2000 Integrated Site Environmental Report

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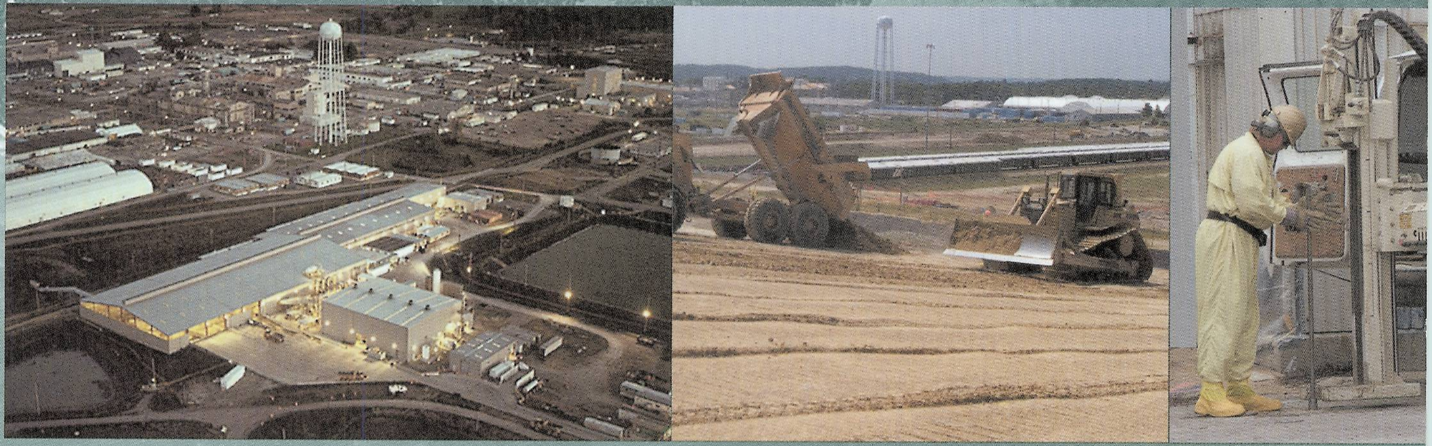

FERNALD
Environmental Management Project

By Fluor Fernald, Inc.
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List of Acronyms

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ALARA	as low as reasonably achievable
AMS	air monitoring station
ARARs	applicable or relevant and appropriate requirements
ATSDR	Agency for Toxic Substances and Disease Registry
BTV	benchmark toxicity value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
FEMP	Fernald Environmental Management Project
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FRL	final remediation level
gpm	gallons per minute
ICRP	International Commission on Radiological Protection
IEMP	Integrated Environmental Monitoring Plan
mrem	millirem
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
OEPA	Ohio Environmental Protection Agency
PCB	polychlorinated biphenyl
RAC	Radiological Assessments Corporation
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendment and Reauthorization Act
TLD	thermoluminescent dosimeter
TSCA	Toxic Substance Control Act

