1001-0302190002

BWXT of Ohio, Inc.

Miamisburg Environmental Management Project

Annual Site Environmental Report for Calendar Year 2001

September 2002

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 2001

September 2002

Mound Plant, January 1949

Prepared by the
Environmental Compliance & Analytical Services 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

ACHP	Advisory Council on Historic Preservation
ALARA	As Low As Reasonably Achievable
APG	Analytical Products Group, Inc.
ATSDR	Agency for Toxic Substances and Disease Registry
ATD	Authorization to Discharge
BCG	Biota Concentration Guide
BDAC	Biota Dose Assessment Committee
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
CY	Calendar Year
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
EADS	Energy Asset Disposal System
EDE	Effective Dose Equivalent
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ERLE	Energy-Related Laboratory Equipment
ERS	Effluent Recovery System
ESA	Endangered Species Act
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
GSA	General Services Administration
HABS	Historic American Buildings Survey
HAER	Historic American Engineering Record
HEPA	High Efficiency Particulate Air
HQ	Headquarters
HSWA	Hazardous and Solid Waste Amendments
HT	Tritium, elemental
HTO	Tritium, oxide

LIST OF ACRONYMS (continued)

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
MHSF	Moderately Hard Synthetic Freshwater
MMCIC	Miamisburg Mound Community Improvement Corporation
MOA	Memorandum of Agreement
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
NPS	National Park Service
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
REM	Roentgen Equivalent Man
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)
Sv	Sievert
SWPPP	Storm Water Pollution Prevention Plan
THMs	Trihalomethanes
TSCA	Toxic Substances Control Act
TU	Toxicity Units
U. S. EPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound

LIST OF ACRONYMS (continued)

WIPP	Waste Isolation Pilot Plant
WM/PP	Waste Minimization/Pollution Prevention

CONTRIBUTORS

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GLOSSARY

Executive Summary

hazardous waste - USEPA uses the term hazardous wastes for chemicals that are regulated under the Resource, Conservation and Recovery Act (40 CFR Part 261.33). Hazardous wastes in transportation are regulated by DOT (49 CFR Parts 170 - 179). Waste chemicals and compounds that are being disposed of that have been determined by the USEPA under the RCRA to require specific procedures for their management and disposal. At Mound, today, most hazardous wastes are waste automotive fluids, solvents and acids associated with environmental laboratory operations, cleaning fluids and photographic wastes.

radioactive waste - Radioactive wastes include process residuals an/or equipment that is being disposed of that contains radioactive residues or that was rendered radioactive because of the close proximity of that equipment or the process residual to a radioactive material.

tritium - A form of hydrogen with a nucleus composed of one proton and two neutrons.

dose - Energy absorbed per unit mass of material. Also, synonymous with radiation absorbed dose.

disintegrations per minute (dpm) - Rate of spontaneous emission of particles and energy from the unstable nucleus of an atom. The Ci is a unit of activity quantifying this process of radioactive decay.

population dose - The average dose in a given area multiplied by the number of people living there.

radiation - The particles and energy associated with the spontaneous change of an atom to a more stable, less energetic state.

maximum contaminant level (MCL) - The maximum permissible level of a contaminant in water delivered to any user of a public water system. MCLs are enforceable standards.

potential release site (PRS) - An area of the site where there is potential for impact to the environment or human health.

curie (Ci) - Unit of radioactivity equal to that quantity of radioactive material in which there are 3.7×10^{10} nuclear transformations per second or 3.7×10^{10} Bq. One μCi is equal to 3.7×10^{4} nuclear transformations per second or one-millionth part of a Ci. In the International System of Units, one Ci is equal to 3.7×10^{10} Bq.

Derived Concentration Guides (DCGs) - 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.

incremental concentration - The amount by which a sample exceeds the background or environmental level. 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.

particulate - Particulate matter includes a wide range of pollutants -- road dust, diesel soot, fly ash, wood smoke, and sulfate aerosols that are suspended as particles in the air. These particles are a mixture of visible and microscopic solid particles and minute liquid droplets known as aerosols.

ambient environment - The surrounding air, water, and soil.

total suspended solids (TSS) - Total suspended solids (TSS) concentrations and turbidity both indicate the amount of solids suspended in the water, whether mineral (e.g., soil particles) or organic (e.g., algae). However, the TSS test measures an actual weight of material per volume of water, while turbidity measures the amount of light scattered from a sample (more suspended particles cause greater scattering).

outfall - The place where an effluent is discharged into receiving waters.

volatile organic compounds (VOCs) - Chemicals that contain carbon. Volatile organic compounds vaporize at room temperature and pressure.

Chp 1

subsurface structural folding - Bending of the subsurface bedrock underlying the glacial till resulting from compressional forces in the geologic past as a result of mountain building.

significant stratigraphic thinning - The tendency of a rock layer in the subsurface or of a layer of glacial till to have pronounced thinning or to lose thickness over distance in any direction.

subsurface faulting - A fracture or fracture zone in the subsurface bedrock underlying the glacial till where there has been displacement of the sides of the underlying bedrock along a fracture.

sole source aquifer - An aquifer that supplies 50 percent or more of the drinking water of an area.

100-year storm event - A rainfall causing storm that is expected to occur, on average, once every 100 years.

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, inhaled or absorbed a radionuclide that will remain inside the body. It is also expressed in 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.

Chp 2

BWXTO - BWXT of Ohio has been the managing contractor at the Miamisburg Environmental Management Project since October 1, 1997.

National Priorities List (NPL) - EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. The list is based primarily on the score a site receives from the Hazard Ranking System. EPA is required to update the NPL at least once a year. A site must be on the NPL to receive money from the Trust Fund for remedial action.

gross alpha - Total activity due to emission of alpha particles. Used as the screening measurement for radioactivity generally due to naturally-occurring radionuclides. Activity is commonly measured in picocuries.

gross beta - Total activity due to emission of beta particles. Used as the screening measurement for radioactivity from man-made radionuclides since the decay products of fission are beta particles and gamma ray emitters. Activity is commonly measured in picocuries.

radium - It is present in all uranium minerals. Emits alpha, beta, and gamma rays. The curie is defined as the amount of radioactivity which has the same disintegration rate as 1 g of Ra^{226}. Loses about 1% of activity every 25 years and the final disintegration product is lead.

total coliform - The total coliform bacteria test is a primary indicator of "potability" , suitability for consumption, of drinking water. It measures the concentration of total coliform bacteria associated with the possible presence of disease causing organisms. Coliform bacteria are a natural part of the microbiology of the intestinal tract of warm blooded mammals, including man. Coliform bacteria can also be found in soil, other animals, insects, etc. The total coliform group is relatively easy to culture in the lab, and therefore, has been selected as the primary indicator bacteria for the presence of disease causing organisms.

mixed wastes - Radioactive wastes that are also regulated by RCRA.

extremely hazardous substance (EHS) - A substance listed in appendices A and B of 40 CFR Part 355. EHSs are acutely toxic chemicals which cause both severe short- and long-term health effects after a single, brief exposure.

hazardous chemical - Any chemical, element, chemical compound, or mixture of elements with one or more of the following characteristics: acute (includes corrosives, highly toxics, irritants, sensitizers, and toxics), chronic (includes carcinogens), fire (includes combustible liquids and flammables), reactive (includes organic peroxides, unstables, and water-reactives), and sudden release of pressure (includes compressed gases and explosives).

polonium - Po^{210} is an alpha emitter with a half-life of 138 days.

Chp 3

ALARA - As Low As Reasonably Achievable

$CBOD_5$ - Five day carbonaceous oxygen demand

COD - Chemical oxygen demand amount of oxygen in milligrams per liter to oxidize both organic and oxidizable inorganic compounds.

Ceriodaphnia dubia and Pimephales promelas - In whole effluent toxicity (WET) tests, organisms are exposed to various effluent concentrations for a specific time period in order to estimate the effluent's toxicity. Receiving water (the water which the effluent is discharged into) is used as the dilution water in WET tests in order to simulate what actually happens in the aquatic environment when the effluent is introduced. The most commonly used organisms in WET tests are the fathead minnow (*Pimephales promelas*) and an invertebrate (*Ceriodaphnia dubia*). Two types of WET tests are used. The objective of an acute test is to determine the concentration of test material that produces lethality during a short-term exposure (48 or 96 hours). Chronic tests estimate the concentration of effluent that interferes with the growth, development, and reproductive potential of aquatic organisms.

environmental levels - Measurable concentrations due to naturally occurring or non-MEMP activities.

groundwater - The supply of fresh water found beneath the Earth's surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants or leaking underground storage tanks.

transuranic - Elements with an atomic number greater than 92, i.e. elements above uranium in the periodic table.

Chp 4

HEPA filters - High Efficiency Particulate Air filters.

confidence level - Upper and lower boundary values of a range of statistical probability numbers.

aliquot - A portion of a solution.

resuspension - Transport of particles from surfaces (inside and environmental) back into the atmosphere.

composite samples - A combination of individual samples taken at selected intervals, generally hourly for some specified period, to minimize the effect of the variability of the individual sample. Individual samples may have equal volume or may be proportioned to the flow at time of sampling.

liquid scintillation counting - The beta decay electron emitted by the radioactive isotope in the sample excites the solvent molecule, which in turn transfers the energy to the solute, or fluor. The energy emission of the solute (the light photon) is converted into an electrical signal by a photomultiplier tube.

Chp 5

zeolite softener - Addition compounds of the type $Na_2O \cdot Al_2O_3 \cdot n\ SiO_2 \cdot m\ H_2O$, with calcium sometimes replacing or present with the sodium. The sodium in the zeolite exchanges with calcium in water, making zeolites useful for water softening. Zeolites soften water by exchanging Ca^{2+} ions with Na^{+} ions.

cooling tower blowdown - The withdrawal of water from an evaporating water system to maintain a solids balance within specified limits of concentration of those solids from a device that aids in heat removal from water used as a coolant.

Notice of Violation (NOV) - A Notice of Violation (NOV) is a letter, sent by Certified mail, advising an individual, corporation or other entity of a violation of a permit, and/or District or State law. It also gives the violator a chance to work out their problem informally, before legal action is taken.

Chp 6

piezometers - An instrument for measuring the pressure head of liquids.

capture pits - Groundwater collection devices used on the Main Hill to isolate and monitor contamination in perched groundwater.

glacial outwash deposits - Sediments occurring today as soils that were deposited in streambeds by glacial melt waters located down gradient from or beyond a glacier as it melted.

interconnected secondary porosity - Connected pore space in rock resulting from forces after the rock was deposited, through natural forces or such as dissolution or stress that has increased the capability of water to move in the rock.

Primary MCLs - The maximum concentrations allowed under the Safe Drinking Water Act (SDWA).

Secondary MCLs - The guidelines for maximum advisable concentrations for other contaminants not limited by Primary MCLs.

turbidity - The cloudy appearance of water caused by the presence of suspended and colloidal matter. In the waterworks field, a turbidity measurement is used to indicate the clarity of water. Technically, turbidity is an optical property of the water based on the amount of light reflected by suspended particles. Turbidity cannot be directly equated to suspended solids because white particles reflect more light than dark-colored particles and many small particles will reflect more light than an equivalent large particle.

bias - A deviation of the expected value of a statistical estimate from the quantity it estimates.

precision - The degree of refinement with which a measurement is stated.

App. B

standard deviation - A measure of the spread in a population that has the same units as the original measurements and as the mean. The standard deviation is the square root of the variance.

EXECUTIVE SUMMARY

The purpose of this report is to characterize the environmental management performance of the Miamisburg Environmental Management Project (MEMP) in calendar year 2001 and to demonstrate compliance with the requirements of DOE Order 5400.1, "General Environmental Protection Program," DOE Order 5400.5, "Radiation Protection of the Public and Environment," and DOE Order 231.1, "Environment, Safety and Health Reporting." The MEMP is a government-owned site operated by BWXT 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), 28 private businesses are operating at the site.

MEMP is comprised of 90 structures on 184 acres of land in Miamisburg, Ohio, approximately 16 km (10 mi) southwest of Dayton. In 2001, 95 acres of property were transferred to MMCIC. More than 10 structures have been demolished or transferred.

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 a mix of farmland, 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 Accomplishments

Many accomplishments occurred in 2001, and some of these are listed below. Further details about these accomplishments are provided in the Executive Summary and in Chapters 2 – 6 of the report.

- six structures (B, 85, Bioremediation, Drop Tower, 71, 73) were demolished;
- more than 47,000 pounds of hazardous waste were shipped offsite;
- over 135,000 ft^3 of radioactive waste was shipped offsite;
- the maximum offsite dose from all radioactive emissions was 0.2% of the DOE standard;
- the population dose from radioactive emissions of 2.8 person-rem was approximately 0.00028% of total background radiation;
- over 1350 NPDES water samples were taken with only 3 reportable exceedances;
- the average tritium concentration detected in Miamisburg drinking water was 0.6% of the U.S. EPA's maximum contaminant level (MCL);

ES.2 Perspective on Radiation

Radionuclides 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 and man-made sources is about 355 mrem (3.55 mSv) per year. (NCRP, 1987) 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.3 Radionuclide Releases from MEMP

Table ES-1 lists the quantities of radionuclides released by MEMP into the air and surface water during 2001. 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 2001

Radionuclide	Released to	Activity, Ci	MEMP Range[b], Ci
Tritium	Air	8.3×10^{2} [a]	$3.8 \times 10^{2} - 8.3 \times 10^{2}$
	Water	2.2	1.7 – 2.5
Plutonium-238	Air	5.7×10^{-6}	$5.7 \times 10^{-6} - 4.5 \times 10^{-5}$
	Water	1.2×10^{-4}	$1.6 \times 10^{-4} - 4.8 \times 10^{-4}$
Plutonium-239,240	Air	4.2×10^{-8}	$3.0 \times 10^{-8} - 1.0 \times 10^{-7}$
	Water	2.3×10^{-6}	$2.3 \times 10^{-6} - 3.6 \times 10^{-6}$
Radon-222	Air	4.6	1.0 – 4.6
Uranium-233,234	Air	1.9×10^{-8}	$8.0 \times 10^{-9} - 1.9 \times 10^{-8}$
	Water	3.4×10^{-4}	$3.4 \times 10^{-4} - 3.9 \times 10^{-4}$
Uranium-238	Air	1.0×10^{-8}	$4.0 \times 10^{-9} - 1.1 \times 10^{-8}$

[a] Tritium released to air consists of: Tritium oxide, 7.07×10^{2} Ci
Elemental tritium, 1.25×10^{2} Ci

[b] Minimum – Maximum (CY1997 – CY2001)

ES.4 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.5 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 2001. This individual was assumed to have:

- breathed exclusively air with radionuclide concentrations corresponding to the location of the maximum 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 2001. CEDEs for tritium, plutonium-238, 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.

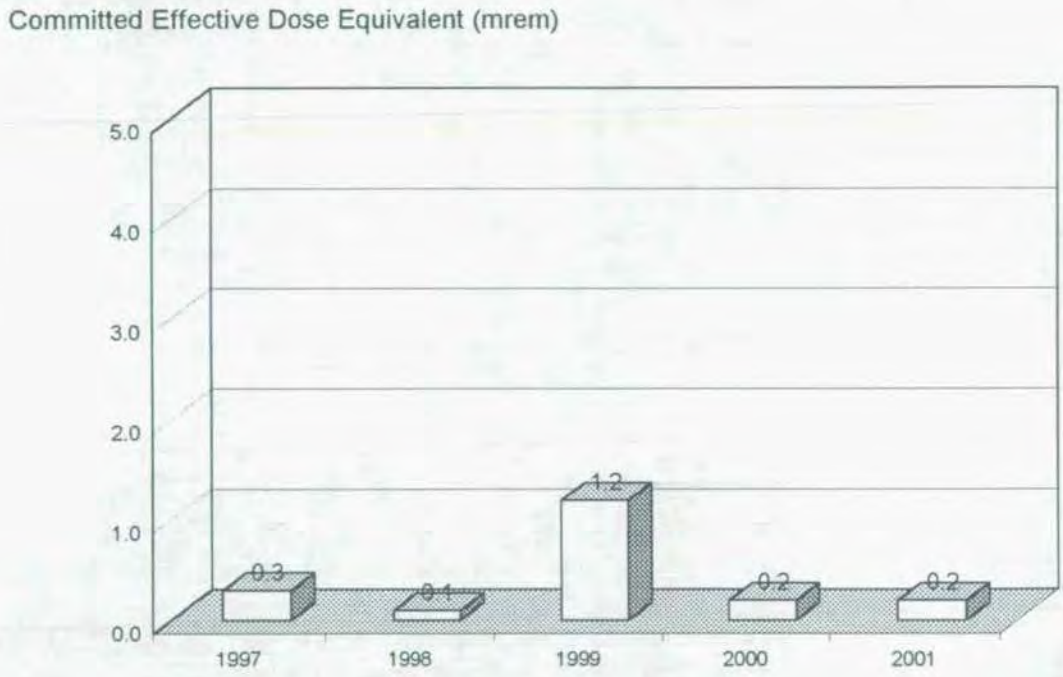
Table ES-3. Maximum Committed Effective Dose Equivalents to a Hypothetical Individual in 2001

Radionuclide	Pathway	mrem	mSv
Tritium	Air	0.006	0.00006
	Drinking water	0.005	0.00005
	Foodstuffs	0.002	0.00002
	Total	0.013	0.00013
Plutonium-238	Air	0.049	0.00049
	Drinking water	ND	ND
	Foodstuffs	0.11	0.0011
	Total	0.159	0.00159
Plutonium-239,240	Air	ND	ND
	Drinking water	ND	ND
	Foodstuffs	ND	ND
	Total	ND	ND
Thorium-228	Air	0.01	0.0001
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.01	0.0001
Thorium-230	Air	0.011	0.00011
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.011	0.00011
Thorium-232	Air	0.038	0.00038
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.038	0.00038
Total		0.23	0.0023

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. Figure ES-1 shows the five year trend in CEDEs. The doses from MEMP activities in 1997-2001 were small fractions of the 100 mrem per year DOE dose limit for members of the public. Most of the 1999 CEDE was due to one set of vegetation samples. These samples had measurable, although very low, levels of Pu-238 that were greater than observed at other locations in previous years.

Figure ES-1. Calculated CEDEs from MEMP Activities, 1997 - 2001



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 2001, the CAP88-PC-estimated maximum offsite dose was 0.07 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 2001 represented 0.7% of the dose limit set by the EPA.

Population doses. CAP88-PC also has the capability of estimating regional population doses from airborne releases. The population, approximately 3,126,615 persons, within a radius of 80 km (50 mi) of MEMP received an estimated 2.84 person-rem from site activities in 2001. 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 2.84 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 3.127 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 0.00028% of that value.

ES.6 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 2001 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 six perimeter stations and by an offsite network of 14 stations (see Figures 4-4 and 4-5). Thirteen 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 2001, average incremental concentrations measured at the onsite samplers were less than 0.015% of the DOE DCG for tritium oxide, and less than 0.055%, 0.0025%, and 0.045% of the DOE DCGs for plutonium-238, plutonium-239,240, and thorium isotopes, respectively.

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. Over 300 samples were collected in 2001. Average tritium concentrations in the river were less than 0.095% 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 0.025% of the DCGs. The average incremental concentrations of uranium-233,234 and uranium-238 were below the environmental level. Average incremental thorium-228, thorium-230 and thorium-232 concentrations were less than 0.095% of the DOE DCGs.

Pond Water. Eighteen samples from local ponds were analyzed for tritium, plutonium-238, and plutonium-239,240. Incremental concentrations of tritium were less than 0.0095% of the DOE DCG. Incremental concentrations of plutonium-238 and plutonium-239,240 were below 0.015% of the DCGs.

Sediment. One hundred forty eight samples were collected. Plutonium and thorium results for river and pond sediments are listed in Appendix B, Tables B-14 through B-18. Maximum and average concentrations for 2001 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. Average incremental concentrations of plutonium-238 ranged from below environmental level to 1523×10^{-9} μCi/g. Average plutonium-239 concentrations in river and stream sediments ranged from 1.0×10^{-9} μCi/g to 14.4×10^{-9} μCi/g. Average incremental concentrations of plutonium-239 in pond sediments ranged from below environmental level to 1.3×10^{-9} μCi/g. Average incremental concentrations of thorium ranged from 0.16×10^{-6} μCi/g to 0.98×10^{-6} μCi/g.

Radiological Monitoring of Foodstuffs

Over thirty samples of locally-grown produce were 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 125×10^{-9} μCi/g, 0.22×10^{-9} μCi/g, and environmental level, respectively. In 2000, average incremental concentrations of tritium, plutonium-238 and plutonium-239,240 were below 55×10^{-9} μCi/g, 0.075×10^{-9} μCi/g, and 0.11×10^{-9} μCi/g, 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 2001, over 1,350 samples were collected to demonstrate compliance with these permits. Three of six NPDES permit exceedances recorded were reportable. Five of the exceedances were total suspended solids (TSS) while the other was oil and grease. Three daily TSS concentration limitations exceedances were exempted due to storm flow conditions. No ATD exceedances occurred in 2001. No enforcement actions were initiated in 2001. Key results are summarized in Appendix C, Table C-3. A review of NPDES and ATD performance over the past five years is shown in Figure 5-2.

ES.7 Groundwater Monitoring Program

MEMP maintains an extensive network of onsite and offsite monitoring wells. In addition, a number of onsite production wells and offsite community water supplies are routinely sampled. Drinking water from MEMP and the Miamisburg area is analyzed for tritium and isotopes of plutonium, uranium, and thorium. Other regional water supplies are sampled for tritium since it is the most mobile of the radionuclides released from the site. Tritium levels in onsite production wells have consistently been less than 1 nCi/L. Average tritium concentrations ranged from less than the blank value to 0.48 nCi/L, or less than 2.4% of the MCL. Results for 2001 are shown in Appendix D, Table D-2 and D-12. 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 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 2001 the dose from plutonium, uranium, and thorium measured in the onsite production wells was 0.08 mrem, which is 2.0% of the dose standard. The dose from tritium was 1.6% of the 4 mrem/year standard, or 0.06 mrem/yr. The total of 0.14 mrem/yr represents 3.5% of the standard.

Monitoring 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 2001 indicated that volatile organic compounds and tritium, respectively, are the primary nonradiological and radiological contaminants of concern. Since the implementation of the OU1 treatment systems, monitoring and production wells have generally seen a decline in VOC concentrations as evident of the five-year trend for Production Well 0076 as shown in Figure 6-9 of Chapter 6.

In addition to the historical contaminants, trihalomethanes (THMs) have been detected in offsite and onsite monitoring wells. THMs are generally considered disinfection-by-products from chlorination. Sixty onsite-monitoring wells are sampled for nearly 40 organic compounds. Fourteen wells have been sampled for semi-volatile organics. Many of the wells are sampled to evaluate containment of the plume and the effectiveness of the OU1 treatment process. A declining trend in VOC concentrations has been observed. Results for 2001 are presented in

Appendix D, Table D-23. In 2001, carbon tetrachloride, trichloroethene, and tetrachloroethene exceeded drinking water MCLs. In addition to the historical contaminants, THMs have been detected in approximately half of the onsite monitoring wells.

Further information about groundwater monitoring results for 2001 can be found in Chapter 6 and Appendix D.

ES.8 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.

The demolition of E Building was completed. In addition, B Building, Building 85, the Bioremediation Facility, the Drop Tower, Building 71, and Building 73 were demolished. Internal components and fixtures were removed from Building 38, HH Building, WD Building, and the SW/R Buildings.

Several Potential Release Sites (PRSs) were sampled and assessed. The Phase III sampling for PRS 66 was completed. In addition, PRS 277/278, 303, 72, 73, 87, 76, 274/275, 276, and 80 were sampled. Highlights of the environmental restoration program during 2001 are described in Chapter 3 of this report.

ES.9 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.

1.0 INTRODUCTION

1.1 Description of the Miamisburg Environmental Management Project

Location

The Miamisburg Environmental Management Project (MEMP) is comprised of 86 buildings on 184 acres of land (at the end of 2001) 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 a mix of farmland, residential areas, small communities and light industry. Many city and township residences, five schools, the Miamisburg downtown area, and six of the city's 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

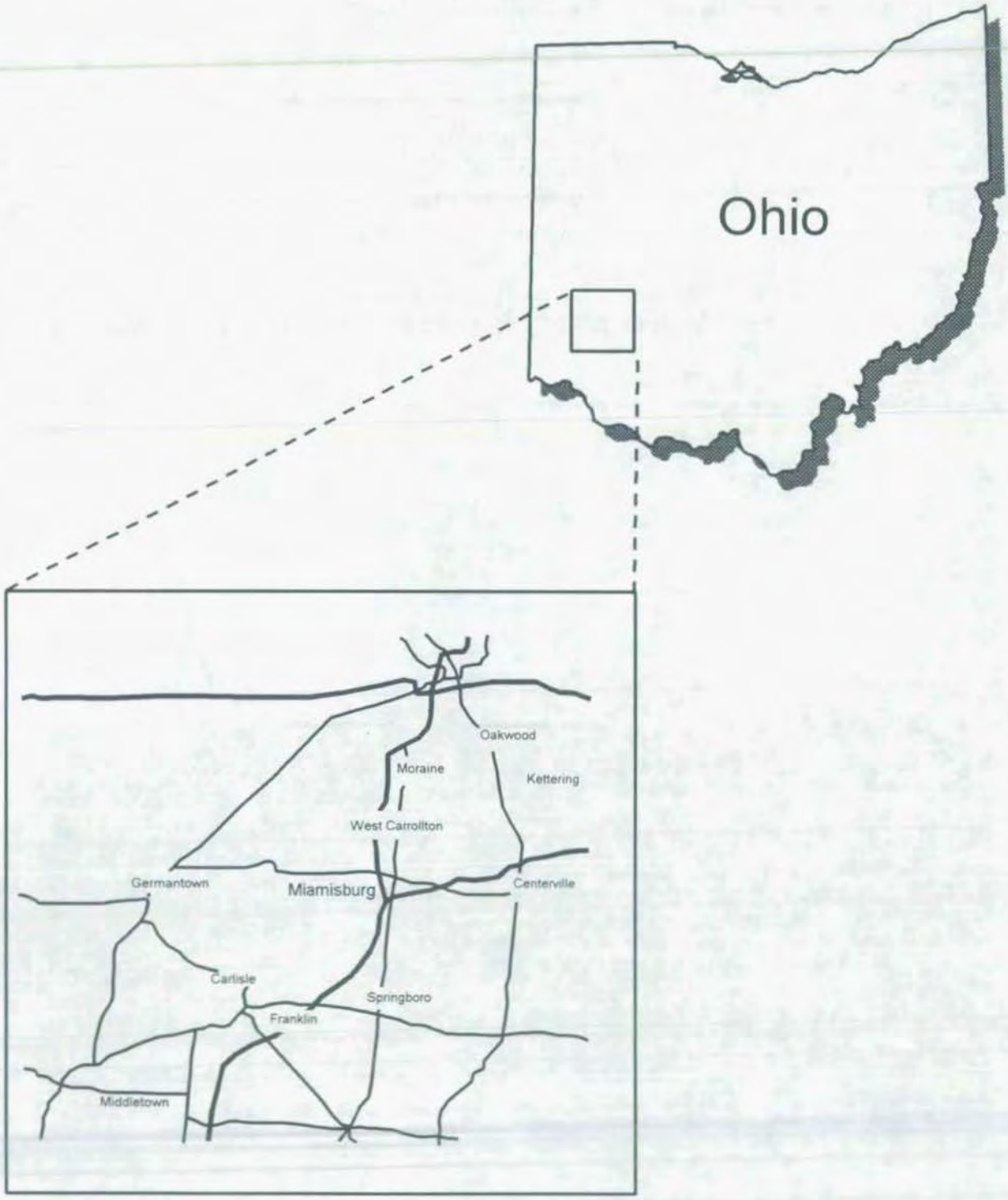
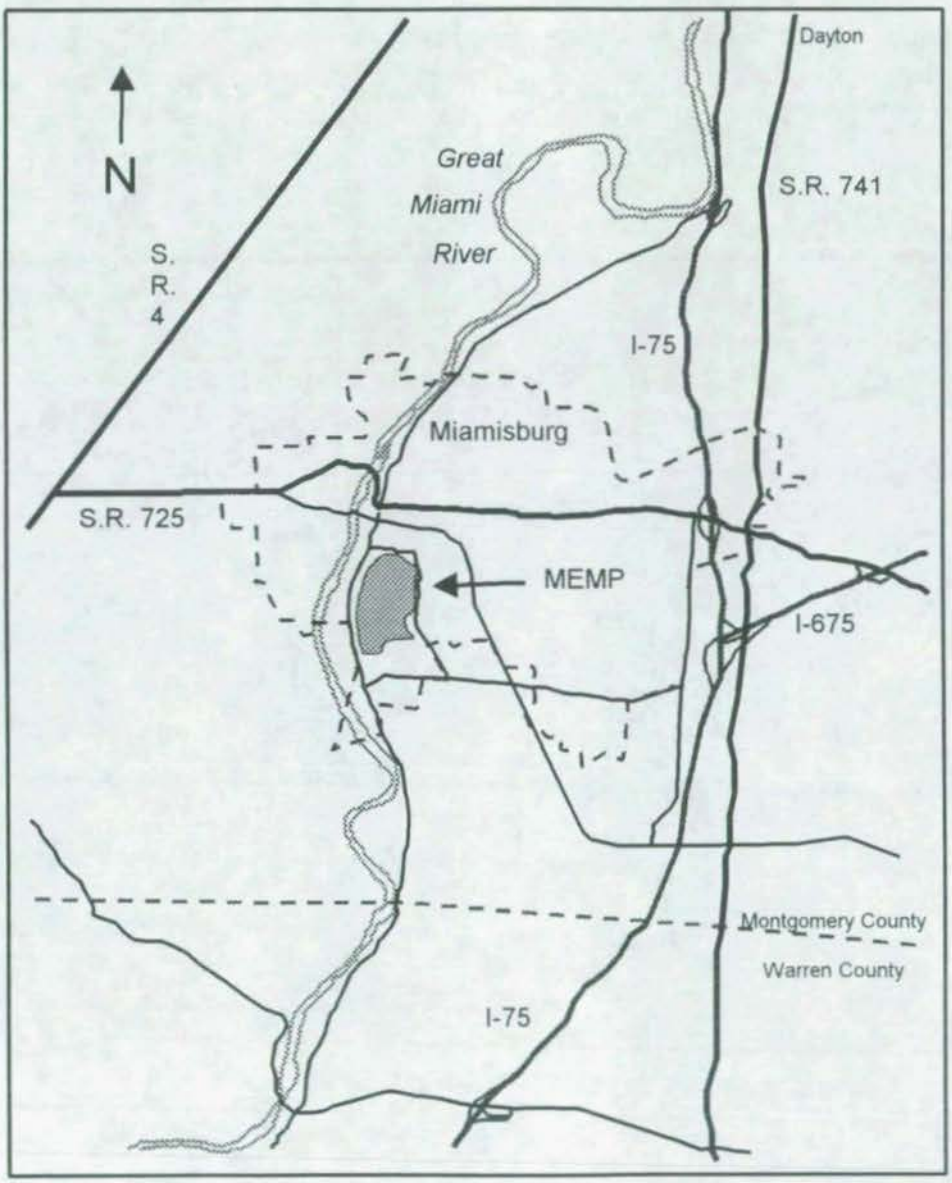


Figure 1-2. Location of MEMP



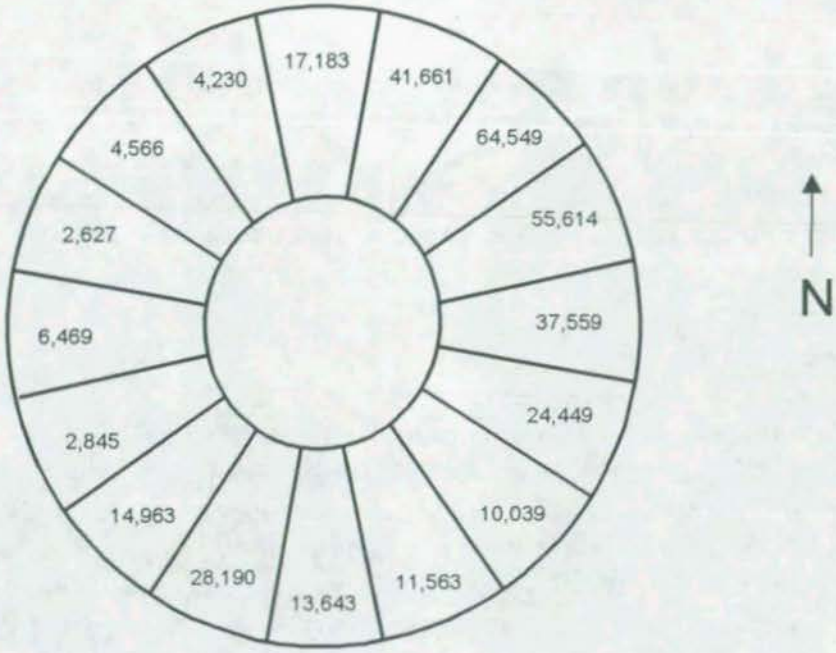
Population and Land Use

Figure 1-3 shows the population distribution within 50 miles (80 km) of the site. The population information was extracted from 2000 Census data by the Ohio Department of Development. The estimated number of individuals residing within the 50-mile radius is 3,126,615 (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.

