	0.001
WDA	Tritium	1.93×10^{-9}	1.9
	Pu-238	2.26×10^{-16}	0.75
	Pu-239,240	1.27×10^{-18}	0.006
	U-233,234	6.10×10^{-19}	0.001
	U-238	3.06×10^{-18}	0.003
WDSS	Pu-238	1.06×10^{-16}	0.36
	Pu-239,240	2.45×10^{-18}	0.012
Building 22	Tritium	2.09×10^{-8}	20.9
Building 23	Tritium	1.40×10^{-7}	139.9
CWPF	Tritium	7.0×10^{-11}	0.07
	Pu-238	1.6×10^{-17}	0.05
	Pu-239,240	1.3×10^{-18}	0.007
	U-233,234	2.8×10^{-18}	0.003
	U-238	7.0×10^{-18}	0.007

[a] DOE DCG values in air:
Tritium = 1.0×10^{-7} μCi/mL.
Pu-238 = 3.0×10^{-14} μCi/mL.
Pu-239 = 2.0×10^{-14} μCi/mL
Pu-234 = 9.0×10^{-14} μCi/mL
U-238 = 1.0×10^{-13} μCi/mL

* Sampling locations shown on Figure 4-1.

Table A-3. Average Annual Concentration of Radionuclides in Water Effluents in 1999

Outfall*	Radionuclide	Average Concentration (µCi/mL)	Average as a Percent of DOE DCG[a]
602	Tritium	3.02×10^{-6}	0.15
	Pu-238	8.53×10^{-11}	0.21
	Pu-239	2.71×10^{-12}	0.009
	U-233,234	3.21×10^{-10}	0.06
	Th-228	5.5×10^{-11}	0.01
	Th-230	8.6×10^{-12}	0.003
	Th-232	5.0×10^{-14}	0.0001
002	Tritium	2.14×10^{-6}	0.11
	Pu-238	4.82×10^{-10}	1.21
	Pu-239	4.45×10^{-12}	0.015
	U-233,234	5.15×10^{-10}	0.1
	Th-228	5.3×10^{-11}	0.01
	Th-230	2.6×10^{-11}	0.009
	Th-232	3.67×10^{-12}	0.007
601	Tritium	5.08×10^{-6}	0.25
	Pu-238	3.6×10^{-11}	0.09
	Pu-239	5.39×10^{-12}	0.018
	U-233,234	3.32×10^{-10}	0.07
	Th-228	1.3×10^{-11}	0.003
	Th-230	6.0×10^{-13}	0.0002
	Th-232	ND	ND
003	Tritium	2.05×10^{-6}	0.1
	Pu-238	3.57×10^{-12}	0.01
	Pu-239,240	3.57×10^{-12}	0.01
	U-233,234	3.62×10^{-10}	0.07
	Th-228	6.53×10^{-11}	0.016
	Th-230	1.53×10^{-11}	0.005
	Th-232	ND	ND

[a] DOE DCG values in water:
Tritium = 2×10^{-3} µCi/mL
Pu-238 = 4×10^{-8} µCi/mL
Pu-239,240 = 3×10^{-8} µCi/mL
U-233,234 = 5×10^{-7} µCi/mL
Th-228 = 4×10^{-7} µCi/mL
Th-230 = 3×10^{-7} µCi/mL
Th-232 = 5×10^{-8} µCi/mL

ND = average results not detected above reagent blanks.

* Sampling locations shown on Figure 4-1.

APPENDIX B

APPENDIX B

ENVIRONMENTAL SURVEILLANCE PROGRAM RESULTS

The environmental surveillance program focuses on environmental conditions in the area surrounding the site and in local communities. Tables summarizing monitoring results from 1999 are presented in this Appendix. In a number of the tables, results are presented as "incremental concentrations." The designation indicates that an average background concentration, or "environmental" concentration, has been subtracted from those values. Therefore, incremental concentrations represent estimates of MEMP's contribution to the radionuclide content of an environmental sample. Environmental concentrations are shown in Table B-1. Environmental sampling results are organized into tables showing:

- number of samples analyzed during the year,
- minimum concentration measured,
- maximum concentration measured,
- average value with error limits, and, when appropriate,
- a comparison to a DOE or EPA standard.

Table B-1. Environmental Concentrations of Radionuclides in Sample Media in 1999

Radionuclide	Number of Samples	Average Concentration[a]	Unit of Measure
Ambient air[b]			
Tritium oxide	50	4.02 ± 2.18	10^{-12} µCi/mL
Plutonium-238	4	6.6 ± 13.89	10^{-18} µCi/mL
Plutonium-239,240	4	0.64 ± 0.83	10^{-18} µCi/mL
Thorium-238	4	5.46 ± 3.18	10^{-18} µCi/mL
Thorium-230	4	6.44 ± 4.91	10^{-18} µCi/mL
Thorium-232	4	4.78 ± 3.57	10^{-18} µCi/mL
River water[c]			
Tritium	11	ND	10^{-6} µCi/mL
Plutonium-238	11	0.05 ± 2.96	10^{-12} µCi/mL
Plutonium-239,240	11	ND	10^{-12} µCi/mL
Uranium-233,234	11	0.71 ± 0.14	10^{-9} µCi/mL
Uranium-238	11	0.64 ± 0.14	10^{-9} µCi/mL
Thorium-228	4	42.33 ± 106.42	10^{-12} µCi/mL
Thorium-230	4	21.78 ± 38.19	10^{-12} µCi/mL
Thorium-232	4	3.6 ± 26.72	10^{-12} µCi/mL
Pond water[d]			
Tritium	1	ND	10^{-6} µCi/mL
Plutonium-238	1	0.06 ± 0.009	10^{-9} µCi/mL
Plutonium-239,240	1	ND	10^{-9} µCi/mL
Thorium-228	1	0.001 ± 0.01	10^{-9} µCi/mL
Thorium-230	1	ND	10^{-9} µCi/mL
Thorium-232	1	0.003 ± 0.002	10^{-9} µCi/mL
Sediment			
Plutonium-238 in river sediment[c]	3	1.86 ± 1.42	10^{-9} µCi/g
Plutonium-238 in pond sediment[d]	1	1.8 ± 0.51	10^{-9} µCi/g
Plutonium-239,240 in river sediment[c]	3	2.32 ± 4.69	10^{-9} µCi/g
Plutonium-239,240 in pond sediment[d]	1	2.3 ± 0.57	10^{-9} µCi/g
Thorium-228 in river sediment[c]	3	359.67 ± 229.12	10^{-9} µCi/g
Thorium-230 in river sediment[c]	3	733.33 ± 528.65	10^{-9} µCi/g
Thorium-232 in river sediment[c]	3	381.33 ± 305.25	10^{-9} µCi/g
Foodstuffs[e]			
Tritium in vegetation	1	0.76 ± 0.01	10^{-6} µCi/g
Plutonium-238 in vegetation	2	0.03 ± 0.01	10^{-9} µCi/g
Plutonium-239,240 in vegetation	2	0.03 ± 0.03	10^{-9} µCi/g

[a] Error limits are estimates of the standard error or estimated error at the 95% confidence level.
[b] Measured 28 mi (45 km) northwest of MEMP.
[c] Measured 25 mi (40 km) upstream of MEMP on the Great Miami River.
[d] Measured 25 mi (40 km) northwest of MEMP.
[e] Measured 30 mi (48 km) north of MEMP.
ND indicates that concentration was not detectable above the average reagent blanks..

Table B-2. Incremental Concentrations[a] of Tritium Oxide in Air in 1999

Location*	Number of Samples	Tritium Oxide 10^{-12} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[d]
Offsite					
101	50	e	26.12	4.10 ± 3.38	0.004
102	48	e	44.26	7.46 ± 4.07	0.007
103	49	e	72.32	3.98 ± 4.53	0.004
104	50	e	35.52	3.21 ± 3.34	0.003
105	50	e	27.73	2.61 ± 3.51	0.003
111	47	e	21.86	0.42 ± 3.13	0.0004
112	48	e	25.74	3.45 ± 3.42	0.003
115	49	e	20.43	e	e
118	44	e	28.55	1.07 ± 3.4	0.001
124	49	e	51.5	7.73 ± 4.38	0.008
CLN	50	e	22.78	3.05 ± 3.15	0.003
Onsite					
211	51	e	38.75	10.67 ± 3.7	0.01
212	36	e	98.41	19.86 ± 7.38	0.02
213	50	e	56.6	9.91 ± 4.26	0.01
214	51	e	34.47	8.12 ± 3.5	0.008
215	48	e	33.21	8.8 ± 3.77	0.009
216	49	e	29.82	7.01 ± 3.59	0.007
217	51	e	61.29	5.95 ± 4.1	0.006
218	51	e	41.63	5.12 ± 3.82	0.005

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for tritium offsite in air is 47 x 10^{-12} µCi/mL. The LDL for tritium in onsite air is 31 x 10^{-12} µCi/mL. The LDL for sample 211 is 35 x 10^{-12} µCi/mL. These differences are due to different calculational methods and propagation of standard deviations due to the number of bubblers in series.

[d] DOE DCG for tritium oxide in air is 100,000 x 10^{-12} µCi/mL.

[e] Below environmental level.

* Onsite sampling locations shown on Figure 4-4. Offsite sampling locations shown on Figure 4-5.

Table B-3. Incremental Concentrations[a] of Plutonium-238 in Air in 1999

Location*	Number of Samples	Plutonium-238 10^{-18} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[d]
Offsite					
101	4	e	2.41	e	e
102	4	e	10.52	2.83 ± 18.54	0.009
103	4	e	8.34	0.02 ± 17.65	0.00007
104	12	e	e	e	e
105	4	e	10.34	e	e
111	4	e	10.34	e	e
112	3	e	3.47	e	e
115	4	e	12.91	0.37 ± 20.21	0.001
118	4	e	9.11	e	e
124	12	e	e	e	e
CLN	11	e	e	e	e
Onsite					
211	12	e	0.3	e	e
212	8	e	e	e	e
213	12	e	9.48	1.3 ± 14.1	0.004
214	12	e	5.53	e	e
215	12	e	0.79	e	e
215T	12	e	2.66	e	e
216	12	e	12.08	e	e
217	10	e	e	e	e
218	12	e	37.92	1.56 ± 15.93	0.005

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for monthly values is 0.7 x 10^{-18} µCi/mL, for quarterly values the LDL is 0.1 x 10^{-18} µCi/mL.

[d] DOE DCG for plutonium-238 in air is 30,000 x 10^{-18} µCi/mL.

[e] Below environmental level.

T = Supplemental sampling height (2m).

* Offsite sampling locations shown on Figure 4-4. Onsite sampling locations shown on Figure 4-5.

Table B-4. Incremental Concentrations[a] of Plutonium-239,240 in Air in 1999

Location*	Number of Samples	Plutonium-239,240 10^{-18} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[d]
Offsite					
101	4	e	0.02	e	e
102	4	e	0.32	e	e
103	4	e	e	e	e
104	12	e	0.8	0.01 ± 0.9	0.00005
105	4	e	e	e	e
111	4	e	e	e	e
112	3	e	e	e	e
115	4	e	e	e	e
118	4	e	0.91	0.01 ± 1.27	0.00005
124	12	e	0.91	e	e
CLN	12	e	1.54	e	e
Onsite					
211	12	e	3.09	0.13 ± 1.04	0.0007
212	8	e	0.32	e	e
213	12	e	1.52	0.24 ± 0.9	0.001
214	12	e	0.78	e	e
215	12	e	0.93	e	e
215T	12	e	1.17	e	e
216	12	e	0.68	0.08 ± 0.87	0.0004
217	10	e	0.92	e	e
218	12	e	1.16	0.16 ± 0.89	0.0008

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for monthly values is 0.6 x 10^{-18} µCi/mL, for quarterly values the LDL is 0.1 x 10^{-18} µCi/mL.

[d] DOE DCG for plutonium-239,240 in air is 20,000 x 10^{-18} µCi/mL.

[e] Below environmental level.

T = Supplemental sampling height (2m).

* Onsite sampling locations shown on Figure 4-4. Offsite sampling locations shown on Figure 4-5.

Table B-5. Incremental Concentrations[a] of Thorium-228, Thorium-230, and Thorium-232 in Air in 1999

Location*	Number of Samples	Thorium-228 10^{-18} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[f]
Offsite					
124	12	g	12.7	3.77 ± 4.23	0.009
Onsite					
213	12	g	14.78	5.55 ± 4.77	0.01
215T	12	g	10.64	4.02 ± 4.09	0.01
216	12	g	18.52	5.18 ± 5.41	0.01
218	12	g	19.56	3.02 ± 4.83	0.008

Location*	Number of Samples	Thorium-230 10^{-18} µCi/mL Minimum	Maximum	Average[b,d]	Average as a percent of DOE DCG[f]
Offsite					
124	12	g	13.72	3.22 ± 5.91	0.008
Onsite					
213	12	g	21.88	5.79 ± 6.47	0.01
215T	12	g	13.37	3.82 ± 5.6	0.01
216	12	g	23.17	5.0 ± 7.31	0.01
218	12	g	17.7	1.98 ± 6.05	0.005

Location*	Number of Samples	Thorium-232 10^{-18} µCi/mL Minimum	Maximum	Average[b,e]	Average as a percent of DOE DCG[f]
Offsite					
124	12	g	7.07	2.24 ± 3.99	0.03
Onsite					
213	12	g	13.25	4.62 ± 4.77	0.07
215T	12	g	28.99	4.96 ± 6.3	0.07
216	12	g	17.4	4.22 ± 5.43	0.06
218	12	g	20.77	2.0 ± 5.34	0.03

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for Th-228 for monthly values is 0.6 x 10^{-18} µCi/mL, for quarterly values the LDL is 0.3 x 10^{-18} µCi/mL.