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Units (Abbreviations) and Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
inches (in)	2.54	centimeters (cm)	cm	0.3937	in
feet (ft)	0.3048	meters (m)	m	3.281	ft
miles (mi)	1.609	kilometers (km)	km	0.6214	mi
pounds (lb)	0.454	kilograms (kg)	kg	2.205	lb
tons	0.9072	metric tons	metric tons	1.102	tons
gallons	3.785	liters (L)	L	0.2642	gallons
square feet (ft^2)	0.0929	square meters (m^2)	m^2	10.76	ft^2
acres	0.4047	hectares	hectares	2.471	acre
cubic yards (yd^3)	0.7646	cubic meters (m^3)	m^3	1.308	yd^3
cubic feet (ft^3)	0.02832	cubic meters (m^3)	m^3	35.31	ft^3
picocuries (pCi)	10^{-12}	curies (Ci)	Ci	10^{12}	pCi
pCi/L	10^{-6}	microcuries per liter (μCi/L)	μCi/L	10^{6}	pCi/L
Ci	3.7×10^{10}	becquerels (Bq)	Bq	2.7×10^{-11}	Ci
pCi	0.037	Bq	Bq	27.03	pCi
millirem (mrem)	0.001	rem	rem	1000	mrem
rem	0.01	Sievert	Sv	100	rem
milligrams per liter (mg/L)	1000	micrograms per liter (μg/L)	μg/L	0.001	mg/L
Fahrenheit (°F)	(°F - 32) x 5/9	Celsius (°C)	°C	(°C x 9/5) + 32	°F
For Natural Uranium in Water					
pCi/L	0.0015	mg/L	mg/L	675.7	pCi/L
pCi/L	1.48	μg/L	μg/L	0.6757	pCi/L
μg/L	0.6757	pCi/L	pCi/L	1.48	μg/L
For Natural Uranium in Soil					
pCi/g	1.48	μg/g	μg/g	0.6757	pCi/g
mg/kg	1	μg/g	μg/g	1	mg/kg

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Executive Summary

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Executive Summary

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The Fernald Environmental Management Project's 2000 Integrated Site Environmental Report is prepared in accordance with U.S. Department of Energy (DOE) Order 5400.1, General Environmental Protection Program, and Fernald's Integrated Environmental Monitoring Plan (IEMP), Revision 1 (DOE 1999a). This annual report provides stakeholders with the results from Fernald's environmental monitoring program for 2000 and provides a summary of DOE's progress toward final remediation of the site. In addition, this report provides a summary of Fernald's compliance with the various environmental regulations, compliance agreements, and DOE policies that govern site activities. All information presented in this Executive Summary is discussed more fully within the body of this summary report and the supporting appendices.

During 2000 Fernald continued to make significant progress toward final cleanup goals established for the site. A wide range of environmental remediation activities continued during the year, including:

- Excavation and shipment of 104,209 tons (94,537 metric tons) of contaminated waste pit material to an off-site disposal facility, Envirocare of Utah, Inc. (Operable Unit 1)
- Large-scale excavation of contaminated soil (Operable Unit 5), as well as materials from the southern waste units (Operable Unit 2)
- Placement of approximately 227,600 cubic yards (174,014 cubic meters) of contaminated soil and debris in the on-site disposal facility (Operable Unit 2)
- Decontamination and dismantlement of 13 former production buildings and support facilities (Operable Unit 3)
- Extraction of 1,879 million gallons (7,112 million liters) of contaminated groundwater from the Great Miami Aquifer (Operable Unit 5).

In addition to these activities, several other important milestones toward remediation of the Fernald site were reached in 2000. The Final Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions was approved by the U.S. Environmental Protection Agency (EPA) and Ohio Environmental Protection Agency (OEPA) in July 2000. The southern waste units excavation was completed to design grade (Operable Unit 2). Also, Cell 1 of the on-site disposal facility was filled to capacity (Operable Unit 2).

The following sections highlight the results of environmental monitoring activities conducted during 2000.

Liquid Pathway Highlights

Groundwater Pathway

The groundwater pathway is routinely monitored at the FEMP to:

- Determine capture and restoration of the total uranium plume, as well as non-uranium constituents, and evaluate water quality conditions in the aquifer that indicate a need to modify the design and/or operation of restoration modules
- Meet compliance-based groundwater monitoring obligations.

During 2000 active restoration of the Great Miami Aquifer continued within each of the following groundwater restoration modules:

- South Field (Phase I) Extraction Module – continued pumping from nine extraction wells, plus two new extraction wells that began operating in February 2000
- South Plume Module/South Plume Optimization Module – continued pumping from six extraction wells
- Re-Injection Module – continued injecting water into the aquifer via five re-injection wells.