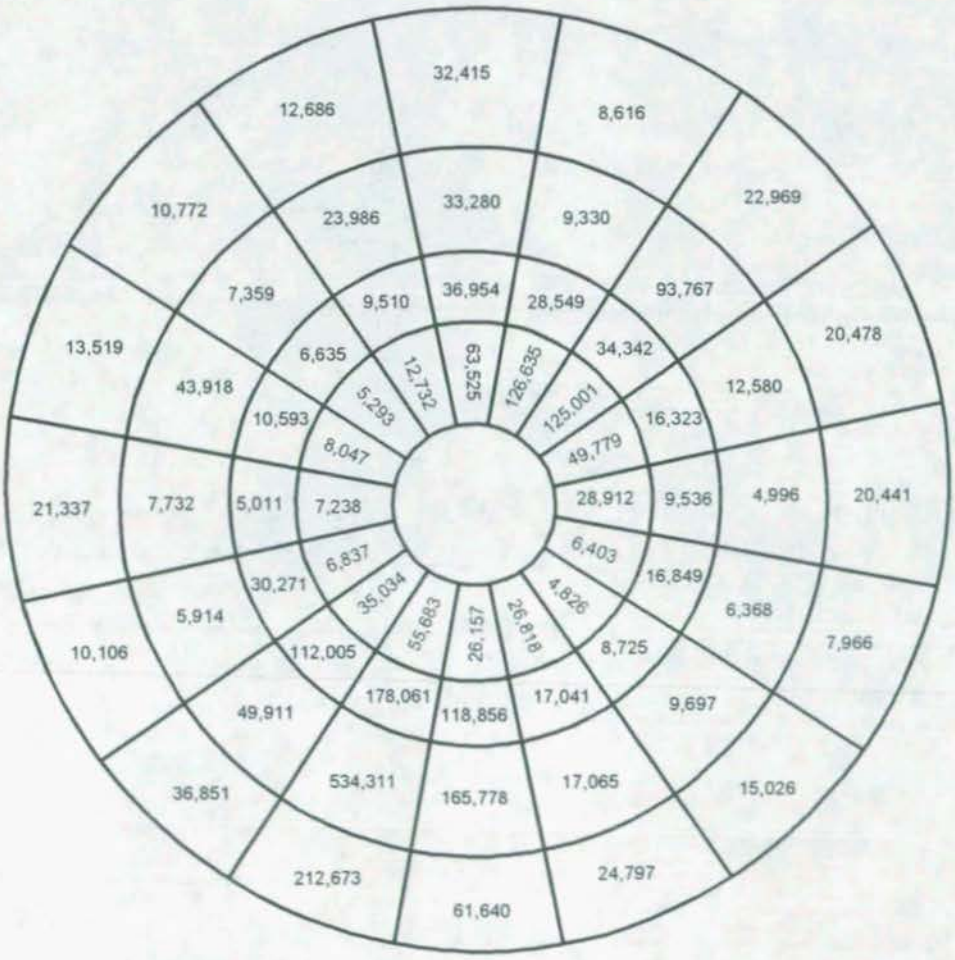
Table 1-1. Population Totals from the 2000 Census

Radius, miles	Total
0-10	340,150
0-20	929,070
0-30	1,568,331
0-40	2,594,323
0-50	3,126,615

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 and is considered a sole source aquifer.

Climate

The climate is moderate. The average annual precipitation rate is 83 cm (33 in) per year. As shown in Figure 1-4, the total precipitation measured at the site in 2001 was 104 cm (41 in). During 2001, winds were predominantly from the south-southwest (Figure 1-6). The annual average wind speed measured at MEMP for 2001 was 5.0 m/s (11.4 mi/hr) (Table 1-2). The average temperature was 13.4 °C (56 °F) with a maximum of 37 °C (98.6 °F) and a minimum of -13 °C (8.6 °F). Average monthly temperatures are shown in Figure 1-5.

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).

Figure 1-4. Monthly Precipitation Measured at MEMP in 2001

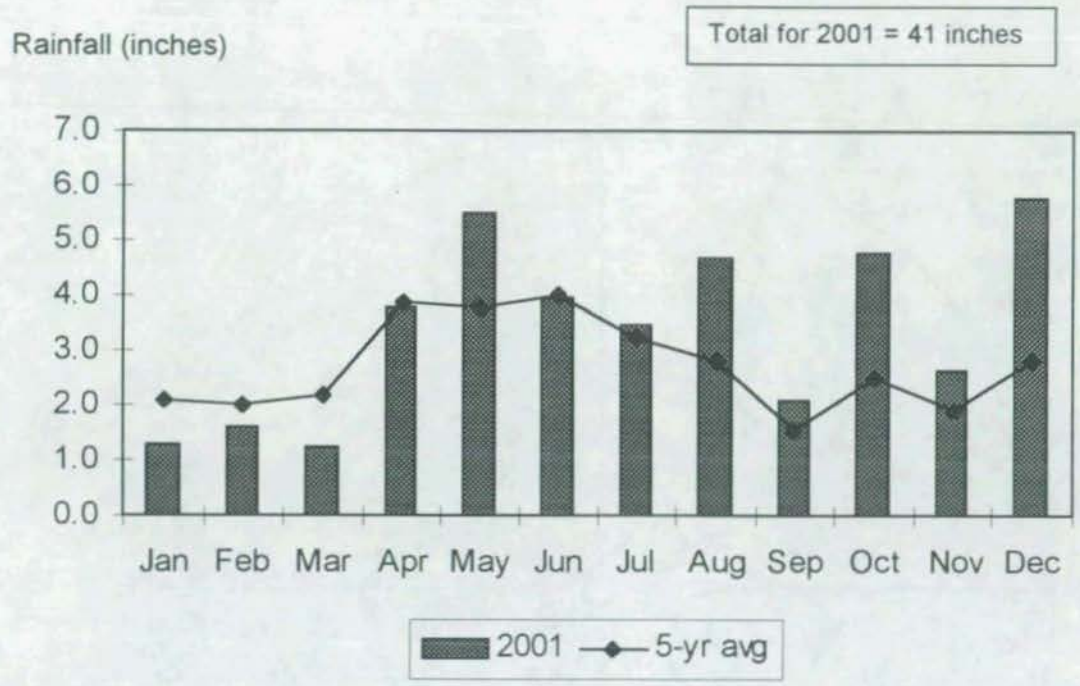


Figure 1-5. Monthly Temperature Measured at MEMP in 2001

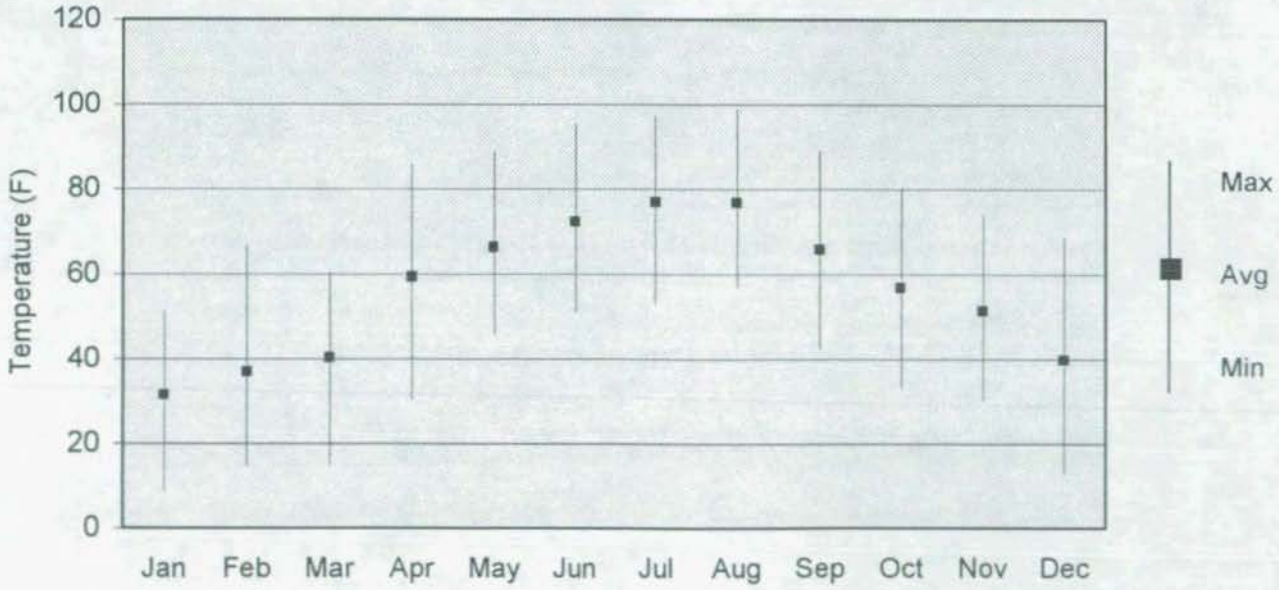


Figure 1-6. 2001 Wind Rose for MEMP

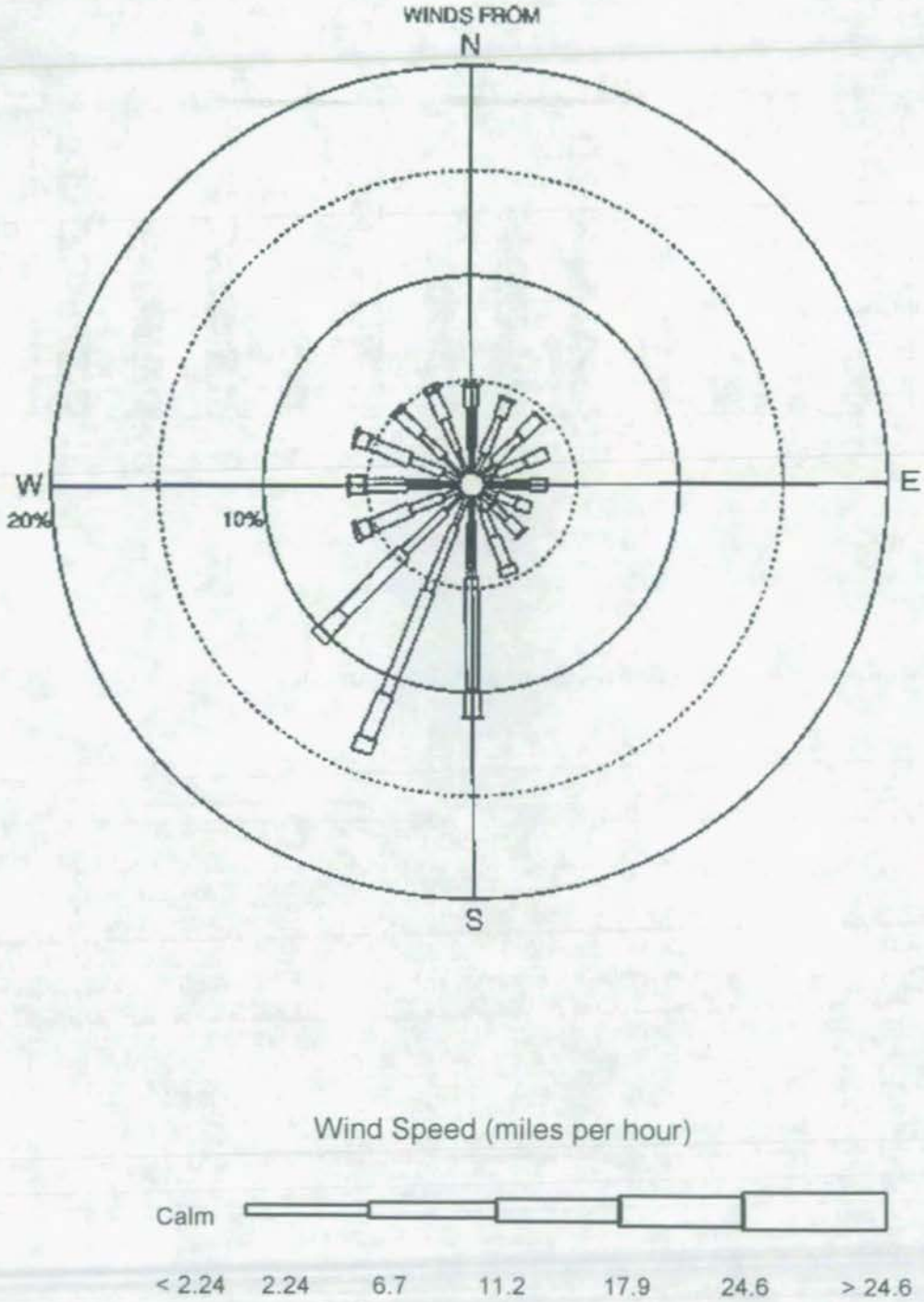


Table 1-2. Percent Frequency of Wind Direction and Wind Speed from MEMP 50-m Meteorological Tower for 2001

Direction	Percent of Time Winds From	Average Speed (m/s)[a]
N	4.5	4.0
NNE	4.4	4.0
NE	4.3	4.2
ENE	3.6	4.1
E	3.3	3.7
ESE	2.8	4.0
SE	3.2	4.1
SSE	4.4	5.0
S	11.2	5.6
SSW	13.7	6.1
SW	10.4	5.7
WSW	5.9	5.4
W	5.7	5.4
WNW	5.8	5.1
NW	4.8	4.4
NNW	4.9	4.5
	Average	5.0

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

Total relative frequency of calms distributed above is 6.9%.

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) isotopes 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.

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 the Miamisburg Mound Community Improvement Corporation (MMCIC), 32 private businesses are operating at the site.

1.2 Perspective on Radiation

This section puts into perspective the potential consequences of the radionuclide releases described in subsequent sections of this report. Radionuclides emit ionizing radiation. Ionizing radiation is radiation possessing enough energy to remove electrons from the substances through which it passes. 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, inhaled or absorbed a radionuclide that will remain inside the body. It is also expressed in 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 United States (U. S.) is 28 mrem (0.28 mSv).

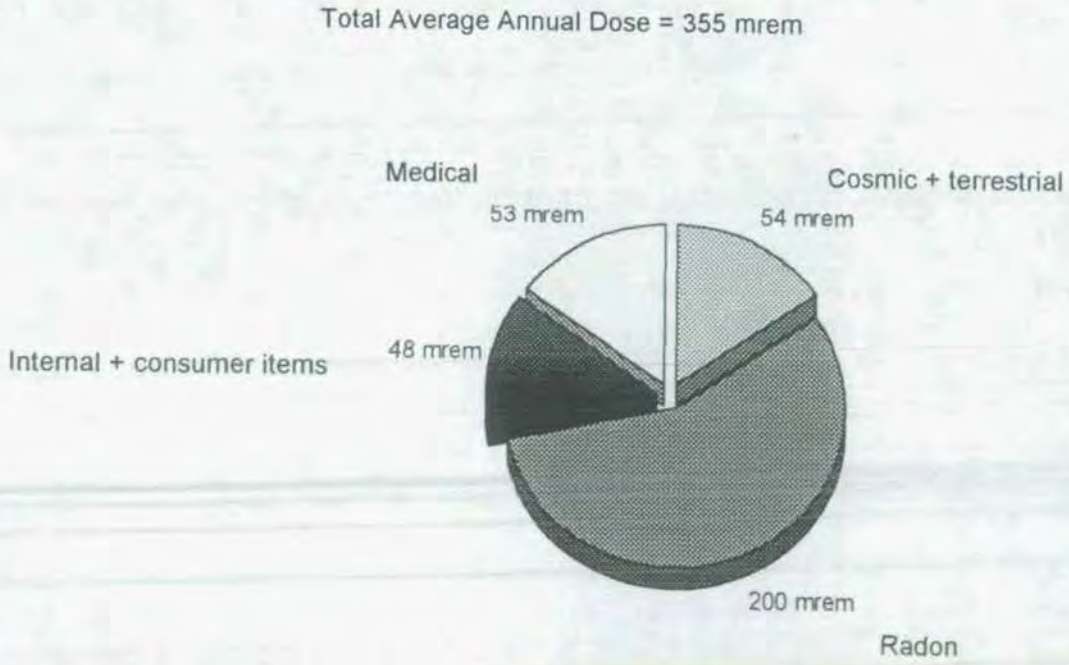
Internal. Besides absorbing radiation from external radionuclides, we can also absorb radiation internally when we ingest radionuclides along with the water, milk, and food we eat or along with the air we inhale. Once in our bodies, radionuclides follow the same metabolic paths as nonradioactive forms of the same elements. The length of time a particular radionuclide remains in the body 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).

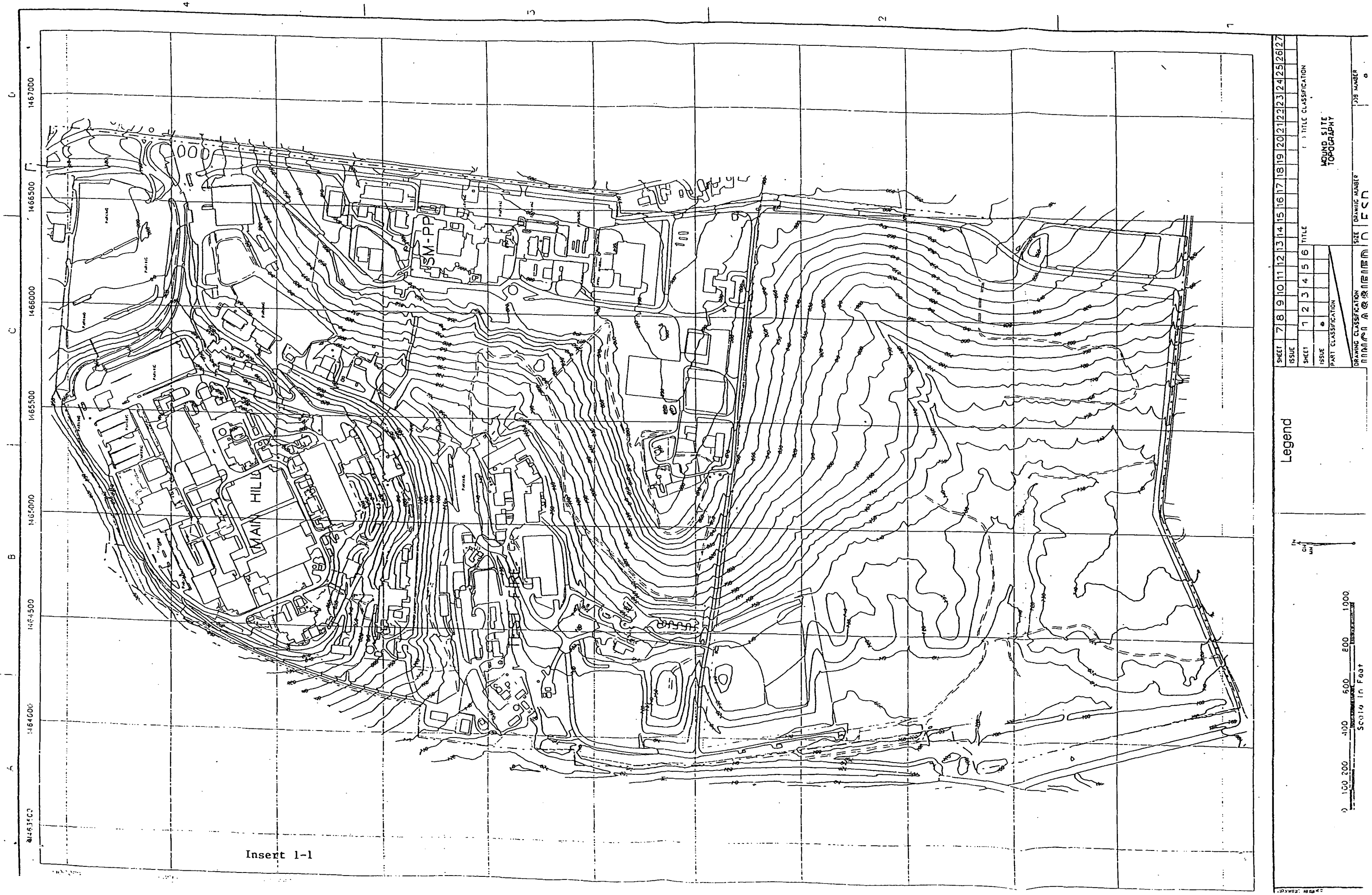
Consumer Products. Many familiar consumer products emit ionizing radiation. Some must emit radiation to perform their functions, e. g., smoke detectors and airport x-ray baggage inspection systems. Other products, e.g., TV sets, emit radiation only incidentally to performing their functions. The average 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 receive much higher doses, and those receiving diagnostic radioactive testing may also receive much higher doses.

Summary. The contributions to an average individual's annual radiation dose are shown in Figure 1-7. MEMP's maximum contribution for 2001, 0.23 mrem, is too small to be seen in the figure.

Figure 1-7. Average Annual Radiation Dose in the U.S. (NCRP, 1987)




MAIN HILL
SM-PP
1467000
1466500
1466000
1465500
1465000
1464500
1464000
1463500
Legend
Scale In Feet
0 100 200 400 600 800 1000
SHEET 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
ISSUE
SHEET 1 2 3 4 5 6
ISSUE
PART CLASSIFICATION
TITLE
TITLE CLASSIFICATION
MOUND SITE TOPOGRAPHY
DRAWING CLASSIFICATION
SIZE
DRAWING NUMBER
JOB NUMBER

Insert 1-1

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 assessment of contamination at the site identified 124 locations of actual or suspected releases. (DOE, 1994) 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. In 2001, over 70 CERCLA documents were presented to regulators and stakeholders, 24 PRS decisions were recorded, and approximately 40 CERCLA meetings were held with regulators. A brief description of environmental restoration activities for 2001 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 2001.

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 3745-15,-31,-35. 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 twenty-two air permits, including seventeen sources on registration status (see Table 3-3). 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 database 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 2001.

Radiological emissions. Ten stacks and eight building vents at the site discharge radioactive effluents to the atmosphere. These releases are subject to 40 Code of Federal Regulations (CFR) Part 61, Subpart H, ("radionuclide NESHAPs"). These NESHAPs regulations are components of the 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 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 2001, the maximum EDE received by a member of the public was 0.07 mrem. This value represents 0.7% of the dose limit and demonstrates that MEMP releases for 2001 were well below allowable release levels.

The NESHAPs also define sampling and monitoring techniques which apply to stacks and vents that release radioactive materials. U. S. EPA Region 5 judged MEMP to be in full compliance with the requirements of 40 CFR 61, Subpart H, in 1998.

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. It is effective until March 2002. The permit defines discharge limits and monitoring frequencies for the site's water effluents. NPDES permit limitations were exceeded six times during 2001. Three of the exceedances were reportable to the Ohio EPA, while the other three were exempted due to storm water flow conditions. See Section 5.2 for more information. No enforcement actions were initiated in 2001. A permit renewal application was submitted to the Ohio EPA in September 2001.

In July 1997, the Ohio EPA issued an Authorization to Discharge (ATD) for the CERCLA OU1 groundwater remediation process. One element of this process involves the continuous pumping of groundwater from a series of extraction wells to prevent migration of 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 2001, 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 2001 the following analyses were performed: total coliform, lead, copper, nitrate, and volatile organic compounds. No exceedances were observed in 2001.

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 in 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. A permit renewal application was submitted to the Ohio EPA in April 2001.

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.

Waste disposition. In 2001, 154,947 pounds of hazardous and other regulated wastes were shipped offsite. Of that amount, 47,117 pounds were RCRA-regulated wastes, 90,961 pounds were asbestos and PCB wastes, and 16,869 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 for more information.

Federal Facility Compliance Act (FFCAct)

The Federal Facility Compliance Act (FFCAct) was signed into law on October 6, 1992. The FFCAct required 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 2001, one mixed waste stream was 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 2001, 90,961 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 until 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, including the Waste Isolation Pilot Plant (WIPP) in New Mexico with interim storage at the Savannah River Site, 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 2001, 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 2001, BWXTO used and/or stored two "extremely hazardous" and six "hazardous" chemicals in excess of EPCRA Section 312 reporting thresholds. See Section 5.3 for more information.

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 2001, BWXTO did not exceed any of the EPCRA Section 313 reporting thresholds.

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). Site activities in 2001 were either conducted pursuant to CERCLA and therefore exempt from the NEPA process or were exempt from review because of prior NEPA evaluations.

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. In October 1999 the eastern massasauga (*Sistrurus catenatus catenatus*) rattlesnake was added to the federal "candidate species" list. Such species warrant threatened or endangered status but are awaiting processing. It is listed as endangered by the State of Ohio. The project area lies within the range of the massasauga. The site is being evaluated for potential massasauga habitat, but none of these snakes have been observed on the site.

Neither the solitary sitings of the rush and the junco, nor the potential habitat for the Indiana bat and eastern massasauga, 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 including those in the State of Ohio be reviewed by the State Historic Preservation Office to determine what effects, if any, the planned activities under these programs will have upon such resources.

At MEMP, two studies were conducted to evaluate non-building archeological resources. 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 their 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). Because MEMP will demolish or transfer the eligible buildings, DOE initiated discussions with the OHPO to establish the terms of a Memorandum of Agreement (MOA). The purpose of the MOA is to mitigate adverse affects to these historic structures which will result from environmental restoration activities and transition of the site.

In early 2000, under the guidelines in the NHPA and the implementing regulations at 36 CFR 800, DOE approached the Advisory Council on Historic Preservation (ACHP) to resolve a dispute with the OHPO concerning the disposition of one of the buildings. The dispute was resolved and the ACHP and the DOE signed the MOA in October 2000. Under the agreement, mitigation will consist of documentation packages for the 17 original buildings and a documentation package for the site (see Appendix G).

Executive Order 11988, "Floodplain Management"

A narrow area along the southwestern border of the South Property lies within the 100-year floodplain. A Notice of Floodplain Involvement was published in the Federal Register in 2000 for the South Property (Parcel 4) transfer. The transfer of 94.9 acres took place April 24, 2001.

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 Ohio EPA, if applicable. The USACE concurred with the updated 1999 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 2001, MEMP submitted an EPCRA Section 312 report for chemicals stored and an EPCRA Section 313 report for chemicals used during calendar year 2000.

The pollution prevention and waste minimization focus has shifted from routine operations to environmental restoration. Accomplishments in 2001 included collection of ferrous and non-ferrous metals, white paper, and toner cartridges for recycling. Lead bricks were recycled for use at other DOE sites.

2.2 Other Key Environmental Compliance Issues

Major External Environmental Audits in 2001

Ohio EPA RCRA inspection. The annual unannounced RCRA inspection by the Ohio EPA was conducted in November of 2001. 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, 2001. All areas rated were judged to be satisfactory.

2.3 Summary of Permits

BWXTO operates in compliance with five state air permits. Two of the permits (HEFS Stack and Fuel Oil Storage Tank) are pending. Seventeen additional sources of air emissions are on registration status with the State of Ohio. An NPDES permit and an ATD govern water releases from the site. Hazardous waste activities are governed by a RCRA Part B permit.

End of Chapter 2

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's 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 (BWXTO, 2000) 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. Meteorological monitoring focuses on weather conditions which are used to determine the environmental impact from air emissions.

3.2 Effluent Monitoring

Air Emissions

Stacks through which radioactive materials are released are sampled 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. 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	13	Weekly
	^{238}Pu, $^{239,240}Pu$	10	Weekly
	$^{233,234}U$, ^{238}U	6	Weekly
	^{228}Th, ^{230}Th, ^{232}Th	3	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 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 NPDES permit and the OU1 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, 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, the prevailing winds, and project activity.

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	6	Weekly
	^{238}Pu, $^{239,240}Pu$	6	Weekly
	^{228}Th, ^{230}Th, ^{232}Th	4	Weekly
	Particulates	6	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	Quarterly
	^{226}Ra, ^{228}Ra	5	Annually
	Gross Alpha	5	Annually
	Gross Beta	5	Annually
	VOCs	5	Quarterly
	MCL Inorganics	5	Annually
	Nitrate	5	Annually
	Lead and Copper	20	Semi-annually
	Total coliform	2	e
Groundwater	HTO	71 [c]	e
	^{238}Pu, $^{239,240}Pu$	17	e
	$^{233,234}U$, ^{238}U	17	e
	^{228}Th, ^{230}Th, ^{232}Th	16	e
	^{226}Ra, ^{228}Ra	10	e
	VOCs	71 [c,d]	e
	Inorganics	25 [c,d]	e

[a] HTO = Tritium oxide, Pu = Plutonium, U = Uranium, Th = Thorium, Ra = Radium, 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	14	Weekly
	^{238}Pu, $^{239,240}Pu$	14	Weekly
	^{228}Th, ^{230}Th, ^{232}Th	2	Weekly
	Particulates	14	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, $^{239,240}Pu$	6	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	18	e
	^{238}Pu, $^{239,240}Pu$	7	e
	$^{233,234}U$, ^{238}U	7	e
	^{228}Th, ^{230}Th, ^{232}Th	7	e
	VOCs	13	e
	Inorganics	13	e
Foodstuffs	HTO	f	Annually
	^{238}Pu, $^{239,240}Pu$	f	Annually

[a] HTO = Tritium oxide, Pu = Plutonium, U = Uranium, Th = Thorium, Ra = Radium, 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
[f] Number of sampling locations varies

Foodstuffs

Locally-grown vegetables are collected and analyzed to estimate a dose via the ingestion pathway from radionuclides of MEMP origin. 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. Measurable concentrations at these locations are due to naturally occurring or non-MEMP activities.

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. Residual sludge from the treatment plant is managed and transported to an offsite permitted disposal facility as low level radioactive waste.

Waste Management

The waste management focus has shifted from support of routine operations to environmental restoration and disposition of legacy wastes. In 2001, 154,947 pounds of hazardous and other regulated wastes were shipped offsite. Of that amount, 47,117 pounds were RCRA-regulated wastes, 90,961 pounds were asbestos and PCB wastes, and 16,869 pounds were other wastes not suitable for sanitary landfilling.

Hazardous wastes. 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 2001, 29 truck shipments (60,110 ft^3) of low-level waste were shipped to NTS and 36 railroad shipments (76,245 ft^3) and 2 truck shipments (944 ft3) 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 onsite in a RCRA-permitted facility until treatment/disposal options have been evaluated. In 2001, one mixed waste stream was 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 2001, MEMP recycled 8 tons of white paper, 2 tons of glass, and 72 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 NPL in 1989. DOE, U. S. EPA, and Ohio EPA administer CERCLA activities in accordance with the terms of a 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.

The demolition of E Building was completed. In addition, B Building, Building 85, the Bioremediation Facility, the Drop Tower, Building 71, and Building 73 were demolished. Internal components and fixtures were removed from Building 38, HH Building, WD Building, and the SW/R Buildings.

Several Potential Release Sites (PRSs) were sampled and assessed. The Phase III sampling for PRS 66 was completed. In addition, PRS 277/278, 303, 72, 73, 87, 76, 274/275, 276, and 80 were sampled.

The site implemented the Contingent Removal Action. This is an approach to a limited number of removals actions that expedites field work. This approach will be applied to PRS 153, 266, 273, 276, 412, and 421. Field work was initiated for the removal of PRSs 276 and 421. These removals will be completed in CY02.

In 2001, several other key environmental restoration projects and waste management initiatives were completed. Descriptions of key accomplishments are provided in the following sections.

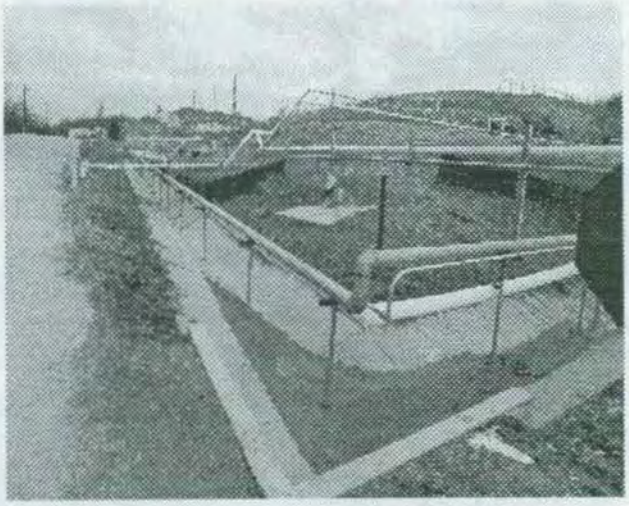
Table 3-3. Environmental Permits

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
Wastewater Discharge (NPDES)	water	1IO00005*HD	pending	Ohio EPA
Wastewater Discharge (OU1 ATD)	water	1IN90010*AD	permanent	Ohio EPA
Building 48	air	P008 (registration)	permanent	Ohio EPA
Crusher	air	F003	12/10/06	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
Powerhouse Boiler 1 and Boiler 2	air	B001 B006	7/31/05	Ohio EPA
Fuel Oil Storage	air	T005	pending	Ohio EPA
R/SW HEFS Stack	air	P030	pending	Ohio EPA
Hazardous Waste Storage	RCRA operation	05-57-0677	pending	Ohio EPA

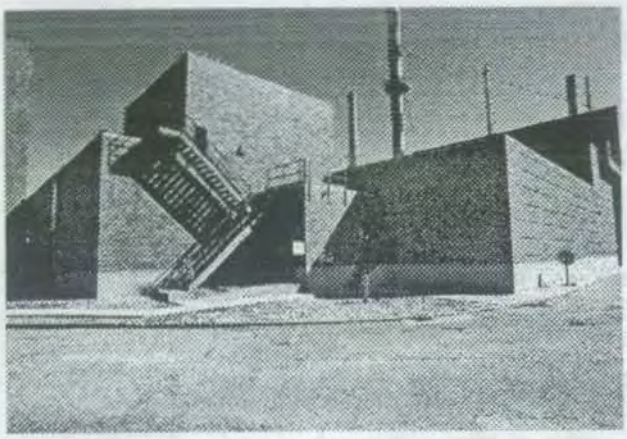
[a] Applied for registration status with Ohio EPA

OU1 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 VOC concentrations before the water is discharged. The water discharges are governed by an ATD issued by the Ohio EPA in July 1997. In 2001, approximately 35,800,000 gallons of water were treated, removing approximately 1.5 pounds of VOCs. Since its inception, the system has removed 25.5 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 3,980 pounds of VOCs.