[d] LDL for Th-230 for monthly values is 1.1 x 10^{-18} µCi/mL, for quarterly values the LDL is 0.2 x 10^{-18} µCi/mL.

[e] LDL for Th-232 for monthly values is 0.5 x 10^{-18} µCi/mL, for quarterly values the LDL is 0.2 x 10^{-18} µCi/mL.

[f] DOE DCG for thorium-228 and thorium-230 in air is 40,000 x 10^{-18} µCi/mL. The DOE DGC for thorium-232 in air is 7,000 x 10^{-18} µCi/mL.

[g] Below environmental level.

T = Supplemental sampling height (2m).

* Offsite sampling locations shown on Figure 4-4. Onsite sampling locations shown on Figure 4-5.

Table B-6. Concentrations[a] of Tritium in the Great Miami River and Stream in 1999

Location*	Number of Samples	Tritium 10^{-6} µCi/mL Minimum	Maximum	Average[b,c]	Average as a Percent of DOE DCG[d]
2	11	e	0.12	0.004 ± 0.05	0.006
4	11	e	0.11	e	e
5	11	e	0.05	e	e
7	11	e	1.91	0.40 ± 0.40	0.02
8	11	e	0.88	0.08 ± 0.18	0.004
Mound Ave Storm	11	0.05	0.52	0.25 ± 0.10	0.01

[a] Average environmental level below reagent blanks.
[b] Error limits are estimates of the standard error of the estimated mean at the 95 % confidence level.
[c] LDL for tritium in water is 0.35 x 10^{-6} µCi/mL.
[d] DOE DCG for tritium in water is 2,000 x 10^{-6} µCi/mL.
[e] Below reagent blanks.
* Sampling locations shown on Figure 4-7.

Table B-7. Incremental Concentrations[a] of Plutonium-238 in the Great Miami River in 1999

Location*	Number of Samples	Plutonium-238 10^{-12} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[d]
2	11	e	7.15	1.23 ± 3.81	0.003
4	11	e	16.95	6.14 ± 5.0	0.02
5	11	e	9.95	1.55 ± 4.47	0.004
7	11	e	35.55	8.97 ± 8.35	0.02
8	11	e	177.55	18.11 ± 35.74	0.05

[a] Average environmental level shown in Table B-1 subtracted from the data.
[b] Error limits are estimates of the standard error of the estimated mean at the 95 % confidence level.
[c] LDL for plutonium-238 in river water (including suspended sediment) is 23.2 x 10^{-12} µCi/mL.
[d] DOE DCG for plutonium-238 in water is 40,000 x 10^{-12} µCi/mL.
[e] Below reagent blanks.
* Sampling locations shown on Figure 4-7.

Table B-8. Concentrations[a] of Plutonium-239,240 in the Great Miami River in 1999

Location*	Number of Samples	Plutonium-239,240 10^{-12} µCi/mL			Average as a percent of DOE DCG[d]
		Minimum	Maximum	Average[b,c]	
2	11	e	11.8	1.91 ± 3.25	0.006
4	11	e	6.6	e	e
5	11	e	5.0	e	e
7	11	e	6.9	0.79 ± 2.75	0.003
8	11	e	7.2	1.68 ± 2.22	0.006

[a] Average environmental level below reagent blanks.

[b] Error limits are estimates of the standard error of the estimated mean at the 95 % confidence level.

[c] LDL for plutonium-239,240 in river water (including suspended sediment) is 17.7 x 10^{-12} µCi/mL.

[d] DOE DCG for plutonium-239,240 in water is 30,000 x 10^{-12} µCi/mL.

[e] Below reagent blanks.

* Sampling locations shown on Figure 4-7.

Table B-9. Incremental Concentrations[a] of Uranium-233,234 and Uranium-238 in the Great Miami River in 1999

Location*	Number of Samples	Uranium-233,234 10^{-9} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[d]
2	11	e	0.19	e	e
4	11	e	0.12	e	e
5	11	e	0.1	e	e
7	11	e	0.07	e	e
8	11	e	0.09	e	e

Location*	Number of Samples	Uranium-238 10^{-9} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[d]
2	11	e	0.16	e	e
4	11	e	0.11	e	e
5	11	e	0.12	e	e
7	11	e	0.1	e	e
8	11	e	0.17	e	e

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95 % confidence level.

[c] LDL for uranium-233,234 and uranium-238 is 0.05 x 10^{-9} µCi/mL.

[d] DOE DCG for uranium-233,234 in water is 500 x 10^{-9} µCi/mL. The DOE DCG for uranium-238 in water is 600 x 10^{-9} µCi/mL.

[e] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-10. Incremental Concentrations[a] of Thorium-228, Thorium-230, and Thorium-232 in the Great Miami River in 1999

Location*	Number of Samples	Thorium-228 Value[b,c] 10^{-12} µCi/mL Minimum	Maximum	Average	Average as a percent of DOE DCG[d]
2	4	e	e	e	e
4	4	e	e	e	e
5	4	e	11.68	e	e
7	4	e	e	e	e
8	4	e	e	e	e

Location*	Number of Samples	Thorium-230 Value[a,b,c] 10^{-12} µCi/mL Minimum	Maximum	Average	Average as a percent of DOE DCG[d]
2	4	e	e	e	e
4	4	e	17.42	e	e
5	4	e	82.43	4.5 ± 91.45	0.002
7	4	e	31.43	e	e
8	4	e	8.13	e	e

Location*	Number of Samples	Thorium-232 Value[a,b,c] 10^{-12} µCi/mL Minimum	Maximum	Average	Average as a percent of DOE DCG[d]
2	4	e	21.4	5.3 ± 32.64	0.01
4	4	e	16.5	0.57 ± 34.83	0.001
5	4	e	104.4	20.5 ± 96.64	0.04
7	4	e	38.0	15.65 ± 43.47	0.03
8	4	e	11.0	3.05 ± 28.36	0.006

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for thorium-228 in river water is 989.7 x 10^{-12} µCi/mL. The LDL for thorium-230 in river water is 152.8 x 10^{-12} µCi/mL. The LDL for thorium-232 in river water is 189.3 x 10^{-12} µCi/mL.

[d] DOE DCG for thorium-228 in water is 400,000 x 10^{-12} µCi/mL. DOE DCG for thorium-230 in water is 300,000 x 10^{-12} µCi/mL. DOE DCG for thorium-232 in water is 50,000 x 10^{-12} µCi/mL.

[e] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-11. Concentrations[a] of Tritium in Pond Water in 1999

Location*	Number of Samples	Tritium Value[b,c] 10^{-6} µCi/mL	Value as a percent of DOE DCG[d]
11	1	e	e
12	1	e	e
14	1	e	e
15	1	0.04 ± 0.15	0.002
17	1	0.002 ± 0.16	0.0001
18	1	0.05 ± 0.15	0.003

[a] Average environmental level below reagent blanks.

[b] Estimated error at the 95% confidence level.

[c] LDL for tritium in pond water is 0.35 x 10^{-6} µCi/mL.

[d] DOE DCG for tritium in water is 2,000 x 10^{-6} µCi/mL.

[e] Below reagent blanks

* Sampling locations shown on Figure 4-7.

Table B-12. Incremental Concentrations[a] of Plutonium-238 in Pond Water in 1999

Location*	Number of Samples	Plutonium-238 Value[b,c] 10^{-12} µCi/mL	Value as a percent of DOE DCG[d]
11	1	e	e
12	1	e	e
14	1	e	e
15	1	e	e
17	1	e	e
18	1	e	e

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Estimated error at the 95% confidence level.

[c] LDL for plutonium-238 in pond water is 23.2 x 10^{-12} µCi/mL.

[d] DOE DCG for plutonium-238 in water is 40,000 x 10^{-12} µCi/mL.

[e] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-13. Concentrations[a] of Plutonium-239,240 in Pond Water in 1999

Location*	Number of Samples	Plutonium-239,240 Value[b,c] 10^{-12} µCi/mL	Value as a Percent of DOE DCG[d]
11	1	e	e
12	1	e	e
14	1	e	e
15	1	e	e
17	1	e	e
18	1	e	e

[a] Average environmental level below reagent blanks.

[b] Estimated error at the 95% confidence level.

[c] LDL for plutonium-239,240 in pond water is 17.7 x 10^{-12} µCi/mL.

[d] DOE DCG for plutonium-239,240 in water is 30,000 x 10^{-12} µCi/mL.

[e] Below reagent blanks.

* Sampling locations shown on Figure 4-7.

Table B-14. Incremental Concentrations[a] of Thorium-228, Thorium-230, and Thorium-232 in Pond Water in 1999

Location*	Number of Samples	Thorium-228 Value[b,c] 10^{-12} µCi/mL	Average as a Percent of DOE DCG[d]
12	1	e	e
15	1	e	e
17	1	e	e
18	1	e	e

Location*	Number Of Samples	Thorium-230 Value[a,b,c,f] 10^{-12} µCi/mL	Average as a Percent of DOE DCG[d]
12	1	6.2 ± 4.9	0.002
15	1	43.2 ± 10.4	0.01
17	1	6.2 ± 5.1	0.002
18	1	g	g

Location*	Number Of Samples	Thorium-232 Value[a,b,c] 10^{-12} µCi/mL	Average as a Percent of DOE DCG[d]
12	1	2.9 ± 4.5	0.006
15	1	18.0 ± 6.3	0.04
17	1	e	e
18	1	e	e

[a] Environmental level shown in Table B-1 subtracted from the data.

[b] Estimated error at the 95% confidence level.

[c] LDL for thorium-228 in pond water is 989.7 x 10^{-12} µCi/mL. The LDL for thorium-230 in river water is 152.8 x 10^{-12} µCi/mL. The LDL for thorium-232 in river water is 189.3 x 10^{-12} µCi/mL.

[d] DOE DCG for thorium-228 in water is 400,000 x 10^{-12} µCi/mL. DOE DCG for thorium-230 in water is 300,000 x 10^{-12} µCi/mL. DOE DCG for thorium-232 in water is 50,000 x 10^{-12} µCi/mL.

[e] Below environmental level.

[f] Environmental level below reagent blank.

[g] Below reagent blank.

* Sampling locations shown on Figure 4-7.

Table B-15. Incremental Concentrations[a] of Plutonium-238 in River and Stream Sediments in 1999

Location*	Number of Samples	Plutonium-238 10^{-9} µCi/g Minimum	Maximum	Average[b,c]
2	3	11.24	16.74	14.01 ± 6.98
4	3	169.24	205.54	187.04 ± 45.14
5	3	4.94	33.24	19.71 ± 35.28
7	3	12.94	2175.64	1249.51± 2768.22
8	3	60.64	3411.74	1199.94 ± 4759.41
Mound Ave Storm	3	74.94	182.94	136.11 ± 137.66

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for plutonium-238 in river sediment is 0.3 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-16. Incremental Concentrations[a] of Plutonium-238 in Pond Sediments in 1999

Location*	Number of Samples	Plutonium-238 Value[b,c] 10^{-9} µCi/g
11	1	d
12	1	d
14	1	d
15	1	12.2 ± 1.43
17	1	141.0 ± 8.08
18	1	2.9 ± 0.9

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Estimated error at the 95% confidence level.

[c] LDL for plutonium-238 in pond sediment is 2.1 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-17. Incremental Concentrations[a] of Plutonium-239,240 in River and Stream Sediments in 1999

Location*	Number of Samples	Plutonium-239,240 10^{-9} µCi/g Minimum	Maximum	Average[b,c]
2	3	d	1.68	0.41 ± 5.43
4	3	0.48	2.68	1.58 ± 5.43
5	3	d	0.98	d
7	3	d	9.08	4.93 ± 15.28
8	3	d	14.08	5.32 ± 20.41
Mound Ave Storm	3	d	2.28	0.93 ± 5.72

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for plutonium-239, 240 in river sediment is 0.3 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-18. Incremental Concentrations[a] of Plutonium-239,240 in Pond Sediments in 1999

Location*	Number of Samples	Plutonium-239,240 Value[b,c] 10^{-9} µCi/g
11	1	0.40 ± 0.87
12	1	6.30 ± 1.15
14	1	1.80 ± 0.87
15	1	1.0 ± 0.86
17	1	d
18	1	d

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Estimated error at the 95% confidence level.

[c] LDL for plutonium-239, 240 in pond sediment is 2.2 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-19. Incremental Concentrations[a] of Thorium-228, Thorium-230, and Thorium-232 in River and Stream Sediments in 1999

Location*	Number of Samples	Thorium-228 10^{-9} µCi/g Minimum	Maximum	Average[b,c]
2	3	d	358.33	130.0 ± 544.22
4	3	d	74.33	47.67 ± 253.45
5	3	d	154.33	50.67 ± 419.81
7	3	95.33	347.33	230.0 ± 389.71
8	3	55.33	298.33	197.0 ± 388.76
Mound Ave Storm	3	267.33	374.33	336.33 ± 273.15

Location*	Number of Samples	Thorium-230 10^{-9} µCi/g Minimum	Maximum	Average[b,c]
2	3	d	628.67	184.33 ± 1121.70
4	3	6.67	69.67	41.67 ± 534.62
5	3	d	225.67	56.0 ± 799.41
7	3	d	379.67	173.0 ± 818.86
8	3	d	780.67	371.0 ± 1143.21
Mound Ave Storm	3	d	96.67	d

Location*	Number of Samples	Thorium-232 10^{-9} µCi/g Minimum	Maximum	Average[b,c]
2	3	d	407.67	132.0 ± 679.2
4	3	1.67	140.67	58.0 ± 355.25
5	3	d	514.67	179.33 ± 812.0
7	3	73.67	274.67	189.0 ± 399.49
8	3	60.67	253.67	166.0 ± 390.0
Mound Ave Storm	3	242.67	388.67	335.53 ± 365.01

[a] Average environmental level shown in Table B-1 subtracted from the data.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for thorium-228 in river sediment is 55.9 x 10^{-9} µCi/g. The LDL for thorium-230 in river sediment is 40.8 x 10^{-9} µCi/g. The LDL for thorium-232 in river sediment is 26.6 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-20. Incremental Concentrations[a] of Tritium in Foodstuffs[b] in 1999

Location	Number of Samples	Tritium 10^{-6} µCi/g			
		Value[c]	Minimum	Maximum	Average[d,e]
Centerville	1	0.02 ± 0.02			
Jefferson Township	1	0.05 ± 0.02			
Miami Township	3		0.02	0.10	0.07 ± 0.11
Miamisburg	2		0.19	0.38	0.28 ± 0.02

[a] The environmental level shown in Table B-1 subtracted from the data.