In addition, approximately 140 monitoring wells were sampled at various frequencies to determine water quality. Water elevations were measured quarterly in up to 184 monitoring wells. The following highlights describe the key findings from the 2000 groundwater data:

- 1,879 million gallons (7,112 million liters) of groundwater were pumped from the Great Miami Aquifer and 299 million gallons (1,132 million liters) of water were re-injected into the aquifer. As a result of these restoration activities, 845 pounds (384 kilograms) of uranium were removed from the aquifer.
- The results of 2000 groundwater capture analysis and monitoring for total uranium and non-uranium constituents indicate that the design of the enhanced groundwater remedy for the aquifer restoration system is appropriate for capture of the plume. However, as identified above, two new extraction wells were installed as a result of a newly defined area of uranium contamination in the South Field area, and began pumping in February 2000. The installation of these additional extraction wells was necessary to support the accelerated aquifer remediation schedule.
- Pumping of the South Plume/South Plume Optimization Module continued to meet the objective of preventing further southward migration of the southern total uranium plume beyond the extraction wells.

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- Groundwater re-injection was adopted as part of the groundwater remedy at the Fernald site. This was based on a successful year-long demonstration of this technology at the site. However, increased plugging of the re-injection wells experienced in 2000 is being investigated to verify the long-term viability of re-injection.

- The designs for aquifer restoration modules in the waste storage area and the Plant 6 area were revised significantly in 2000 based on groundwater sampling efforts completed in 1999 and 2000. A groundwater restoration module does not appear to be required in the Plant 6 area.

Leak detection monitoring at Cells 1, 2 and 3 of the on-site disposal facility indicates that all the individual cell liner systems are performing within the specifications outlined in the approved cell design.

Surface Water and Treated Effluent Pathway

Surface water and treated effluent are monitored to determine the effects of Fernald remediation activities on Paddys Run, the Great Miami River, and the underlying Great Miami Aquifer; and to meet compliance-based surface water and treated effluent monitoring obligations. In addition, the results from sediment sampling are discussed as a component of this primary exposure pathway.

In 2000, 16 surface water and treated effluent locations were sampled at various frequencies and 16 sediment locations were monitored. The following highlights describe the key findings from the 2000 surface water and treated effluent and sediment monitoring programs:

- The estimated total pounds of uranium released through the surface water and treated effluent pathway was approximately 376 pounds [171 kg], a decrease of 10 percent from the 1999 estimate of 419 pounds (190 kg). This is largely due to the revised loading term used to estimate total uranium in uncontrolled surface water runoff. 2000 was the first full year that the revised loading term was used.

- No surface water or treated effluent analytical results from samples collected in 2000 exceeded the final remediation level (FRL) for total uranium, the site's primary contaminant. FRL exceedances were limited to six constituents, while one benchmark toxicity value exceedance occurred. These occasional, sporadic exceedances are expected to occur until site remediation is complete.

- During 2000, permitted discharges were in compliance with requirements of the previous and current National Pollutant Discharge Elimination System (NPDES) Permits in 99.8 percent of the samples collected. The current NPDES Permit went into effect on March 1, 2000.

- The 2000 sediment results were within the range of historical concentrations. In addition, there were no FRL exceedances for sediment in 2000.

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Air Pathway Highlights

The air pathway is routinely monitored to assess the impact of FEMP emissions of radiological air particulates, radon, and direct radiation on the surrounding environment. In addition, the data are used to demonstrate compliance with various regulations and DOE Orders.

Radiological Air Particulate Monitoring

- Data collected from the network of 17 fenceline and two background air monitoring stations showed that the annual average radionuclide concentrations were all less than one percent of DOE-derived concentration guidelines contained in DOE Order 5400.5, Radiation Protection of the Public and the Environment.

- Biweekly thorium analysis was initiated in the fourth quarter of 2000 in response to evolving work activities and dose contributions from thorium isotopes generated from the Waste Pits Remedial Action Project (WPRAP). Thorium-230 has become the major dose contributor to the air inhalation dose. This represents a departure from historical Fernald emission patterns in which uranium was the major dose contributor. The increase in the percentage of dose from thorium-230 is the result of fugitive emissions from the WPRAP operations where thorium-230 is the primary isotope of concern.