Building demolition projects. B Building, the Bioremediation Facility, the Drop Tower, and Buildings 71, 73, and 85 were demolished in 2001. The demolition of E Building was completed.



B Building Demolition Project

3.9 Cost Recovery Grant

The Cost Recovery Grant (CRG) represents an added dimension to the environmental monitoring programs in place at MEMP. The 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 MEMP. 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 41 CFR Parts 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 MMCIC. Depending on the type and condition of equipment, and the associated acquisition cost, excess property is also made available to DOE 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 MEMP.

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. Unrestricted release is the release of property/waste from anywhere within the Mound site boundaries without restriction on future movement, disposal or use in accordance with the guidelines or requirements of DOE 5400.5.

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.

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

Radionuclide [2]	Direct Total or Average Total (Fixed + Removable) (dpm/100 cm^2)[1]	Maximum Total (Fixed + Removable) (dpm/100cm^2)[1]	Removable (dpm/100cm^2)[1]
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 [3]	5,000	15,000	1,000
Tritium, all forms (surface and subsurface)	NA	NA	10,000

Notes:

(1) As used in this table, disintegrations per minute (dpm) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

(2) Where surface contamination by both alpha and beta-gamma-emitting radionuclides exists, the limits established for alpha and beta-gamma-emitting radionuclides should apply independently.

(3) This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from other fission products or mixtures where the Sr-90 has been enriched.

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.

2001 Activities. Excess equipment was donated to the Twin Valley Community School District, Valley View Local Schools, John XXIII Catholic Elementary School, Francis Dunlavy Elementary School, Springboro Schools, Warren County Career Center, New Lebanon Schools, Dixie High School, McGuffey Foundation School, Greenon Local School District, Carlisle Local Schools, Lebanon Christian School, Miami Valley CTC, and Valley View Middle School.

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 2001, 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. The program estimated sediment values if not available.

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

Site Description: *MEMP CY2001*

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Aquatic System Data Entry / BCG Worksheet

Limits for Water and Sediments in Std Units

Nuclide	Nuclide data from single media or co-located samples?	Water Limit pCi/L	WATER Site Data	Partial Fraction	Sediment Limit pCi/g	SEDIMENT 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	2.E+03	7.2E-06	4.E+05	2.E-03	5.07E-09	7.18E-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	2.E-02	8.6E-05	6.E+03	1.E+00	1.71E-04	2.56E-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	7.E-01	5.39E-04	6.71E-04
U-233	● Water ○ Sediment ○ Both	2.E+02	2.E-01	8.0E-04	5.E+03	8.E-03	1.52E-06	8.03E-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	2.E-01	9.0E-04	2.E+03	1.E-02	4.02E-06	9.00E-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 →	1.92E-03		Sum of fractions for radionuclides in sediment →	7.15E-04	2.64E-03	

You have passed the site screen.

End of Chapter 3

4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM INFORMATION

MEMP activities result in the discharge of radioactive effluents to the air and the Great Miami River. 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

2001 Data

Table 4-1 lists the quantities of radionuclides released by MEMP into the air and water during 2001. 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 2001

Radionuclide	Released to	Activity, Ci	MEMP Range[b], Ci
Tritium	Air	8.3×10^{2} [a]	$3.8 \times 10^{2} - 8.3 \times 10^{2}$
	Water	2.2	1.7 – 2.5
Plutonium-238	Air	5.7×10^{-6}	$5.7 \times 10^{-6} - 4.5 \times 10^{-5}$
	Water	1.2×10^{-4}	$1.6 \times 10^{-4} - 4.8 \times 10^{-4}$
Plutonium-239,240	Air	4.2×10^{-8}	$3.0 \times 10^{-8} - 1.0 \times 10^{-7}$
	Water	2.3×10^{-6}	$2.3 \times 10^{-6} - 3.6 \times 10^{-6}$
Radon-222	Air	4.6	1.0 – 4.6
Uranium-233,234	Air	1.9×10^{-8}	$8.0 \times 10^{-9} - 1.9 \times 10^{-8}$
	Water	3.4×10^{-4}	$3.4 \times 10^{-4} - 3.9 \times 10^{-4}$
Uranium-238	Air	1.0×10^{-8}	$4.0 \times 10^{-9} - 1.1 \times 10^{-8}$

[a] Tritium released to air consists of: Tritium oxide, 7.07×10^{2} Ci
Elemental tritium, 1.25×10^{2} Ci

[b] Minimum – Maximum (1997-2001)

4.2 Effluent Monitoring Program

Effluent monitoring focuses on releases from the site, i.e., stack and water discharges. It is MEMP's 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 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. MEMP monitors twelve point sources 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 areas where a release potential exists, ventilation air passes through one or more 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 2001 effluent data (Table 4-1) in the interest of completeness. Radium-226 was used in past operations and decays to radon-222, which is a gas. This radon-222 and radon-222 from natural sources is released to the atmosphere from SW Building via a small roof vent. The estimated dose to the public from radon, as predicted by CAP88-PC, was 0.008 mrem for 2001.

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 2001 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 2001.

Figure 4-1. Effluent Air and Water Sampling Locations

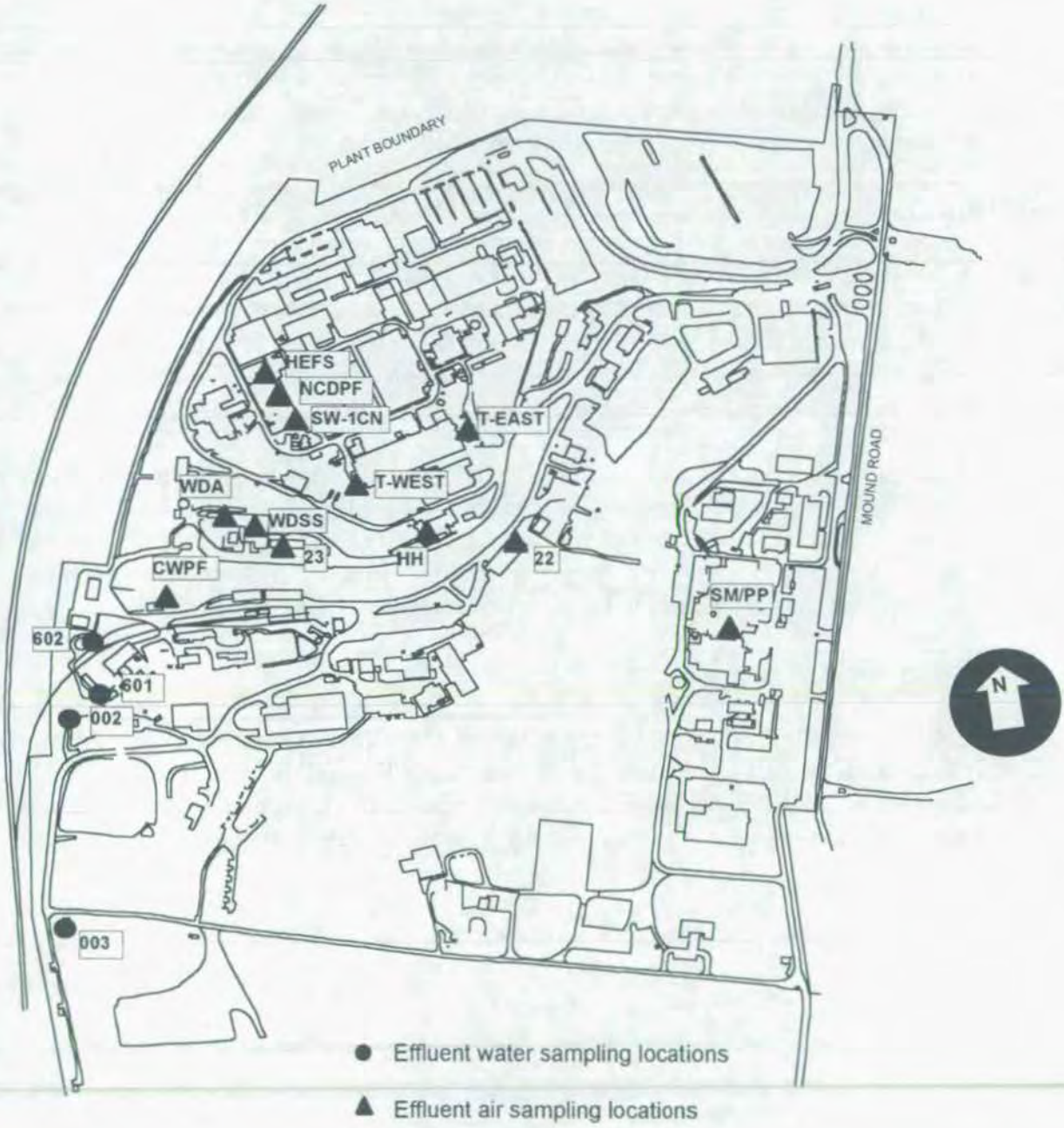
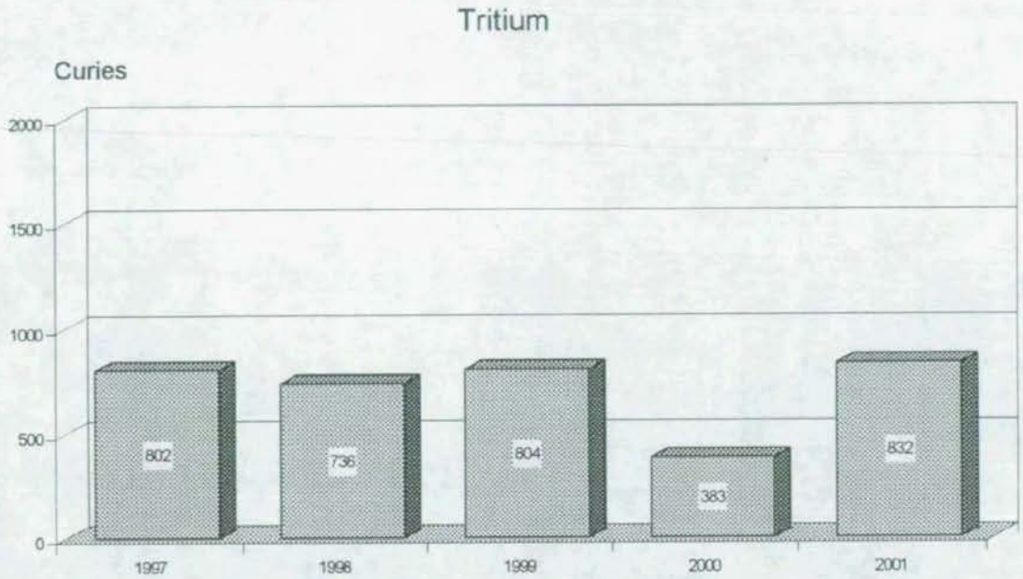


Figure 4-2. Tritium and Plutonium-238 Releases from MEMP to the Atmosphere, 1997 – 2001



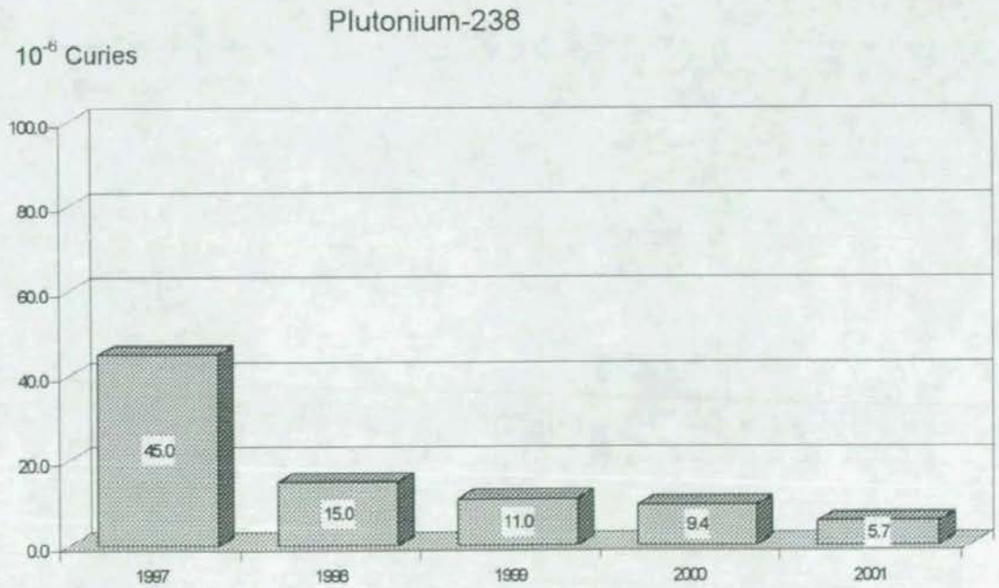
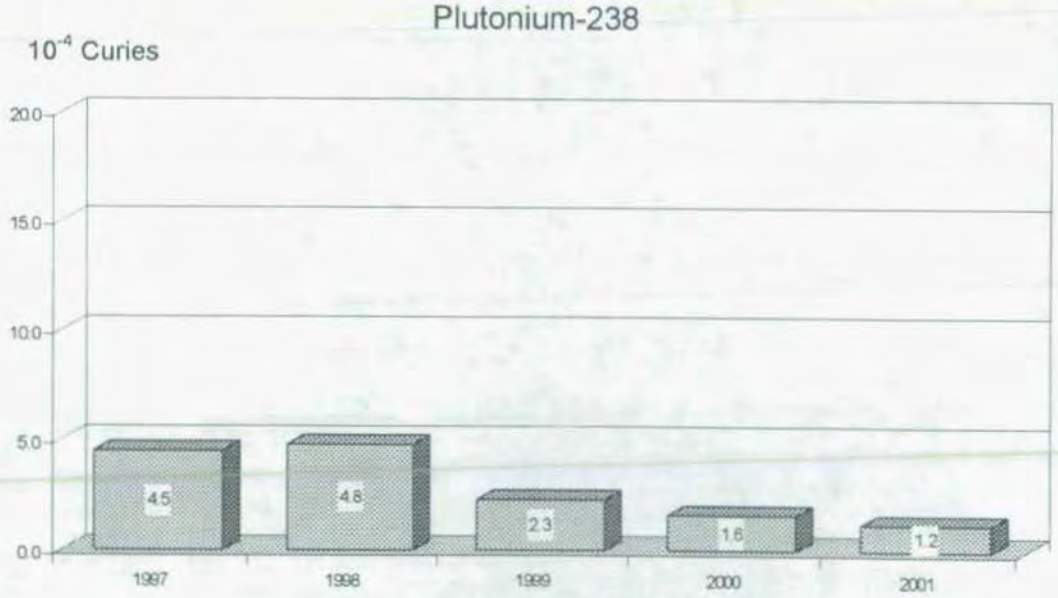


Figure 4-3. Tritium and Plutonium-238 Releases from MEMP to the Great Miami River, 1997 - 2001



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 CEDE 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.

Radionuclide sample analysis

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.

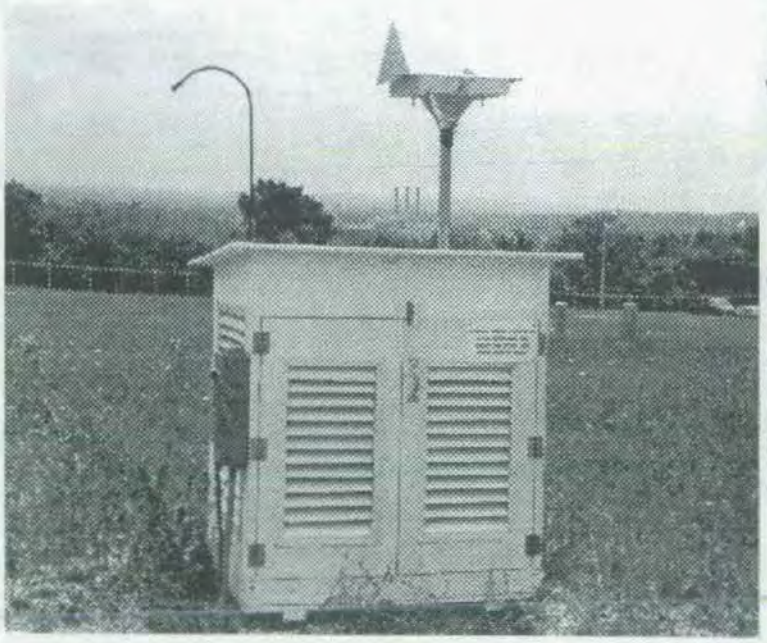
With decreasing release rates of radionuclides, it has become increasingly difficult to observe MEMP's contribution to radionuclide concentrations in the environment. For this reason, many of the tables in Appendix B report data as "below environmental levels." In those cases, it is not possible to observe 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. Samples are analyzed for other radionuclides, as needed. A second air sample, collected in a bubbler apparatus, is analyzed for tritium oxide. In 2001, 20 sampling stations were in operation: six onsite and 14 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

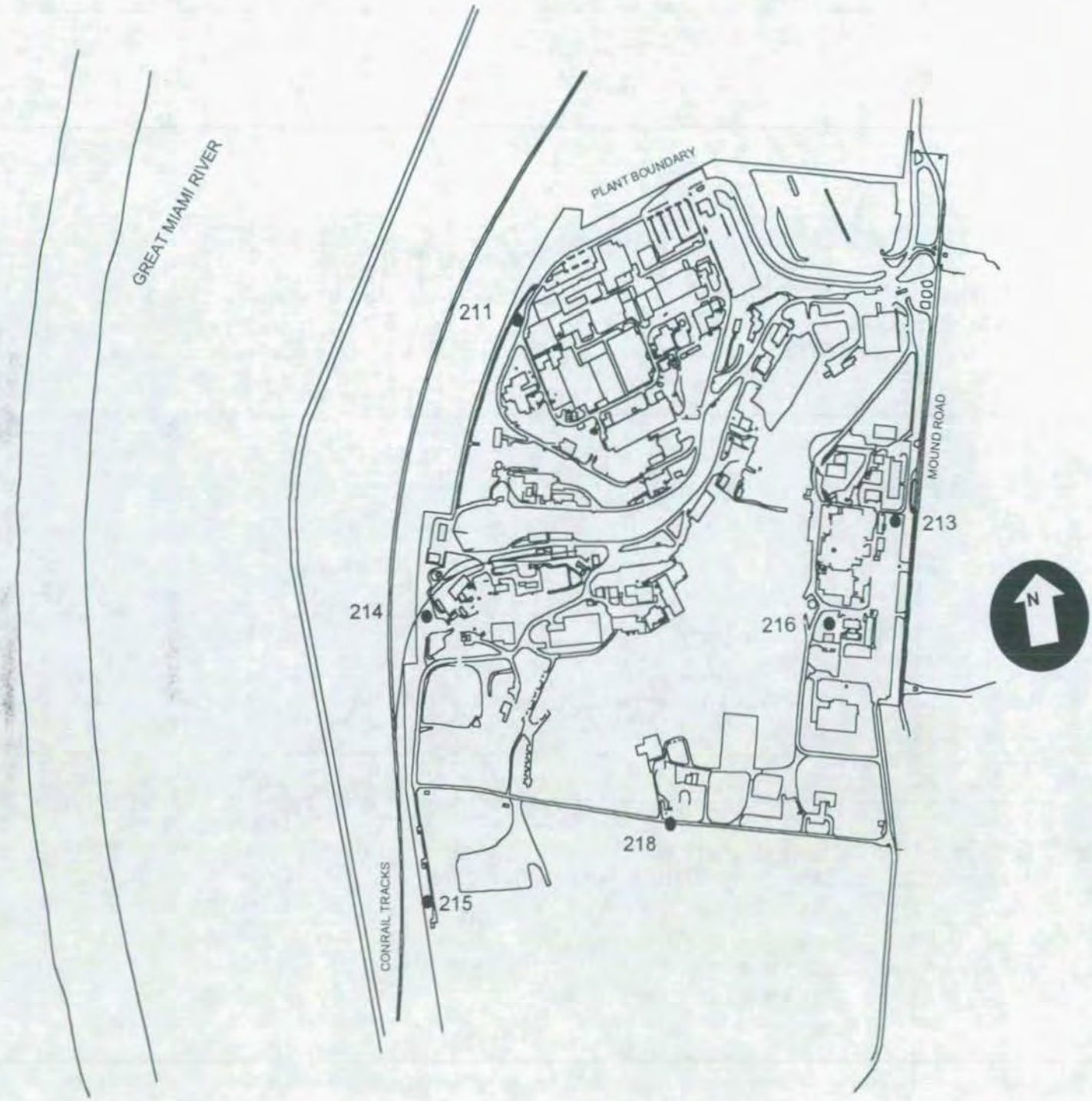
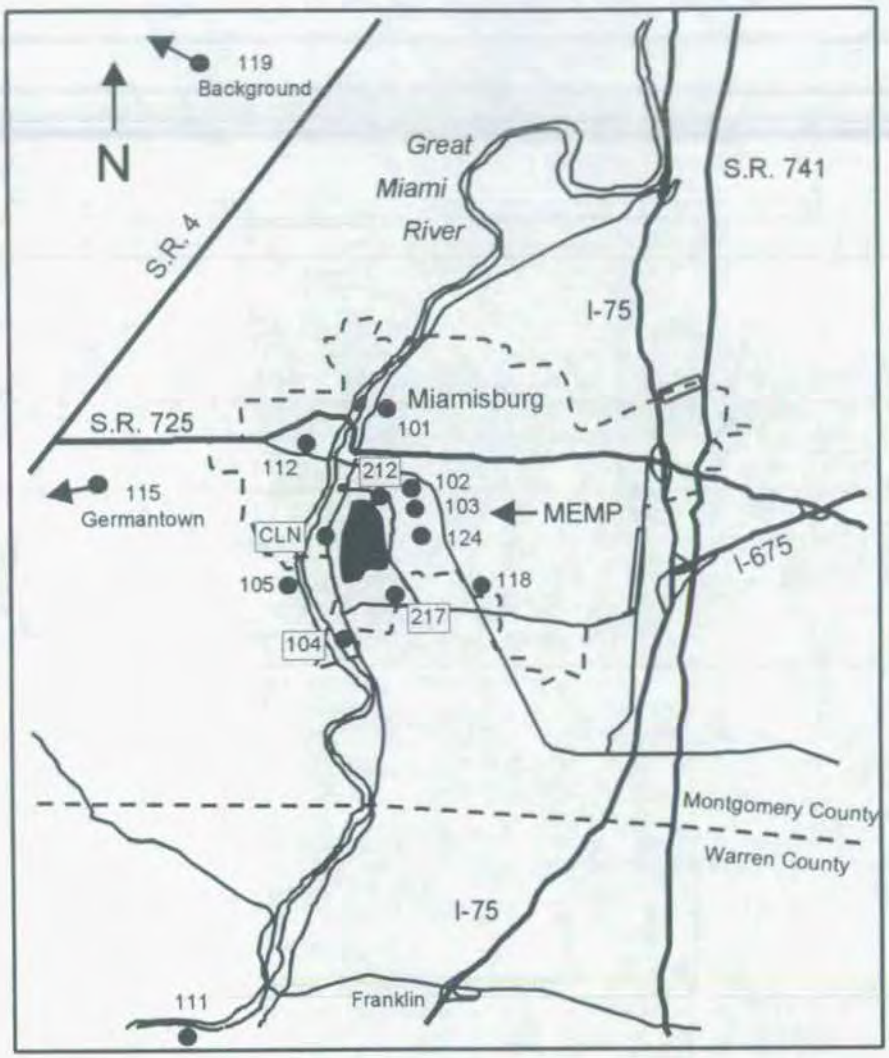


Figure 4-5. Offsite Ambient Air Sampling Locations



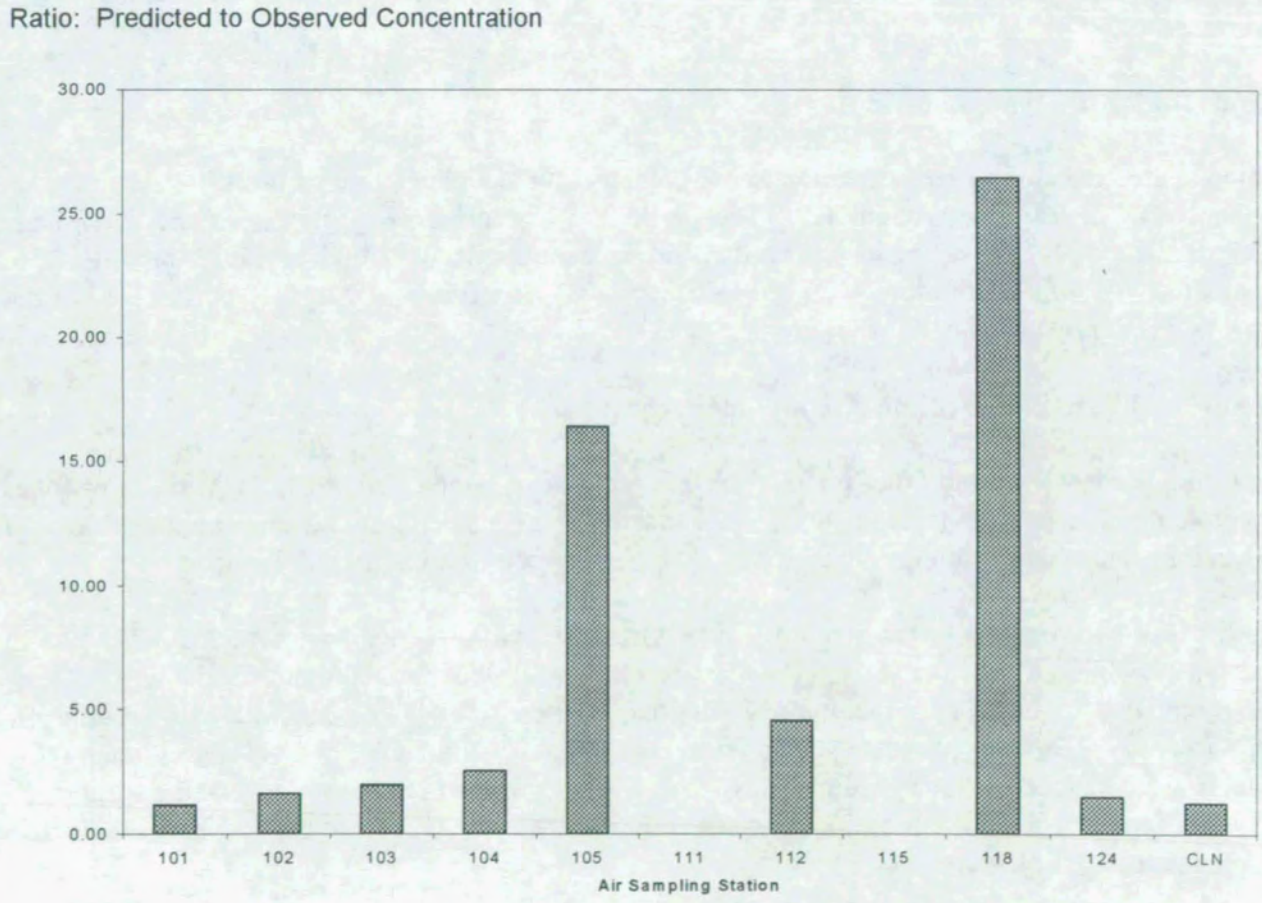
Tritium. Air samples for tritium analyses are collected on a continuous basis. Air is bubbled through 200 mL of ethylene glycol at a flow rate of approximately 1000 cm^3/min. Ethylene glycol is used as a trapping solution because it is not subject to loss by evaporation and will not freeze when exposed 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 2001, tritium air concentrations predicted from modeling stack emissions with the EPA CAP88-PC dispersion model were compared to air concentrations observed during routine monitoring. Essentially all of the impact from plutonium has been observed to be from resuspension of soil. The plutonium concentrations predicted from modeling stack emissions were much lower than those measured offsite. Since 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 2001. Figure 4-6 shows the results of the comparison. Two concentrations were below the environmental level. This too indicates that observed results were much lower than those predicted by the model.

Figure 4-6. Predicted and Observed Concentrations of Airborne Tritium in 2001



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 2001 – Ambient Air

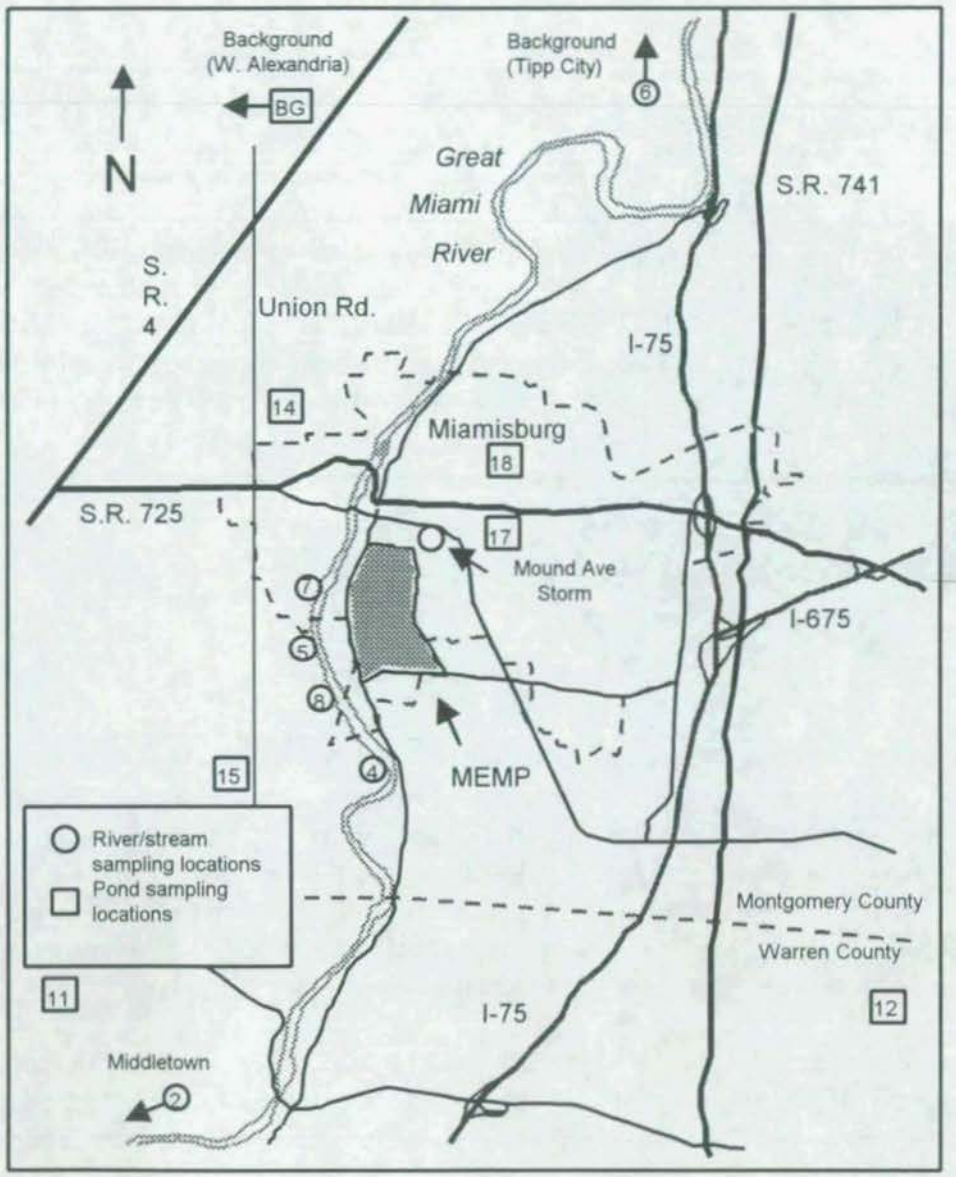
Radionuclide concentrations measured at environmental air sampling stations in 2001 are shown in Appendix B, Tables B-2 through B-5. The results are also presented in terms of the percentage DCG they represent. The tables show that air concentrations of tritium oxide, plutonium-238, plutonium 239,240, and thorium averaged less than 0.015%, 0.055%, 0.0025%, and 0.045% of the respective DCGs established for those radionuclides.