[b] Tomato, parsley, cabbage, and pepper samples were analyzed.

[c] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[d] Error limits are estimated error at the 95% confidence level.

[e] The LDL for tritium in foodstuffs is 0.15 x 10^{-6} µCi/g..

Table B-21. Incremental Concentrations[a] of Plutonium-238 in Foodstuffs[b] in 1999

Location	Number of Samples	Plutonium-238 10^{-9} µCi/g			
		Value[c]	Minimum	Maximum	Average[d,e]
Miami Township	2		1.52	2.62	2.07 ± 0.2
Miamisburg	1	0.12 ± 0.05			

[a] Environmental level shown in Table B-1 subtracted from the data.

[b] Potato, cabbage, beans, parsley, and pepper samples were analyzed.

[c] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[d] Error limits are the estimated error at the 95% confidence level.

[e] The LDL for plutonium–238 in foodstuffs is 0.15 x 10^{-9} µCi/g.

[f] Below environmental level.

Table B-22. Incremental Concentrations[a] of Plutonium-239,240 in Foodstuffs[b] in 1999

Location	Number of Samples	Plutonium-239,240 10^{-9} µCi/g			
		Value[c]	Minimum	Maximum	Average[d,e]
Miami Township	2		0.007	0.04	0.02 ± 0.04
Miamisburg	1	f			

[a] Environmental level shown in Table B-1 subtracted from the data.

[b] Potato, cabbage, parsley, kohlrabi, and beet samples were analyzed.

[c] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[d] Error limits are the estimated error at the 95% confidence level.

[e] The LDL for plutonium–239,240 in foodstuffs is 0.25 x 10^{-9} µCi/g..

[f] Below environmental level.

APPENDIX C

APPENDIX C

NONRADIOLOGICAL MONITORING RESULTS

Effluent and environmental samples are analyzed for nonradiological parameters. Tables summarizing monitoring results from 1999 are presented in this Appendix. Nonradiological airborne effluent rates are calculated using a mass balance approach and the annual emission rate is reported as a percent of the applicable EPA standard. The remainder of the tables show:

- number of samples analyzed during the year,
- minimum concentration measured,
- maximum concentration measured,
- average value, and, when appropriate,
- a comparison to a DOE or EPA standard.

Table C-1. Nonradiological Air Emissions Data for 1999

Pollutant	Emission Rate (tons/yr) [b]	Emission Threshold Limit (tons/yr) [a]	% of Standard
Total suspended particulates	8.1	100	8.1
Sulfur oxides	0.2	100	0.1
Nitrogen oxides	14.0	100	14.0
VOCs	0.9	100	0.9
Carbon monoxide	3.9	100	1.5
Lead	0.0001	0.6	0.2

[a] Threshold limits defined in 40 CFR Part 70 and Ohio Administrative Code 3745-77, Title V Permits
[b] Emission rates are calculated using a material balance approach or AP-42 (EPA, 1985) emission factors.

Table C-2. 1999 Particulate Air Concentrations

Sampling Location*	Number of Samples	Particulate Concentration ($\mu g/m^3$) Minimum	Maximum	Arithmetic Average [a,b] ($\mu g/m^3$)
Offsite				
101	50	18	63	34 ± 3
102	48	15	99	31 ± 5
103	50	1	40	25 ± 2
104	50	16	56	29 ± 3
105	50	7	40	24 ± 2
111	48	15	91	39 ± 5
112	34	15	41	26 ± 3
115	49	15	51	28 ± 3
118	50	14	58	28 ± 3
119 [c]	50	15	41	26 ± 2
124	48	14	50	31 ± 3
CLN	49	21	67	37 ± 3
Onsite				
211	52	16	53	31 ± 2
212	32	2	48	27 ± 3
213	52	18	73	38 ± 4
214	52	14	47	27 ± 2
215	50	17	82	35 ± 4
215T	51	18	95	40 ± 5
216	52	15	87	32 ± 4
217	41	17	50	28 ± 2
218	51	8	65	28 ± 3

[a] Values are weekly averages. Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[b] Ohio ambient air quality standard is 50 $\mu g/m^3$ (3-year average).

[c] Background location.

* Sampling locations shown on Figures 4-4 and 4-5 for onsite and offsite sampling stations, respectively.

Table C-3. NPDES Permit and ATD Data for 1999

Sampling Location *	No. of Samples	Minimum	Maximum	Annual Average	Highest Monthly Average	NPDES Permit Limit Daily	NPDES Permit Limit Monthly Average
Outfall 601 Parameters							
Flow rate, MGD	a	0.010	0.204	0.065	0.112	n/a	n/a
pH, s.u.	202	7.1	8.7	8.0	8.2	6.5-9.0	n/a
Chlorine: total [d], mg/L	101	<0.01	0.60	<0.01	<0.01	n/a	n/a
Suspended solids, mg/L	104	<1	10.8	1.2	3.6	30	15
Fecal coliform [d], n/100mL	27	1	1600	2 [e]	3 [e]	2000	1000
Ammonia, mg/L as N	25	<0.30	0.78	<0.30	0.39	n/a	n/a
$CBOD_5$, mg/L	104	<4	9	<4	2.9	15	10
Oil and grease [b], mg/L	4	<1	<1	<1	<1	n/a	n/a
Cadmium, µg/L	13	<1	<1	<1	<1	n/a	n/a
Chromium, µg/L	13	<2	<2	<2	<2	n/a	n/a
Copper, µg/L	13	<5	76	27	76	n/a	n/a
Nickel, µg/L	13	<5	16	<5	16	n/a	n/a
Lead, µg/L	13	<1	3	<1	3	n/a	n/a
Zinc, µg/L	13	<50	66	<50	66	n/a	n/a
VOCs [b,f]	5	ND	11.3	5.54	11.3	n/a	n/a
Outfall 602 Parameters							
Flow rate, MGD	a	0.010	0.550	0.149	0.286	n/a	n/a
pH, s.u.	53	7.9	8.7	8.4	8.6	6.5-9.0	n/a
Suspended solids [c], mg/L	52	<1	40.2	9.0	22.0	45	30
Chemical oxygen demand, mg/L	52	<1	749	102	210	n/a	n/a
Oil and grease, mg/L	12	<5	<1	<1	<1	10	n/a

[a] Continuous.

[b] Quarterly samples collected in Mar., Jun., Aug., Dec.

[c] Limit n/a if > 0.25 inches of rainfall 2 days during the week.

[d] Summer months only (May 1 through October 31).

[e] Average reported as a geometric mean.

[f] Chloroform results reported (no other compounds detected).

* Sampling locations shown on Figure 5-1.

ND = below minimum detection limit.

MGD = million gallons per day.

n/a = not applicable, no permit limits.

Table C-3. NPDES Permit and ATD Data for 1999 (continued)

Sampling Location*	No. of Samples	Minimum	Maximum	Annual Average	Highest Monthly Average	NPDES Permit Limit	
						Daily	Monthly Average
Outfall 002 Parameters							
Flow rate, MGD	a	0.016	3.920	0.318	0.696	n/a	n/a
pH, s.u.	53	7.5	8.9	8.2	8.7	6.5-9.0	n/a
Suspended solids [c], mg/L	53	1.8	64.6	14.6	27.8	45	30
Outfall 001 Parameters							
Flow rate, MGD	a	0.025	0.611	0.213	0.393	n/a	n/a
pH, s.u.	28	8.0	8.5	8.3	8.4	6.5-9.0	n/a
Cyanide, µg/L	12	<5	<5	<5	<5	n/a	n/a
Cadmium, µg/L	12	<1	<1	<1	<1	n/a	n/a
Chromium, µg/L	12	<2	<2	<2	<2	n/a	n/a
Copper, µg/L	12	<5	46	26	46	120	n/a
Nickel, µg/L	12	<5	13	<5	13	n/a	n/a
Lead, µg/L	12	<1	8	2	8	n/a	n/a
Zinc, µg/L	12	<50	135	<50	135	n/a	n/a

a Continuous.

c Limit n/a if > 0.25 inches of rainfall 2 days during the week.

* Sampling locations shown on Figure 5-1.

MGD = million gallons per day.

n/a = not applicable, no permit limits.

Table C-3. NPDES Permit and ATD Data for 1999 (continued)

Sampling Location*	No. of Samples	Minimum	Maximum	Annual Average	Highest Monthly Average	ATD Limit Daily	ATD Limit Monthly Average
Outfall 003 Parameters							
Flow rate, MGD	a	0.08	0.193	0.126	0.140	n/a	n/a
pH, s.u.	52	7.7	8.5	8.0	8.2	6.5-9.0	n/a
Dissolved oxygen, mg/L	52	1.3	13.1	10.1	11.9	n/a	n/a
Dissolved solids, mg/L	24	661	918	750	842	n/a	n/a
Suspended solids, mg/L	24	<1	14.3	1	7.2	45	30
$CBOD_5$, mg/L	12	<4	<4	<4	<4	n/a	n/a
Mercury, µg/L	52	<0.2	<0.2	<0.2	<0.2	2.2	0.023
Selenium, µg/L	12	<5	<5	<5	<5	n/a	n/a
Silver, µg/L	12	<0.5	<0.5	<0.5	<0.5	n/a	n/a
Chromium, µg/L	53	<2	<2	<2	<2	9800	1100
Copper, µg/L	52	<5	8	<5	<5	120	65
Nickel, µg/L	36	<5	36	<5	27	n/a	n/a
Lead, µg/L	34	<1	<1	<1	<1	n/a	n/a
Zinc, µg/L	34	<50	<50	<50	<50	n/a	n/a
VOCs [f], µg/L	12	ND	1.2	ND	1.2	10	5
Bis (2-ethylhexyl) phthalate [b], µg/L	4	<5	<5	<5	<5	n/a	n/a
Ceriodaphnia dubia [b]							
acute, TU	4	ND	ND	ND	ND	1.0	n/a
chronic, TU	4	ND	1.4	0.7	1.4	2.8	n/a
Pimephales promelas [b]							
acute, TU	4	ND	ND	ND	ND	1.0	n/a
chronic, TU	4	ND	ND	ND	ND	2.8	n/a

[a] Continuous.

[b] Quarterly samples collected in Mar., Jun., Aug., Dec.

[f] Chloroform results reported (no other compounds detected).

TU = toxicity units.

* Sampling locations shown on Figure 5-1.

MGD = million gallons per day.

ND = below minimum detection limit.

n/a = not applicable, no permit limits.

APPENDIX D

APPENDIX D

GROUNDWATER MONITORING RESULTS

Groundwater samples are collected from onsite and offsite drinking water supplies, monitoring wells, and seeps. These samples are analyzed for radionuclides, volatile organic compounds (VOCs), and inorganic substances. Results of groundwater monitoring activities in 1999 are presented in this Appendix. DOE or EPA standards for drinking water are also provided for comparison. Such standards are established to protect drinking water supplies. It should be noted that for monitoring wells, these standards are provided for reference only as these wells do not serve as sources of drinking water.

Radionuclide results tables show the number of samples analyzed during the year, minimum and maximum concentrations measured, and the average value with error limits. Because of the large volume of nonradiological data for onsite monitoring wells, VOC and inorganic results have been summarized. Data for onsite monitoring wells have only been included in the tables if detectable levels of VOCs or inorganics were observed during one of the sampling events (all VOCs are included; inorganic parameters which have been assigned an MCL are included).

Table D-1. Environmental Concentrations of Radionuclides in Groundwater in 1999

Radionuclide	Number of Samples	Average Concentration [a, b]	Unit of Measure
Tritium	12	0.12 ± 0.14	nCi/L
Plutonium-238	12	0.002 ± 0.003	10^{-9} µCi/ml
Plutonium-239,240	12	c	10^{-9} µCi/ml
Uranium-233,234	12	0.45 ± 0.05	10^{-9} µCi/ml
Uranium-238	12	0.41 ± 0.06	10^{-9} µCi/ml
Thorium-238	5	c	c
Thorium-230	5	c	c
Thorium-232	5	0.01 ± 0.02	10^{-9} µCi/ml

[a] Measured 25 mi (40 km) north of MEMP in Tipp City.

[b] Error limits are estimates of the standard error at the 95% confidence level.

[c] Below reagent blanks.

Table D-2. Tritium Concentrations in Offsite Drinking Water and Private Wells in 1999

Sampling Location*	Historic Designation	Number of Samples	Tritium nCi/L Value [a,b]	Minimum	Maximum	Average [c,d]	Average as a % of the EPA Standard [e]
0904	J-1	8		0.12	1.08	0.39 ± 0.24	2.0
0905	Tr-1	1	0.16 ± 0.01				0.8
0907	B-H	7		0.2	0.76	0.53 ± 0.19	2.7
0909 [g]	MCD	12		f	0.99	0.20 ± 0.18	1.0
Franklin [g]		12		f	0.14	0.05 ± 0.04	0.3
Germantown [g]		12		f	0.32	0.08 ± 0.06	0.4
Miamisburg [g]		12		0.04	0.36	0.22 ± 0.06	1.1
Middletown [g]		12		f	0.17	0.07 ± 0.04	0.4
Springboro [g]		12		f	0.22	0.11 ± 0.05	0.6
W. Carrollton [g]		12		f	0.12	0.05 ± 0.03	0.3

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Estimated error at the 95% confidence level.