- The maximum effective dose at the fenceline from 2000 airborne emissions (excluding radon) was estimated to be 1.1 millirem (mrem) per year and occurred at AMS-3 along the eastern fenceline of the site. This represents 11 percent of the annual National Emission Standards for Hazardous Air Pollutants Subpart H limit of 10 mrem per year. This is an increase compared to the 1999 annual maximum effective dose of 0.29 mrem.

Radon Monitoring

In 2000, an expanded continuous radon-monitoring network was used for determining compliance with the applicable limits. The continuous radon-monitoring network was expanded in preparation for the Accelerated Waste Retrieval Project.

- The annual average radon concentration recorded at the site's fenceline ranged from 0.2 picoCuries per liter (pCi/L) to 0.6 pCi/L (inclusive of background concentrations). Annual average background concentrations measured in 2000 ranged between 0.2 pCi/L and 0.3 pCi/L. Fenceline results were well below the DOE radon standard of 3.0 pCi/L above background concentrations.

- Radon concentrations in the vicinity of Silos 1 and 2 (Operable Unit 4) showed a notable decrease in 2000 compared to 1999. The decrease indicates that the resealing of the silo domes during 1999 resulted in a substantial reduction in radon concentrations in the K-65 Silo area. There were only six exceedances of the DOE limit of 100 pCi/L in 2000, compared to 47 exceedances in 1999. To better evaluate radon concentrations in the vicinity of Silos 1 and 2 during the Accelerated Waste Retrieval Project, five radon monitors were added in this area.

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- Radon concentrations within the silo headspace continued to increase in 2000. The increase was due to the protective layer of bentonite clay (placed over the silo material in 1991 to lower headspace concentrations) continuing to dry out and lose effectiveness during 2000.

Direct Radiation Monitoring

As in years past, measurements of direct radiation in 2000 increase with proximity to Silos 1 and 2. The direct radiation measurements correlate with the slowly increasing radon concentrations and associated decay products in the headspaces of these silos. However, these levels are approximately 53 percent lower than radiation levels measured in 1991 prior to the addition of the bentonite layer to Silos 1 and 2.

Biota (Produce) Monitoring

Produce is collected once every three years to ensure that airborne emissions from remediation activities at the Fernald site are not adversely affecting produce grown nearby. In 2000 produce and grain samples from 15 locations were collected and analyzed for uranium, thorium, and radium. The majority of uranium and thorium results were less than detectable, and all radium concentrations were less than detectable. Moreover, total uranium concentrations were within historical background levels. These results suggest that there is currently no substantial impact from past or current Fernald emissions on produce grown in the area.

The committed effective dose equivalent was calculated to be 0.9 mrem for produce. Of this estimated value, total uranium contributed 0.46 mrem and thorium-230 contributed 0.44 mrem. The 2000 dose represents less than one percent of the DOE all-pathways dose limit of 100 mrem per year.

Estimated Dose for 2000

In 2000 the maximally exposed individual living nearest the Fernald site in a west-southwest direction could have hypothetically received a maximum dose of approximately 11.2 mrem above the background dose. This estimate represents the maximum incremental dose above background attributable to the site and is exclusive of the dose received from radon. The contributions to this all-pathway dose were 0.28 mrem from air inhalation dose, 10 mrem from direct radiation, and 0.9 mrem from produce. This dose can be compared to the limit of 100 mrem above background for all pathways (exclusive of radon) that was established by the International Commission on Radiological Protection and adopted by DOE.

Natural Resources

Natural resources encompass the diversity of plant and animal life and their supporting habitats found in and around the Fernald site. During 2000 the following activities associated with natural resource monitoring and restoration occurred.