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 at the point of entry and 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 2001 – Surface Water and Sediment

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, plutonium, and thorium concentrations were less than 0.095%, 0.025%, and 0.095% of the respective DOE DCGs. Average concentrations of uranium isotopes were less than the environmental level.

Pond water. Radionuclide concentrations measured in pond water are shown in Appendix B, Tables B-11 through B-13. Average tritium and plutonium concentrations were less than 0.0095% and 0.015% of the respective DOE DCGs. Average concentrations of plutonium 239,240 were below the environmental level.

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 2001 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. Average river sediment concentrations of plutonium and thorium isotopes ranged from below environmental level to 1.5×10^{-6} μCi/g. Average plutonium isotope concentrations in pond sediment ranged from below environmental level to 10.4×10^{-9} μCi/g.

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 2001, samples of root crops and/or 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 2001 - Foodstuffs

The results for foodstuff analyses are shown in Appendix B, Tables B-20 through B-22. Average incremental concentrations of tritium and plutonium-238 were below 125×10^{-9} and 0.22×10^{-9} μCi/g, respectively. Average concentrations of plutonium-239,240 were below the environmental level.

4.8 Offsite Dose Impacts

Dose Estimates Based on Measured Concentrations

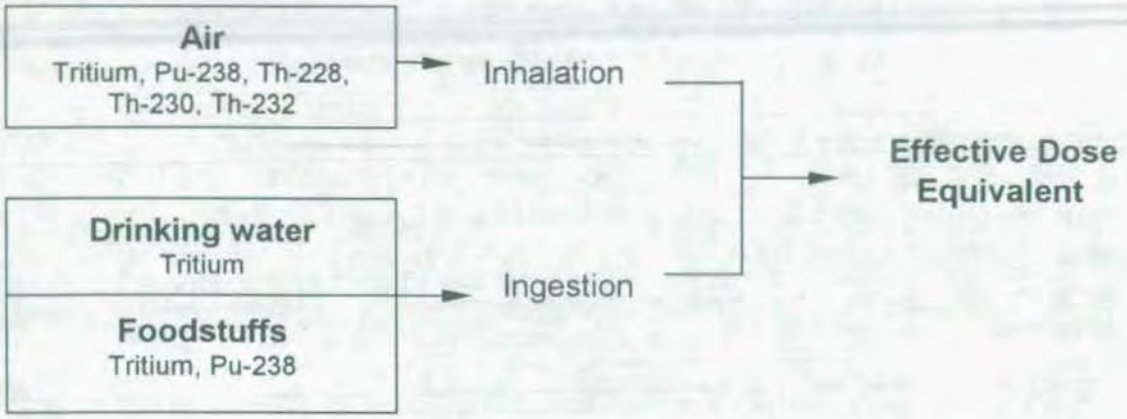
MEMP used the data presented in this report to estimate maximum doses to an offsite individual. The figure-of-merit used to calculate those doses was the CEDE. CEDE calculations are required of DOE facilities. These calculations are also useful in evaluating the success of ALARA policies. It is the philosophy 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 2001. This individual was assumed to have:

- breathed exclusively air with radionuclide concentrations corresponding to the location of the maximum 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 2001 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 2001



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 2001 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 0.07 mrem. This estimate represents 0.7% of the dose standard.

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

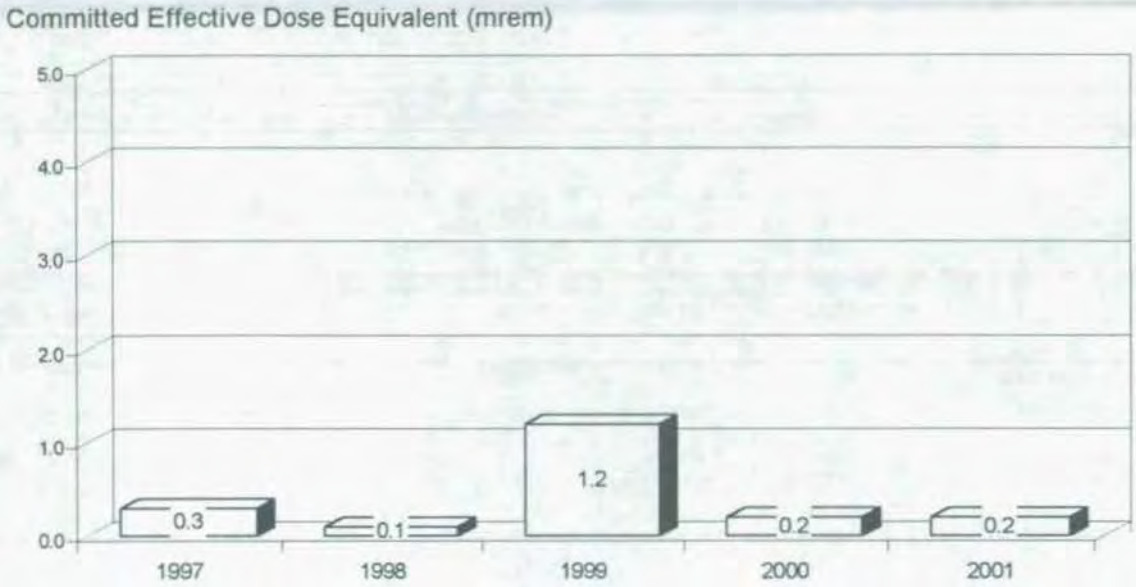
Figure 4-9 presents a plot showing the 5-year trend in CEDE to a hypothetical individual. The dose from MEMP activities in 2001 was a small fraction of the 100 mrem DOE dose limit for members of the public.

Table 4-2. Maximum Committed Effective Dose Equivalents to a Hypothetical Individual in 2001

Radionuclide	Pathway	mrem	mSv
Tritium	Air	0.006	0.00006
	Drinking water	0.005	0.00005
	Foodstuffs	0.002	0.00002
	Total	0.013	0.00013
Plutonium-238	Air	0.049	0.00049
	Drinking water	ND	ND
	Foodstuffs	0.11	0.0011
	Total	0.159	0.00159
Plutonium-239,240	Air	ND	ND
	Drinking water	ND	ND
	Foodstuffs	ND	ND
	Total	ND	ND
Thorium-228	Air	0.01	0.0001
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.01	0.0001
Thorium-230	Air	0.011	0.00011
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.011	0.00011
Thorium-232	Air	0.038	0.00038
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.038	0.00038
Total		0.23	0.0023

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

Figure 4-9. Committed Effective Dose Equivalents to a Hypothetical Individual, 1997 - 2001



Population doses. CAP88-PC also has the capability of estimating regional population doses from airborne releases. The population, approximately 3,126,615 persons, within a radius of 80 km (50 mi) of MEMP received an estimated 2.84 person-rem from site activities in 2001. 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 2.84 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 3.127 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, 2.84 person-rem, is approximately 0.00028% 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. The primary concern for air pollutants is particulate matter. MEMP monitors the impact of nonradiological airborne releases by measuring airborne particulates at both onsite and offsite locations. Nonradiological releases to water are also subject to extensive sampling protocols. In 2001, MEMP collected over 1,350 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 0.1-0.5% sulfur content is burned during unusually cold weather or if the natural gas supply to the site is interrupted. Approximately 151,400 liters (40,000 gallons) of fuel oil and 4,962,131 m^3 (175,236,000 ft^3) of natural gas were burned during 2001. Powerhouse emissions are comprised primarily of sulfur oxides, nitrogen oxides, organic compounds, 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 six onsite and 14 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 2001 are presented in Appendix C, Table C-2.

Results for 2001 – Air Monitoring

Nonradioactive air emissions from MEMP in 2001 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 annual ambient air quality (OAC 3745-17). In 2001, average particulate concentrations measured at all onsite and offsite sampling locations but one were below this standard. Sampler 211 had a higher concentration due to the B Building demolition. See Table C-2.

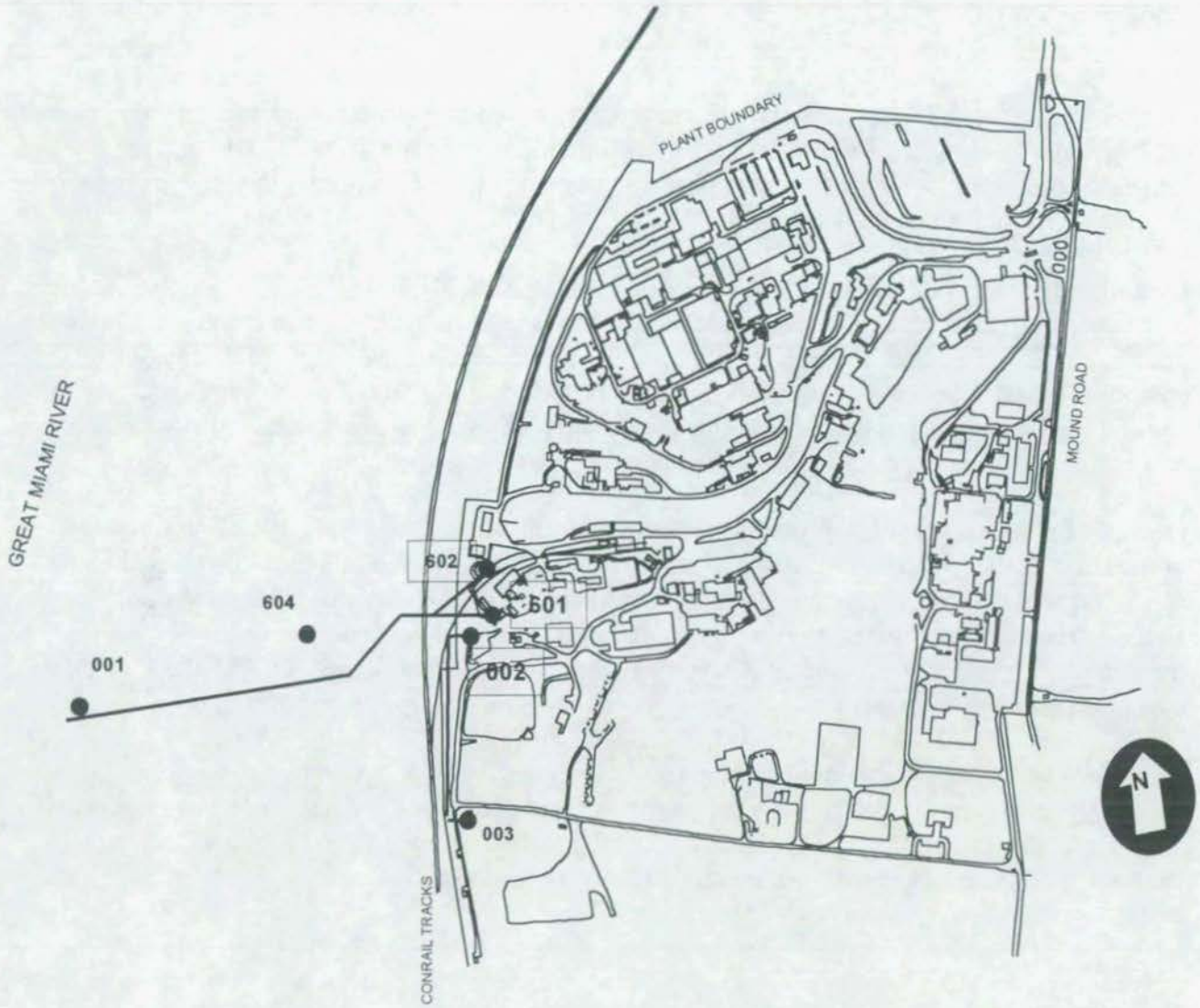
5.2 Water Monitoring Program

MEMP releases wastewater to offsite surface waters via three discharge systems. In 2001, MEMP discharged an average of 0.64 million gallons (2.42 million liters) of water per day to the Great Miami River. U. S. Geological Survey data indicate that the 2001 flow rate in the river averaged 1,881 million gallons per day (MGD), with minimum and maximum flow rates of 395 MGD and 17,968 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 OU1 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. This outfall will be deleted when the permit is modified.

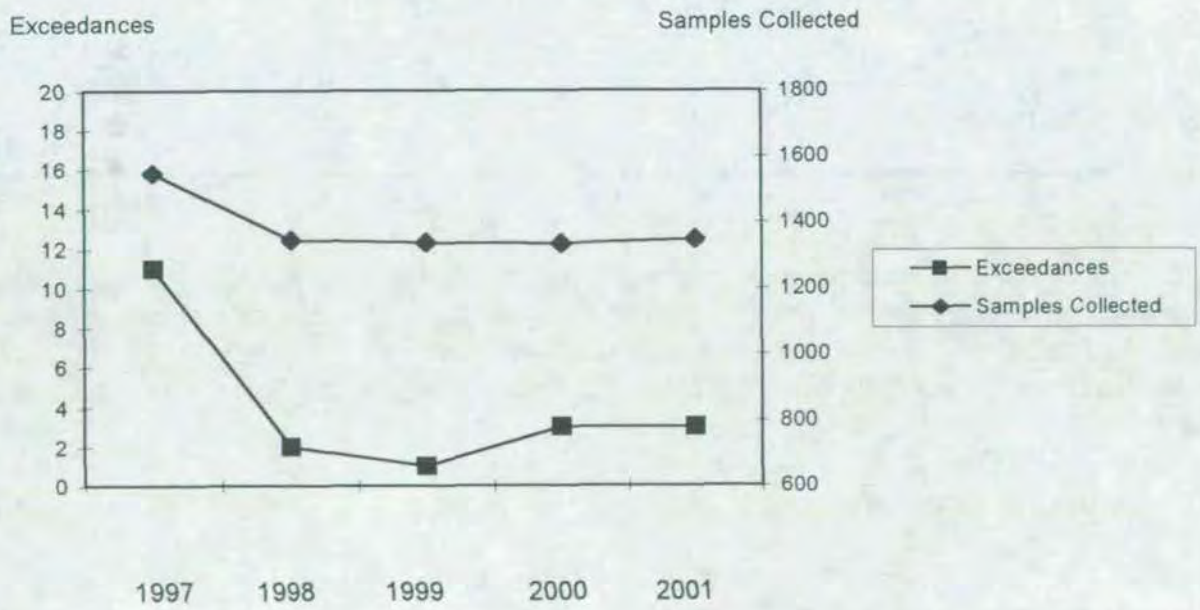
Outfall 003. Outfall 003 is the discharge from the CERCLA OU1 groundwater pump and treat system. Time-proportional, 24-hour composite samples and periodic grab samples are collected at this outfall. Monitoring requirements for this location focus on VOCs and heavy metals. Biotoxicity tests are also performed quarterly each year at this outfall.

Results for 2001 – Water Monitoring

More than 1,350 samples were analyzed for NPDES and ATD parameters in 2001, of which three of the six NPDES permit exceedances recorded were reportable. Five of the exceedances were total suspended solids (TSS) while the other was oil and grease. The oil and grease exceedance occurred at Outfall 602 in January. No cause could be determined for the exceedance. Two TSS exceedances occurred in August at Outfall 002. One was a daily exceedance and the other was a 30-day average. The exceedances were the result of five inches of rain during the month of August. Three daily TSS concentration limitations exceedances were exempted due to storm flow conditions. These occurrences happened once in April (602) and twice in July (002 & 602). No ATD exceedances occurred in 2001. No enforcement actions were initiated in 2001. Key results are summarized in Appendix C, Table C-3. A review of NPDES and ATD performance over the past five years is shown in Figure 5-2.

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.

Figure 5-2. NPDES and ATD Sampling Profile, 1997 - 2001



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 2001, 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. 2001 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. A "Form R" was submitted in 2001 for ethylene glycol usage in CY2000. In CY2001, BWXTO did not exceed Section 313 reporting thresholds.

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 2001.

CHAPTER 6

6.0 GROUNDWATER MONITORING PROGRAM

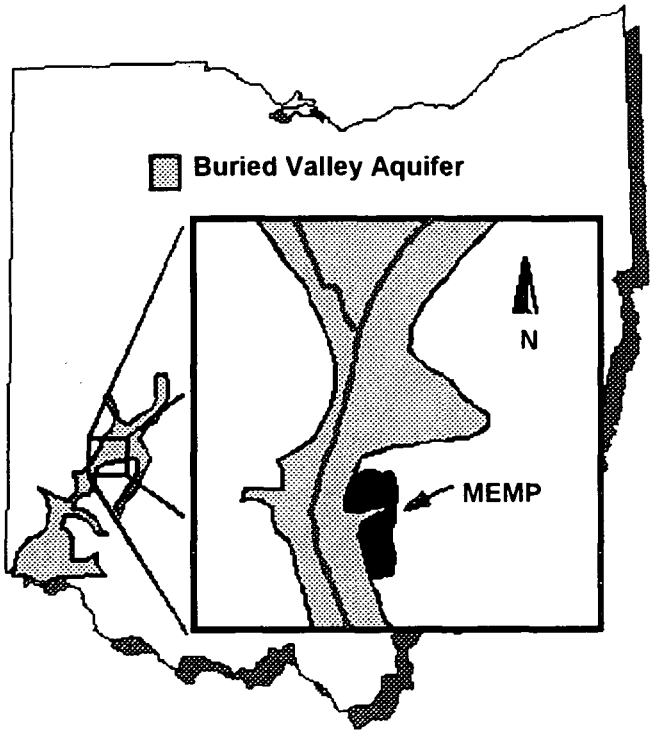
The MEMP site lies along and atop of a portion of Ohio's largest sole-source aquifers, the Buried Valley Aquifer (BVA). The City of Miamisburg and a number of other communities in the area draw drinking water from the BVA. MEMP also relies on the BVA for drinking and process water.

MEMP maintains approximately 180 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, 122 monitoring wells, 38 piezometers, five capture pits, and 13 community water supplies and private wells. About 100 of these points are actively monitored. 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 2001.

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. 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. The City of Miamisburg operates five 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).

6.2 Site Hydrology

As seen in Figure 6-1, a "tongue" of the BVA underlies the site. Within the historical limits of the property, the maximum known thickness of the aquifer is in excess of 100 ft in the southwest portion of the site. Present usage of the BVA by MEMP ranges approximately from 1.19 to 2.08 million liters per day (313,100 to 550,500 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, 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 6 m (20 ft) 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 (0 to 0.2 gal/day/ft^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 northern and western portions of the 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. Seeps, although not considered a potable drinking water source, are indicative of the groundwater quality in the bedrock system from which they emerge. The bedrock system in the vicinity of Mound, due to its relatively low yield, is not utilized as a drinking water source. The water quality in the bedrock system is however important because the bedrock flow system ultimately discharges into the Buried Valley Aquifer flow system. The relatively low VOC concentrations and somewhat elevated tritium levels seen in the bedrock seeps are unlikely to negatively impact the BVA. Simple volumetric flow considerations suggest that considerable dilution will take place as the relatively low yield bedrock system discharges into the highly prolific BVA flow system. Mound

Figure 6-2. Production and Monitoring Well Locations

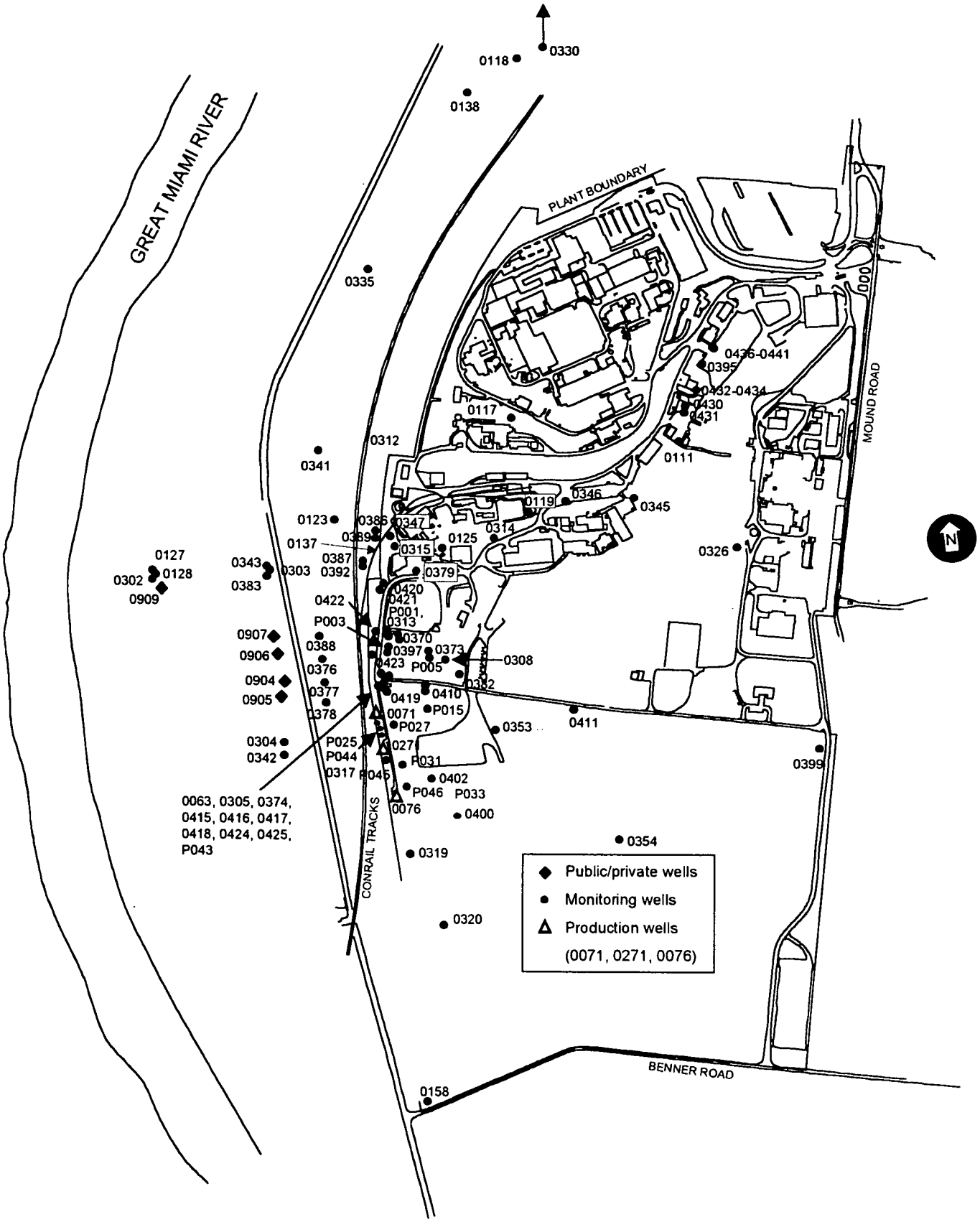
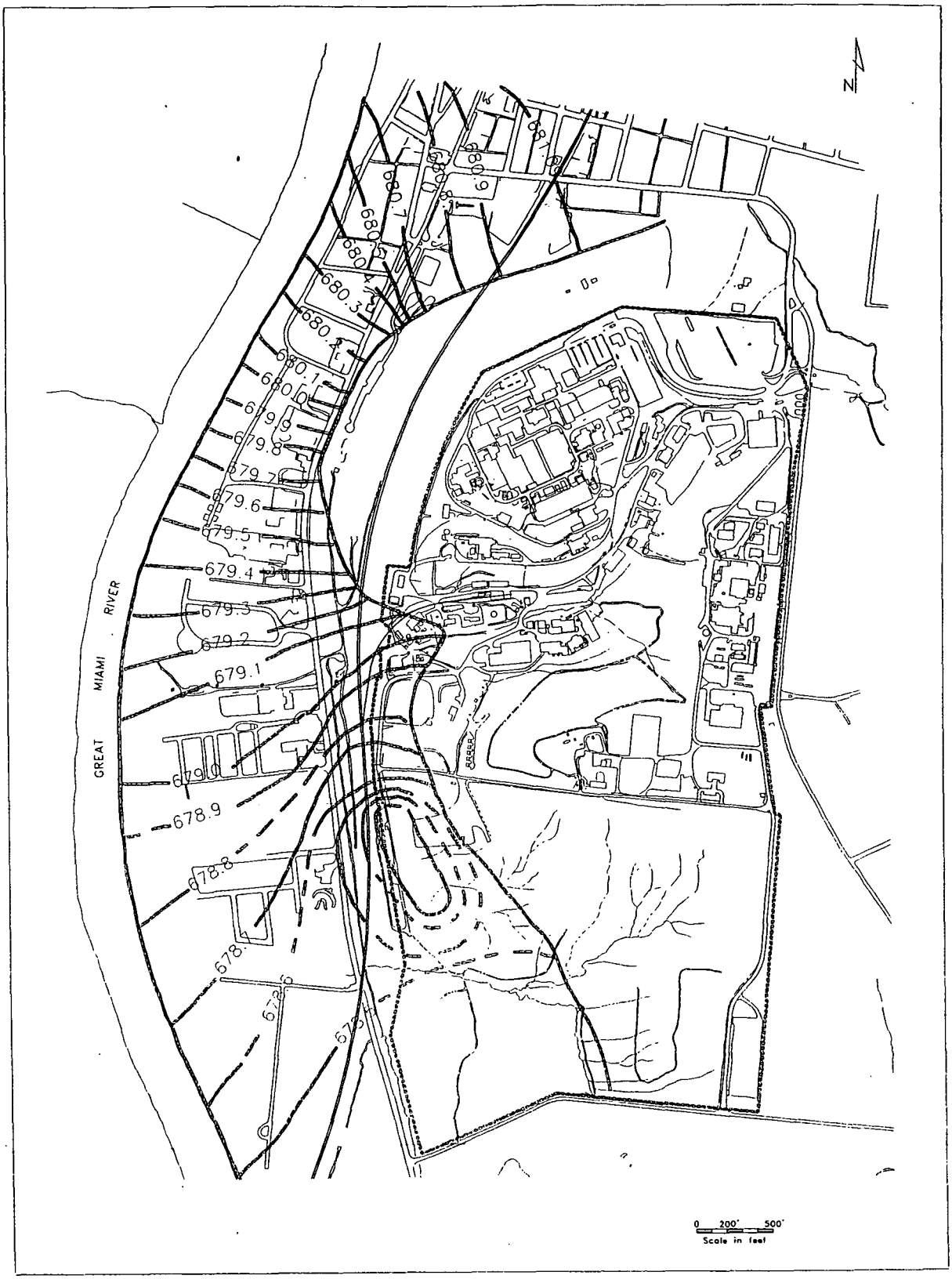


Figure 6-3. Groundwater Elevations for Water in the Bedrock

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

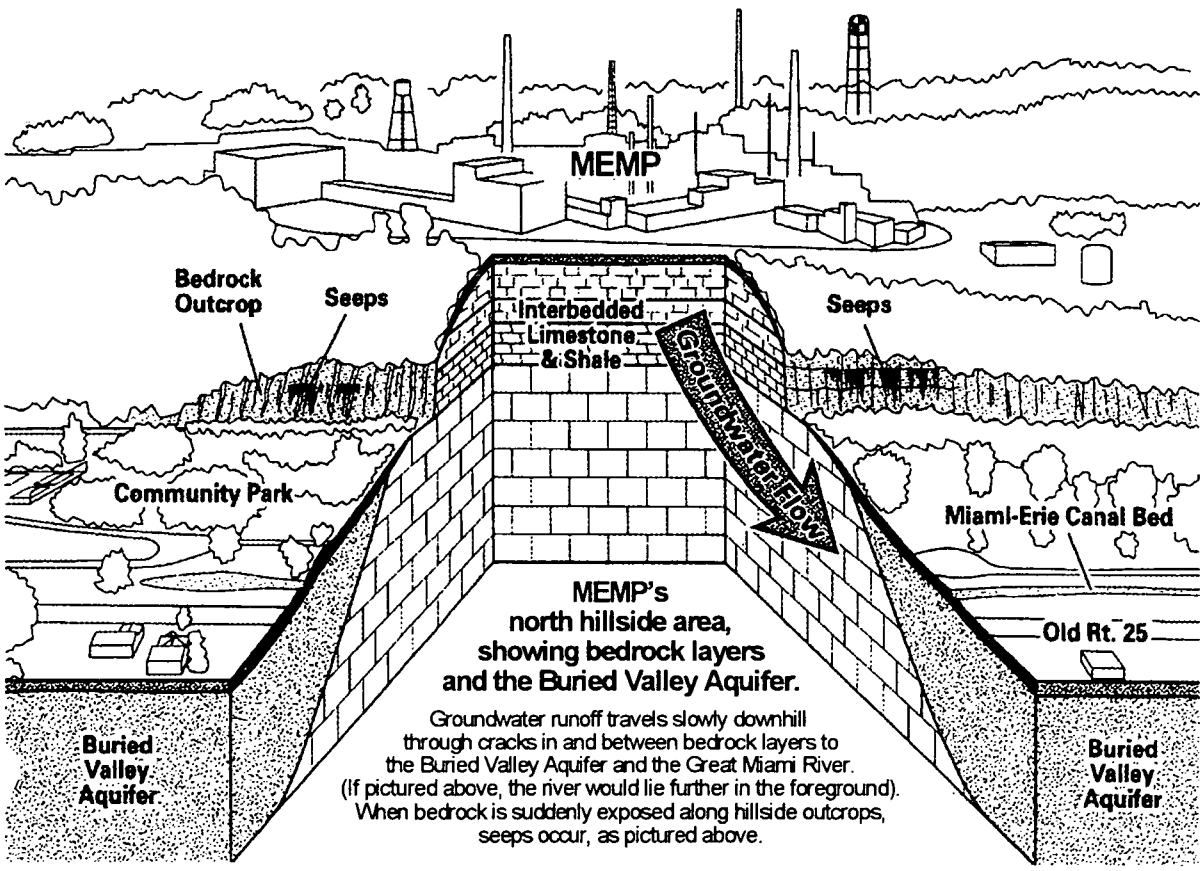


monitoring data from wells positioned offsite in the BVA confirm this with both tritium and VOC concentrations remaining below their respective MCLs.

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 6-5. 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 DCGs. The DCG for a radionuclide is defined as the concentration of that radionuclide which will result in a 50-year CEDE 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 2001 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 onsite and offsite monitoring wells screened in both the BVA and bedrock flow systems. Samples are analyzed for radionuclides, VOCs, and inorganic substances. A description of the analytical procedures used to generate these results can be found in the Environmental Monitoring Plan (BWXTO, 2000) 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 2001 are shown in Appendix D, Table D-2. Average tritium concentrations ranged from less than the blank value to 0.48 nCi/L, or less than 2.4% of the MCL. 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 at least quarterly. Results for 2001 are shown in Appendix D, Tables D-3 through D-5. Many results for 2001 were comparable to background levels for these radionuclides; average concentrations were less than 3.2% 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 2001 are shown in Appendix D, Table D-6. Average tritium concentrations ranged from less than the blank value to 6.68 nCi/L, or less than 33.4% of the MCL.

Monitoring wells along the western boundary of the site are also analyzed for plutonium-238, plutonium-239,240, uranium-233,234, uranium-235, uranium-238, thorium-228, thorium-230, thorium-232, radium-226, and radium-228. The results are shown in Appendix D, Tables D-7 through D-10. Average concentrations for nuclides other than radium ranged from non-detectable to 8.5% of the respective EPA dose standard. Radium concentrations ranged from seven percent to 251% of the respective EPA dose standard. Two of the offsite wells (0335, 0341) showed radium levels in excess of the 5 pCi/L MCL. Both monitoring wells are screened in the low permeability bedrock flow system. This system is not used as a drinking water source at this location. Numerous wells screened within the BVA hydraulically upgradient and downgradient of wells 0335 and 0341 have been monitored. All of these wells show radium levels below the MCL. Although the source of radium has not been positively identified, speculation is that a historical coal pile associated with the old Miamisburg power plant (previously located near well 0335) may be the source. Coal naturally contains uranium and thorium that are parent isotopes for radium-226 and radium-228. The elevated radium appears to be restricted to the bedrock system and is not impacting the BVA. Radium monitoring is also conducted in the tributary valley groundwater system, which is downgradient of the PRS 66 area. The discharge area of the tributary valley is located hydraulically downgradient from wells 0335 and 0341. MEMP will continue to monitor radium concentrations in offsite wells.

VOCs and Inorganics. Twelve 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-11. Historical contaminants, such as tetrachloroethene, trichloroethene, 1,1,1-trichloroethane, were observed in approximately two thirds of the offsite wells monitored in 2001. Although the MCL of 5 μg/L was reached for trichloroethene at well 0386, no MCLs were exceeded in 2001. Well 0386 is in a localized area of subsurface trichloroethene contamination near the site boundary. This area is scheduled for further assessment in 2002. In addition to the historical contaminants, trihalomethanes (THMs) have been detected in eight of the twelve monitoring wells. THMs (bromoform, chloroform, bromodichloromethane, and dibromochloromethane) are generally considered disinfection-by-

products from chlorination. THMs were introduced into the aquifer as a result of a valve failure at the old Miamisburg Well #2 the fall of 1999. Chlorinated potable water from the City of Miamisburg leaked into the aquifer for approximately nine months before the leak was found.