[c] Error limits are estimates of the standard error of the estimated mean at the 95 % confidence level.

[d] LDL for tritium in private well water is 1.1 nCi/L. LDL for tritium in community drinking water is 0.46 nCi/L.

[e] The EPA standard for tritium in drinking water is 20 nCi/L.

[f] Below the blank value.

[g] Municipality drinking water supply.

* Well locations shown on Figure 6-2.

Table D-3. Plutonium Concentrations in Offsite Drinking Water in 1999

Sampling Location*	Number of Samples	Plutonium-238 10^{-9} µCi/mL			Average as a % of the EPA Standard [c]
		Minimum	Maximum	Average [a,b]	
Miamisburg	12	d	0.012	0.002 ± 0.003	0.13

Sampling Location*	Number of Samples	Plutonium-239,240 10^{-9} µCi/mL			Average as a % of the EPA Standard [c]
		Minimum	Maximum	Average [a,b]	
Miamisburg	12	d	0.007	d	d

[a] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[b] LDL for plutonium-238 is 0.02 x 10^{-9} µCi/mL. LDL for plutonium-239,240 is 0.024 x 10^{-9} µCi/mL.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for plutonium-238 and plutonium-239,240 are 1.6 x 10^{-9} µCi/mL and 1.2 x 10^{-9} µCi/mL, respectively.

[d] Below reagent blank.

* Well locations shown on Figure 6-2.

Table D-4. Uranium Concentrations in Offsite Drinking Water in 1999

Sampling Location*	Number of Samples	Uranium-233,234 10^{-9} µCi/mL			Average as a % of the EPA Standard [c]
		Minimum	Maximum	Average [a,b]	
Miamisburg	12	0.44	0.71	0.57 ± 0.05	2.9

Sampling Location*	Number of Samples	Uranium-238 10^{-9} µCi/mL			Average as a % of the EPA Standard [c]
		Minimum	Maximum	Average [a,b]	
Miamisburg	12	0.35	0.57	0.46 ± 0.04	1.9

[a] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[b] LDL for uranium-233,234 is 0.04 x 10^{-9} µCi/mL. LDL for uranium-238 is 0.04 x 10^{-9} µCi/mL.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for uranium-233,234 and uranium-238 are 20 x 10^{-9} µCi/mL and 24 x 10^{-9} µCi/mL, respectively.

* Well locations shown on Figure 6-2.

Table D-5. Thorium Concentrations in Offsite Drinking Water in 1999

Sampling Location*	Number of Samples	Thorium-228 10^{-9} µCi/mL			Average as a % of the EPA Standard [c]
		Minimum	Maximum	Average [a,b]	
Miamisburg	5	d	0.01	d	d

Sampling Location*	Number Of Samples	Thorium-230 10^{-9} µCi/mL			Average as a % of the EPA Standard [c]
		Minimum	Maximum	Average [a,b]	
Miamisburg	5	d	0.014	d	d

Sampling Location*	Number Of Samples	Thorium-232 10^{-9} µCi/mL			Average as a % of the EPA Standard [c]
		Minimum	Maximum	Average [a,b]	
Miamisburg	5	d	0.008	0.002 ± 0.005	0.1

[a] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[b] LDL for thorium-228 is 1.17 x 10^{-9} µCi/mL. LDL for thorium-230 is 0.10 x 10^{-9} µCi/mL. LDL for thorium-232 is 0.08 x 10^{-9} µCi/mL.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for thorium-228, thorium-230, and thorium-232 are 16 x 10^{-9} µCi/mL, 12 x 10^{-9} µCi/mL, and 2 x 10^{-9} µCi/mL, respectively.

[d] Below reagent blank.

* Well locations shown on Figure 6-2.

Table D-6. Tritium Concentrations in Offsite Monitoring Wells in 1999

Well I.D.*	Number of Samples	Tritium nCi/L Value [a]	Minimum	Maximum	Average [b,c]	Average as a % of the EPA Standard [d]
0123	1	0.12				0.6
0127	4		e	0.34	0.13 ± 0.15	0.6
0128	4		e	0.17	0.08 ± 0.08	0.4
0302	1	2.24				11.2
0303	4		6.43	11.22	8.67 ± 1.98	43.4
0343	3		5.90	8.40	7.05 ± 1.26	35.3
0376	4		0.31	1.00	0.62 ± 0.33	3.1
0377	4		e	0.80	0.31 ± 0.35	1.6
0378	1	0.30				1.5
0383	4		0.14	4.89	1.73 ± 2.17	8.7
0386	2		1.66	2.26	1.96 ± 0.42	9.8
0387	2		0.63	5.52	3.08 ± 3.46	15.4
0388	4		e	1.85	0.65 ± 0.82	3.2
0389	2		2.70	2.76	2.73 ± 0.04	13.7
0392	1	5.76				28.8

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[c] LDL for tritium in monitoring wells is 0.5 nCi/L.

[d] The EPA standard for tritium in drinking water is 20 nCi/L.

[e] Below the blank value.

• Well locations shown on Figure 6-2.

Table D-7. Plutonium Concentrations in Offsite Monitoring Wells in 1999

Sampling Location*	Number of Samples	Plutonium-238 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.012 [d]	0.017	0.015 ± 0.004	0.9
0376	2		0.013 [d]	0.022 [d]	0.018 ± 0.006	1.1
0377	2		0.016 [d]	0.025 [d]	0.021 ± 0.006	1.3
0378	1	0.010 [d]				0.6
0383	2		0.017 [d]	0.024	0.021 ± 0.005	1.3
0383	2		0.017 [d]	0.024	0.021 ± 0.005	1.3
0386	1	0.009 [d]				0.6
0388	2		0.016 [d]	0.067	0.042 ± 0.036	2.6

Sampling Location*	Number of Samples	Plutonium-239 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.011 [d]	0.012 [d]	0.012 ± 0.001	1.0
0376	2		0.013 [d]	0.014 [d]	0.014 ± 0.001	1.1
0377	2		0.009 [d]	0.016 [d]	0.013 ± 0.005	1.0
0378	1	0.006 [d]				0.5
0383	2		0.012 [d]	0.013 [d]	0.013 ± 0.001	1.0
0386	1	0.005 [d]				0.4
0388	2		0.010 [d]	0.016 [d]	0.013 ± 0.004	1.1

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for plutonium-238, and plutonium-239,240 are 1.6 x 10^{-9} µCi/mL and 1.2 x 10^{-9} µCi/mL, respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-8. Uranium Concentrations in Offsite Monitoring Wells in 1999

Sampling Location*	Number of Samples	Uranium-233,234 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.016 [d]	0.017	0.017 ± 0.001	0.1
0376	2		0.212	0.269	0.241 ± 0.040	1.2
0377	2		0.135	0.166	0.151 ± 0.022	0.8
0378	1	0.170				0.9
0383	2		0.157	0.166	0.162 ± 0.006	0.8
0386	1	0.440				2.2
0388	2		0.255	0.312	0.284 ± 0.040	1.4

Sampling Location*	Number of Samples	Uranium-238 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.008	0.013 [d]	0.011 ± 0.004	0.1
0376	2		0.167	0.178	0.173 ± 0.008	0.7
0377	2		0.114	0.218	0.166 ± 0.074	0.7
0378	1	0.169				0.7
0383	2		0.169	0.189	0.179 ± 0.014	0.7
0386	1	0.360				1.5
0388	2		0.243	0.261	0.252 ± 0.013	1.1

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for uranium-233,234 and uranium-238 are 20 x 10^{-9} µCi/mL and 24 x 10^{-9} µCi/mL, respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-9. Thorium Concentrations in Offsite Monitoring Wells in 1999

Sampling Location*	Number of Samples	Thorium-227 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.025 [d]	0.036	0.031 ± 0.031	0.02
0376	2		0.016 [d]	0.026	0.021 ± 0.007	0.01
0377	2		0.014	0.018 [d]	0.016 ± 0.003	0.01
0378	1	0.015				0.01
0383	2		0.010	0.019 [d]	0.015 ± 0.006	0.01
0386	1	0.007 [d]				>0.01
0388	2		0.021	0.035	0.028 ± 0.010	0.02

Sampling Location*	Number of Samples	Thorium-228 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.021 [d]	0.036	0.029 ± 0.011	0.2
0376	2		0.014	0.019 [d]	0.017 ± 0.004	0.1
0377	2		0.017 [d]	0.036	0.027 ± 0.013	0.2
0378	1	0.021 [d]				0.1
0383	2		0.013	0.016 [d]	0.015 ± 0.002	0.1
0386	1	0.013 [d]				0.1
0388	2		0.082	0.106	0.094 ± 0.017	0.6

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for thorium-227, thorium-228, thorium-230, and thorium-232 are 160 x 10^{-9} µCi/mL, 16 x 10^{-9} µCi/mL, 12 x 10^{-9} µCi/mL, and 2 x 10^{-9} µCi/mL respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-9. Thorium Concentrations in Offsite Monitoring Wells in 1999 (continued)

Sampling Location*	Number of Samples	Thorium-230 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.017	0.021	0.019 ± 0.003	0.2
0376	2		0.011	0.012 [d]	0.012 ± 0.001	0.1
0377	2		0.012 [d]	0.018 [d]	0.015 ± 0.004	0.1
0378	1	0.008 [d]				0.1
0383	2		0.016	0.020 [d]	0.018 ± 0.003	0.2
0386	1	0.013 [d]				0.1
0388	2		0.008	0.017 [d]	0.013 ± 0.006	0.1

Sampling Location*	Number of Samples	Thorium-232 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0303	2		0.012	0.019 [d]	0.016 ± 0.005	0.8
0376	2		0.014 [d]	0.016 [d]	0.015 ± 0.001	0.8
0377	2		0.016 [d]	0.024 [d]	0.020 ± 0.006	1.0
0378	1	0.008 [d]				0.4
0383	2		0.015 [d]	0.017 [d]	0.016 ± 0.001	0.8
0386	1	0.013 [d]				0.7
0388	2		0.018 [d]	0.026 [d]	0.022 ± 0.006	1.1

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for thorium-227, thorium-228, thorium-230, and thorium-232 are 160 x 10^{-9} µCi/mL, 6 x 10^{-9} µCi/mL, 12 x 10^{-9} µCi/mL, and 2 x 10^{-9} µCi/mL respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-10. VOC Concentrations in Offsite Monitoring Wells in 1999

Well I.D.*	Compound	µg/L 1st Quarter	3rd Quarter	MCL
0123		ND	NS	-
0302		ND	NS	-
0303		ND	NS	-
0343		ND	NS	-
0376		ND	NS	-
0377	1,1,1-Trichloroethane	16.0	NS	200
0378	1,1,1-Trichloroethane	2.20	NS	200
0383		ND	NS	-
0386	Trichloroethene	10.0	8.10	5
0387	Tetrachloroethene	0.58	NS	5
0388		ND	NS	
0389	Tetrachloroethene	0.60	0.59	5
	Trichloroethene	3.40	3.20	5
0392		ND	NS	-

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

ND = Results below the method detection limit.

NS = Not Sampled.

* Well locations shown on Figure 6-2.

Table D-11. Inorganic Concentrations in Offsite Monitoring Wells in 1999

Well I.D.*	Compound	µg/L 1st Quarter	µg/L MCL
0123	Aluminum	37.9	50-200[c]
	Manganese	409	50[b]
0302	Aluminum	1890	50-200[c]
	Arsenic	15.2	50[a]
	Barium	386	2000[a]
	Chromium	17.3	100[a]
	Iron	7010	300[b]
	Lead	8.5	15[d]
	Manganese	132	50[b]
	Zinc	272	5000[b]
0303	Aluminum	200	50-200[c]
	Barium	235	2000[a]
	Iron	5830	300[b]
	Manganese	412	50[b]
0343	Aluminum	79.5	50-200[c]
	Chromium	38.3	100[a]
	Iron	3910	300[b]
	Manganese	392	50[b]
0376	Aluminum	36.0	50-200[c]
	Chromium	309	100[a]
	Iron	5260	300[b]
	Manganese	67.6	50[b]
	Nickel	270	100[a]
0377	Aluminum	31.5	50-200[c]
	Chromium	533	100[a]
	Iron	8120	300[b]
	Manganese	89.4	50[b]
	Nickel	217	100[a]

[a] Primary Maximum Contaminant Level.

[b] Secondary Maximum Contaminant Level.

[c] The secondary MCL for aluminum is a range; final MCL values have not been established.

[d] Action level.

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-11. Inorganic Concentrations in Offsite Monitoring Wells in 1999 (continued)

Well I.D.*	Compound	µg/L 1st Quarter	µg/L MCL
0378	Aluminum	28.7	50-200[c]
	Chromium	300	100[a]
	Iron	4880	300[b]
	Manganese	92.8	50[b]
	Nickel	221	100[a]
0383	Chromium	30.5	100[a]
	Iron	338	300[b]
0386	Aluminum	28.7	50-200[c]
	Chromium	220	100[a]
	Iron	2810	300[b]
	Manganese	22.3	50[b]
	Nickel	118	100[a]
0388	Aluminum	107	50-200[c]
	Chromium	930	100[a]
	Iron	12000	300[b]
	Manganese	43.8	50[b]
	Nickel	158	100[a]
0389	Chromium	13.5	100[a]
	Iron	173	300[b]
0392	Aluminum	6770	50-200[c]
	Arsenic	13.2	50[a]
	Chromium	590	100[a]
	Copper	45.6	1300[d]
	Iron	28700	300[b]
	Lead	13.5	15[d]
	Manganese	399	50[b]
	Nickel	181	100[a]
	Zinc	285	5000[b]

[a] Primary Maximum Contaminant Level.