Inorganic substances are also evaluated in offsite monitoring wells. The metals and other inorganics of interest are those regulated under the SDWA. In 2001, only those parameters with MCL detectable concentrations are presented in Appendix D, Table D-12. In 2001, the primary MCLs were exceeded for chromium and nickel. 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."* The sampling method was changed from the standard high-volume well purge to a low-flow micropurge to reduce induced turbidity.

In some cases, low-flow micropurge samples continued to show elevated levels of chromium and nickel. Wells showing chromium and nickel exceedances are constructed of stainless steel. Suspicion is that the well casings may be corroding slightly and providing a source for chromium and nickel. Fieldwork initiated in the fall of 2001 was conducted to determine the source of the elevated chromium and nickel in several monitoring wells. The fieldwork will be summarized in a report in 2002. The fieldwork showed that the elevated chromium and nickel in the wells was highly localized and not widespread. Crevice corrosion of the wire slotted stainless steel well casing is the suspected mechanism for releasing the chromium and nickel from the casing to the groundwater adjacent to the well. Secondary MCLs were exceeded for iron and manganese.

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 ensure 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, VOCs, and inorganic substances. A description of the analytical procedures used to generate these results can be found in the Environmental Monitoring Plan (BWXTO, 2000) 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 are collected monthly, while thorium is done at least quarterly. Results for 2001 are summarized in Appendix D, Tables D-13 through D-16. Average tritium concentrations observed in 2001 were less than 0.4 nCi/L. This value represents less than 2.0% of the MCL. Average concentrations of other radionuclides measured in 2001 in production wells represented less than 0.3×10^{-9} µCi/mL.

MEMP's production wells are also analyzed for approximately 60 organic compounds quarterly each year. The three halogenated solvents typically present in trace concentrations are 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene. As seen in the offsite monitoring wells, THMs are present in the production wells. THMs are being drawn onsite by the production wells large cone of influence as seen in Figure 6-4. Results for 2001 are shown in Appendix D, Table D-17. 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 2001. In 2001, no MCL exceedances were observed in the production wells.

Table 6-1. SDWA Compliance Summary

Parameter	Maximum Concentration	MCL
Tritium	0.7 nCi/L	20 nCi/L
Bromodichloromethane	0.7 µg/L	100 µg/L
Chloroform	7.0 µg/L	100 µg/L
Tetrachloroethene	0.7 µg/L	5 µg/L
Trichloroethene	1.9 µg/L	5 µg/L
1,1,1-Trichloroethane	2.1 µg/L	200 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 2001, the dose from plutonium, uranium, and thorium measured in the onsite production wells was 0.08 mrem. This represents 2.0% of the dose standard. The dose from tritium was 0.06 mrem.

To demonstrate compliance with the SDWA, samples are collected from the distribution system. These samples are analyzed for total coliform, lead, copper, nitrate, inorganics, and volatile organic compounds. No exceedances were observed in 2001.

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 2001 are shown in Appendix D, Table D-18. The maximum average concentration observed in 2001 was 9.9 nCi/L. This value represents 49.5% 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-228, thorium-230, thorium-232, radium-226, and radium-228. Monitoring for these constituents are part of the PRS 66 field investigation, including the tributary valley. Results for 2001 are shown in Appendix D, Tables D-19 through D-22. In 2001, average values ranged from below detection limits to 56.1% of the respective EPA dose standard. Combined radium levels were below the MCL standard. Of the constituents analyzed for, radium-228 was most often the higher percentage with respect to the standard. The higher radium numbers tend to be from wells located within the PRS 66 footprint. PRS 66 and the tributary valley are hydraulically downgradient from the radium values seen offsite.

VOCs and Inorganics. Onsite monitoring wells in the upper and lower units of the BVA have been sampled since 1988. Sixty onsite-monitoring wells are sampled for nearly 40 organic compounds. Fourteen wells have been sampled for semi-volatile organics. Results continue to 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.

The CERCLA OU1 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. Many of the wells are sampled to evaluate containment of the plume and the effectiveness of the OU1 treatment process. A declining trend in VOC concentrations has been observed as shown in Figures 6-6 and 6-7. Current rates of removal indicate completion in 2004. Additional testing will be required to test the effectiveness of the remedy. Results for 2001 are presented in Appendix D, Table D-23. In 2001, carbon tetrachloride, trichloroethene, and tetrachloroethene exceeded drinking water MCLs. In addition to the historical contaminants, THMs have been detected in approximately half of the onsite monitoring wells.

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-24. In 2001, concentrations above primary MCLs were observed for chromium and nickel. Secondary MCLs were exceeded for aluminum, iron, and manganese. In 1999, a field

Figure 6-6. Pump and Treat Composite Influent Contaminant Levels

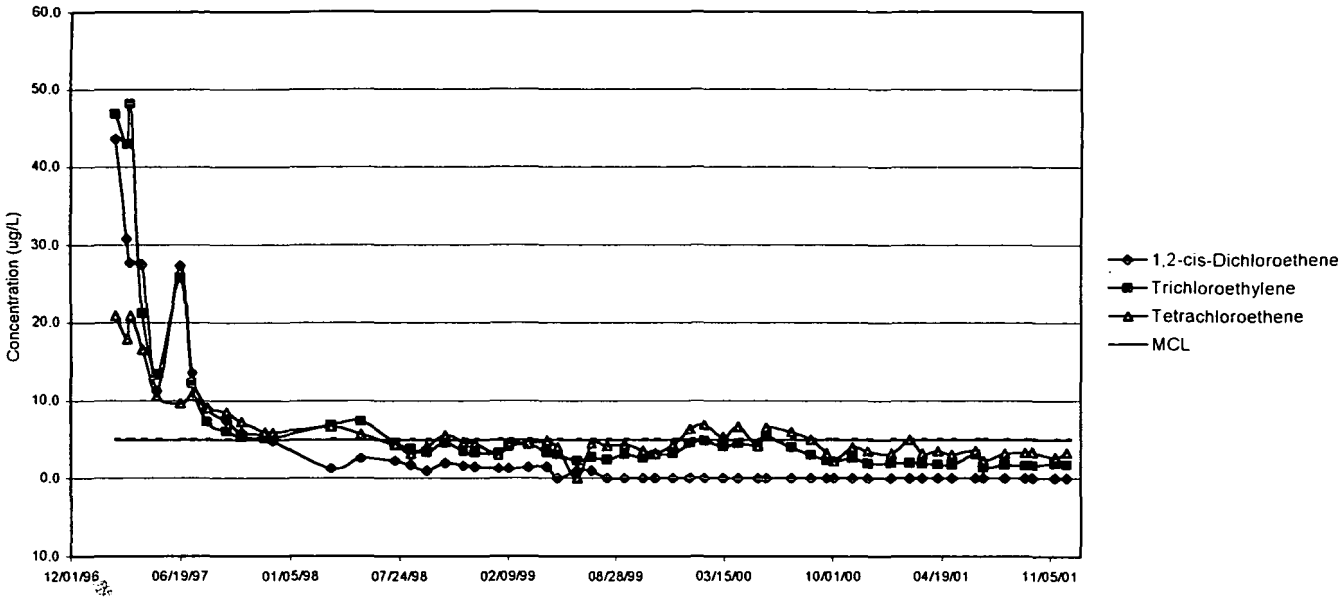
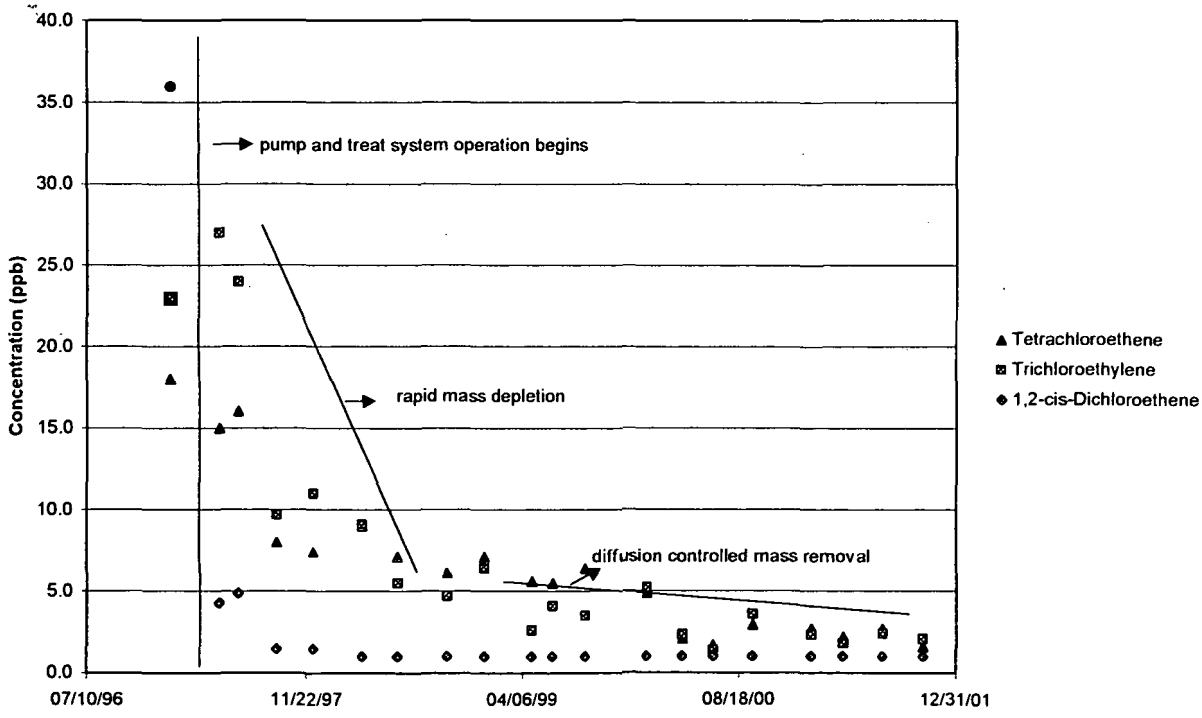


Figure 6-7. VOC Concentrations in Well 0305 During Pump and Treat Operation



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."* The sampling method was changed from the standard high-volume well purge to a low-flow micropurge to reduce induced turbidity.

In some cases, low-flow micropurge samples continued to show elevated levels of chromium and nickel. Wells showing chromium and nickel exceedances are constructed of stainless steel. Suspicion is that the well casings may be corroding slightly and providing a source for chromium and nickel. Fieldwork initiated in the fall of 2001 was conducted to determine the source of the elevated chromium and nickel in several monitoring wells. The fieldwork will be summarized in a report in 2002. The fieldwork showed that the elevated chromium and nickel in the wells was highly localized and not widespread. Crevice corrosion of the wire slotted stainless steel well casing is the suspected mechanism for releasing the chromium and nickel from the casing to the groundwater adjacent to the well.

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-25 shows concentrations of tritium in seep samples in 2001. In 2001, the highest tritium concentrations were associated with Seep 601, consistent with observations in previous years. The sampling locations are shown on Figure 6-8.

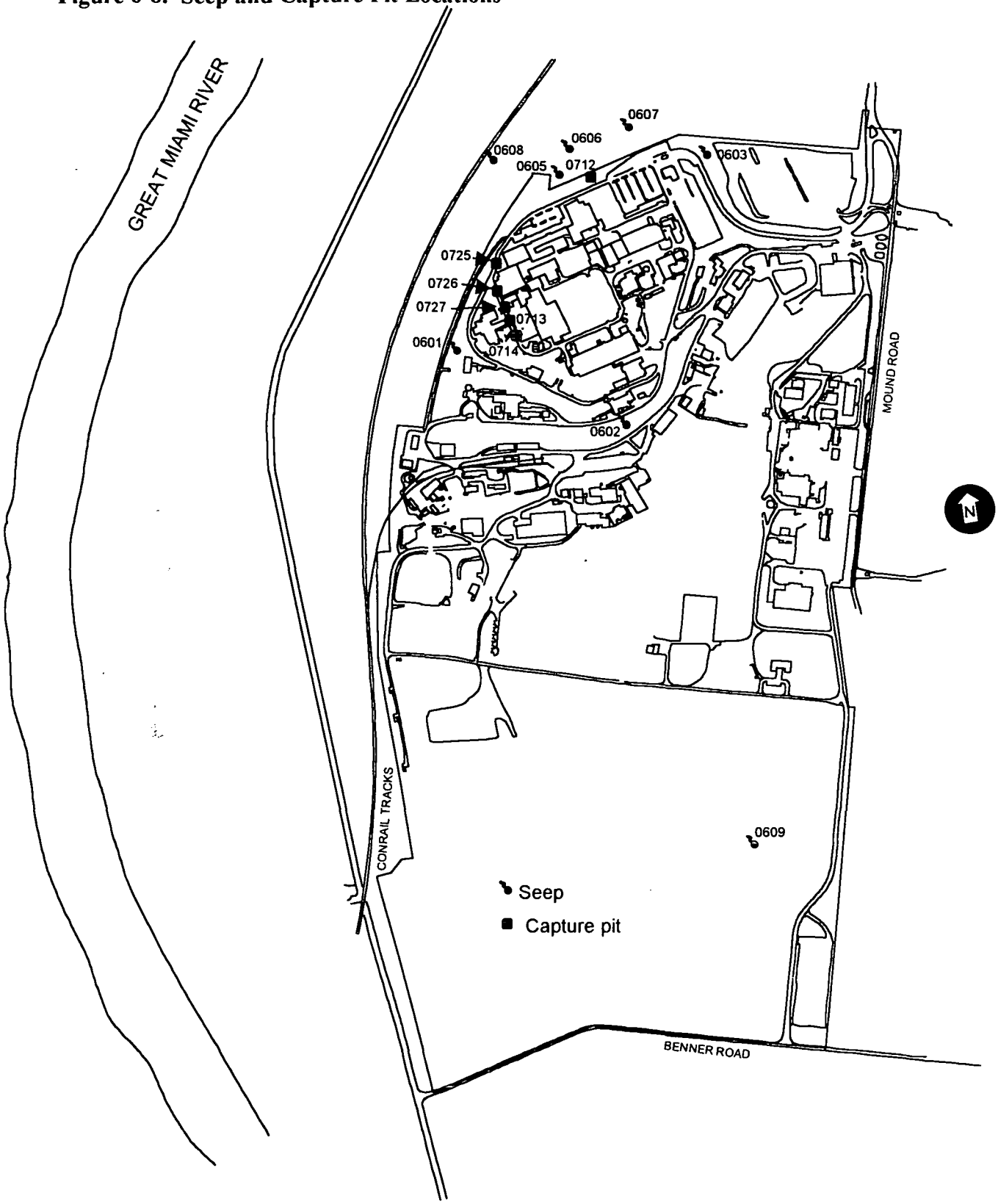
Samples collected in 1988 first confirmed the presence of VOCs in Seeps 0601, 0602, 0605, and 0607 (EG&G, 1991). VOC monitoring results for the seeps in 2001 are presented in Appendix D, Table D-26. In 2001, trichloroethene and tetrachloroethene were observed at concentrations greater than the drinking water MCL.

It is suspected that the soils underlying the SW-R tritium complex are the source area for both the VOCs and the tritium seen in the bedrock seeps. As these soils are removed after building demolition, it is anticipated that the concentrations of both VOCs and tritium will decline to acceptable levels.

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 2001, samples were collected from the capture pits and analyzed for tritium. The results are shown in Appendix D, Table D-27. The sampling locations are shown on Figure 6-8.

Monitoring in previous years has indicated that the VOC contamination exists in the capture pits. The results are shown in Appendix D, Table D-28. In 2001, trichloroethene was the only compound to exceed the MCL value.

Figure 6-8. Seep and Capture Pit Locations



6.8 Five-Year Trends for Wells of Interest

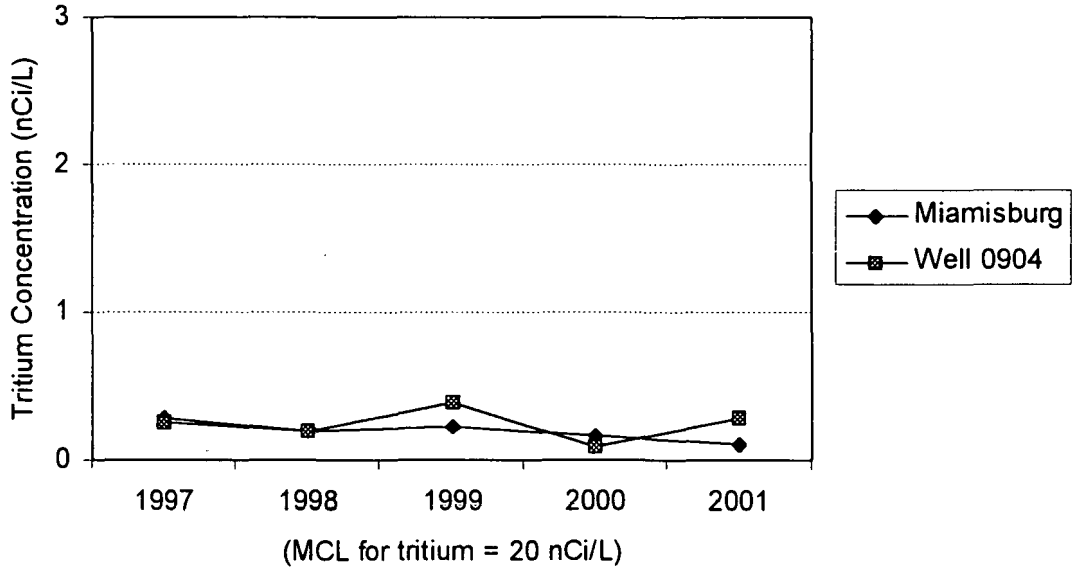
As seen in the preceding sections of this Chapter, a large volume of groundwater monitoring data is generated each year. It is important that the data be reviewed for evidence of long-term trends, especially in cases where there is some history of elevated concentrations of contaminants. In this section, 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 6-9. 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 20 nCi/L MCL for tritium.

Figure 6-9. Annual Average Tritium Concentrations in Offsite Drinking Water, 1997 – 2001



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 6-10 and 6-11 for tritium and trichloroethene (TCE), respectively. Prior to the start of the pump and treat system and the air sparge/vapor extraction system, TCE concentrations were 1.5 – 1.8 μg/L. Similarly, Figures 6-12 and 6-13 present five-year trend data for tritium and trichloroethene at Seep 0601.

Figure 6-10 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 6-11). However, measured concentrations have steadily decreased and remained well below the applicable MCL (5 μg/L). From 1993-1996, tricloroethene levels ranged from 1.5 – 1.8 μg/L.

Figure 6-12 presents tritium concentration data for Seep 0601. Data for the period 1997-2001 show the yearly average for tritium concentrations ranging from approximately 57 nCi/L to 90 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 five 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 average tritium and VOC concentrations have steadily declined as operations continued to be shutdown and removed. It is expected that these trends will continue downward as cleanup operations continue and eventually the source in the soil is removed under these buildings. The risks associated with contamination in the seeps and the appropriate remediation actions will be evaluated under CERCLA.

Figure 6-10. Annual Average Tritium Concentration in Production Well 0076, 1997 - 2001

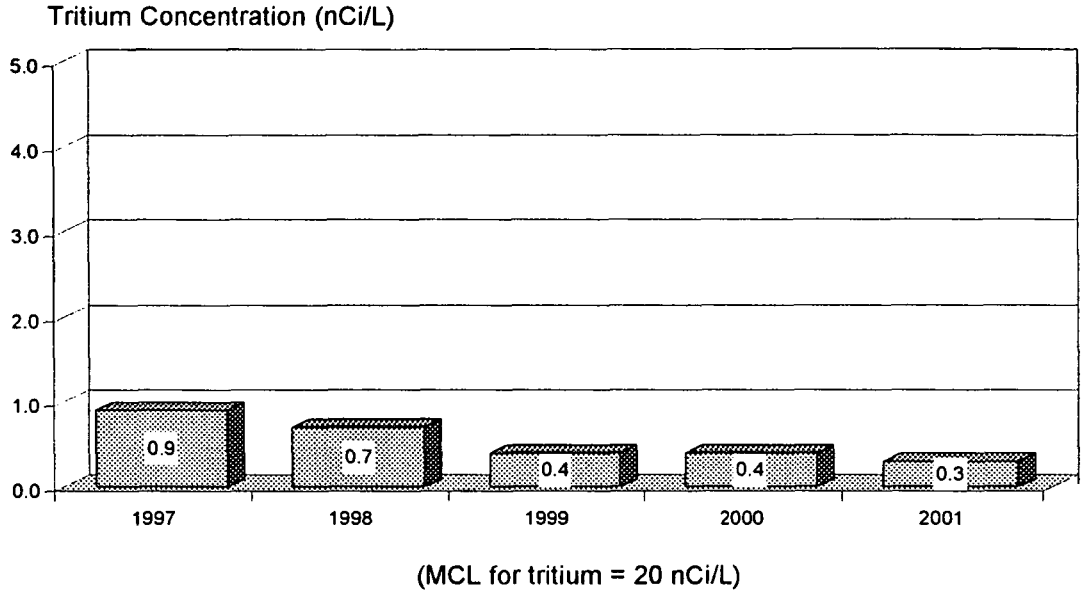


Figure 6-11. Annual Average Indicator VOC Concentration in Production Well 0076, 1997 - 2001

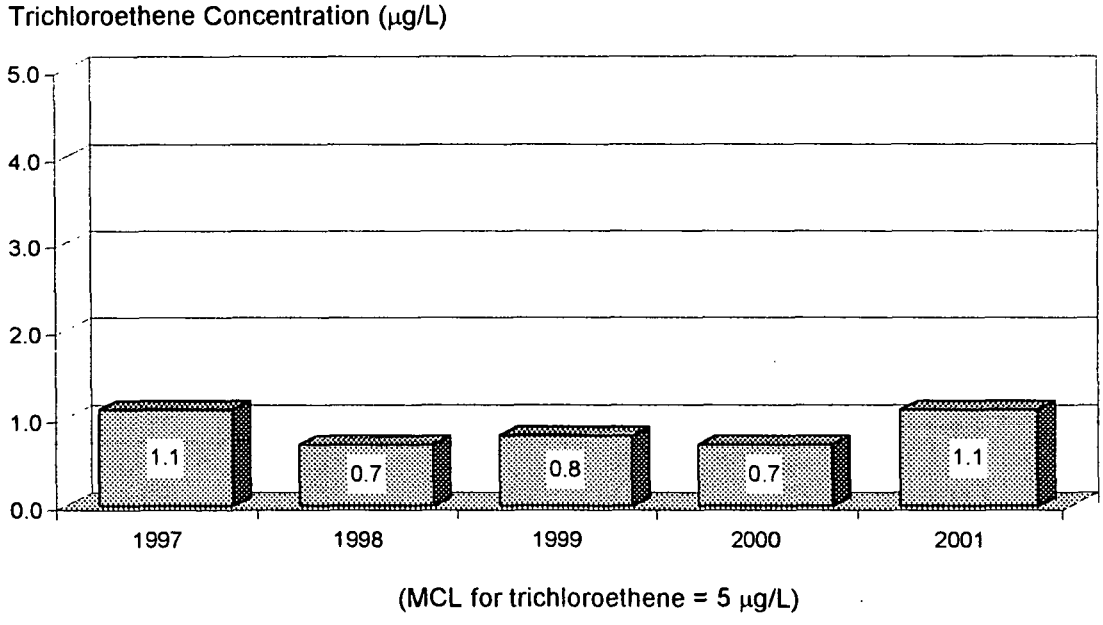


Figure 6-12. Annual Average Tritium Concentration for Seep 0601, 1997 - 2001

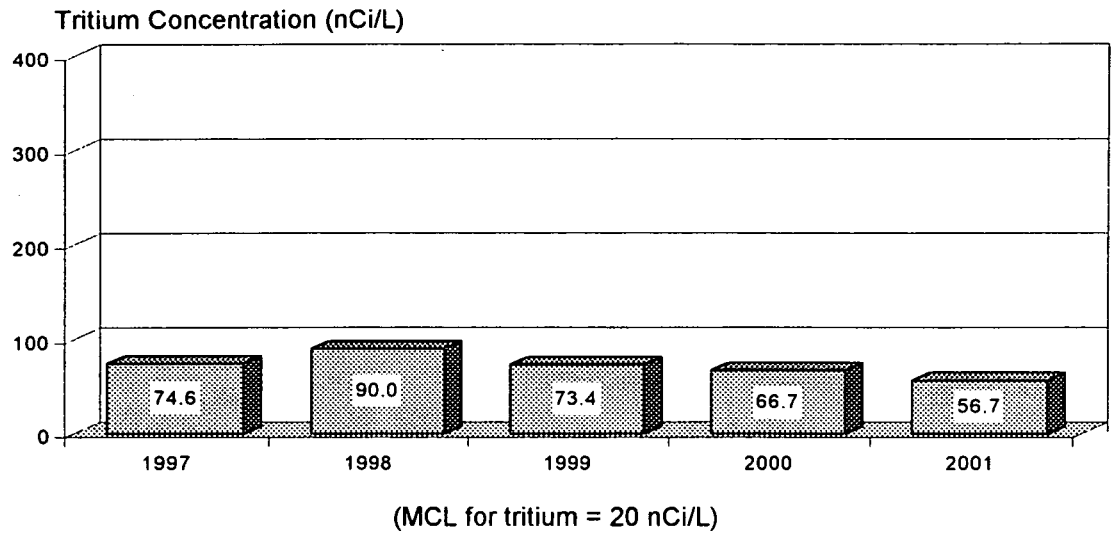
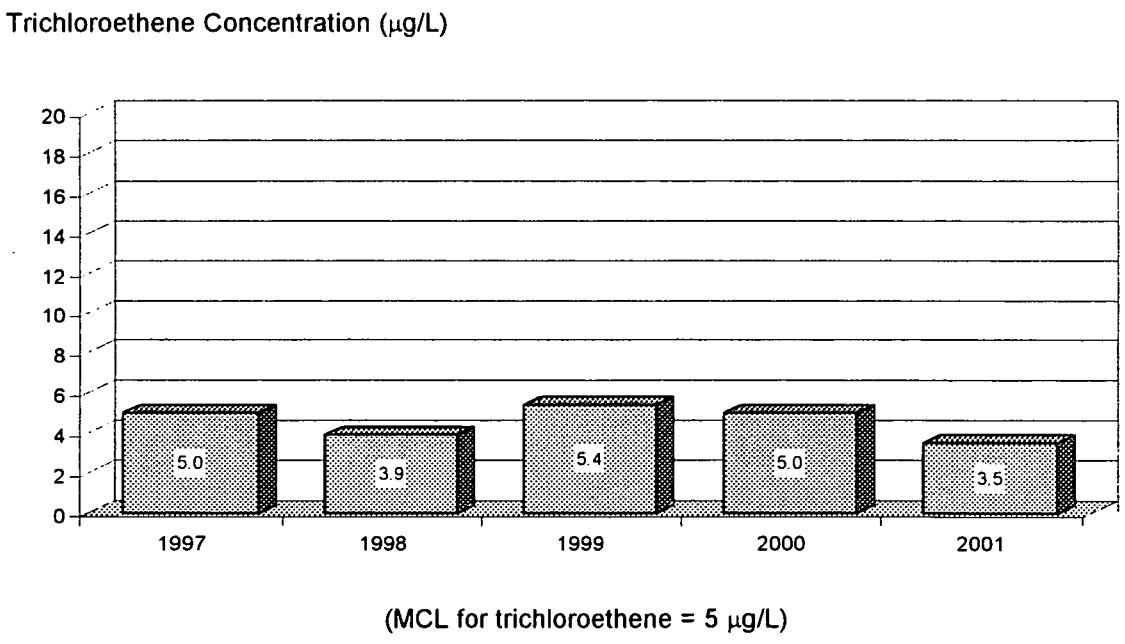


Figure 6-13. Annual Average Indicator VOC Concentration for Seep 0601, 1997 – 2001



End of Chapter 6

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. The environmental manager and staff have developed performance monitoring tools ("metrics"). The metrics are prepared and reviewed by the Environmental Data Administrator on a monthly or as-generated basis. The metrics are also reviewed by the Environmental Manager. Trends of concern are identified and brought to the attention of Senior Management.

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 2001 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 0.97.

DOE MAPEP Quality Assessment Program. The primary objective of the DOE Radiological and Environmental Sciences Laboratory Mixed Analyte Performance Evaluation Program (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 2001 and the corresponding MAPEP reference values are shown in Table 7-2. The soil results for 2001 were not submitted in time for evaluation. However, MEMP results in all categories were within acceptability limits. A water sample was requested but not received.

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 requires 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 2001, MEMP participated in the NPDES QA exercise. In this program, a contract laboratory supplies water samples containing specific unknown quantities of analytes to participating laboratories. Laboratories analyze these samples and submit the results to the contractor. The contractor evaluates the data based on limits for acceptability. MEMP's performance in the NPDES QA exercise in 2001 is shown in Table 7-3. Performance evaluation results are placed in one of four categories: "acceptable," "not acceptable," "unusable," or "check for error." Three of the 15 parameters evaluated were rated as "check for error." This reporting code is advisory; the data were judged acceptable.

Table 7-1. DOE EML Quality Assessment Program Results for 2001: Radionuclides in Environmental Samples

Sample Type [a]	Date	Radionuclide	MEMP Result	EML [b] Reference	Ratio [c] MEMP/EML
Air filters, Bq/filter	June	Pu-238	0.220	0.215	1.02
		Pu-239	0.150	0.136	1.10
		U-234	0.042	0.046	0.91
		U-238	0.041	0.046	0.89
	December	Pu-238	0.065	0.071	0.92
		Pu-239	0.230	0.229	1.00
		U-234	0.110	0.108	1.02
		U-238	0.110	0.109	1.01
Vegetation, Bq/kg	June	Pu-239	7.85	9.58	0.82
	December	Pu-239	10.930	11.022	0.99
Soil, Bq/kg	June	Pu-239	25.59	25.60	1.00
		U-234	38.37	43.60	0.88
		U-238	40.11	46.10	0.87
	December	Pu-239	8.440	8.948	0.94
		U-234	88.46	92.23	0.96
		U-238	93.13	98.33	0.95
Water, Bq/L	June	Tritium	67.65	79.30	0.85
		Pu-238	1.66	1.58	1.05
		Pu-239	1.77	1.64	1.08
		U-234	1.00	1.04	0.96
		U-238	1.06	1.04	1.02
	December	Tritium	211.88	207.00	1.02
		Pu-238	1.100	1.088	1.01
		Pu-239	1.690	1.628	1.04
		U-234	1.120	1.166	0.96
		U-238	1.150	1.169	0.98

[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 2001

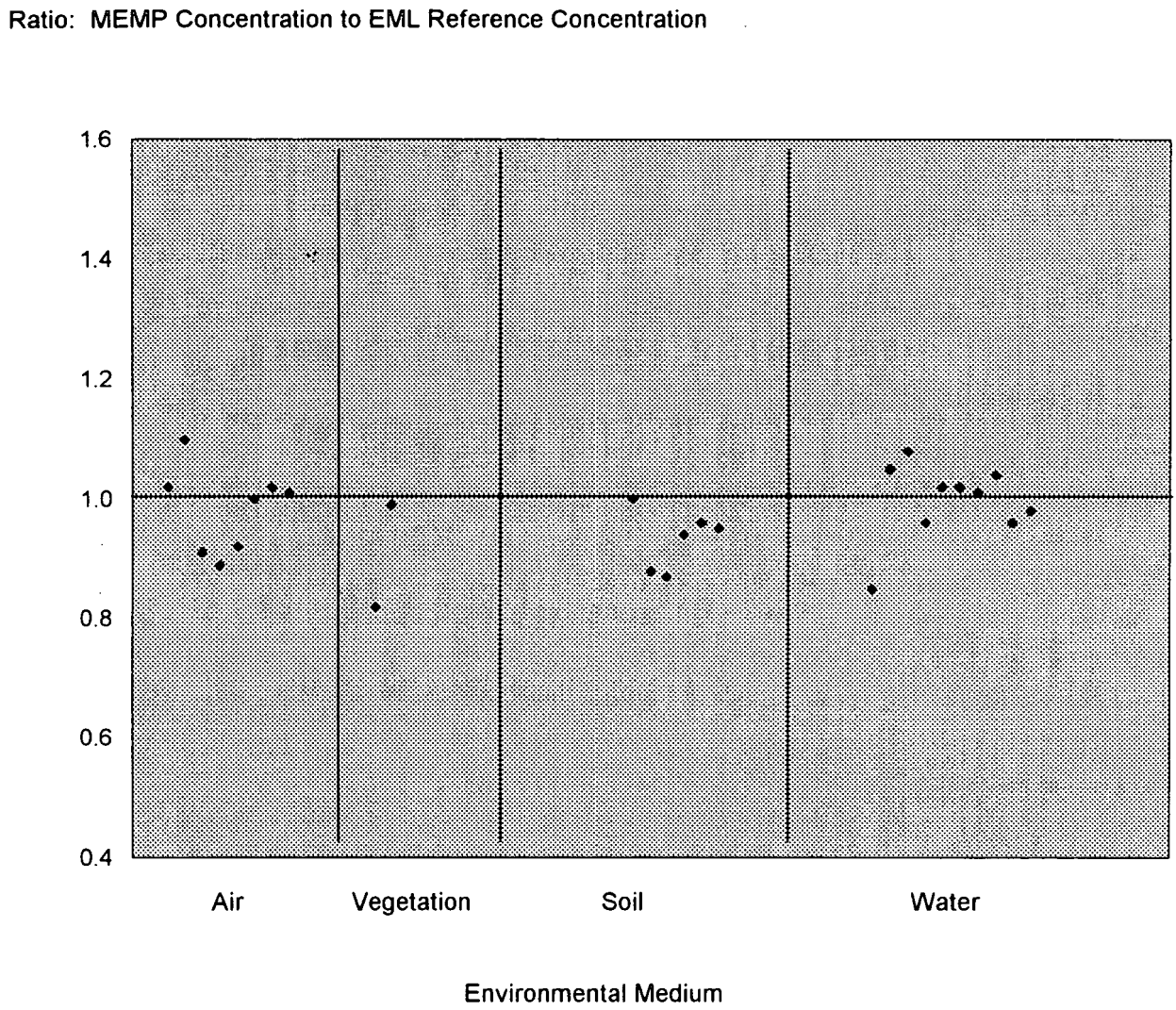


Table 7-2. DOE MAPEP Quality Assessment Results for 2001: Radionuclides in Environmental Samples

Sample Type [a]	Radionuclide	MEMP Result	MAPEP[b] Reference Concentration	Acceptable Range
Soil (Bq/kg)	Pu-238	125.24	115	80.50 – 149.50
	Pu-239/240	86.69	83.4	58.38 – 108.42
	U-233,234	61.72	60	42.00 – 78.00
	U-238	184.11	191	133.70 – 248.30
Water[c]	NA			

[a] 1 Bq = 2.7 x 10^{-11} Ci
[b] DOE Mixed Analyte Performance Evaluation Program.
[c] MEMP requested but did not receive a water sample in 2001.

Table 7-3. NPDES DMR Quality Assessment Program Results for 2001

Parameter	MEMP Value	DMR QA[a] Reference Value	MEMP Performance Evaluation
Trace Metals, µg/L			
Cadmium	29.3	29.6	Acceptable
Chromium	93	104	Check for error
Copper	109	122	Check for error
Mercury	13	16.3	Check for error
Nickel	183	189	Acceptable
Lead	184	199	Acceptable
Selenium	250	251.6	Acceptable
Zinc	179	188	Acceptable
Miscellaneous, mg/L			
Total residual chlorine	1.37	1.36	Acceptable
Total suspended solids	31.1	32.4	Acceptable
Oil and grease	13	13.2	Acceptable
Demand, mg/L			
Chemical oxygen demand	67	102	Not Acceptable
Carbonaceous biochemical oxygen demand	69	54.3	Acceptable
Nutrients, mg/L			
Ammonia as N	5.24	5.72	Acceptable
pH, standard units			
pH	6.81	6.8	Acceptable

[a] EPA Discharge Monitoring Report Quality Assurance Program.

End of Chapter 7

CHAPTER 8

8.0 REFERENCES

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10 CFR 1022. *Compliance with Floodplain/Wetlands Environmental Review Requirements.*

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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.*

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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

RADIOLOGICAL RELEASE RESULTS

Effluent monitoring focuses on releases from the site, i.e., stack and liquid (wastewater) discharges. Tables summarizing monitoring results from 2001 are presented in this Appendix. The tables show the average concentration and a comparison to a DOE standard when applicable. For such releases, DCG values are provided for comparative purposes.

Table A-1. Radiological Effluent Data for 2001

Radionuclide	Released to	Activity, Ci	MEMP Range[b], Ci
Tritium	Air	8.3×10^{2} [a]	$3.8 \times 10^{2} - 8.3 \times 10^{2}$
	Water	2.2	1.7 – 2.5
Plutonium-238	Air	5.7×10^{-6}	$5.7 \times 10^{-6} - 4.5 \times 10^{-5}$
	Water	1.2×10^{-4}	$1.6 \times 10^{-4} - 4.8 \times 10^{-4}$
Plutonium-239,240	Air	4.2×10^{-8}	$3.0 \times 10^{-8} - 1.0 \times 10^{-7}$
	Water	2.3×10^{-6}	$2.3 \times 10^{-6} - 3.6 \times 10^{-6}$
Radon-222	Air	4.6	1.0 – 4.6
Uranium-233,234	Air	1.9×10^{-8}	$8.0 \times 10^{-9} - 1.9 \times 10^{-8}$
	Water	3.4×10^{-4}	$3.4 \times 10^{-4} - 3.9 \times 10^{-4}$
Uranium-238	Air	1.0×10^{-8}	$4.0 \times 10^{-9} - 1.1 \times 10^{-8}$

[a] Tritium released to air consists of: Tritium oxide, 7.07×10^{2} Ci
Elemental tritium, 1.25×10^{2} Ci

[b] Minimum – Maximum (1997-2001)

Table A-2. Average Annual Concentration of Radionuclide Air Emissions in 2001

Stack*	Radionuclide	Average Concentration (μCi/mL)
HH	Tritium	1.86×10^{-9}
NCDPF	Tritium	2.30×10^{-7}
SM/PP	Pu-238	1.18×10^{-14}
	Pu-239,240	7.26×10^{-17}
	U-233,234	6.66×10^{-18}
	U-238	2.35×10^{-18}
SW-1CN	Tritium	5.85×10^{-9}
	Pu-238	3.78×10^{-18}
	Pu-239,240	8.00×10^{-19}
	U-233,234	5.93×10^{-19}
	U-238	5.16×10^{-19}
T-West	Tritium	1.27×10^{-7}
	Pu-238	2.57×10^{-16}
	Pu-239,240	4.19×10^{-18}
	U-233,234	5.94×10^{-18}
	U-238	3.25×10^{-18}
T-East	Tritium	1.18×10^{-9}
HEFS	Tritium	5.55×10^{-7}
	Pu-238	9.66×10^{-18}
	Pu-239,240	7.41×10^{-19}
	U-233,234	2.78×10^{-18}
	U-238	6.96×10^{-19}
WDA	Tritium	3.83×10^{-11}
	Pu-238	2.23×10^{-16}
	Pu-239,240	2.52×10^{-18}
	U-233,234	1.72×10^{-18}
	U-238	1.26×10^{-18}
WDSS	Pu-238	4.84×10^{-17}
	Pu-239,240	2.59×10^{-18}
Building 22	Tritium	1.38×10^{-9}
Building 23	Tritium	7.50×10^{-8}
CWPF	Tritium	5.05×10^{-9}
	Pu-238	1.75×10^{-16}
	Pu-239,240	2.07×10^{-18}
	U-233,234	6.12×10^{-18}
	U-238	4.48×10^{-18}

* Sampling locations shown in Figure 4-1.

Table A-3. Average Annual Concentration of Radionuclides in Water Effluents in 2001

Outfall*	Radionuclide	Average Concentration (μCi/mL)	Average as a Percent of DOE DCG[a]
602	Tritium	2.94×10^{-6}	0.15
	Pu-238	4.73×10^{-11}	0.12
	Pu-239,240	1.83×10^{-12}	0.006
	U-233,234	4.38×10^{-10}	0.09
	Th-228	2.08×10^{-11}	0.005
	Th-230	1.09×10^{-11}	0.004
	Th-232	4.09×10^{-12}	0.008
002	Tritium	2.41×10^{-6}	0.12
	Pu-238	2.12×10^{-10}	0.53
	Pu-239,240	3.51×10^{-12}	0.012
	U-233,234	4.61×10^{-10}	0.09
	Th-228	1.49×10^{-11}	0.004
	Th-230	2.09×10^{-11}	0.007
	Th-232	8.54×10^{-12}	0.017
601	Tritium	9.34×10^{-6}	0.47
	Pu-238	1.09×10^{-11}	0.03
	Pu-239,240	2.31×10^{-12}	0.008
	U-233,234	3.33×10^{-10}	0.07
	Th-228	**	**
	Th-230	**	**
	Th-232	2.00×10^{-13}	0.0004
003	Tritium	1.74×10^{-6}	0.09
	Pu-238	4.84×10^{-12}	0.012
	Pu-239,240	1.52×10^{-12}	0.005
	U-233,234	3.56×10^{-10}	0.07
	Th-228	4.49×10^{-11}	0.011
	Th-230	1.30×10^{-12}	0.0004
	Th-232	6.00×10^{-13}	0.001

[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

* Sampling locations shown on Figure 4-1.

** Average at or below reagent blanks.

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 2001 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 2001

Radionuclide	Number of Samples	Average Concentration[a]	Unit of Measure
Ambient air[b]			
Tritium oxide	47	2.54 ± 2.66	10^{-12} µCi/mL
Plutonium-238	4	ND	10^{-18} µCi/mL
Plutonium-239,240	4	0.36 ± 0.49	10^{-18} µCi/mL
Thorium-238	4	5.20 ± 4.47	10^{-18} µCi/mL
Thorium-230	4	6.39 ± 6.26	10^{-18} µCi/mL
Thorium-232	4	4.56 ± 4.63	10^{-18} µCi/mL
River water[c]			
Tritium	11	ND	10^{-6} µCi/mL
Plutonium-238	10	0.98 ± 1.99	10^{-12} µCi/mL
Plutonium-239,240	10	ND	10^{-12} µCi/mL
Uranium-233,234	11	0.90 ± 0.09	10^{-9} µCi/mL
Uranium-238	11	0.85 ± 0.09	10^{-9} µCi/mL
Thorium-228	6	6.23 ± 21.82	10^{-12} µCi/mL
Thorium-230	6	16.62 ± 31.08	10^{-12} µCi/mL
Thorium-232	6	2.30 ± 7.55	10^{-12} µCi/mL
Pond water[d]			
Tritium	1	ND	10^{-6} µCi/mL
Plutonium-238	1	0.005 ± 0.005	10^{-9} µCi/mL
Plutonium-239,240	1	ND	10^{-9} µCi/mL
Sediment			
Plutonium-238 in river sediment[c]	4	31.75 ± 92.74	10^{-9} µCi/g
Plutonium-238 in pond sediment[d]	1	0.85 ± 0.40	10^{-9} µCi/g
Plutonium-239,240 in river sediment[c]	4	ND	10^{-9} µCi/g
Plutonium-239,240 in pond sediment[d]	1	4.00 ± 0.65	10^{-9} µCi/g
Thorium-228 in river sediment[c]	4	344.40 ± 59.21	10^{-9} µCi/g
Thorium-230 in river sediment[c]	4	601.80 ± 136.69	10^{-9} µCi/g
Thorium-232 in river sediment[c]	4	276.35 ± 77.85	10^{-9} µCi/g
Foodstuffs[e]			
Tritium in vegetation	1	0.21 ± 0.03	10^{-6} µCi/g
Plutonium-238 in vegetation	1	0.10 ± 0.02	10^{-9} µCi/g
Plutonium-239,240 in vegetation	1	0.06 ± 0.02	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 instrument background or reagent blanks..

Table B-2. Incremental Concentrations[a] of Tritium Oxide in Air in 2001

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	51	e	37.24	3.99 ± 3.52	0.004
102	49	e	64.72	6.09 ± 4.58	0.006
103	51	e	63.13	4.76 ± 4.33	0.005
104	51	e	19.57	1.33 ± 3.55	0.001
105	50	e	20.50	0.28 ± 3.23	0.0003
111	34	e	5.56	e	e
112	51	e	27.65	0.83 ± 3.30	0.0008
115	51	e	12.72	e	e
118	50	e	34.08	0.17 ± 3.35	0.0002
124	48	e	76.74	7.28 ± 4.84	0.007
CLN	49	e	30.32	3.91 ± 3.50	0.004
212	51	e	75.94	9.79 ± 4.40	0.01
217	42	e	19.28	1.88 ± 3.25	0.002
Onsite					
211	48	e	26.01	5.06 ± 3.21	0.005
213	50	e	44.09	7.61 ± 3.60	0.008
214	51	e	24.72	4.60 ± 3.16	0.005
215	51	e	30.61	2.82 ± 3.27	0.003
216	49	e	52.39	5.24 ± 3.77	0.005
218	49	e	48.81	2.98 ± 3.96	0.003

[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 in offsite air is 15 x 10^{-12} µCi/mL, except for samplers 212 and 217. The LDL for tritium in onsite air, including samplers 212 and 217, is 23 x 10^{-12} µCi/mL. The LDL for sampler 211 is 26 x 10^{-12} µCi/mL. These differences are due to different calculation 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. Concentrations[a] of Plutonium-238 in Air in 2001

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	0.20	0.09 ± 0.15	0.0003
102	4	0.25	0.40	0.32 ± 0.13	0.001
103	4	0.46	5.55	1.91 ± 3.87	0.006
104	12	e	1.44	0.25 ± 0.25	0.0008
105	4	0.02	0.12	0.06 ± 0.07	0.0002
111	4	e	0.29	0.09 ± 0.24	0.0003
112	4	e	0.08	e	e
115	4	e	0.04	0.01 ± 0.05	0.00003
118	4	e	0.30	0.14 ± 0.23	0.0005
124	12	0.22	2.45	1.32 ± 0.46	0.004
CLN	11	0.10	2.11	0.91 ± 0.36	0.003
212	12	0.61	4.57	1.56 ± 0.78	0.005
217	11	0.01	1.55	0.40 ± 0.29	0.001
Onsite					
211	12	1.46	20.16	5.51 ± 3.66	0.02
213	12	1.26	121.73	15.19 ± 21.40	0.05
214	12	0.72	5.69	2.90 ± 0.86	0.007
215	11	e	4.50	1.61 ± 0.97	0.005
215T	12	0.24	5.74	1.62 ± 0.95	0.005
216	12	0.39	22.27	5.58 ± 3.86	0.02
218	12	0.96	7.01	4.01 ± 1.29	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 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-238 in air is 30,000 x 10^{-18} µCi/mL.

[e] Below reagent blanks.

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 2001

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	0.49	e	e
102	4	e	0.15	e	e
103	4	e	0.17	e	e
104	12	e	0.61	e	e
105	4	e	1.40	0.17 ± 1.40	0.0009
111	4	e	1.17	0.11 ± 1.23	0.0006
112	4	e	1.56	0.38 ± 1.35	0.002
115	4	e	1.17	0.26 ± 1.13	0.001
118	4	e	0.53	0.05 ± 0.75	0.0003
124	12	e	0.49	0.003 ± 0.54	0.00002
CLN	11	e	0.90	0.11 ± 0.55	0.0006
212	12	e	0.56	e	e
217	11	e	1.09	0.04 ± 0.60	0.0002
Onsite					
211	12	e	0.69	0.01 ± 0.55	0.00005
213	12	e	1.62	e	e
214	12	e	0.70	e	e
215	11	e	1.85	0.20 ± 0.63	0.001
215T	12	e	1.64	e	e
216	12	e	0.51	0.03 ± 0.56	0.0002
218	12	e	1.09	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 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-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 2001

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	12.35	1.67 ± 5.05	0.004
Onsite					
213	12	g	20.97	4.01 ± 5.81	0.01
215T	12	g	13.56	3.29 ± 5.13	0.008
216	12	g	12.48	4.30 ± 5.02	0.01
218	12	g	12.05	3.56 ± 5.05	0.009

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	11.77	0.95 ± 6.83	0.002
Onsite					
213	12	g	20.99	3.91 ± 7.33	0.01
215T	12	g	9.69	2.80 ± 6.72	0.007
216	12	g	9.74	3.28 ± 6.63	0.008
218	12	g	14.52	2.17 ± 6.87	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	9.97	0.94 ± 5.03	0.01
Onsite					
213	12	g	14.31	2.82 ± 5.29	0.04
215T	12	g	7.00	2.13 ± 5.03	0.03
216	12	g	8.15	2.37 ± 4.89	0.03
218	12	g	11.01	1.67 ± 5.10	0.02

[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 0.8 x 10^{-18} µCi/mL, for quarterly values the LDL is 0.2 x 10^{-18} µCi/mL.

[d] LDL for Th-230 for monthly values is 1.5 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 0.4 x 10^{-18} µCi/mL, for quarterly values the LDL is 0.1 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 2001

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	0.03	e	e
4	11	e	e	e	e
5	11	e	0.06	e	e
7	11	e	10.68	1.74 ± 2.14	0.09
8	11	e	e	e	e
Mound Ave Storm	10	e	0.27	0.12 ± 0.09	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 tritium in water is 0.16 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 2001

Location*	Number of Samples	Plutonium-238 10^{-12} µCi/mL Minimum	Maximum	Average[b,c]	Average as a percent of DOE DCG[d]
2	10	e	10.02	e	e
4	10	e	21.02	2.22 ± 5.76	0.006
5	10	e	16.02	2.40 ± 4.64	0.006
7	10	e	23.02	7.17 ± 9.03	0.02
8	10	e	9.52	1.02 ± 3.96	0.003

[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 31.6 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-8. Concentrations[a] of Plutonium-239,240 in the Great Miami River in 2001

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	10	e	6.10	0.35 ± 3.09	0.001
4	10	e	4.30	0.04 ± 2.16	0.0001
5	10	e	12.40	e	e
7	10	e	6.50	e	e
8	10	e	3.90	e	e

[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 26.1 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 2001

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	0.44	e	e
4	11	e	0.31	e	e
5	11	e	0.09	e	e
7	11	e	0.01	e	e
8	11	e	0.10	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	0.59	e	e
4	11	e	0.24	e	e
5	11	e	0.02	e	e
7	11	e	e	e	e
8	11	e	0.03	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 0.02×10^{-9} µCi/mL.

[d] DOE DCG for uranium-233,234 in water is 500×10^{-9} µCi/mL. The DOE DCG for uranium-238 in water is 600×10^{-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 2001

Location*	Number of Samples	Thorium-228 Value[a, b, c] 10^{-12} µCi/mL Minimum	Maximum	Average	Average as a percent of DOE DCG[d]
2	6	e	17.77	e	e
4	6	e	196.77	49.92 ± 85.5	0.01
5	6	e	57.77	14.97 ± 33.94	0.004
7	6	e	25.77	e	e
8	6	e	28.77	9.15 ± 28.23	0.002

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	6	e	17.38	1.33 ± 33.87	0.0004
4	6	e	282.28	68.50 ± 120.92	0.02
5	6	e	57.68	7.33 ± 47.83	0.002
7	6	e	60.28	16.35 ± 46.13	0.006
8	6	e	60.38	9.33 ± 47.82	0.003

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	6	1.20	25.70	11.10 ± 12.83	0.02
4	6	7.70	135.70	42.75 ± 51.53	0.09
5	6	e	20.70	11.08 ± 11.09	0.02
7	6	e	19.70	11.92 ± 12.08	0.02
8	6	e	18.70	10.73 ± 11.40	0.02

[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 87.4 x 10^{-12} µCi/mL. The LDL for thorium-230 in river water is 79.9 x 10^{-12} µCi/mL. The LDL for thorium-232 in river water is 15.8 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 2001

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	0.04 ± 0.05	0.002
15	1	0.17 ± 0.06	0.009
17	1	0.02 ± 0.05	0.001
18	1	e	e

[a] Average environmental level below reagent blanks.

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

[c] LDL for tritium in pond water is 0.16 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 2001

Location*	Number of Samples	Plutonium-238 Value[b,c] 10^{-12} µCi/mL	Value as a percent of DOE DCG[d]
11	1	1.80 ± 6.61	0.005
12	1	e	e
14	1	4.40 ± 7.12	0.01
15	1	e	e
17	1	2.40 ± 7.97	0.006
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 31.6 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 2001

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 26.1 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 Plutonium-238 in River and Stream Sediments in 2001

Location*	Number of Samples	Plutonium-238 10^{-9} µCi/g Minimum	Maximum	Average[b,c]
2	4	d	83.25	4.58 ± 124.90
4	4	d	236.55	81.63 ± 192.49
5	4	d	d	d
7	4	179.45	4429.25	1523.30 ± 3133.58
8	4	d	467.25	152.83 ± 366.37
Mound Ave Storm	4	50.35	673.25	311.45 ± 427.71

[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 8.1 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-15. Incremental Concentrations[a] of Plutonium-238 in Pond Sediments in 2001

Location*	Number of Samples	Plutonium-238 Value[b,c] 10^{-9} µCi/g
11	1	d
12	1	0.03 ± 0.50
14	1	10.35 ± 1.26
15	1	3.25 ± 2.76
18	1	2.45 ± 0.78

[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 2.4 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-16. Concentrations[a] of Plutonium-239,240 in River and Stream Sediments in 2001

Location*	Number of Samples	Plutonium-239,240 10^{-9} µCi/g Minimum	Maximum	Average[b,c]
2	4	d	5.20	1.15 ± 5.55
4	4	d	6.60	3.50 ± 4.46
5	4	d	5.40	1.00 ± 6.19
7	4	d	49.00	14.40 ± 36.86
8	4	d	14.60	3.78 ± 12.58
Mound Ave Storm	4	d	10.00	4.88 ± 7.18

[a] Average environmental level below instrument background.

[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 6.4 x 10^{-9} µCi/g.

[d] At or below instrument background.

* Sampling locations shown on Figure 4-7.

Table B-17. Incremental Concentrations[a] of Plutonium-239,240 in Pond Sediments in 2001

Location*	Number of Samples	Plutonium-239,240 Value[b,c] 10^{-9} µCi/g
11	1	d
12	1	d
14	1	d
15	1	d
18	1	1.30 ± 1.03

[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 1.9 x 10^{-9} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-18. Incremental Concentrations[a] of Thorium-228, Thorium-230, and Thorium-232 in River and Stream Sediments in 2001

Location*	Number of Samples	Thorium-228 10^{-6} µCi/g Minimum	Maximum	Average[b,c]
2	4	0.118	1.104	0.420 ± 0.734
4	4	0.235	0.506	0.350 ± 0.190
5	4	0.083	0.221	0.158 ± 0.117
7	4	0.276	1.60	0.707 ± 0.973
8	4	0.056	0.665	0.317 ± 0.409
Mound Ave Storm	4	0.140	0.312	0.233 ± 0.146

Location*	Number of Samples	Thorium-230 10^{-6} µCi/g Minimum	Maximum	Average[b,c]
2	4	0.213	0.878	0.539 ± 0.477
4	4	0.409	0.861	0.628 ± 0.325
5	4	0.104	0.523	0.331 ± 0.330
7	4	0.499	1.74	0.977 ± 0.905
8	4	0.164	1.14	0.613 ± 0.657
Mound Ave Storm	4	0.142	0.455	0.247 ± 0.264

Location*	Number of Samples	Thorium-232 10^{-6} µCi/g Minimum	Maximum	Average[b,c]
2	4	0.142	0.974	0.445 ± 0.597
4	4	0.327	0.433	0.380 ± 0.113
5	4	0.148	0.300	0.205 ± 0.137
7	4	0.287	1.50	0.675 ± 0.898
8	4	0.09	0.546	0.321 ± 0.307
Mound Ave Storm	4	0.232	0.423	0.309 ± 0.151

[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 0.0427 x 10^{-6} µCi/g. The LDL for thorium-230 in river sediment is 0.0333 x 10^{-6} µCi/g. The LDL for thorium-232 in river sediment is 0.0238 x 10^{-6} µCi/g.

[d] Below environmental level.

* Sampling locations shown on Figure 4-7.

Table B-19. Incremental Concentrations[a] of Tritium in Foodstuffs[b] in 2001

Location	Number of Samples	Tritium 10^{-6} µCi/g			
		Value[c]	Minimum	Maximum	Average[d,e]
Carlisle	1	f			
Germantown	1	f			
Miamisburg	7		0.007	0.19	0.11 ± 0.07
Springboro	1	0.12 ± 0.04			

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

[b] Tomato 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 1.7 x 10^{-6} µCi/g..

[f] Below environmental level.

Table B-20. Incremental Concentrations[a] of Plutonium-238 in Foodstuffs[b] in 2001

Location	Number of Samples	Plutonium-238 10^{-9} µCi/g			
		Value[c]	Minimum	Maximum	Average[d,e]
Carlisle	1	f			
Farmersville	1	f			
Miamisburg	3		f	0.41	0.22 ± 0.18

[a] The environmental level shown in Table B-1 subtracted from the data.
[b] Potatoes 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 0.19 x 10^{-9} µCi/g.
[f] Below environmental level.

Table B-21. Incremental Concentrations[a] of Plutonium-239,240 in Foodstuffs[b] in 2001

Location	Number of Samples	Plutonium-239,240 10^{-9} µCi/g			
		Value[c]	Minimum	Maximum	Average[d,e]
Carlisle	1	f			
Farmersville	1	f			
Miamisburg	3		f	f	f

[a] The environmental level shown in Table B-1 subtracted from the data.
[b] Potatoes 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–239,240 in foodstuffs is 0.14 x 10^{-9} µCi/g..
[f] Below environmental level.

End of Appendix B

APPENDIX C

APPENDIX C

NONRADIOLOGICAL MONITORING RESULTS

Effluent and environmental samples are analyzed for nonradiological parameters. Tables summarizing monitoring results from 2001 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 2001

Pollutant	Emission Rate (tons/yr) [b]	Emission Threshold Limit (tons/yr) [a]	% of Standard
Total suspended particulates	10.2	100	10.2
Sulfur dioxide	1.6	100	1.6
Nitrogen oxides	13.7	100	13.7
Organic compounds	1.1	100	1.1
Carbon monoxide	3.7	100	3.7

[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. 2001 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	48	12	51	27 ± 3
102	44	12	40	20 ± 2
103	51	10	56	25 ± 2
104	50	11	57	27 ± 3
105	50	12	54	24 ± 2
111	34	16	83	34 ± 6
112	51	7	66	28 ± 3
115	51	11	55	24 ± 2
118	45	8	66	24 ± 3
119 [c]	51	12	63	26 ± 2
124	48	14	71	29 ± 3
CLN	47	18	71	35 ± 3
212	51	13	61	28 ± 3
217	43	13	64	29 ± 3
Onsite				
211	51	10	88	51 ± 5
213	51	16	75	34 ± 4
214	51	14	55	28 ± 2
215	51	15	71	30 ± 3
215T [d]	49	17	96	33 ± 4
216	51	16	72	33 ± 3
218	49	12	79	31 ± 4

[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 $\mu g/m^3$, annual arithmetic mean (OAC 3745-17-02).

[c] Background location.

[d] 215T is an additional particulate air sampler located at station 215.

* 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 2001

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	0.015	0.128	0.043	0.055	n/a	n/a
pH, s.u.	203	6.88	8.44	7.62	7.75	6.5-9.0	n/a
Chlorine: total [d], mg/L	104	< 0.01	0.02	< 0.01	< 0.01	n/a	n/a
Suspended solids, mg/L	104	< 1	8.0	1.6	2.2	30	15
Fecal coliform [d], n/100mL	27	1	50	4 [e]	10 [e]	2000	1000
Ammonia, mg/L as N	27	< 0.30	0.31	< 0.30	< 0.30	n/a	n/a
$CBOD_5$, mg/L	104	< 4	13.0	< 4	< 4	15	10
Oil and grease [b], mg/L	5	< 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	2.1	< 2.0	2.1	n/a	n/a
Copper, µg/L	12	17.7	119.0	70.1	119.0	n/a	n/a
Nickel, µg/L	12	< 5	11.0	6.0	11.0	n/a	n/a
Lead, µg/L	12	< 1	2.6	< 1	2.6	n/a	n/a
Zinc, µg/L	12	< 50	77	< 50	77	n/a	n/a
VOCs [b,f]	5	ND	7.6	1.4	5.6	n/a	n/a
Outfall 602 Parameters							
Flow rate, MGD	a	0.000	0.287	0.035	0.074	n/a	n/a
pH, s.u.	48	7.06	8.81	8.13	8.47	6.5-9.0	n/a
Suspended solids [c], mg/L	48	1.0	58.0	10.6	20.1	45	30
Chemical oxygen demand, mg/L	48	1	193	51	90	n/a	n/a
Oil and grease, mg/L	13	< 5	405	19.2	203	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 2001 (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	0.024	1.928	0.381	0.513	n/a	n/a
pH, s.u.	52	6.50	8.60	7.60	7.92	6.5-9.0	n/a
Suspended solids [c], mg/L	53	3.9	94.8	15.6	36.1	45	30
Outfall 001 Parameters							
Flow rate, MGD	a	0.025	0.415	0.074	0.096	n/a	n/a
pH, s.u.	43	7.13	8.39	8.01	8.34	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	19.2	87.3	56.1	87.3	120	n/a
Nickel, µg/L	12	< 5	27.6	7.4	27.6	n/a	n/a
Lead, µg/L	12	< 1	3.0	< 1	3.0	n/a	n/a
Zinc, µg/L	12	< 50	108	< 50	108	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 2001 (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	0.031	0.148	0.107	0.126	n/a	n/a
pH, s.u.	52	7.44	8.23	7.81	8.00	6.5-9.0	n/a
Dissolved oxygen, mg/L	52	8.84	14.61	10.60	11.54	n/a	n/a
Dissolved solids, mg/L	25	696.0	872.5	772.8	842.5	n/a	n/a
Suspended solids, mg/L	25	< 1	< 1	< 1	< 1	45	30
$CBOD_5$, mg/L	12	< 4	5.0	< 4	5.0	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	52	< 2	7.0	< 2	< 2	9800	1100
Copper, µg/L	52	< 5	5.1	< 5	< 5	120	65
Nickel, µg/L	27	< 5	6.7	< 5	6.6	n/a	n/a
Lead, µg/L	27	< 1	1.9	< 1	1.0	n/a	n/a
Zinc, µg/L	27	< 50	120.0	< 50	60.0	n/a	n/a
VOCs, µg/L	12	ND	ND	ND	ND	10	5
Bis (2-ethylhexyl) phthalate[b], µg/L	4	< 5	< 5	< 5	< 5	n/a	n/a
Ceriodaphnia dubia[b]							
acute, TU	5	ND	ND	ND	ND	1.0	n/a
chronic, TU	4	ND	ND	ND	ND	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.

TU = toxicity units.

n/a = not applicable, no permit limits.

* Sampling locations shown on Figure 5-1.

MGD = million gallons per day.

ND = below minimum detection limit.

End of Appendix C

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 2001 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 since 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. Generally, data for monitoring wells have only been included in the tables if detectable levels of VOCs or inorganics were observed during one of the sampling.