[b] Secondary Maximum Contaminant Level.

[c] The secondary MCL for aluminum is a range; final MCL values have not been established.

[d] Action level.

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-12. Tritium Concentrations in Onsite Production Wells in 1999

Well I.D.*	Historic Designation	Number of Samples	Tritium nCi/L Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	43	d	0.79	0.43 ± 0.06	2.2
0271	2	47	0.15	0.67	0.43 ± 0.04	2.2
0076	3	47	0.15	0.07	0.40 ± 0.04	2.0

[a] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[b] LDL for tritium in onsite well water is 0.67 nCi/L.

[c] The EPA standard for tritium in drinking water is 20 nCi/L.

[d] Below reagent blank.

* Well locations shown on Figure 6-2.

Table D-13. Plutonium Concentrations in Onsite Production Wells in 1999

Well I.D.*	Historic Designation	Number of Samples	Plutonium-238 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	12	d	0.009	0.003 ± 0.003	0.19
0271	2	12	d	0.007	0.002 ± 0.002	0.13
0076	3	12	d	0.011	0.003 ± 0.004	0.19

Well I.D.*	Historic Designation	Number of Samples	Plutonium-239,240 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	12	d	0.006	d	d
0271	2	12	d	0.004	d	d
0076	3	12	d	0.004	d	d

[a] Error limits are estimates of the standard error of the estimated mean at the 95 % confidence level.

[b] LDL for plutonium-238 is 0.02 x 10^{-9} µCi/mL. LDL for plutonium-239,240 is 0.024 x 10^{-9} µCi/mL.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for plutonium-238, and plutonium-239,240 are 1.6 x 10^{-9} µCi/mL and 1.2 x 10^{-9} µCi/mL, respectively.

[d] Below reagent blank.

* Well locations shown on Figure 6-2.

Table D-14. Uranium Concentrations in Onsite Production Wells in 1999

Well I.D.*	Historic Designation	Number of Samples	Uranium-233,234 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	12	0.13	0.21	0.17 ± 0.02	0.9
0271	2	12	0.17	0.26	0.21 ± 0.02	1.1
0076	3	12	0.18	0.35	0.24 ± 0.03	1.2

Well I.D.*	Historic Designation	Number Of Samples	Uranium-238 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	12	0.10	0.19	0.13 ± 0.02	1.5
0271	2	12	0.13	0.25	0.18 ± 0.02	0.8
0076	3	12	0.15	0.36	0.21 ± 0.04	0.9

[a] Error limits are estimates of the standard error of the estimated mean at the 95 % confidence level.

[b] LDL for uranium-233,234 is 0.04 x 10^{-9} µCi/mL. LDL for uranium-238 is 0.05 x 10^{-9} µCi/mL.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for uranium-233,234 and uranium-238 are 20 x 10^{-9} µCi/mL and 24 x 10^{-9} µCi/mL, respectively.

* Well locations shown on Figure 6-2.

Table D-15. Thorium Concentrations in Onsite Production Wells in 1999

Well I.D.*	Historic Designation	Number of Samples	Thorium-228 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	5	d	0.01	d	d
0271	2	5	d	0.01	d	d
0076	3	5	d	0.02	0.002 ± 0.016	0.01

Well I.D.*	Historic Designation	Number of Samples	Thorium-230 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	5	d	0.006	d	d
0271	2	5	d	d	d	d
0076	3	5	d	0.009	d	d

Well I.D.*	Historic Designation	Number Of Samples	Thorium-232 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0071	1	5	d	0.02	0.006 ± 0.01	0.3
0271	2	5	0.0006	0.04	0.010 ± 0.02	0.5
0076	3	5	d	0.03	0.008 ± 0.01	0.4

[a] Error limits are estimates of the standard error of the estimated mean at the 95% confidence level.

[b] LDL for thorium-228 is 1.17 x 10^{-9} µCi/mL. LDL for thorium-230 is 0.10 x 10^{-9} µCi/mL. LDL for thorium-232 is 0.08 x 10^{-9} µCi/mL.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for thorium-228, thorium-230, and thorium-232 are 16 x 10^{-9} µCi/mL, 12 x 10^{-9}, and 2 x 10^{-9} µCi/mL, respectively.

[d] Below reagent blank.

* Well locations shown on Figure 6-2.

Table D-16. VOC Concentrations in Onsite Production Wells in 1999

Well I.D.*	Historic Designation	Compound	Number of Samples	µg/L Minimum	Maximum	Average [a]	MCL
0071	1	1,1,1-Trichloroethane	4	2.1	3.0	2.7 ± 0.4	200
0271	2	Tetrachloroethene	4	b	1.0	0.7 ± 0.5	5
		Trichloroethene	4	b	1.2	0.7 ± 0.5	5
		1,1,1-Trichloroethane	4	1.6	2.5	1.9 ± 0.4	200
0076	3	Trichloroethene	4	0.6	1.0	0.8 ± 0.2	5

[a] Error limits are one standard deviation of the estimated mean.

[b] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-17. Tritium Concentrations in Onsite Monitoring Wells in 1999

Well I.D.*	Number of Samples	Tritium nCi/L Value [a]	Minimum	Maximum	Average [b,c]	Average as a % of the EPA Standard [d]
0063	4		1.70	2.38	2.01 ± 0.34	10.0
0111	2		1.05	1.07	1.06 ± 0.01	5.3
0119	2		1.25	1.54	1.40 ± 0.21	7.0
0125	2		1.13	1.86	1.50 ± 0.52	7.5
0158	1	0.33				1.7
0305	4		0.65	1.17	0.95 ± 0.23	4.7
0312	1	3.10				15.5
0313	4		2.46	3.47	2.96 ± 0.49	14.8
0314	2		2.75	2.79	2.77 ± 0.03	13.9
0315	2		1.91	2.23	2.07 ± 0.23	10.4
0317	4		e	0.59	0.39 ± 0.25	1.9
0345	2		0.95	1.09	1.02 ± 0.10	5.1
0346	2		2.68	3.02	2.85 ± 0.24	14.3
0347	1	1.44				7.2
0353	2		1.09	1.27	1.18 ± 0.13	5.9
0370	4		2.17	3.22	2.79 ± 0.49	14.0
0373	4		2.30	2.69	2.50 ± 0.17	12.5
0374	4		0.64	2.58	1.59 ± 1.04	8.0
0379	2		3.73	4.03	3.88 ± 0.21	19.4
0382	2		0.72	0.74	0.73 ± 0.01	3.7
0395	1	1.10				5.5
0397	4		1.26	1.72	1.47 ± 0.21	7.3
0410	4		0.20	4.11	1.58 ± 1.75	7.9
0411	3		0.14	1.04	0.65 ± 0.46	3.3
0415	4		0.58	1.27	0.92 ± 0.33	4.6
0416	4		0.11	0.77	0.49 ± 0.27	2.5
0417	4		0.21	0.77	0.53 ± 0.25	2.6
0418	4		0.58	1.36	0.86 ± 0.35	4.3
0419	4		0.14	2.54	1.24 ± 1.09	6.2
0420	4		2.69	3.57	3.13 ± 0.49	15.6
0421	3		0.80	1.19	1.00 ± 0.20	5.0

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] LDL for tritium in monitoring wells is 0.5 nCi/L.

[d] The EPA standard for tritium in drinking water is 20 nCi/L.

[e] Below the blank value.

* Well locations shown on Figure 6-2.

Table D-17. Tritium Concentrations in Onsite Monitoring Wells in 1999 (continued)

Well I.D.*	Number of Samples	Tritium nCi/L				Average as a % of the EPA Standard [d]
		Value [a]	Minimum	Maximum	Average [b,c]	
0422	4		2.15	4.03	2.87 ± 0.81	14.4
0423	3		0.49	1.18	0.78 ± 0.36	3.9
0424	4		0.60	1.19	0.82 ± 0.26	4.1
0425	4		0.42	7.38	2.36 ± 3.34	11.8
P001	1	2.90				14.5
P002	1	4.84				24.2
P003	1	1.82				9.1
P005	1	3.32				16.6
P015	3		0.96	1.97	1.48 ± 0.51	7.4
P027	4		0.45	1.19	0.84 ± 0.37	4.2
P031	4		0.39	0.75	0.62 ± 0.16	3.1
P043	4		2.27	4.15	2.95 ± 0.83	14.7
P044	4		e	0.66	0.35 ± 0.28	1.7
P045	4		0.32	0.89	0.61 ± 0.24	3.1
P046	4		0.85	1.41	1.24 ± 0.26	6.2

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] LDL for tritium in monitoring wells is 0.5 nCi/L.

[d] The EPA standard for tritium in drinking water is 20 nCi/L.

[e] Below the blank value.

* Well locations shown on Figure 6-2.

Table D-18. Plutonium Concentrations in Onsite Monitoring Wells in 1999

Sampling Location*	Number of Samples	Plutonium-238 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	2		0.013 [d]	0.023 [d]	0.018 ± 0.007	1.1
0119	2		0.015 [d]	0.020 [d]	0.018 ± 0.004	1.1
0125	2		0.019 [d]	0.095	0.057 ± 0.054	3.6
0314	2		0.014	0.020 [d]	0.017 ± 0.004	1.1
0315	1	0.013 [d]				0.8
0345	2		0.009	0.029 [d]	0.019 ± 0.014	1.2
0346	2		0.013	0.014 [d]	0.014 ± 0.001	0.8

Sampling Location*	Number of Samples	Plutonium-239 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	2		0.013 [d]	0.039 [d]	0.026 ± 0.018	2.2
0119	2		0.013 [d]	0.131	0.072 ± 0.083	6.0
0125	2		0.012 [d]	0.017 [d]	0.015 ± 0.004	1.2
0314	2		0.014 [d]	0.162	0.088 ± 0.105	7.3
0315	1	0.011				0.9
0345	2		0.010 [d]	0.013 [d]	0.012 ± 0.002	1.0
0346	2		0.006 [d]	0.021 [d]	0.014 ± 0.011	1.1

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for plutonium-238, and plutonium-239,240 are 1.6 x 10^{-9} µCi/mL and 1.2 x 10^{-9} µCi/mL, respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-19. Uranium Concentrations in Onsite Monitoring Wells in 1999

Sampling Location*	Number of Samples	Uranium-233,234 10^{-9} µCi/mL Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0111	2		0.255	0.294	0.275 ± 0.028	1.4
0119	2		0.296	0.332	0.314 ± 0.025	1.6
0125	2		2.076	3.416	2.746 ± 0.948	13.7
0314	2		0.992	1.118	1.055 ± 0.089	5.3
0315	1	0.560				2.8
0345	2		0.185	0.190	0.188 ± 0.004	0.9
0346	2		0.334	0.442	0.388 ± 0.076	1.9

Sampling Location*	Number of Samples	Uranium-235 10^{-9} µCi/mL Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0111	2		0.007 [d]	0.014 [d]	0.011 ± 0.005	0.05
0119	2		0.014 [d]	0.029	0.022 ± 0.011	0.1
0125	2		0.060	0.225	0.143 ± 0.117	0.6
0314	2		0.041	0.063	0.052 ± 0.016	0.2
0315	1	0.024				0.1
0345	2		0.011 [d]	0.012	0.012 ± 0.001	0.05
0346	2		0.019	0.020	0.020 ± 0.001	0.1

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for uranium-233,234, uranium-235, and uranium-238 are 20 x 10^{-9} µCi/mL, 24 x 10^{-9} µCi/mL, and 24 x 10^{-9} µCi/mL, respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-19. Uranium Concentrations in Onsite Monitoring Wells in 1999 (continued)

Sampling Location*	Number of Samples	Uranium-238 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	2		0.164	0.238	0.201 ± 0.052	0.8
0119	2		0.230	0.263	0.247 ± 0.023	1.0
0125	2		1.634	2.800	2.217 ± 0.824	9.2
0314	2		0.751	0.834	0.793 ± 0.059	3.3
0315	1	0.477				2.0
0345	2		0.151	0.158	0.155 ± 0.005	0.6
0346	2		0.197	0.234	0.216 ± 0.026	0.9

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for uranium-233,234, uranium-235, and uranium-238 are 20 x 10^{-9} µCi/mL, 24 x 10^{-9} µCi/mL, and 24 x 10^{-9} µCi/mL, respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-20. Thorium Concentrations in Onsite Monitoring Wells in 1999

Sampling Location*	Number of Samples	Thorium-227 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	2		0.019 [d]	0.033	0.026 ± 0.010	0.02
0119	2		0.019 [d]	0.021	0.020 ± 0.001	0.01
0125	2		0.017 [d]	0.066	0.042 ± 0.035	0.03
0314	2		0.058	0.080	0.069 ± 0.016	0.04
0315	1	0.013 [d]				0.01
0345	2		0.023 [d]	0.025	0.024 ± 0.001	0.02
0346	2		0.025 [d]	0.034	0.030 ± 0.006	0.02

Sampling Location*	Number of Samples	Thorium-228 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	2		0.018 [d]	0.023 [d]	0.021 ± 0.004	0.1
0119	2		0.017 [d]	0.020	0.019 ± 0.002	0.1
0125	2		0.038	0.667	0.353 ± 0.455	2.2
0314	2		0.048	0.537	0.293 ± 0.346	1.8
0315	1	0.025				0.2
0345	2		0.018 [d]	0.027	0.023 ± 0.006	0.1
0346	2		0.018 [d]	0.023 [d]	0.021 ± 0.004	0.1

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for thorium-227, thorium-228, thorium-230, and thorium-232 are 160 x 10^{-9} µCi/mL, 16 x 10^{-9} µCi/mL, 12 x 10^{-9} µCi/mL, and 2 x 10^{-9} µCi/mL, respectively.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-20. Thorium Concentrations in Onsite Monitoring Wells in 1999 (continued)

Sampling Location•	Number of Samples	Thorium-230 10^{-9} µCi/mL Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0111	2		0.010	0.014 [d]	0.012 ± 0.003	0.1
0119	2		0.008 [d]	0.017	0.013 ± 0.006	0.1
0125	2		0.050	0.561	0.306 ± 0.361	2.5
0314	2		0.248	0.624	0.436 ± 0.266	3.6
0315	1	0.013 [d]				0.1
0345	2		0.013 [d]	0.028	0.021 ± 0.011	0.2
0346	2		0.016 [d]	0.017	0.017 ± 0.001	0.1

Sampling Location*	Number of Samples	Thorium-232 10^{-9} µCi/mL Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0111	2		0.014 [d]	0.019 [d]	0.017 ± 0.004	0.8
0119	2.		0.013 [d]	0.019 [d]	0.016 ± 0.004	0.8
0125	2		0.019 [d]	0.458	0.239 ± 0.310	11.9
0314	2		0.130	0.149	0.140 ± 0.013	7.0
0315	1	0.013 [d]				0.7
0345	2		0.013 [d]	0.021 [d]	0.017 ± 0.006	0.9
0346	2		0.013 [d]	0.023 [d]	0.018 ± 0.007	0.9

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The averages have been reported as a percentage of the EPA dose standard of 4 mrem/year. The dose standard concentrations for thorium-227, thorium-228, thorium-230, and thorium-232 are 160 x 10^{-9} µCi/mL, 16 x 10^{-9} µCi/mL, 12 x 10^{-9} µCi/mL, and 2 x 10^{-9} µCi/mL respectively.