Table D-1. Environmental Concentrations of Radionuclides in Groundwater in 2001

Radionuclide	Number of Samples	Average Concentration [a, b]	Unit of Measure
Tritium	11	c	c
Plutonium-238	12	0.001 ± 0.003	10^{-9} μCi/ml
Plutonium-239,240	12	0.002 ± 0.002	10^{-9} μCi/ml
Uranium-233,234	12	0.44 ± 0.03	10^{-9} μCi/ml
Uranium-238	12	0.41 ± 0.03	10^{-9} μCi/ml
Thorium-228	7	c	c
Thorium-230	7	0.001 ± 0.023	10^{-9} μCi/ml
Thorium-232	4	0.001 ± 0.004	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 2001

Sampling Location*	Historic Designation	Number of Samples	Tritium nCi/L Minimum	Maximum	Average [c,d]	Average as a % of the EPA Standard [e]
0904	J-1	9	f	0.48	0.29 ± 0.14	1.5
0907	B-H	7	0.17	0.66	0.48 ± 0.16	2.4
0909 [g]	MCD	12	f	0.51	0.25 ± 0.09	1.3
Franklin [g]		12	f	0.03	f	f
Germantown [g]		12	f	0.17	f	f
Miamisburg [g]		12	f	0.29	0.11 ± 0.09	0.6
Middletown [g]		12	f	0.08	f	f
Springboro [g]		12	f	0.13	0.002 ± 0.06	0.01
W. Carrollton [g]		12	f	0.19	f	f

[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 0.3 nCi/L. LDL for tritium in community drinking water is 0.31 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 2001

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	0.006	d	d

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	0.006	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 0.03 x 10^{-9} µCi/mL. LDL for plutonium-239,240 is 0.02 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 2001

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	0.53	0.74	0.63 ± 0.04	3.2

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	0.41	0.63	0.52 ± 0.04	2.2

[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 0.02 x 10^{-9} µCi/mL. LDL for uranium-238 is 0.02 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 2001

Sampling Location*	Number of Samples	Thorium-228 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
Miamisburg	7	d	0.01	d	d

Sampling Location*	Number Of Samples	Thorium-230 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
Miamisburg	7	d	0.025	d	d

Sampling Location*	Number Of Samples	Thorium-232 10^{-9} µCi/mL Minimum	Maximum	Average [a,b]	Average as a % of the EPA Standard [c]
Miamisburg	7	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 thorium-228 is 0.07 x 10^{-9} µCi/mL. LDL for thorium-230 is 0.07 x 10^{-9} µCi/mL. LDL for thorium-232 is 0.02 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 2001

Well I.D.*	Number of Samples	Tritium nCi/L Value [a]	Minimum	Maximum	Average [b,c]	Average as a % of the EPA Standard [d]
0118	1	0.38				1.9
0123	1	e				
0127	4		e	0.66	0.35 ± 0.23	1.8
0128	4		e	0.60	0.39 ± 0.19	2.0
0138	1	1.34				6.7
0302	4		1.37	2.19	1.73 ± 0.41	8.6
0303	4		6.25	6.87	6.58 ± 0.28	32.9
0304	4		1.53	3.09	2.42 ± 0.76	12.1
0330	4		e	0.34	0.09 ± 0.17	0.5
0335	2		e	e	e	
0341	2		0.57	0.78	0.68 ± 0.15	3.4
0342	4		0.72	0.95	0.84 ± 0.10	4.2
0343	4		6.09	7.12	6.68 ± 0.43	33.4
0376	4		e	0.48	0.40 ± 0.08	2.0
0377	4		e	e	e	
0378	1	e				
0383	4		0.59	0.93	0.76 ± 0.15	3.8
0386	4		0.57	0.90	0.70 ± 0.16	3.5
0387	4		0.53	0.93	0.69 ± 0.19	3.4
0388	4		0.75	5.86	2.19 ± 2.46	10.9
0389	4		0.74	1.12	0.89 ± 0.16	4.4
0392	1	0.69				3.5

[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 2001

Sampling Location*	Number of Samples	Plutonium-238 10^{-9} µCi/mL Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0303	3		0.006 [d]	0.074 [d]	0.030 ± 0.038	1.9
0376	3		0.011 [d]	0.021 [d]	0.017 ± 0.006	1.1
0377	3		0.011 [d]	0.015 [d]	0.013 ± 0.002	0.8
0383	3		0.018 [d]	0.031 [d]	0.026 ± 0.007	1.6
0388	3		0.013 [d]	0.031 [d]	0.024 ± 0.009	1.5

Sampling Location*	Number of Samples	Plutonium-239 10^{-9} µCi/mL Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0303	3		0.006 [d]	0.036 [d]	0.020 ± 0.015	1.6
0376	3		0.011 [d]	0.019 [d]	0.016 ± 0.004	1.3
0377	3		0.015 [d]	0.049 [d]	0.034 ± 0.017	2.9
0383	3		0.010 [d]	0.019 [d]	0.013 ± 0.005	1.1
0388	3		0.013 [d]	0.039 [d]	0.023 ± 0.014	1.9

[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 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 2001

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]
0303	3		0.013	0.017 [d]	0.014 ± 0.002	0.1
0304	2		0.408	0.597	0.503 ± 0.134	2.5
0376	3		0.221	0.292	0.246 ± 0.040	1.2
0377	3		0.168	0.186	0.177 ± 0.009	0.9
0383	3		0.283	0.442	0.366 ± 0.080	1.8
0388	3		0.311	0.383	0.338 ± 0.039	1.7

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]
0303	3		0.005 [d]	0.039 [d]	0.018 ± 0.019	0.1
0304	2		0.171 [d]	0.222 [d]	0.197 ± 0.036	0.8
0376	3		0.018	0.044	0.028 ± 0.014	0.1
0377	3		0.019 [d]	0.038	0.026 ± 0.011	0.1
0383	3		0.019	0.094	0.049 ± 0.040	0.2
0388	3		0.016 [d]	0.196	0.078 ± 0.102	0.3

[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-8. Uranium Concentrations in Offsite Monitoring Wells in 2001 (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]	
0303	3		0.005 [d]	0.017 [d]	0.011 ± 0.006	<0.1
0304	2		0.368	0.882	0.625 ± 0.363	2.6
0376	3		0.190	0.239	0.213 ± 0.025	0.9
0377	3		0.134	0.192	0.156 ± 0.032	0.6
0383	3		0.325	0.376	0.346 ± 0.027	1.4
0388	3		0.256	0.339	0.284 ± 0.048	1.2

[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] 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-9. Thorium Concentrations in Offsite Monitoring Wells in 2001

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	3		0.014	0.059	0.030 ± 0.025	0.2
0335	1	0.592				3.7
0376	3		0.010 [d]	0.047 [d]	0.024 ± 0.020	0.2
0377	3		0.027 [d]	0.038 [d]	0.031 ± 0.006	0.2
0383	3		0.015 [d]	0.065 [d]	0.038 ± 0.025	0.2
0388	3		0.008	0.054	0.030 ± 0.023	0.2

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	3		0.011	0.028	0.020 ± 0.009	0.2
0335	1	0.170 [d]				1.4
0376	3		0.015	0.050	0.031 ± 0.018	0.3
0377	3		0.007 [d]	0.031	0.022 ± 0.013	0.2
0383	3		0.024	0.041	0.035 ± 0.010	0.3
0388	3		0.008	0.015 [d]	0.011 ± 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-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 the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-9. Thorium Concentrations in Offsite Monitoring Wells in 2001 (continued)

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	3		0.010 [d]	0.015 [d]	0.013 ± 0.003	0.7
0335	1	0.170 [d]				8.5
0376	3		0.010 [d]	0.046 [d]	0.024 ± 0.019	1.2
0377	3		0.007 [d]	0.014 [d]	0.010 ± 0.004	0.5
0383	3		0.008	0.044 [d]	0.021 ± 0.020	1.1
0388	3		0.006 [d]	0.015 [d]	0.011 ± 0.005	0.5

[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] 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 the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-10. Radium Concentrations in Offsite Monitoring Wells in 2001

Sampling Location*	Number of Samples	Radium-226 pCi/L				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0118	1	0.416				8.3
0138	1	0.351				7.0
0304	2		0.394	1.470	0.932 ± 0.761	18.6
0335	2		3.420	11.72	7.570 ± 5.869	151
0341	2		3.560	3.640	3.600 ± 0.057	72.0

Sampling Location*	Number of Samples	Radium-228 pCi/L				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0118	1	0.788				15.8
0138	1	0.772				15.4
0304	1	1.210				24.2
0335	2		8.340	16.80	12.57 ± 5.982	251
0341	2		2.970	3.760	3.365 ± 0.559	67.3

[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-226 and radium-228, combined in drinking water is 5 pCi/L.

* Well locations shown on Figure 6-2.

Table D-11. VOC Concentrations in Offsite Monitoring Wells in 2001

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0123	None detected	1	c				
0302	None detected	1	c				
0303	None detected	3		c	c		
0343	None detected	1	c				
0376	Chloroform	4		1.30	2.30	1.80 ± 0.42	100
	Tetrachloroethene	4		c	0.61	0.27 ± 0.23	5
	1,1,1-Trichloroethane	4		c	1.30	0.44 ± 0.58	200
0377	Chloroform	4		0.90	1.90	1.38 ± 0.46	100
	1,1,1-Trichloroethane	4		2.10	4.30	2.85 ± 1.04	200
0378	Chloroform	1	0.86				100
	1,1,1-Trichloroethane	1	2.80				200
0383	Chloroform	4		1.80	3.00	2.40 ± 0.50	100
	Tetrachloroethene	4		0.77	1.20	1.00 ± 0.19	5
0386	Bromodichloromethane	1	1.50				100
	Chloroform	1	0.80				100
	Tetrachloroethene	1	0.31				5
	Trichloroethene	1	5.00				5
0388	Chloroform	4		1.10	2.00	1.58 ± 0.38	100
	Tetrachloroethene	4		0.55	0.71	0.63 ± 0.08	5
	1,1,1-Trichloroethane	4		c	0.31	0.19 ± 0.08	200

[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 Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-11. VOC Concentrations in Offsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0389	Chloroform	1	1.10				100
	Tetrachloroethene	1	0.50				5
0392	Chloroform	1	1.90				100
	Tetrachloroethene	1	0.58				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 Primary Drinking Water Standards).

* Well locations shown on Figure 6-2.

Table D-12. Inorganic Concentrations in Offsite Monitoring Wells in 2001

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0123	Iron	1	116				300 [d]
	Lithium	1	325				h
	Manganese	1	410				50 [d]
0302	Aluminum	1	24.4				50-200 [e]
	Barium	1	370				2000 [c]
	Iron	1	2230				300 [d]
	Manganese	1	35.9				50 [d]
0303	Aluminum	4		g	33.6	23.5 ± 10.4	50-200 [e]
	Barium	4		253	262	258 ± 4.1	2000 [c]
	Iron	4		7110	7430	7330 ± 150	300 [d]
	Manganese	4		408	418	414 ± 4.9	50 [d]
0343	Aluminum	1	159				50-200 [e]
	Iron	1	4200				300 [d]
	Lead	1	4.8				15 [f]
	Manganese	1	365				50 [d]
0376	Aluminum	4		g	49.1	29.3 ± 14.3	50-200 [e]
	Chromium	4		g	93.0	52.2 ± 42.5	100 [c]
	Iron	4		117	589	367 ± 226	300 [d]
	Molybdenum	4		4.0	31.8	13.4 ± 13.0	h
	Nickel	4		115	166	130 ± 24.5	100 [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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-12. Inorganic Concentrations in Offsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0377	Aluminum	4		g	32.8	20.6 ± 10.7	50-200 [e]
	Chromium	4		49.1	478	232 ± 180	100 [c]
	Iron	4		563	2360	1155 ± 818	300 [d]
	Manganese	4		9.8	26.8	17.4 ± 7.2	50 [d]
	Molybdenum	4		7.3	62.8	29.3 ± 24.7	h
	Nickel	4		92.2	172	126 ± 34.3	100 [c]
0378	Aluminum	1	48.3				50-200 [e]
	Chromium	1	104				100 [c]
	Iron	1	726				300 [d]
	Manganese	1	20.1				50 [d]
	Nickel	1	126				100 [c]
0383	Aluminum	4		16.8	36.9	28.6 ± 9.3	50-200 [e]
	Chromium	4		70.6	616	212 ± 269	100 [c]
	Copper	4		g	45.2	14.1 ± 20.8	1300 [f]
	Iron	4		327	2630	1131 ± 1023	300 [d]
	Manganese	4		10.3	35.4	18.2 ± 11.6	50 [d]
	Molybdenum	4		6.8	105	34.4 ± 47.2	h
	Nickel	4		108	322	184 ± 98.4	100 [c]
0386	Aluminum	1	39.4				50-200 [e]
	Chromium	1	39.1				100 [c]
	Iron	1	811				300 [d]
	Manganese	1	15.3				50 [d]
	Nickel	1	126				100 [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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-12. Inorganic Concentrations in Offsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0388	Aluminum	4		11.6	39.8	23.6 ± 12.9	50-200 [e]
	Chromium	4		115	302	208 ± 85.6	100 [c]
	Iron	4		689	1470	946 ± 354	300 [d]
	Manganese	4		10.5	34.5	17.8 ± 11.3	50 [d]
	Molybdenum	4		13.6	41.2	24.5 ± 11.8	h
	Nickel	4		74.7	154	109 ± 35.2	100 [c]
0389	Aluminum	1	53.8				50-200 [e]
	Chromium	1	156				100 [c]
	Iron	1	431				300 [d]
	Molybdenum	1	24.6				h
	Nickel	1	63.8				100 [c]
0392	Aluminum	1	37.4				50-200 [e]
	Chromium	1	148				100 [c]
	Iron	1	572				300 [d]
	Manganese	1	17.2				50 [d]
	Nickel	1	126				100 [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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-13. Tritium Concentrations in Onsite Production Wells in 2001

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	42	d	0.58	0.25 ± 0.04	1.3
0271	2	43	0.08	0.55	0.28 ± 0.03	1.4
0076	3	39	0.14	0.67	0.32 ± 0.04	1.6

[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 0.41 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-14. Plutonium Concentrations in Onsite Production Wells in 2001

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	15	d	0.008	0.001 ± 0.002	0.06
0271	2	15	d	0.011	0.0006 ± 0.004	0.04
0076	3	14	d	0.005	0.0004 ± 0.002	0.03

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	15	d	0.005	d	d
0271	2	15	d	0.007	0.0007 ± 0.002	0.06
0076	3	14	d	0.006	0.002 ± 0.002	0.17

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

[b] LDL for plutonium-238 is 0.03 x 10^{-9} µCi/mL. LDL for plutonium-239,240 is 0.02 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-15. Uranium Concentrations in Onsite Production Wells in 2001

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	15	0.13	0.29	0.20 ± 0.03	1.0
0271	2	15	0.18	0.25	0.21 ± 0.01	1.1
0076	3	14	0.23	0.33	0.26 ± 0.01	1.3

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	15	0.08	0.21	0.15 ± 0.02	0.6
0271	2	15	0.15	0.25	0.20 ± 0.02	0.8
0076	3	14	0.19	0.25	0.22 ± 0.01	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 0.02 x 10^{-9} µCi/mL. LDL for uranium-238 is 0.02 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-16. Thorium Concentrations in Onsite Production Wells in 2001

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	10	d	0.015	0.002 ± 0.006	0.01
0271	2	10	d	0.022	d	d
0076	3	9	d	0.014	d	d

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	10	d	0.025	d	d
0271	2	10	d	0.021	0.003 ± 0.011	0.03
0076	3	9	d	0.050	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	10	d	0.013	0.0001 ± 0.004	0.005
0271	2	10	d	0.007	d	d
0076	3	9	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 thorium-228 is 0.07 x 10^{-9} µCi/mL. LDL for thorium-230 is 0.07 x 10^{-9} µCi/mL. LDL for thorium-232 is 0.02 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-17. VOC Concentrations in Onsite Production Wells in 2001

Well I.D.*	Historic Designation	Compound	Number of Samples	µg/L Minimum	Maximum	Average [a]	MCL
0071	1	Bromodichloromethane	4	b	0.7	0.3 ± 0.4	100
		Chloroform	4	b	1.0	0.7 ± 0.5	100
		1,1,1-Trichloroethane	4	0.8	2.1	1.7 ± 0.6	200
0271	2	Chloroform	4	b	0.5	0.3 ± 0.3	100
		Tetrachloroethene	4	b	0.7	0.3 ± 0.4	5
		Trichloroethene	4	b	0.6	0.3 ± 0.3	5
		1,1,1-Trichloroethane	4	b	1.4	0.9 ± 0.6	200
0076	3	Chloroform	4	b	7.0	1.8 ± 3.5	100
		Tetrachloroethene	4	b	0.7	0.2 ± 0.4	5
		Trichloroethene	4	0.6	1.9	1.1 ± 0.6	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-18. Tritium Concentrations in Onsite Monitoring Wells in 2001

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		e	0.52	0.26 ± 0.21	1.3
0111	2		0.69	0.78	0.74 ± 0.06	3.7
0117	3		4.10	4.81	4.37 ± 0.38	21.9
0119	2		1.28	1.63	1.46 ± 0.25	7.3
0125	2		0.91	1.53	1.22 ± 0.44	6.1
0137	4		e	1.18	0.65 ± 0.41	3.2
0158	4		e	e	e	
0305	4		e	0.50	0.30 ± 0.15	1.5
0312	1	2.57				12.9
0313	4		0.46	1.50	0.96 ± 0.47	4.8
0314	2		1.51	1.83	1.67 ± 0.23	8.4
0315	2		0.82	1.69	1.26 ± 0.62	6.3
0317	4		e	0.65	0.48 ± 0.26	2.4
0319	4		0.62	1.08	0.82 ± 0.19	4.1
0320	1	0.59				3.0
0326	3		e	0.64	0.38 ± 0.29	1.9
0345	4		0.74	1.13	0.92 ± 0.16	4.6
0346	2		2.16	2.24	2.20 ± 0.06	11.0
0347	4		0.75	0.98	0.83 ± 0.10	4.2
0353	2		0.71	0.75	0.73 ± 0.03	3.7
0370	4		1.39	1.75	1.58 ± 0.16	7.9
0373	4		1.21	1.81	1.56 ± 0.26	7.8
0374	4		1.26	2.14	1.60 ± 0.38	8.0
0379	2		0.26	3.76	2.01 ± 2.48	10.0
0382	2		e	e	e	
0395	2		3.02	3.57	3.30 ± 0.39	16.5
0397	4		e	1.42	0.71 ± 0.59	3.5
0399	1	0.48				2.4
0400	4		e	e	e	
0402	4		e	0.51	0.39 ± 0.18	2.0
0410	4		0.38	2.62	1.27 ± 1.05	6.3
0411	4		0.79	1.94	1.19 ± 0.54	6.0
0415	4		0.45	1.04	0.68 ± 0.28	3.4

[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. Tritium Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Number of Samples	Tritium nCi/L Value [a]	Minimum	Maximum	Average [b,c]	Average as a % of the EPA Standard [d]
0416	4		e	1.00	0.57 ± 0.31	2.9
0417	4		e	0.53	0.25 ± 0.22	1.3
0418	4		e	0.59	0.42 ± 0.15	2.1
0419	4		0.92	2.23	1.54 ± 0.67	7.7
0420	4		e	1.32	0.99 ± 0.54	4.9
0421	4		0.62	1.81	1.08 ± 0.51	5.4
0422	4		0.54	0.90	0.69 ± 0.15	3.5
0423	4		e	1.17	0.82 ± 0.34	4.1
0424	4		e	0.74	0.47 ± 0.27	2.4
0425	4		e	0.52	0.39 ± 0.14	2.0
0430	4		9.19	10.49	9.90 ± 0.54	49.5
0431	4		2.70	3.80	3.31 ± 0.53	16.5
0432	4		1.41	1.58	1.52 ± 0.08	7.6
0433	4		0.54	1.48	1.20 ± 0.45	6.0
0434	4		0.82	2.51	1.81 ± 0.78	9.0
0436	4		1.65	2.01	1.86 ± 0.18	9.3
0437	4		e	1.71	1.26 ± 0.59	6.3
0438	4		0.60	0.87	0.71 ± 0.12	3.6
0439	4		1.38	2.18	1.92 ± 0.37	9.6
0440	4		2.05	3.27	2.49 ± 0.54	12.5
0441	4		1.97	2.52	2.25 ± 0.23	11.3
P001	4		1.38	1.62	1.47 ± 0.11	7.3
P003	4		e	0.96	0.69 ± 0.32	3.4
P005	4		1.11	1.65	1.37 ± 0.22	6.9
P015	4		1.30	2.04	1.67 ± 0.31	8.3
P025	3		e	0.61	0.52 ± 0.11	2.6
P027	4		e	0.68	0.43 ± 0.26	2.2
P031	4		e	0.75	0.40 ± 0.24	2.0
P033	4		e	0.50	0.29 ± 0.19	1.4
P043	4		1.10	1.83	1.34 ± 0.33	6.7
P044	4		0.20	0.27	0.23 ± 0.03	1.2
P045	4		e	1.07	0.51 ± 0.54	2.5
P046	4		e	0.95	0.64 ± 0.29	3.2

[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-19. Plutonium Concentrations in Onsite Monitoring Wells in 2001

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	1	0.014 [d]				0.9
0119	1	0.020 [d]				1.3
0125	1	0.014 [d]				0.9
0314	1	0.009				0.6
0315	1	0.015 [d]				0.9
0345	1	0.018 [d]				1.1
0346	1	0.015 [d]				0.9
0395	1	0.018 [d]				1.1
0430	4		0.006 [d]	0.062 [d]	0.031 ± 0.025	1.9
0431	4		0.007 [d]	0.049 [d]	0.022 ± 0.019	1.4
0432	4		0.010 [d]	0.015 [d]	0.012 ± 0.002	0.8
0433	4		0.012 [d]	0.068	0.027 ± 0.028	1.7
0434	4		0.012 [d]	0.043 [d]	0.021 ± 0.015	1.3
0436	4		0.005 [d]	0.032 [d]	0.014 ± 0.013	0.9
0437	4		0.016 [d]	0.038 [d]	0.029 ± 0.009	1.8
0438	4		0.010 [d]	0.092	0.032 ± 0.040	2.0
0439	4		0.005 [d]	0.034 [d]	0.019 ± 0.015	1.2
0440	4		0.006 [d]	0.019 [d]	0.013 ± 0.005	0.8
0441	4		0.018 [d]	0.417	0.183 ± 0.191	11.4

[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. Plutonium Concentrations in Onsite Monitoring Wells in 2001 (continued)

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	1	0.014 [d]				1.2
0119	1	0.006 [d]				0.5
0125	1	0.014 [d]				1.2
0314	1	0.016 [d]				1.3
0315	1	0.015 [d]				1.3
0345	1	0.018 [d]				1.5
0346	1	0.005 [d]				0.4
0395	1	0.018 [d]				1.5
0430	4		0.006 [d]	0.018 [d]	0.013 ± 0.005	1.1
0431	4		0.015 [d]	0.042 [d]	0.024 ± 0.012	2.0
0432	4		0.006 [d]	0.031 [d]	0.019 ± 0.013	1.6
0433	4		0.005 [d]	0.043 [d]	0.022 ± 0.020	1.9
0434	4		0.006 [d]	0.043 [d]	0.025 ± 0.017	2.1
0436	4		0.005 [d]	0.040 [d]	0.023 ± 0.016	1.9
0437	4		0.014 [d]	0.033 [d]	0.023 ± 0.009	1.9
0438	4		0.014 [d]	0.032 [d]	0.026 ± 0.008	2.2
0439	4		0.011 [d]	0.042 [d]	0.020 ± 0.015	1.7
0440	4		0.012 [d]	0.019 [d]	0.015 ± 0.003	1.2
0441	4		0.006 [d]	0.038	0.017 ± 0.014	1.4

[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-20. Uranium Concentrations in Onsite Monitoring Wells in 2001

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]	
0111	1	0.252				1.3
0119	1	0.329				1.6
0125	1	2.597				13.0
0314	1	0.713				3.6
0315	1	0.564				2.8
0345	1	0.288				1.4
0346	1	0.388				1.9
0395	1	0.813				4.1
0430	4		0.142	0.166	0.156 ± 0.010	0.8
0431	4		0.567	0.682	0.636 ± 0.049	3.2
0432	4		0.067	0.538	0.359 ± 0.204	1.8
0433	4		0.015 [d]	0.294	0.198 ± 0.125	1.0
0434	4		0.264	0.331	0.302 ± 0.030	1.5
0436	4		0.008	0.319	0.163 ± 0.160	0.8
0437	4		0.738	0.946	0.832 ± 0.097	4.2
0438	4		1.505	1.777	1.628 ± 0.141	8.1
0439	4		0.444	0.795	0.658 ± 0.160	3.3
0440	4		0.983	1.096	1.024 ± 0.053	5.1
0441	3		0.801	2.853	2.044 ± 1.093	10.2

[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] 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. Uranium Concentrations in Onsite Monitoring Wells in 2001 (continued)

Sampling Location*	Number of Samples	Uranium-235 10^{-9} µCi/mL				Average as a % of the EPA Standard [c]
		Value [a]	Minimum	Maximum	Average [b]	
0111	1	0.018				0.1
0119	1	0.014 [d]				0.1
0125	1	0.172				0.7
0314	1	0.034				0.1
0315	1	0.084 [d]				0.4
0345	1	0.012				0.1
0346	1	0.046 [d]				0.2
0395	1	0.035				0.1
0430	3		0.016 [d]	0.047 [d]	0.026 ± 0.018	0.1
0431	3		0.020	0.055 [d]	0.034 ± 0.019	0.1
0432	3		0.015 [d]	0.029	0.022 ± 0.007	0.1
0433	3		0.012	0.030	0.019 ± 0.010	0.1
0434	3		0.014 [d]	0.027 [d]	0.020 ± 0.007	0.1
0436	3		0.012	0.044 [d]	0.023 ± 0.018	0.1
0437	3		0.041 [d]	0.047	0.044 ± 0.003	0.2
0438	3		0.065	0.096	0.081 ± 0.016	0.3
0439	3		0.030	0.049 [d]	0.040 ± 0.010	0.2
0440	3		0.038	0.114	0.071 ± 0.039	0.3
0441	3		0.042 [d]	0.237	0.148 ± 0.099	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 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. Uranium Concentrations in Onsite Monitoring Wells in 2001 (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	1	0.220				0.9
0119	1	0.262				1.1
0125	1	2.016				8.4
0314	1	0.653				2.7
0315	1	0.431				1.8
0345	1	0.229				1.0
0346	1	0.364				1.5
0395	1	0.589				2.5
0430	4		0.093	0.166	0.129 ± 0.031	0.5
0431	4		0.417	0.484	0.436 ± 0.032	1.8
0432	4		0.044	0.378	0.241 ± 0.145	1.0
0433	4		0.016	0.222	0.137 ± 0.087	0.6
0434	4		0.266	0.311	0.285 ± 0.020	1.2
0436	4		0.005 [d]	0.278	0.144 ± 0.153	0.6
0437	4		0.522	0.694	0.620 ± 0.083	2.6
0438	4		1.202	1.479	1.330 ± 0.126	5.5
0439	4		0.435	0.737	0.565 ± 0.128	2.4
0440	4		0.791	1.020	0.872 ± 0.102	3.6
0441	3		0.640	1.982	1.508 ± 0.753	6.3

[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-21. Thorium Concentrations in Onsite Monitoring Wells in 2001

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	1	0.015				0.1
0119	1	0.030				0.2
0125	1	0.565				3.5
0314	1	0.369				2.3
0315	1	0.034 [d]				0.2
0345	1	0.015 [d]				0.1
0346	1	0.042				0.3
0395	1	0.015 [d]				0.1
0430	4		0.046	0.117	0.073 ± 0.031	0.5
0431	4		0.009 [d]	0.053 [d]	0.022 ± 0.021	0.1
0432	4		0.015 [d]	0.068 [d]	0.034 ± 0.024	0.2
0433	4		0.020	0.077 [d]	0.049 ± 0.028	0.3
0434	4		0.022	0.065	0.041 ± 0.019	0.3
0436	4		0.021 [d]	0.082	0.049 ± 0.026	0.3
0437	4		0.019 [d]	0.048 [d]	0.028 ± 0.014	0.2
0438	4		0.040 [d]	0.077	0.056 ± 0.016	0.4
0439	4		0.034	0.756	0.220 ± 0.357	1.4
0440	4		0.019 [d]	0.075 [d]	0.048 ± 0.027	0.3
0441	4		0.042	2.755	0.920 ± 1.243	5.7

[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-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 the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-21. Thorium Concentrations in Onsite Monitoring Wells in 2001 (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]	
0111	1	0.044				0.4
0119	1	0.030				0.3
0125	1	0.691				5.8
0314	1	0.369				3.1
0315	1	0.029				0.2
0345	1	0.015 [d]				0.1
0346	1	0.008 [d]				0.1
0395	1	0.028				0.2
0430	4		0.015 [d]	0.078 [d]	0.046 ± 0.026	0.4
0431	4		0.013	0.053	0.035 ± 0.020	0.3
0432	4		0.011	0.030 [d]	0.020 ± 0.008	0.2
0433	4		0.018	0.105	0.048 ± 0.039	0.4
0434	4		0.011 [d]	0.041	0.023 ± 0.013	0.2
0436	4		0.021	0.054	0.031 ± 0.015	0.3
0437	4		0.026	0.064 [d]	0.047 ± 0.016	0.4
0438	4		0.022	0.055	0.035 ± 0.015	0.3
0439	4		0.010 [d]	0.711	0.217 ± 0.331	1.8
0440	4		0.021	0.048	0.034 ± 0.013	0.3
0441	4		0.039	0.967	0.317 ± 0.441	2.6

[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-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 the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-21. Thorium Concentrations in Onsite Monitoring Wells in 2001 (continued)

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	1	0.013 [d]				0.7
0119	1	0.008 [d]				0.4
0125	1	0.529				26.5
0314	1	0.230				11.5
0315	1	0.008 [d]				0.4
0345	1	0.015 [d]				0.8
0346	1	0.008 [d]				0.4
0395	1	0.015 [d]				0.8
0430	4		0.015 [d]	0.029 [d]	0.019 ± 0.007	1.0
0431	4		0.009 [d]	0.020 [d]	0.014 ± 0.005	0.7
0432	4		0.015 [d]	0.030 [d]	0.021 ± 0.006	1.1
0433	4		0.011 [d]	0.028 [d]	0.023 ± 0.008	1.2
0434	4		0.014 [d]	0.029 [d]	0.021 ± 0.007	1.0
0436	4		0.008 [d]	0.019 [d]	0.013 ± 0.005	0.7
0437	4		0.019 [d]	0.038 [d]	0.025 ± 0.009	1.3
0438	4		0.015 [d]	0.022	0.018 ± 0.004	0.9
0439	4		0.010 [d]	0.565	0.155 ± 0.274	7.7
0440	4		0.012 [d]	0.052 [d]	0.025 ± 0.019	1.2
0441	4		0.018	1.308	0.418 ± 0.602	20.9

[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-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 the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-22. Radium Concentrations in Onsite Monitoring Wells in 2001

Sampling Location*	Number of Samples	Radium-226 pCi/L Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0111	2		0.344	0.355	0.350 ± 0.008	7.0
0119	2		0.528	0.818	0.673 ± 0.205	13.5
0125	2		0.153 [d]	2.130	1.142 ± 1.398	22.8
0314	2		0.321	0.344	0.333 ± 0.016	6.7
0315	2		0.193	0.229	0.211 ± 0.025	4.2
0345	2		0.157	0.212	0.185 ± 0.039	3.7
0346	2		0.549	0.596	0.573 ± 0.033	11.5
0395	2		0.164	0.237	0.201 ± 0.052	4.0
0430	4		1.610	1.880	1.753 ± 0.111	35.1
0431	4		0.416	0.534	0.464 ± 0.052	9.3
0432	4		0.345	0.678	0.498 ± 0.149	10.0
0433	4		0.204	0.401	0.308 ± 0.086	6.2
0434	4		0.249	0.461	0.324 ± 0.098	6.5
0436	4		0.222	0.387	0.273 ± 0.077	5.5
0437	4		0.122	0.369	0.225 ± 0.104	4.5
0438	4		0.195	0.569	0.306 ± 0.176	6.1
0439	4		0.361	1.810	0.753 ± 0.706	15.1
0440	4		0.176	0.387	0.306 ± 0.095	6.1
0441	4		0.223	1.510	0.765 ± 0.600	15.3

[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-226 and radium-228, combined in drinking water is 5 pCi/L.

[d] Below the indicated LDL.

* Well locations shown on Figure 6-2.

Table D-22. Radium Concentrations in Onsite Monitoring Wells in 2001 (continued)

Sampling Location*	Number of Samples	Radium-228 pCi/L Value [a]	Minimum	Maximum	Average [b]	Average as a % of the EPA Standard [c]
0111	2		0.528 [d]	0.851	0.690 ± 0.228	13.8
0119	2		0.536	0.961	0.749 ± 0.301	15.0
0125	2		0.521 [d]	1.610	1.066 ± 0.770	21.3
0314	2		0.571	0.608	0.590 ± 0.026	11.8
0315	2		0.449 [d]	0.457 [d]	0.453 ± 0.006	9.1
0345	2		0.691	0.755	0.723 ± 0.045	14.5
0346	2		0.638	0.820	0.729 ± 0.129	14.6
0395	2		0.448 [d]	0.492	0.470 ± 0.031	9.4
0430	4		2.030	2.400	2.185 ± 0.156	43.7
0431	4		0.468 [d]	1.030	0.784 ± 0.250	15.7
0432	3		0.462 [d]	0.560 [d]	0.513 ± 0.049	10.3
0433	4		0.540	1.030	0.694 ± 0.227	13.9
0434	4		0.504 [d]	0.817	0.682 ± 0.147	13.6
0436	4		1.850	4.060	2.795 ± 1.073	55.9
0437	4		0.485 [d]	0.681	0.556 ± 0.088	11.1
0438	4		2.550	2.990	2.805 ± 0.209	56.1
0439	4		1.530	2.790	2.095 ± 0.524	41.9
0440	4		0.604	0.713	0.667 ± 0.047	13.3
0441	4		0.709	4.920	2.502 ± 1.815	50.0

[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] The EPA standard for radium-226 and radium-228, combined in drinking water is 5 pCi/L.

[d] Results below the method detection limit.

* Well locations shown on Figure 6-2.