[d] Below the indicated LDL.

• Well locations shown on Figure 6-2.

Table D-21. Radium Concentrations in Onsite Monitoring Wells in 1999

Sampling Location*	Number of Samples	Radium-226 pCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	2		d	0.314	0.157 ± 0.222	3.1
0119	2		0.120	0.708	0.414 ± 0.416	8.3
0125	2		d	0.905	0.453 ± 0.640	9.1
0314	2		d	0.460	0.230 ± 0.325	4.6
0315	1	0.100				2.0
0345	2		d	0.249	0.125 ± 0.176	2.5
0346	2		d	0.630	0.315 ± 0.445	6.3

Sampling Location*	Number of Samples	Radium-228 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	2		d	0.486	0.243 ± 0.344	4.9
0119	2		d	0.732	0.366 ± 0.518	7.3
0125	2		d	1.280	0.640 ± 0.905	12.8
0314	2		d	0.460	0.230 ± 0.325	4.6
0315	1	d				0.0
0345	2		d	0.583	0.292 ± 0.412	5.8
0346	2		d	0.764	0.382 ± 0.540	7.6

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] The EPA standard for radium in drinking water is 5 pCi/L.

[d] Results below the method detection limit.

* Well locations shown on Figure 6-2.

Table D-22. VOC Concentrations in Onsite Monitoring Wells in 1999

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0063	Tetrachloroethene	4		1.70	2.38	2.01 ± 0.34	5
	Trichloroethene	4		2.60	3.90	3.25 ± 0.70	5
0119	None detected	2		d	d		
0125	None detected	2		d	d		
0111	Chloroform	2		2.80	2.80	2.80 ± 0.00	100
0158	None detected	1	d				
0305	Tetrachloroethene	4		5.50	7.10	6.35 ± 0.66	5
	Trichloroethene	3		3.50	6.40	4.60 ± 1.26	5
	1,1,1-Trichloroethane	3		4.60	5.70	5.03 ± 0.48	200
0312	cis-1,2-Dichloroethene	1	2.40				70
	Trichloroethene	1	18.0				5
0313	Tetrachloroethene	4		3.30	6.50	5.35 ± 1.49	5
	Trichloroethene	4		2.50	6.50	3.60 ± 1.94	5
0314	None detected	2		d	d		
0315	Carbon Tetrachloride	2		2.00	2.30	2.15 ± 0.21	5
	Trichloroethene	2		5.80	9.20	7.50 ± 2.40	5
0317	None detected	4		d	d		
0345	None detected	2		d	d		
0346	Tetrachloroethene	2		d	0.73	0.37 ± 0.52	5

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] No MCL assigned.

[d] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-22. VOC Concentrations in Onsite Monitoring Wells in 1999 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0347	Carbon Tetrachloride	1	5.70				5
	Trichloroethene	1	22.0				5
0353	None detected	2		d	d		
0370	Carbon Tetrachloride	4		d	3.10	1.50 ± 1.32	5
	Chloroform	4		d	4.30	1.73 ± 1.85	100
	cis-1,2-Dichloroethene	4		1.70	7.10	4.40 ± 2.22	70
	Tetrachloroethene	4		51.0	74.0	61.8 ± 9.74	5
	Trichloroethene	4		17.0	32.0	25.3 ± 6.18	5
0373	Carbon Tetrachloride	4		1.30	3.60	2.40 ± 0.94	5
	Chloroform	4		d	1.90	1.09 ± 0.92	100
	cis-1,2-Dichloroethene	4		d	1.90	0.83 ± 0.97	70
	Tetrachloroethene	4		15.0	25.0	21.0 ± 4.55	5
	Trichloroethene	4		8.50	15.0	12.0 ± 3.49	5
	1,1,1-Trichloroethane	4		d	0.45	0.11 ± 0.23	200
0374	Chloroform	4		d	1.40	0.68 ± 0.78	100
	cis-1,2-Dichloroethene	4		14.0	72.0	36.8 ± 24.8	70
	Tetrachloroethene	4		12.0	15.0	13.8 ± 1.26	5
	Trichloroethene	4		11.0	18.0	14.0 ± 2.94	5
	1,1,1-Trichloroethane	4		2.00	4.20	3.30 ± 0.96	200
0379	Carbon Tetrachloride	2		d	1.00	0.50 ± 0.71	5
	Tetrachloroethene	2		0.31	0.79	0.55 ± 0.34	5
0382	None detected	2		d	d		
0395	None detected	1	d				
0397	Tetrachloroethene	4		7.30	9.70	8.65 ± 1.24	5
	Trichloroethene	4		2.00	2.90	2.35 ± 0.44	5

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] No MCL assigned.

[d] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-22. VOC Concentrations in Onsite Monitoring Wells in 1999 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0410	Chloroform	4		d	2.10	0.53 ± 1.05	100
	cis-1,2-Dichloroethene	4		d	180.0	52.5 ± 86.2	70
	Tetrachloroethene	4		2.60	5.70	4.03 ± 1.34	5
	Trichloroethene	4		18.0	66.0	33.8 ± 22.4	5
0411	cis-1,2-Dichloroethene	3		2.20	4.80	3.10 ± 1.47	70
	Trichloroethene	3		18.0	21.0	20.0 ± 1.73	5
0415	Tetrachloroethene	4		0.41	1.80	0.99 ± 0.58	5
	Trichloroethene	4		d	2.00	0.69 ± 0.94	5
0416	Tetrachloroethene	4		d	0.63	0.16 ± 0.32	5
	Trichloroethene	4		d	1.90	0.48 ± 0.95	5
	1,1,1-Trichloroethane	4		1.00	4.30	2.53 ± 1.38	200
0417	Tetrachloroethene	4		0.56	1.40	0.83 ± 0.40	5
	Trichloroethene	4		d	2.20	0.90 ± 1.09	5
	1,1,1-Trichloroethane	4		5.00	6.80	5.60 ± 0.85	200
0418	Tetrachloroethene	4		5.10	10.0	7.55 ± 2.02	5
	Trichloroethene	4		3.00	8.50	5.48 ± 2.27	5
	1,1,1-Trichloroethane	4		5.00	6.80	5.60 ± 0.85	200
0419	Carbon Tetrachloride	4		d	1.70	0.78 ± 0.90	5
	Chloroform	4		1.20	2.50	1.98 ± 0.56	100
	Freon	4		d	3.00	1.30 ± 1.50	c
	cis-1,2-Dichloroethene	4		1.90	75.0	26.9 ± 34.1	70
	Tetrachloroethene	4		14.0	18.0	15.5 ± 1.91	5
	Trichloroethene	4		37.0	44.0	41.0 ± 3.16	5
0420	Tetrachloroethene	4		5.70	8.10	6.75 ± 1.24	5
	Trichloroethene	4		1.40	2.70	2.08 ± 0.54	5

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] No MCL assigned.

[d] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-22. VOC Concentrations in Onsite Monitoring Wells in 1999 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0421	Tetrachloroethene	3		0.60	1.10	0.80 ± 0.27	5
0422	Tetrachloroethene	4		5.00	6.00	5.30 ± 0.47	5
	Trichloroethene	4		3.80	7.30	6.08 ± 1.57	5
0423	Tetrachloroethene	4		1.30	2.00	1.50 ± 0.34	5
0424	Tetrachloroethene	4		0.35	0.69	0.52 ± 0.17	5
	1,1,1-Trichloroethane	4		5.10	7.50	6.33 ± 1.08	200
0425	Tetrachloroethene	4		d	0.62	0.40 ± 0.29	5
	1,1,1-Trichloroethane	4		5.60	12.0	8.85 ± 2.62	200
P001	Carbon Tetrachloride	1	2.00				5
	Tetrachloroethene	1	10.0				5
	Trichloroethene	1	5.30				5
P002	None detected	1	d				
P003	Tetrachloroethene	1	4.90				5
	Trichloroethene	1	1.80				5
P005	Carbon Tetrachloride	1	2.20				5
	Chloroform	1	0.89				100
	cis-1,2-Dichloroethene	1	1.20				70
	Tetrachloroethene	1	26.0				5
	Trichloroethene	1	16.0				5
P015	Chloroform	4		1.30	2.60	1.85 ± 0.58	100
	cis-1,2-Dichloroethene	4		2.60	7.10	4.58 ± 1.87	70
	Tetrachloroethene	4		5.70	8.90	7.43 ± 1.45	5
	Trichloroethene	4		15.0	27.0	22.0 ± 5.60	5

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] No MCL assigned.

[d] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-22. VOC Concentrations in Onsite Monitoring Wells in 1999 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
P027	Tetrachloroethene	4		d	2.00	1.02 ± 0.83	5
	Trichloroethene	4		d	2.20	0.88 ± 1.08	5
	1,1,1-Trichloroethane	4		2.90	5.00	4.05 ± 0.87	200
P031	Tetrachloroethene	4		1.60	2.50	2.08 ± 0.38	5
	Trichloroethene	4		2.60	3.20	3.00 ± 0.27	5
	1,1,1-Trichloroethane	4		2.60	3.60	2.98 ± 0.43	200
P043	None detected	4		d	d		
P044	1,1,1-Trichloroethane	4		3.10	4.80	3.68 ± 0.78	200
P045	None detected	4		d	d		
P046	Chloroform	4		0.75	1.30	0.93 ± 0.26	100
	Tetrachloroethene	4		0.64	1.10	0.87 ± 0.19	5
	Trichloroethene	4		1.90	3.70	2.98 ± 0.76	5

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] No MCL assigned.

[d] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-23. Inorganic Concentrations in Onsite Monitoring Wells in 1999

Well I.D.*	Compound	µg/L 1st Quarter	3rd Quarter	MCL
0111	Aluminum	27.8	NS	50-200[c]
	Chromium	40.9	NS	100[a]
	Iron	221	NS	300[b]
0119	Aluminum	43.7	43.3	50-200[c]
	Iron	1450	1180	300[b]
	Manganese	47.1	40.8	50[b]
0125	Aluminum	167	5410	50-200[c]
	Arsenic	e	11.2	50[a]
	Chromium	13.1	2030	100[a]
	Copper	e	101	1300[d]
	Iron	455	26400	300[b]
	Lead	e	43.4	15[d]
	Manganese	e	641	50[b]
	Nickel	e	23.0	100[a]
	Zinc	e	80.6	5000[b]
0314	Aluminum	6290	4220	50-200[c]
	Arsenic	605	436	50[a]
	Chromium	137	67.8	100[a]
	Iron	112000	97900	300[b]
	Lead	11.8	14.7	15[d]
	Manganese	239	291	50[b]
	Nickel	80.2	43.3	100[a]
	Silver	29.4	e	100[b]
	Zinc	56.0	83.4	5000[b]

[a] Primary Maximum Contaminant Level.

[b] Secondary Maximum Contaminant Level.

[c] The secondary MCL for aluminum is a range; final MCL values have not been established.

[d] Action level.

[e] Results below method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary and Secondary Drinking Water Standards).

NS = Not sampled.

* Well locations shown on Figure 6-2.

Table D-23. Inorganic Concentrations in Onsite Monitoring Wells in 1999 (continued)

Well I.D.*	Compound	µg/L 1st Quarter	3rd Quarter	MCL
0315	Chromium	97.4	NS	100[a]
	Iron	2180	NS	300[b]
	Manganese	19.6	NS	50[b]
	Nickel	86.0	NS	100[a]
0345	Iron	e	109	300[b]
	Manganese	21.5	20.2	50[b]
0346	Iron	368	1110	300[b]
	Manganese	66.0	52.2	50[b]
0353	Aluminum	444	188	50-200[c]
	Chromium	95.0	e	100[a]
	Iron	3520	1840	300[b]
	Manganese	138	73.9	50[b]
	Nickel	142	e	100[a]
0379	Aluminum	25.5	e	50-200[c]
	Chromium	855	592	100[a]
	Iron	12400	7760	300[b]
	Manganese	19.2	e	50[b]
	Nickel	186	144	100[a]
0382	Aluminum	72.7	28.9	50-200[c]
	Barium	297	313	2000[a]
	Chromium	24.7	e	100[a]
	Iron	371	275	300[b]
	Manganese	21.3	22.5	50[b]

[a] Primary Maximum Contaminant Level.

[b] Secondary Maximum Contaminant Level.

[c] The secondary MCL for aluminum is a range; final MCL values have not been established.

[d] Action level.

[e] Results below method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary and Secondary Drinking Water Standards).

NS = Not sampled.

* Well locations shown on Figure 6-2.

Table D-23. Inorganic Concentrations in Onsite Monitoring Wells in 1999 (continued)

Well I.D.*	Compound	µg/L		
		1st Quarter	3rd Quarter	MCL
0395	Aluminum	NS	37300	50-200 [c]
	Antimony	NS	39.5	6 [a]
	Arsenic	NS	16.4	50 [a]
	Barium	NS	294	2000 [a]
	Beryllium	NS	2.4	4 [a]
	Chromium	NS	11500	100 [a]
	Copper	NS	496	1300 [d]
	Iron	NS	179000	300 [b]
	Lead	NS	414	15 [d]
	Manganese	NS	3570	50 [b]
	Mercury	NS	0.30	2 [a]
	Nickel	NS	10800	100 [a]
	Zinc	NS	10400	5000 [b]

[a] Primary Maximum Contaminant Level.

[b] Secondary Maximum Contaminant Level.

[c] The secondary MCL for aluminum is a range; final MCL values have not been established.

[d] Action level.

[e] Results below method detection limit.

MCL = Maximum Contaminant Level (based on EPA Primary and Secondary Drinking Water Standards).

NS = Not sampled.

* Well locations shown on Figure 6-2.

Table D-24. Tritium Concentrations in Seeps in 1999

Well I.D.*	Historic Designation	Number of Samples	Tritium nCi/L Value [a]	Minimum	Maximum	Average [b,c]	Average as a % of the EPA Standard [d]
0601	S001	272		34.61	254.86	73.41 ± 23.24	367
0602	S002	0					-
0603	S003	0					-
0605	S005	0					-
0606	S006	1	7.99				40
0607	S007	25		7.66	18.15	13.63 ± 2.79	68
0608	S008	3		10.07	11.11	10.67 ± 0.54	53
0609	S009	2		0.16	0.24	0.20 ± 0.06	1

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] LDL for tritium in seep water is 0.5 nCi/L.

[d] The EPA standard for tritium in drinking water is 20 nCi/L.

* Seep locations are shown on Figure 6-6.

Table D-25. VOC Concentrations in Seeps in 1999

Seep I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0601	cis-1,2-Dichloroethene	4		c	2.50	0.93 ± 1.19	70
	Tetrachloroethene	4		10.0	15.0	12.75 ± 2.22	5
	Trichloroethene	4		4.70	6.20	5.40 ± 0.63	5
0602	cis-1,2-Dichloroethene	1	1.60				70
	Trichloroethene	1	1.80				5
0603	Not sampled						
0605	Not sampled						
0606	Trichloroethene	1	4.50				5
0607	Trichloroethene	4		1.10	2.70	2.25 ± 0.77	5
0608	None detected	3		c	c	c	c
0609	None detected	2		c	c	c	c

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Drinking Water Standard).

* Seep locations are shown on Figure 6-6.

Table D-26. Tritium Concentrations in Capture Pits in 1999

Well I.D.*	Historic Designation	Number of Samples	Tritium nCi/L Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
0712	P012	22	1.13	2.89	1.96 ± 0.46	9.8
0714	P014	21	34.52	221.64	86.17 ± 43.43	431
0725	W005	22	1.20	4.76	2.53 ± 0.88	12.7
0726	W006	22	4.91	249.87	88.05 ± 80.46	440
0727	W007	21	64.29	509.14	197.33 ± 100.75	985

[a] Error limits are one standard deviation of the estimated mean.

[b] LDL for tritium in capture pit water is 0.5 nCi/L.

[c] The EPA standard for tritium in drinking water is 20 nCi/L.

* Capture pit locations are shown on Figure 6-6.

Table D-27. VOC Concentrations in Capture Pits in 1999

Capture Pit I.D.*	Compound	Number of Samples	µg/L Value [a]	Minmum	Maximum	Average [b]	MCL
0712	cis-1,2-Dichloroethene	2		1.30	2.00	1.65 ± 0.49	70
	Tetrachloroethene	2		c	0.50	0.25 ± 0.35	5
	Trichloroethene	2		c	2.40	1.20 ± 1.70	5
0713	Tetrachloroethene	1	0.4				5
0714	Tetrachloroethene	2		0.33	0.62	0.48 ± 0.21	5
0725	Trichloroethene	1	2.0				5
0726	cis-1,2-Dichloroethene	2		2.50	4.90	3.70 ± 1.70	70
	trans-1,2-Dichloroethene	2		1.10	1.30	1.20 ± 0.14	70
	Tetrachloroethene	2		0.54	0.93	0.74 ± 0.28	5
	Trichloroethene	2		31	40	35.5 ± 6.4	5
0727	Tetrachloroethene	2		c	0.73	0.37 ± 0.52	5

[a] In cases where only one sample was collected, minimum, maximum, and average values do not apply.

[b] Error limits are one standard deviation of the estimated mean.

[c] Results below the method detection limit.

MCL = Maximum Contaminant Level (based on EPA Drinking Water Standard).

* Capture pit locations are shown on Figure 6-6.

APPENDIX E

APPENDIX E

DOSE ASSESSMENT METHODOLOGY

E.1 Exposure Routes

Members of the public receive radiation doses via various exposure pathways. For radionuclides discharged to the atmosphere, a person may inhale or be immersed in airborne radionuclides. Other routes of airborne exposure include ground deposition of radionuclides and consumption of food products that were contaminated by airborne releases. For radionuclides released to water, a person may consume contaminated water or fish. The other potential water-based exposure pathways (e.g., swimming and boating) generally do not add significantly to the dose.

E.2 Dose Calculations Based on Measured Data

For DOE reporting requirements, doses are presented as 50-year committed effective dose equivalents (CEDEs). The CEDE is the total dose equivalent that will be received by an individual over a 50-year time period as a result of one year of exposure to ionizing radiation. The total CEDE reported for MEMP is the sum of the CEDEs from the air, drinking water, and foodstuff pathways.

CEDEs for tritium, plutonium-238, plutonium-239,240, thorium-228, and thorium-230 were calculated for 1999. (Concentrations of other radionuclides were below background levels or were too small to affect the overall dose.) The CEDEs are evaluated using environmental monitoring data measured on and near the site. A CEDE for a given radionuclide is calculated as shown below. Specific input values for 1999 are shown in Table E-1. The CEDEs for all radionuclides are then summed to provide a single value for reporting purposes.

$$CEDE = \sum_{1}^{p} C_r \bullet I_a \bullet DCF$$

where CEDE = total committed effective dose equivalent, mrem.

$\sum_{1}^{p}$ = summation over the exposure pathways 1 through p.

C_r = maximum average concentration of the radionuclide.

I_a = annual intake of the environmental medium.

DCF = dose conversion factor for the radionuclide and intake type.

Table E-1. Factors Used to Calculate 1999 CEDEs

Radionuclide	Concentration[a]	Location*	Dose Conversion Factor, mrem/μCi
Tritium			
Air	9.91×10^{-12} μCi/mL	213	6.3×10^{-2} (a)
Drinking water	0.16×10^{-6} μCi/mL	Miamisburg	6.3×10^{-2}
Foodstuffs	0.28×10^{-6} μCi/mL	Miamisburg	6.3×10^{-2}
Plutonium-238			
Air	1.3×10^{-18} μCi/mL	213	3.8×10^{5} (b)
Drinking water	ND	Miamisburg	ND
Foodstuffs	2.07×10^{-9} μCi/g	Miami Township	1.93×10^{3} (b)
Plutonium-239,240			
Air	0.24×10^{-18} μCi/mL	213	4.2×10^{5} (b)
Drinking water	ND	Miamisburg	ND
Foodstuffs	0.02×10^{-9} μCi/g	Miami Township	2.18×10^{3} (b)
Thorium-228			
Air	5.55×10^{-18} μCi/mL	213	3.1×10^{5}
Drinking Water	ND	Miamisburg	ND
Foodstuffs	NA		
Thorium-230			
Air	5.79×10^{-18} μCi/mL	213	3.2×10^{5}
Drinking Water	ND	Miamisburg	ND
Foodstuffs	NA		
Thorium-232			
Air	4.62×10^{-18} μCi/mL	213	1.6×10^{6}
Drinking Water	ND	Miamisburg	ND
Foodstuffs	NA		

[a] Represents the average radionuclide concentrations in air corresponding to the location of the maximum offsite dose, average incremental radionuclide concentrations from the Miamisburg water supply, and average produce concentrations from the Miamisburg area.

ND indicates that concentrations were not detectable above the environmental level or reagent blanks.

NA = not applicable (not measured).

* Air sampling locations shown on Figure 4-4.

Annual Intake Rates	
Air	8400 m^3
Drinking water	730 L
Foodstuffs	260 kg

(a) To calculate the CEDE, the dose factor shown in the table is multiplied by 1.5 to include absorption of tritium through the skin.

(b) Plutonium releases from MEMP are believed to be insoluble (Class Y). However, to provide a reasonable degree of conservatism in the dose estimates, the Pu-238 and Pu-239 dose factors are averages of Class W and Class Y values.

E.3 Dose Calculations for NESHAPs Compliance

To demonstrate compliance with the requirements of the National Emission Standards for Hazardous Air Pollutants (NESHAPs, 40 CFR 61, Subpart H), MEMP performs additional dose calculations each year for all airborne releases. As approved by the EPA, the computer code CAP88-PC is used to calculate those doses.

The CAP88-PC computer model is a set of computer programs, databases, and associated utility programs for estimation of dose and risk from radionuclide emissions to air. CAP88-PC was developed by the U.S. EPA to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAPs) or radionuclides under 40 CFR Part 61, Subpart H.

Whenever available, MEMP uses site-specific data as input to the code. Meteorological data measured onsite are used to evaluate transport and dispersion. Stack specific release rates are used as shown below (Table E-2). Table E-2 also lists the relevant stack information used for the 1999 CAP88-PC runs.

Table E-2. 1999 CAP88-PC Input Data

Stack ID	Stack Height (meters)	Stack Diameter (meters)	Exit Velocity (meters/sec)	Radionuclide(s)	1999 Release Rate (Ci/yr)
HH	34	1.7	1.3	Tritium	3.1×10^{0}
NCDPF	41	0.6	27.9	Tritium	2.8×10^{1}
SM/PP	60	1.8	5.6	Pu-238	1.0×10^{-5}
				Pu-239,240	2.1×10^{-8}
				U-233,234	1.5×10^{-9}
				U-238	7.1×10^{-10}
SW-1CN	46	0.9	13.7	Tritium	9.0×10^{0}
				Pu-238	3.5×10^{-9}
				Pu-239,240	3.6×10^{-10}
				U-233,234	5.4×10^{-10}
				U-238	6.8×10^{-10}
T-West	60	2.4	13.4	Tritium	2.1×10^{2}
				Pu-238	6.0×10^{-7}
				Pu-239,240	9.8×10^{-9}
				U-233,234	4.1×10^{-9}
				U-238	3.3×10^{-9}
T-East	60	1.8	8.3	Tritium	9.0×10^{-2}
HEFS	46	1.9	10.2	Tritium	5.5×10^{2}
				Pu-238	8.2×10^{-9}
				Pu-239,240	9.9×10^{-10}
				U-233,234	1.6×10^{-9}
				U-238	1.2×10^{-9}
WDSS	16	0.3	11.2	Pu-238	2.7×10^{-9}
				Pu-239,240	6.1×10^{-11}
WDA	9	1.0	10.5	Tritium	4.0×10^{-1}
				Pu-238	5.9×10^{-8}
				Pu-239,240	3.3×10^{-10}
				U-233,234	1.6×10^{-10}
				U-238	7.9×10^{-10}
Building 22	7	0.9	0[a]	Tritium	2.4×10^{0}
Building 23	2	0.3	0[a]	Tritium	6.2×10^{0}
CWPF	9	0.8	12.1	Tritium	4.0×10^{-3}
				Pu-238	9.2×10^{-10}
				Pu-239,240	7.6×10^{-11}
				U-233,234	1.6×10^{-10}
				U-238	4.0×10^{-10}

[a] No credit taken for exit velocity due to orientation of the building vent.

APPENDIX F

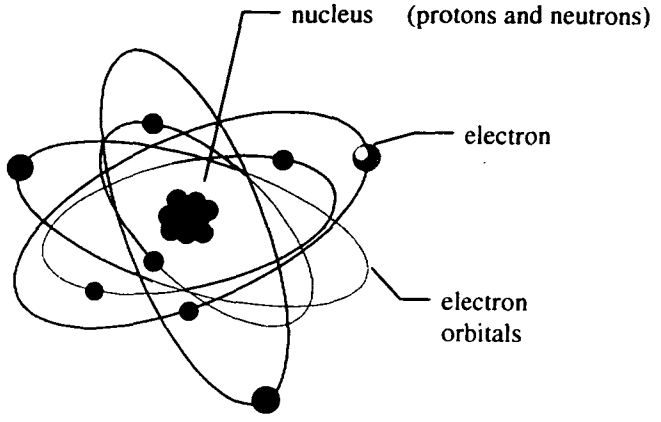
APPENDIX F

PRINCIPLES OF RADIATION

The Atom

All substances are composed of atoms. Atoms are exceedingly small with an average diameter of only about 0.000,000,001 inch. To put this in perspective, approximately 100,000 atoms lying side by side in a straight line touching one another would span the thickness of a sheet of thin paper. Atoms are composed of three basic parts:

- electrons,
- protons , and
- neutrons



Atom Model

Protons and neutrons compose the part of an atom called the nucleus. The protons have a positive electrical charge while the neutrons have no electrical charge. Protons and neutrons are similar in mass and are considerably more massive than electrons (approximately 1,800 times as massive). Therefore the nucleus contains nearly all of the mass of the atom. The electrons, which carry a negative electrical charge, orbit the nucleus. Typically, the number of protons (positive charges) in the nucleus is equivalent to the number of electrons (negative charges) in the orbits, thus creating an atom that is electrically neutral (no net charge).