Table D-23. VOC Concentrations in Onsite Monitoring Wells in 2001

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0063	Chloroform	4		1.50	2.70	2.05 ± 0.52	100
	Tetrachloroethene	4		3.50	4.50	4.08 ± 0.46	5
	Trichloroethene	4		1.70	2.40	1.95 ± 0.31	5
0111	Chloroform	3		1.40	1.80	1.63 ± 0.21	100
0117	None detected	3		d	d		
0119	None detected	2		d	d		
0125	None detected	2		d	d		
0137	Chloroform	4		d	2.40	1.59 ± 0.94	100
	Trichloroethene	4		d	2.70	2.05 ± 0.97	5
0158	None detected	1	d				
0305	Chloroform	4		0.82	1.40	1.23 ± 0.28	100
	Tetrachloroethene	4		1.60	2.70	2.18 ± 0.56	5
	Trichloroethene	4		2.10	2.40	2.25 ± 0.13	5
	1,1,1-Trichloroethane	4		0.55	0.80	0.69 ± 0.10	200
0312	cis-1,2-Dichloroethene	1	1.10				70
	Trichloroethene	1	8.90				5
0313	Bromodichloromethane	4		d	1.20	0.68 ± 0.35	100
	Chloroform	4		1.10	2.00	1.49 ± 0.39	100
	Tetrachloroethene	4		2.20	3.80	3.03 ± 0.71	5
	Trichloroethene	4		d	1.80	1.25 ± 0.52	5
0314	None detected	2		d	d		

[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. VOC Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0315	Bromodichloromethane	2		d	1.60	1.05 ± 0.78	100
	Carbon Tetrachloride	2		1.40	3.00	2.20 ± 1.13	5
	Chloroform	2		0.96	1.60	1.28 ± 0.45	100
	Trichloroethene	2		10.0	18.0	14.0 ± 5.66	5
0317	None detected	4		d	d		
0326	None detected	3		d	d		
0345	None detected	4		d	d		
0346	None detected	2		d	d		
0347	Carbon Tetrachloride	4		3.90	5.40	4.95 ± 0.71	5
	Chloroform	4		d	1.10	0.46 ± 0.43	100
	Trichloroethene	4		22.0	27.0	24.3 ± 2.63	5
0353	None detected	2		d	d		
0370	Bromodichloromethane	4		d	1.13	0.66 ± 0.32	100
	Carbon Tetrachloride	4		d	1.35	0.94 ± 0.39	5
	Chloroform	4		1.90	2.80	2.25 ± 0.39	100
	Dibromochloromethane	4		d	1.50	0.85 ± 0.50	100
	cis-1,2-Dichloroethene	4		d	1.50	0.90 ± 0.49	70
	Tetrachloroethene	4		34.0	47.0	42.3 ± 5.74	5
	Trichloroethene	4		7.50	11.0	9.63 ± 1.49	5
0373	Bromodichloromethane	4		d	1.40	0.90 ± 0.47	100
	Carbon Tetrachloride	4		d	1.40	1.15 ± 0.38	5
	Chloroform	4		0.89	1.60	1.25 ± 0.36	100
	Dibromochloromethane	4		d	1.20	0.75 ± 0.37	100
	Tetrachloroethene	4		11.0	12.0	11.5 ± 0.58	5
	Trichloroethene	4		1.80	4.00	3.35 ± 1.05	5
	1,1,1-Trichloroethane	4		0.57	0.90	0.68 ± 0.15	200

[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. VOC Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0374	Chloroform	4		d	0.92	0.53 ± 0.34	100
	cis-1,2-Dichloroethene	4		5.80	11.0	8.78 ± 2.18	70
	Tetrachloroethene	4		4.00	5.30	4.75 ± 0.58	5
	Trichloroethene	4		1.90	5.40	3.28 ± 1.50	5
	1,1,1-Trichloroethane	4		d	0.46	0.23 ± 0.16	200
0379	Tetrachloroethene	2		0.70	0.83	0.77 ± 0.09	5
	Trichloroethene	2		1.30	1.70	1.50 ± 0.28	5
0382	None detected	2		d	d		
0395	None detected	2		d	d		
0397	Chloroform	4		2.40	3.20	2.75 ± 0.41	100
	Dibromochloromethane	4		d	1.00	0.59 ± 0.28	100
	Tetrachloroethene	4		3.80	4.70	4.33 ± 0.38	5
	Trichloroethene	4		1.40	2.50	1.80 ± 0.48	5
0410	Chloroform	4		d	1.40	0.96 ± 0.50	100
	cis-1,2-Dichloroethene	4		1.20	37.0	18.9 ± 19.8	70
	Freon-113	4		d	2.60	1.40 ± 0.80	c
	Tetrachloroethene	4		2.50	4.60	3.35 ± 0.90	5
	Trichloroethene	4		15.0	23.0	18.8 ± 4.35	5
0411	cis-1,2-Dichloroethene	4		1.50	2.40	1.85 ± 0.40	70
	Trichloroethene	4		12.0	14.0	13.3 ± 0.96	5
0412	Bromodichloromethane	12		d	1.70	0.70 ± 0.38	100
	Chloroform	12		d	1.90	1.30 ± 0.25	100
	Tetrachloroethene	12		d	6.70	4.70 ± 1.67	5
	Trichloroethene	12		d	3.60	2.70 ± 0.96	5
0413	Chloroform	12		1.60	2.90	2.00 ± 0.40	100
	Tetrachloroethene	12		1.20	4.40	2.10 ± 0.80	5
	Trichloroethene	12		d	3.40	0.90 ± 0.80	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. VOC Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0414	Chloroform	12		d	1.70	1.30 ± 0.30	100
	cis-1,2-Dichloroethene	12		d	2.30	1.30 ± 0.70	70
	Tetrachloroethene	12		4.00	7.10	5.50 ± 1.00	5
	Trichloroethene	12		2.90	3.90	3.40 ± 0.40	5
0415	Chloroform	4		1.10	2.20	1.75 ± 0.47	100
	Tetrachloroethene	4		0.95	1.60	1.14 ± 0.31	5
0416	Chloroform	4		d	2.00	1.36 ± 0.77	100
	Tetrachloroethene	4		d	0.56	0.33 ± 0.17	5
	1,1,1-Trichloroethane	4		d	0.60	0.37 ± 0.25	200
0417	Chloroform	4		1.20	1.70	1.50 ± 0.22	100
	Tetrachloroethene	4		d	0.86	0.67 ± 0.35	5
	1,1,1-Trichloroethane	4		0.48	0.93	0.66 ± 0.20	200
0418	Chloroform	4		1.10	2.00	1.68 ± 0.40	100
	Tetrachloroethene	4		2.00	2.70	2.35 ± 0.31	5
	Trichloroethene	4		1.50	2.70	2.00 ± 0.56	5
	1,1,1-Trichloroethane	4		0.78	1.00	0.88 ± 0.11	200
0419	Carbon Tetrachloride	4		d	2.20	1.20 ± 0.77	5
	Chloroform	4		1.30	2.00	1.53 ± 0.32	100
	cis-1,2-Dichloroethene	4		2.60	38.0	14.7 ± 16.6	70
	trans-1,2-Dichloroethene	4		d	1.80	0.83 ± 0.65	100
	Freon-113	4		d	3.60	2.63 ± 1.14	c
	Tetrachloroethene	4		7.80	11.0	9.33 ± 1.38	5
	Trichloroethene	4		20.0	23.0	21.5 ± 1.29	5
0420	Chloroform	4		1.20	2.40	1.93 ± 0.55	100
	Tetrachloroethene	4		2.60	4.30	3.58 ± 0.71	5
	Trichloroethene	4		d	1.40	0.98 ± 0.43	5
	1,1,1-Trichloroethane	4		d	0.68	0.28 ± 0.27	200

[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. VOC Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0421	Chloroform	4		0.91	1.80	1.33 ± 0.36	100
	Tetrachloroethene	4		0.94	1.90	1.39 ± 0.41	5
0422	Bromodichloromethane	4		d	1.60	0.78 ± 0.55	100
	Chloroform	4		1.20	2.80	2.03 ± 0.67	100
	Tetrachloroethene	4		2.10	3.40	2.68 ± 0.68	5
	Trichloroethene	4		1.40	2.80	2.25 ± 0.68	5
0423	Bromodichloromethane	4		d	1.30	0.70 ± 0.40	100
	Chloroform	4		2.20	3.40	2.80 ± 0.52	100
	Tetrachloroethene	4		1.00	1.90	1.50 ± 0.37	5
0424	Chloroform	4		1.30	1.40	1.35 ± 0.06	100
	Tetrachloroethene	4		0.46	0.76	0.61 ± 0.16	5
	1,1,1-Trichloroethane	4		1.20	3.10	1.73 ± 0.92	200
0425	Chloroform	4		1.20	1.90	1.58 ± 0.29	100
	Tetrachloroethene	4		d	0.80	0.37 ± 0.31	5
	1,1,1-Trichloroethane	4		1.00	1.60	1.38 ± 0.29	200
0430	None detected	4		d	d		
0431	None detected	4		d	d		
0432	Toluene	4		d	2.80	1.45 ± 0.90	1000
0433	None detected	4		d	d		
0434	None detected	4		d	d		
0436	None detected	4		d	d		

[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. VOC Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0437	None detected	4		d	d		
0438	None detected	4		d	d		
0439	None detected	4		d	d		
0440	None detected	4		d	d		
0441	None detected	4		d	d		
P001	Carbon Tetrachloride	4		1.10	1.70	1.40 ± 0.24	5
	Chloroform	4		0.68	1.70	1.05 ± 0.47	100
	Dibromochloromethane	4		d	1.10	0.61 ± 0.33	100
	Tetrachloroethene	4		3.50	4.20	3.93 ± 0.31	5
	Trichloroethene	4		2.80	3.60	3.33 ± 0.36	5
P003	Chloroform	4		2.10	2.60	2.43 ± 0.24	100
	Tetrachloroethene	4		2.30	3.00	2.75 ± 0.31	5
	Trichloroethene	4		d	1.40	0.80 ± 0.40	5
P005	Bromodichloromethane	4		d	1.40	0.95 ± 0.52	100
	Carbon Tetrachloride	4		d	1.50	0.98 ± 0.45	5
	Chloroform	4		0.86	1.40	1.14 ± 0.31	100
	Dibromochloromethane	4		d	0.93	0.57 ± 0.24	100
	Tetrachloroethene	4		10.0	12.0	11.0 ± 0.82	5
	Trichloroethene	4		3.50	4.90	4.10 ± 0.63	5
	1,1,1-Trichloroethane	4		0.48	0.68	0.58 ± 0.09	200
P015	Chloroform	4		0.72	1.60	1.07 ± 0.42	100
	cis-1,2-Dichloroethene	4		1.90	2.40	2.10 ± 0.22	70
	Tetrachloroethene	4		4.30	6.00	5.48 ± 0.79	5
	Trichloroethene	4		9.60	14.0	12.4 ± 1.93	5
P025	Chloroform	3		d	0.54	0.35 ± 0.17	100
	1,1,1-Trichloroethane	3		0.96	1.50	1.25 ± 0.27	200

[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. VOC Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
P027	Chloroform	4		0.73	1.60	1.18 ± 0.44	100
	Tetrachloroethene	4		0.80	1.10	0.94 ± 0.13	5
	1,1,1-Trichloroethane	4		1.30	2.00	1.60 ± 0.29	200
P031	Chloroform	4		d	1.70	0.93 ± 0.78	100
	Tetrachloroethene	4		1.60	2.10	1.88 ± 0.21	5
	Trichloroethene	4		1.30	2.30	1.75 ± 0.42	5
	1,1,1-Trichloroethane	4		1.10	1.50	1.35 ± 0.17	200
P043	None detected	4		d	d		
P044	Chloroform	4		d	1.20	0.86 ± 0.42	100
	1,1,1-Trichloroethane	4		1.90	5.90	3.48 ± 1.76	200
P045	None detected	4		d	d		
P046	Chloroform	4		d	1.30	0.81 ± 0.48	100
	Tetrachloroethene	4		0.62	0.81	0.71 ± 0.09	5
	Trichloroethene	4		3.60	5.30	4.50 ± 0.83	5
	1,1,1-Trichloroethane	4		0.70	0.92	0.83 ± 0.10	200

[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-24. Inorganic Concentrations in Onsite Monitoring Wells in 2001

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0111	Aluminum	2		g	28.8	21.6 ± 10.3	50-200 [e]
	Chromium	2		14.9	21.2	18.1 ± 4.5	100 [c]
	Iron	2		142	232	187 ± 63.6	300 [d]
0119	Aluminum	2		24.0	41.3	32.7 ± 12.2	50-200 [e]
	Iron	2		1090	1450	1270 ± 255	300 [d]
	Manganese	2		34.1	38.5	36.3 ± 3.1	50 [d]
0125	Aluminum	2		31.5	31.5	31.5 ± 0	50-200 [e]
	Chromium	2		19.5	24.4	22.0 ± 3.5	100 [c]
	Zinc	2		g	33.6	18.1 ± 22.0	5000 [d]
0158	Aluminum	4		g	41.9	23.6 ± 12.7	50-200 [e]
	Chromium	4		7.1	65.1	27.9 ± 26.6	100 [c]
	Iron	4		127	621	269 ± 236	300 [d]
	Nickel	4		9.2	49.8	21.9 ± 19.2	100 [c]
0314	Aluminum	2		16.5	51.8	34.2 ± 25.0	50-200 [e]
	Iron	2		31.3	2810	1421 ± 1965	300 [d]
	Manganese	2		33.3	36.0	34.7 ± 1.9	50 [d]
0315	Chromium	2		94.6	116	105 ± 15.1	100 [c]
	Iron	2		475	583	529 ± 76.4	300 [d]
	Nickel	2		108	109	109 ± 0.7	100 [c]
	Silver	2		g	14.5	7.4 ± 10.1	100 [d]

[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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-24. Inorganic Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0319	Aluminum	4		34.4	78.0	58.8 ± 20.6	50-200 [e]
	Chromium	4		36.4	174	80.1 ± 64.3	100 [c]
	Iron	4		412	1550	924 ± 555	300 [d]
	Manganese	4		274	541	431 ± 112	50 [d]
	Nickel	4		229	441	295 ± 100	100 [c]
0320	Aluminum	1	122				50-200 [e]
	Chromium	1	11.6				100 [c]
	Iron	1	291				300 [d]
	Manganese	1	48.2				50 [d]
0345	Aluminum	2		g	20.7	13.9 ± 9.7	50-200 [e]
	Chromium	2		6.6	12.1	9.4 ± 3.9	100 [c]
	Iron	2		82.0	105	93.5 ± 16.3	300 [d]
	Manganese	2		26.2	41.0	33.6 ± 10.5	50 [d]
	Nickel	2		43.4	73.7	58.6 ± 21.4	100 [c]
0346	Aluminum	2		47.7	87.1	67.4 ± 27.9	50-200 [e]
	Chromium	2		6.1	32.5	19.3 ± 18.7	100 [c]
	Iron	2		828	912	870 ± 59.4	300 [d]
	Manganese	2		54.6	58.9	56.8 ± 3.0	50 [d]
	Nickel	2		34.4	69.2	51.8 ± 24.6	100 [c]
0353	Aluminum	2		g	180	96.1 ± 119	50-200 [e]
	Chromium	2		g	98.9	49.9 ± 69.3	100 [c]
	Iron	2		1170	1760	1465 ± 417	300 [d]
	Manganese	2		125	127	126.0 ± 1.4	50 [d]
	Nickel	2		24.6	225	124.8 ± 142	100 [c]
	Zinc	2		5.7	106	55.9 ± 70.9	5000 [d]

[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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-24. Inorganic Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0379	Aluminum	2		g	38.4	24.4 ± 19.8	50-200 [e]
	Chromium	2		10.1	99.7	54.9 ± 63.4	100 [c]
	Iron	2		515	1510	1013 ± 704	300 [d]
	Manganese	2		11.2	15.4	13.3 ± 3.0	50 [d]
	Nickel	2		105	160	133 ± 38.9	100 [c]
0382	Aluminum	2		g	40.6	27.5 ± 18.5	50-200 [e]
	Barium	2		209	223	216 ± 9.9	2000 [c]
	Iron	2		44.9	259	152 ± 151	300 [d]
	Lithium	2		204	221	213 ± 12.0	h
	Manganese	2		24.7	27.4	26.1 ± 1.9	50 [d]
0395	Aluminum	2		55.4	85.8	70.6 ± 21.5	50-200 [e]
	Chromium	2		13.4	41.7	27.6 ± 20.0	100 [c]
	Iron	2		201	498	350 ± 210	300 [d]
	Manganese	2		28.2	75.0	51.6 ± 33.1	50 [d]
	Nickel	2		415	428	422 ± 9.2	100 [c]
	Zinc	2		113	128	121 ± 10.6	5000 [d]
0399	Aluminum	1	283				50-200 [e]
	Chromium	1	65.3				100 [c]
	Iron	1	476				300 [d]
	Lithium	1	341				h
	Manganese	1	28.1				50 [d]
	Nickel	1	164				100 [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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-24. Inorganic Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0400	Aluminum	4		35.4	87.2	64.4 ± 23.1	50-200 [e]
	Chromium	4		23.0	81.0	41.8 ± 26.5	100 [c]
	Iron	4		239	678	382 ± 205	300 [d]
	Manganese	4		g	31.2	18.3 ± 10.3	50 [d]
	Nickel	4		72.5	120	101 ± 21.4	100 [c]
	Zinc	4		g	26.5	10.8 ± 11.3	5000 [d]
0402	Aluminum	4		80.8	207	121 ± 58.1	50-200 [e]
	Chromium	4		6.3	10.8	8.0 ± 2.0	100 [c]
	Copper	4		g	30.5	9.4 ± 14.2	1300 [f]
	Iron	4		139	377	215 ± 111	300 [d]
	Zinc	4		g	191	49.9 ± 94.1	5000 [d]
0411	Aluminum	4		19.4	143	75.1 ± 51.1	50-200 [e]
	Chromium	4		g	217	79.9 ± 101	100 [c]
	Iron	4		20.6	942	340 ± 419	300 [d]
	Nickel	4		7.6	61.6	29.2 ± 22.9	100 [c]
	Zinc	4		g	25.3	13.4 ± 13.5	5000 [d]
0430	Aluminum	4		19.5	89.9	50.5 ± 33.4	50-200 [e]
	Iron	4		3950	4660	4250 ± 299	300 [d]
	Lithium	4		97.4	136	113 ± 16.9	h
	Manganese	4		105	110	107 ± 2.2	50 [d]
0431	Aluminum	4		g	90.5	41.1 ± 38.4	50-200 [e]
	Iron	4		1040	1470	1315 ± 191	300 [d]
	Manganese	4		37.1	43.2	40.7 ± 2.9	50 [d]
0432	Aluminum	4		17.7	30.2	23.5 ± 5.4	50-200 [e]
	Iron	4		17.8	212	96.2 ± 89.8	300 [d]
	Manganese	4		55.4	64.4	58.8 ± 4.0	50 [d]

[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] Primary Maximum Contaminant Level.
[d] Secondary Maximum Contaminant Level.
[e] The secondary MCL for aluminum is a range; final MCL values have not been established.
[f] Action level.
[g] Results below the method detection limit.
[h] No MCL assigned.
MCL = Maximum Contaminant Level (based on EPA Primary Drinking Water Standards).
* Well locations shown on Figure 6-2.

Table D-24. Inorganic Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0433	Aluminum	4		59.8	88.8	73.5 ± 13.7	50-200 [e]
	Iron	4		121	179	147 ± 24.8	300 [d]
	Manganese	4		14.9	56.9	34.8 ± 17.8	50 [d]
	Zinc	4		g	51.5	21.0 ± 22.4	5000 [d]
0434	Aluminum	4		g	45.6	28.6 ± 16.2	50-200 [e]
	Iron	4		2180	3300	2695 ± 542	300 [d]
	Manganese	4		1140	1950	1455 ± 357	50 [d]
	Zinc	4		8.2	29.3	17.2 ± 8.8	5000 [d]
0436	Aluminum	4		21.5	43.8	32.4 ± 12.6	50-200 [e]
	Iron	4		2290	3710	3000 ± 669	300 [d]
	Manganese	4		167	249	210 ± 41.1	50 [d]
	Zinc	4		g	45.8	15.8 ± 20.1	5000 [d]
0437	Aluminum	4		g	91.4	50.7 ± 33.9	50-200 [e]
	Iron	4		1100	3110	1960 ± 843	300 [d]
	Manganese	4		148	182	163 ± 16.7	50 [d]
	Zinc	4		g	38.5	15.8 ± 15.5	5000 [d]
0438	Aluminum	4		g	298	121 ± 130	50-200 [e]
	Iron	4		105	519	288 ± 195	300 [d]
	Manganese	4		178	382	279 ± 96.8	50 [d]
	Zinc	4		g	31.4	14.1 ± 12.3	5000 [d]
0439	Aluminum	4		g	89.9	33.8 ± 38.2	50-200 [e]
	Iron	4		g	273	97.7 ± 124	300 [d]
	Lead	4		g	3.3	1.7 ± 1.3	15 [f]
	Manganese	4		391	991	659 ± 249	50 [d]

[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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-24. Inorganic Concentrations in Onsite Monitoring Wells in 2001 (continued)

Well I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0440	Aluminum	4		33.8	376	164 ± 148	50-200 [e]
	Iron	4		266	623	393 ± 159	300 [d]
	Manganese	4		238	390	308 ± 64.7	50 [d]
	Mercury	4		g	0.50	0.16 ± 0.23	2 [c]
	Zinc	4		15.2	30.8	23.4 ± 8.0	5000 [d]
0441	Aluminum	4		27.1	46.5	33.8 ± 8.6	50-200 [e]
	Barium	4		52.3	315	214 ± 115	2000 [c]
	Iron	4		g	2000	546 ± 972	300 [d]
	Manganese	4		115	2310	1287 ± 1028	50 [d]
	Zinc	4		9.9	30.8	17.8 ± 9.1	5000 [d]
P015	Aluminum	4		19.2	80.7	45.3 ± 26.9	50-200 [e]
	Chromium	4		g	14.0	8.2 ± 4.2	100 [c]
	Iron	4		42.4	310	149 ± 117	300 [d]
	Mercury	4		g	0.35	0.13 ± 0.15	2 [c]
	Nickel	4		5.2	44.3	18.6 ± 17.8	100 [c]
P031	Aluminum	4		16.0	132	62.1 ± 54.6	50-200 [e]
	Chromium	4		g	39.4	12.5 ± 18.2	100 [c]
	Iron	4		17.5	227	126 ± 93.0	300 [d]
P033	Aluminum	4		32.4	93.2	63.5 ± 25.0	50-200 [e]

[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] Primary Maximum Contaminant Level.

[d] Secondary Maximum Contaminant Level.

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

[f] Action level.

[g] Results below the method detection limit.

[h] No MCL assigned.

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

* Well locations shown on Figure 6-2.

Table D-25. Tritium Concentrations in Seeps in 2001

Seep 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	289		20.15	99.92	56.69 ± 13.57	284
0602	S002	2		9.47	11.08	10.28 ± 1.14	51.4
0603	S003	1	0.57				2.9
0605	S005	3		34.86	38.85	37.24 ± 2.10	186
0606	S006	1	7.67				38.4
0607	S007	15		6.95	17.94	12.38 ± 3.85	61.9
0608	S008	3		10.77	12.23	11.48 ± 0.73	57.4
0617		1	0.42				2.1
S01		3		e	e	e	

[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.

[e] Below the blank value.

* Seep locations are shown on Figure 6-8.

Table D-26. VOC Concentrations in Seeps in 2001

Seep I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0601	cis-1,2-Dichloroethene	3		0.50	1.50	0.83 ± 0.58	70
	Tetrachloroethene	3		9.40	12.0	10.47 ± 1.36	5
	Trichloroethene	3		2.50	5.00	3.47 ± 1.34	5
0602	cis-1,2-Dichloroethene	2		0.50	4.50	2.50 ± 2.83	70
	Trichloroethene	2		1.20	6.40	3.80 ± 3.68	5
0605	cis-1,2-Dichloroethene	3		3.10	5.80	4.43 ± 1.35	70
	Trichloroethene	3		2.40	5.80	4.23 ± 1.72	5
0607	cis-1,2-Dichloroethene	3		0.50	1.40	0.80 ± 0.52	70
	Trichloroethene	3		1.20	2.30	1.73 ± 0.55	5
0608	None detected	3		c	c	c	
0617	cis-1,2-Dichloroethene	1	3.1				70
	Trichloroethene	1	12.0				5
S01	None detected	3		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 6-8.

Table D-27. Tritium Concentrations in Capture Pits in 2001

Capture Pit 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	32	e	2.38	1.47 ± 0.54	7.4
0714	P014	33	16.35	110.0	47.80 ± 26.17	239
0725	W005	35	0.69	20.04	4.22 ± 4.63	21.1
0726	W006	37	e	245.4	82.60 ± 88.33	413
0727	W007	2	182.6	199.8	191.2 ± 8.63	956

[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.

[e] Below the blank value.

* Capture Pit locations are shown on Figure 6-8.

Table D-28. VOC Concentrations in Capture Pits in 2001

Capture Pit I.D.*	Compound	Number of Samples	µg/L Value [a]	Minimum	Maximum	Average [b]	MCL
0712	cis-1,2-Dichloroethene	2		1.00	2.10	1.55 ± 0.78	70
	Trichloroethene	2		1.50	2.30	1.90 ± 0.57	5
0714	None detected	2		c	c	c	
0726	cis-1,2-Dichloroethene	1	1.30				70
	Tetrachloroethene	1	0.43				5
	Trichloroethene	1	14.0				5
0727	cis-1,2-Dichloroethene	2		1.00	1.50	1.25 ± 0.35	70
	Tetrachloroethene	2		0.54	1.80	1.17 ± 0.89	5
	Trichloroethene	2		6.10	9.10	7.60 ± 2.12	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 6-8.

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 2001. (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 2001 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 2001 CEDEs

Radionuclide	Concentration[a]	Location*	Dose Conversion Factor, mrem/μCi
Tritium			
Air	7.61×10^{-12} μCi/mL	213	6.3×10^{-2} (a)
Drinking water	0.11×10^{-6} μCi/mL	Miamisburg	6.3×10^{-2}
Foodstuffs	0.11×10^{-6} μCi/mg	Miamisburg	6.3×10^{-2}
Plutonium-238			
Air	15.19×10^{-18} μCi/mL	213	3.8×10^{5} (b)
Drinking water	ND	Miamisburg	ND
Foodstuffs	0.22×10^{-9} μCi/g	Miamisburg	1.9×10^{3} (b)
Plutonium-239,240			
Air	ND	213	ND
Drinking water	ND	Miamisburg	ND
Foodstuffs	ND	Miamisburg	ND
Thorium-228			
Air	4.01×10^{-18} μCi/mL	213	3.1×10^{5}
Drinking Water	ND	Miamisburg	ND
Foodstuffs	NA		
Thorium-230			
Air	3.91×10^{-18} μCi/mL	213	3.2×10^{5}
Drinking Water	ND	Miamisburg	ND
Foodstuffs	NA		
Thorium-232			
Air	2.82×10^{-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 = concentrations 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 2001 CAP88-PC runs.

Table E-2. 2001 CAP88-PC Input Data

Stack	Stack Height (meters)	Stack Diameter (meters)	Exit velocity (meters/sec)	Radionuclide(s)	2001 Release Rate (Ci/yr)
HH	34	1.7	1.3	H-3	1.8×10^{-1}
NCDPF	41	0.6	29.3	H-3	6.0×10^{1}
SM/PP	60	1.8	5.4	Pu-238	5.1×10^{-6}
				Pu-239	3.1×10^{-8}
				U-233,234	2.9×10^{-9}
				U-238	1.0×10^{-9}
SW-ICN	46	0.9	13.7	H-3	1.6×10^{0}
				Pu-238	1.0×10^{-9}
				Pu-239	2.2×10^{-10}
				U-234	1.6×10^{-10}
				U-238	1.4×10^{-10}
T-WEST	60	2.4	14.3	H-3	2.6×10^{2}
				Pu-238	5.2×10^{-7}
				Pu-239	8.5×10^{-9}
				U-234	1.2×10^{-8}
				U-238	6.6×10^{-9}
T-EAST	60	1.8	8.3	H-3	7.9×10^{-1}
HEFS	46	1.9	10.2	H-3	5.1×10^{2}
				Pu-238	8.8×10^{-9}
				Pu-239	6.8×10^{-10}
				U-234	2.5×10^{-9}
				U-238	6.3×10^{-10}
WDSS	16	0.3	15.7	Pu-238	1.7×10^{-9}
				Pu-239	9.1×10^{-11}
WDA	9	1	10.5	H-3	1.0×10^{-2}
				Pu-238	5.8×10^{-8}
				Pu-239	6.6×10^{-10}
				U-233,234	4.5×10^{-10}
				U-238	3.3×10^{-10}
BLDG 22	7	0.9	0 (a)	H-3	1.6×10^{-01}
BLDG 23	2	0.3	0 (a)	H-3	3.3×10^{0}
BLDG 124 (CWPF)	9	0.8	11.7	H-3	9.4×10^{-1}
				Pu-238	3.3×10^{-8}
				Pu-239	3.9×10^{-10}
				U-234	1.1×10^{-9}
				U-238	8.3×10^{-10}

(a) No credit taken for exit velocity due to orientation of the building vent.

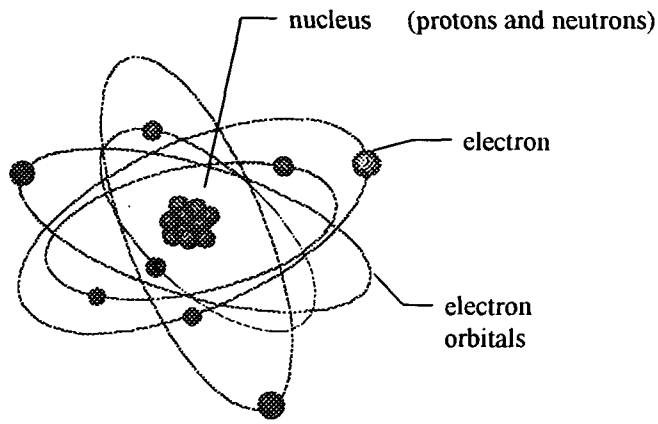
APPENDIX F

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. 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)	87.7
plutonium-239	(94 protons + 145 neutrons = mass number 239)	24,100
plutonium-240	(94 protons + 146 neutrons = mass number 240)	6,560
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)	7.5×10^4
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 generally is no longer the same kind of atom, it transforms into an element of different atomic number. As noted above, the radioactive decay is brought about by instability in the nucleus. 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 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. Tritium is an example of a radionuclide used by MEMP that decays by emitting a very low-energy beta particle.

Gamma rays, unlike alpha and beta particles, are not 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 that are typically shorter than 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 dose is a measure of the amount of energy 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 body. The individual is therefore exposed to this radiation for the remainder of his life (or approximately 80 years).

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, inhaled or absorbed a radionuclide that will remain inside the body. It is also expressed in 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 (if there is one). 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 medical uses of radiation, not including therapeutic uses, is 53 mrem.

Radiation Environment at MEMP

On average the annual radiation dose due to natural 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 2001 was 0.23 mrem, or a very small fraction of the dose received from background.

MEMP's dose contribution for 2001 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.

End of Appendix F

Radiation Environment at MEMP

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MEMP's dose contribution for 2001 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.

End of Appendix F

APPENDIX G

APPENDIX G

MEMORANDUM OF AGREEMENT

The original seventeen buildings constructed at Mound to support the polonium mission have been determined to be eligible for placement on the National Register of Historic Places, because of the contribution of the activities in those buildings to the development of nuclear power and to the development of the nuclear industry in the United States. Under the Mound Exit Project (MEP), the site will be transferred, and the seventeen National Register eligible buildings will either be transferred or demolished. The transfer and or demolition of federally owned National Register eligible buildings is a potential adverse impact, as defined by the National Historic Preservation Act (NHPA) and the implementing regulations of that Act.

A Memorandum of Agreement (MOA) has been negotiated between the DOE and the Advisory Council on Historic Preservation (ACHP) to mitigate this potential adverse impact caused by MEP activities to Mound's National Register eligible structures. As stated in the MOA, the original seventeen buildings that were associated with Mound's original polonium mission will be adversely impacted as a consequence of Mound's environmental restoration activities and the subsequent transfer of the property. The MOA defines mitigation for potential adverse activities on building operations and building disposition-grouping basis, as follows:

1. The first grouping is operations related buildings that will be demolished or transferred. This group includes B, E, HH, I, M, R, and T Buildings.

   MITIGATIVE ACTIVITIES: Mitigative measures for these buildings is a multi-phased process that proceeds as follows: 1) Before demolition begins, a physical description of the structure and a collection of photographs as the building exists today is compiled. 2) A "Historic American Buildings Survey" or HABS Level II documentation package that contains specific information pertaining to that structure is prepared. These documentation packages will be submitted to the National Park Service (NPS) for inclusion in the HABS/Historic American Engineering Record (HAER) archive and to the Ohio Historic Preservation Office (OHPO). The documentation standards to be used are derived from the Secretary of Interior standards and guidelines for historic building documentation.

2. The second grouping is support-type structures that will be (or have been) either demolished or transferred. This group includes A, C, G, GH, H, P, PH, SD, W, and WD Buildings.

   MITIGATIVE ACTIVITIES: Mitigative measures for these buildings includes color photographs, floor plans, a physical description of the building and a description of the building's historic function within the Mound plant will be prepared. This package shall be submitted to the OHPO.

EXTERNAL

U.S. Department of Energy

Headquarters (10 copies)

Ohio Field Office (8 copies)

Miamisburg Environmental Management Project (15 copies)

State and Federal Officials

The Honorable George Voinovich
U.S. Senator

The Honorable Michael DeWine
U.S. Senator

The Honorable John Boehner
U.S. Representative

The Honorable Rob Portman
U.S. Representative

The Honorable David Hobson
U.S. Representative

The Honorable Jeff Jacobson
Ohio Senator

The Honorable Scott Nein
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