The atomic number is an identifying characteristic of an element and equals the number of protons in the atomic nucleus of an atom. Each element has an associated atomic number that serves as an identifier. For example, hydrogen has an atomic number of one corresponding to one proton in the nucleus (the hydrogen atom also has an electron that orbits the nucleus thus keeping the atom electrically neutral). Plutonium, a much more massive atom, has an atomic number of 94 corresponding to 94 protons in the nucleus and 94 electrons orbiting the nucleus to maintain electrical neutrality.

The sum of the protons and neutrons in an atom's nucleus is called the mass number. Although the number of protons in the nucleus will always be the same for any given element, the number of neutrons in the nucleus can vary. For example, most hydrogen atoms have a nucleus composed of a single proton with no neutrons giving it a mass number of 1. Hydrogen atoms with mass number two are known as deuterium and have both a proton and a neutron in the nucleus.

nucleus. Tritium, a form of hydrogen important to past MEMP operations, has a nucleus composed of one proton and two neutrons. As can be seen from this example, all three forms of hydrogen have exactly one proton in the nucleus, but have differing numbers of neutrons. Chemically, these three forms of hydrogen all behave in a similar manner. These forms of hydrogen all having the same atomic number but different mass numbers are known as isotopes.

The radionuclides that are of concern at MEMP are:

Radionuclide	Mass Number	Half-Life (years)
plutonium-238	(94 protons + 144 neutrons = mass number 238)	86
plutonium-239	(94 protons + 145 neutrons = mass number 239)	24,400
plutonium-240	(94 protons + 146 neutrons = mass number 240)	6,580
uranium-233	(92 protons + 141 neutrons = mass number 233)	1.6×10^5
uranium-234	(92 protons + 142 neutrons = mass number 234)	2.5×10^5
uranium-235	(92 protons + 143 neutrons = mass number 235)	7.1×10^8
uranium-238	(92 protons + 146 neutrons = mass number 238)	4.5×10^9
thorium-228	(90 protons + 138 neutrons = mass number 228)	1.9
thorium-230	(90 protons + 140 neutrons = mass number 230)	8.4×10^4
thorium-232	(90 protons + 142 neutrons = mass number 232)	1.4×10^{10}
hydrogen-3 (tritium)	(one proton + two neutrons = mass number 3)	12.3

Radioactivity and Radiation

The atomic nucleus is held together by exceedingly strong forces of attraction which act indiscriminately between its protons and neutrons, protons and protons, neutrons and neutrons. Certain isotopes, because of their own physical makeup, are unstable. This instability is due to an unbalanced ratio between the number of protons and the number of neutrons. This instability in the nucleus causes the atom to change spontaneously to a more stable, less energetic state. This spontaneous change is called radioactivity and the atom is said to decay or disintegrate. Radiation is the particles and energy associated with the radioactivity. The three major types of radiation are alpha, beta, and gamma.

When a radioactive atom decays, its nucleus changes and the resultant atom may no longer be the same kind of atom; it can transform into an element of different atomic number. As noted above, the radioactive decay is brought about by instability in the nucleus and therefore, by the process of radioactive decay, the atom strives to achieve a more stable configuration. The ultimate stable configuration is not always reached in decay transformation. In fact, the new element, called a "daughter" resulting from the radioactive decay may be more unstable than the "parent." Ultimately the original radionuclide will be transformed into a stable element through a series of transformations. The decay sequence from radioactive parent to radioactive daughter is called a radioactive decay chain. The time required for one-half of all the atoms of a radionuclide to decay is called its "half-life." The half-life is an average value for any very large number of atoms. It does not accurately apply to a small number of atoms.

Each atom essentially takes its own time to decay and there is no predicting when its instability will cause it to do so. Radionuclides with short half-lifes such as iodine-131 (used in medical radiotherapy) decay away rapidly and may not pose as much of an environmental concern as a long lived (long half-life) radionuclide like plutonium-239 which may remain in the environment for many thousands of years.

As noted above, there are three primary types of radiation:

- alpha
- beta
- gamma

Alpha particles result when the unstable nucleus of a radionuclide ejects a particle consisting of two protons and two neutrons. The resulting particle has a net positive charge and will therefore react with any atoms that are nearby (i.e. with the negative electronic charges of the orbital electrons or the positive electronic charge of the protons in the nucleus). These interactions cause the alpha particle to give up some of the original energy it contained when ejected from the nucleus. In fact there are enough atoms within the thickness of an ordinary sheet of paper to react with and bring to rest most alpha particles. The alpha particle will therefore not penetrate solid material to any significant depth. If, however, an alpha particle is released inside the human body (by means such as inhaling radioactive particles) the emitted alpha particle will be brought to rest rapidly within a small volume of human tissue. Thus all of the energy of the alpha particle is released within a small volume of tissue and cellular damage can occur. Isotopes of plutonium and uranium are examples of radionuclides used by MEMP that decay by emitting alpha particles.

Beta particles result when the unstable nucleus of a radionuclide ejects a particle consisting of a negatively charged electron. As with alpha particles, the charged beta particle interacts with any atoms that are nearby thus losing some of its initial energy. However, because beta particles have only half the charge of an alpha particle and are ejected from the nucleus with a much greater velocity, most can penetrate solids more readily than alpha particles. When compared to an alpha particle, beta particles give up their initial energy over a longer distance. This results in less localized damage to tissue that may interact with a beta particle. Tritium is an example of a radionuclide used by MEMP that decays by emitting a beta particle.

Gamma rays, unlike alpha and beta particles, are not discrete physical particles. Instead a gamma ray is a package of energy that behaves as though it were a particle. Gamma rays are exactly the same in nature as visible light, heat waves, radio waves, radar rays and x-rays. They have very short wavelengths like those of most x-rays and are generally more energetic than x-rays. The penetrating power of x-rays is well known and since gamma radiation is very much like the radiation of x-rays the penetrating power of gamma radiation is also very high. Gamma rays can pass through the human body giving up small amounts of energy along the way. Many radionuclides emit both alpha and gamma or beta and gamma radiation upon decay. Isotopes of plutonium are examples of radionuclides used by MEMP that decay by emitting both alpha and gamma radiation.

Units of Measurement

Radioactivity is typically measured in terms of "activity." Activity corresponds to the number of atomic nuclei of any particular radionuclide that decay over a specified time interval. A "curie" (Ci) is a unit typically used to define activity. One curie is equal to the amount of radioactive material that decays at a rate of 37 billion atoms per second. This disintegration rate is almost exactly the rate at which one gram of radium-226 decays. As noted earlier, each radioactive isotope follows its own specific decay schedule in accordance with its half-life. As a result, for a given quantity of material (e.g. one gram), different radionuclides will vary in the number of nuclei that will disintegrate over a given time period. Therefore equal masses of different radionuclides have varying activity levels that are dependent on each radionuclide's half-life. As an example, one gram of radium-226 (radium-226 has a half-life of 1,600 years) is equivalent to one curie of activity. It would take about 1.5 million grams of uranium-238 (half-life 4.5 billion years) to have an activity of one curie. In other words it would take 1.5 million grams of uranium-238 to yield 37 billion disintegrations per second. As can be seen from the example, radionuclides that decay rapidly (short half-lives) have relatively high activity levels compared to radionuclides that have very long half-lives.

It should be noted that a curie is only related to the number of disintegrations that occur in a given time frame and does not indicate the biological damage that the radionuclide could cause if it comes into contact with a person. That is to say that one curie of tritium is not equivalent to one curie of plutonium-238 in terms of the biological effect on living tissue. The activity levels of radionuclides in the environment due to MEMP activities operations are typically very small fractions of a curie. A convenient way to express these very small curie fractions is introducing two additional units: the microcurie (μCi) (one millionth of a curie) and the picocurie (pCi) (one trillionth of a curie). These units are used throughout this Report.

Radiation Dose

Radiation exposure is described in terms of a "dose." Dose is a measure of the amount of radiation delivered to a body. As noted in the previous section, for a given activity level, different radionuclides will vary in their ability to cause biological damage (e.g., at a given activity level, alpha radiation is more damaging than beta). A "dose equivalent" is a means of comparing the dose resulting from exposure to various radionuclides. The Roentgen Equivalent Man (rem) is the unit used to express the dose equivalent. A rem is defined as the dose, measured in terms of a specific amount of energy, which produces the biological equivalent to that produced by the same amount of x-ray energy. The rem allows for a direct comparison of the potential damage that may be caused by exposure to various radionuclides. The higher the rem value, the greater the potential for biological damage.

Dose can be viewed in several different ways and is typically reported with respect to either a specific organ, an effective dose, a committed effective dose, or a whole body dose. Each dose measure will be discussed below.

The ***organ dose*** is the estimated dose received by a specific organ due to exposure to radiation. Certain radionuclides may tend to accumulate within specific organs of the body. Critical organs can be identified based on the chemistry of the radionuclide, the amount of radiation, the sensitivity of the organ to radiation, and the importance of the organ to the body.

The ***effective dose*** estimates the health risk that a radiation dose poses to an individual. The effective dose is calculated by summing the weighted organ dose for each organ. The weighted organ dose is simply the original calculated organ dose multiplied by an importance factor that takes into account the relative risk to the exposed organ.

Some radionuclides assimilated into the body can remain in the body for long periods of time. When particulate material (e.g., dust) contaminated with plutonium is breathed, the plutonium is deposited in the lung tissue. The plutonium will slowly be removed from the body - the original quantity will be reduced over time due to radioactive decay and biological factors. The plutonium is continually emitting alpha and gamma radiation while in the lungs. The individual is therefore exposed to this radiation for the remainder of his life.

The ***committed effective dose equivalent*** indicates the total dose over the individual's projected remaining lifetime (assumed to be 50 years) which results from an intake during one year. The committed effective dose equivalent (CEDE) expresses the dose of internal radiation received when an individual has ingested or inhaled a radionuclide that will remain inside the body for months or years. It is also expressed in rem, mrem (1000 mrem = 1 rem), or Sieverts.

Dose Due to Exposure to Background Radiation Sources

Every day our bodies absorb ionizing radiation. Most of it comes from natural sources. Consumer products and medical procedures that use radiation are other common sources of ionizing radiation.

Natural Sources. Natural radiation comes from two sources: cosmic and terrestrial. Cosmic radiation results when energetic particles from outer space, traveling at nearly the speed of light, collide with nuclei in our atmosphere, creating showers of radioactive particles that continue towards earth. The average annual dose equivalent received from cosmic radiation is 26 mrem for an individual living at sea level. Because cosmic radiation dissipates as it travels through the atmosphere, individuals living at lower altitudes receive less dose from this source than those living at higher altitudes.

Terrestrial radiation results when radionuclides that are a natural part of the earth's rocks and soils emit ionizing radiation. Because the concentrations of these radionuclides vary geographically, an individual's exposure depends on his location. The average annual dose equivalent from terrestrial radiation for an individual living in the U. S. is 28 mrem.

Besides absorbing radiation from external radionuclides, we can also absorb radiation internally when we ingest radionuclides along with the food, milk, and water we ingest or along with the air we inhale. Once in our bodies, radionuclides follow the same metabolic paths as nonradioactive forms of the same elements. The length of time a particular radionuclide remains and emits radiation depends on whether the body eliminates it quickly or stores it for a long period, and on how long it takes for the radionuclide to decay into a nonradioactive form. The principal source of internal exposure in the U. S. is believed to be radon. Inhalation of radon contributes about 200 mrem to the average annual dose equivalent from internal radiation. Other radionuclides present in the body contribute approximately 39 mrem.

Consumer Products. Many familiar consumer products emit ionizing radiation. Some must emit radiation to perform their functions, e. g., smoke detectors and airport x-ray baggage inspection systems. Other products, e.g., TV sets, emit radiation only incidentally to performing their functions. The average annual effective dose equivalent to an individual from consumer products ranges from 6 to 12 mrem.

Medical Uses. Radiation is a tool for diagnosing and treating disease. The average annual dose equivalent for an individual in the U. S. from diagnostic radiation is 53 mrem. Individuals undergoing radiation therapeutic procedures may receive much higher doses.

Radiation Environment at MEMP

On average the annual radiation dose due to background radiation to a person living in the United States is about 300 millirem. The total contribution to this dose due to MEMP activities in 1999 was 1.17 mrem, or a very small fraction of the dose received from background.

MEMP's dose contribution for 1999 was well within all applicable guidelines, limits, and regulatory standards. These guidelines, limits and standards are levels which present very low risk to individuals near the site. MEMP, like all DOE sites, strives to keep worker and public doses as low as reasonably achievable.

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WDTN-TV

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WHIO Radio

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WMMX Radio
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WING Radio

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WONE/WTUE Radio

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WFCJ Radio

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WROU Radio

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Miamisburg News

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Associated Press

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Dayton Daily News

Heather Martin
The Business News

Marianne McMullen
Impact Weekly

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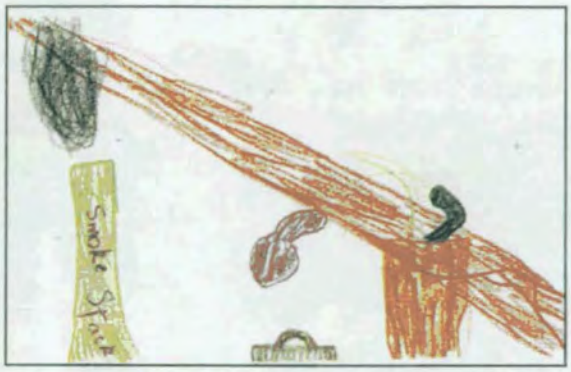

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