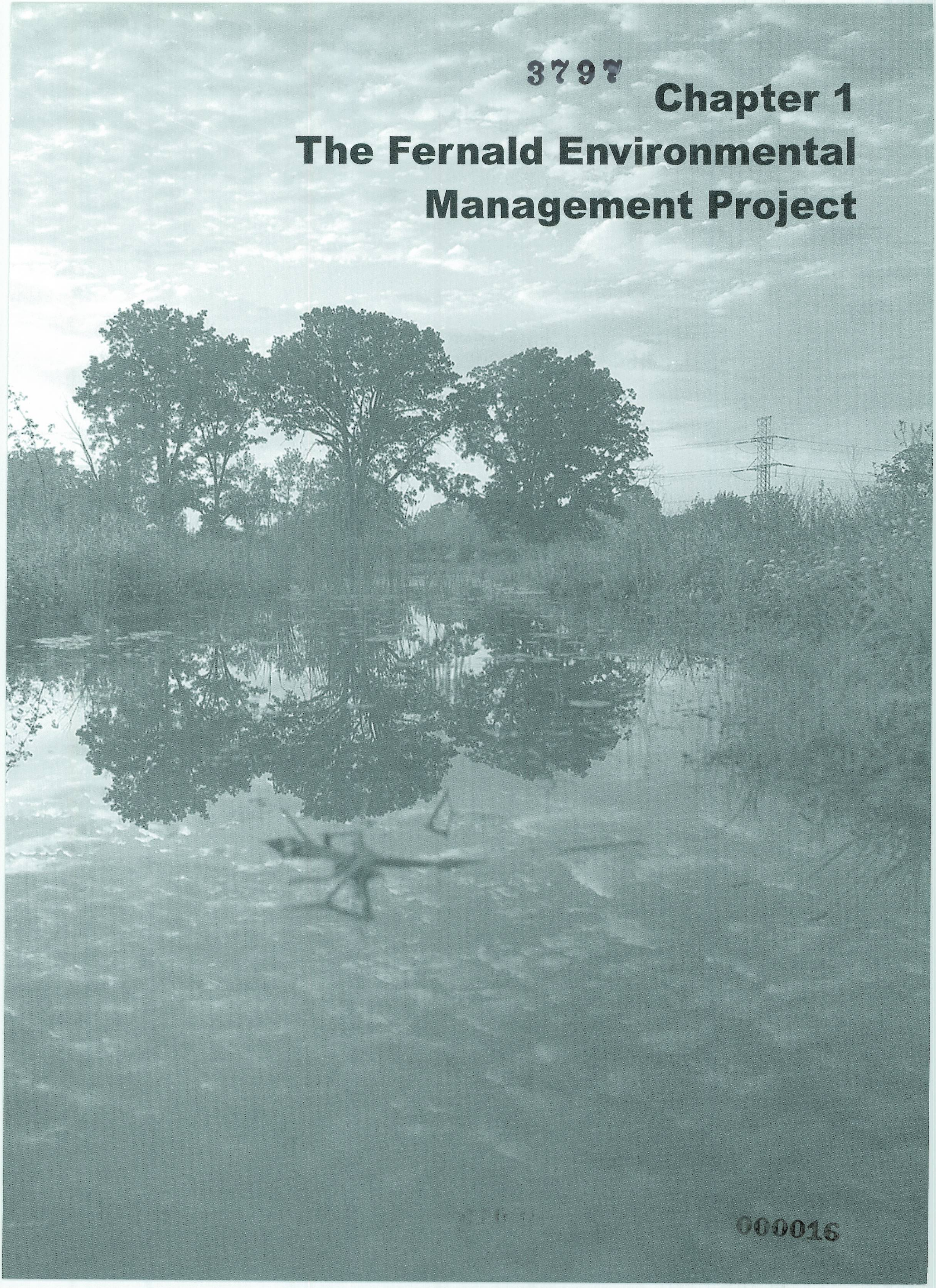
- The Area 8, Phase II Forest Demonstration Project was essentially completed in 2000 in the northwest corner of the Fernald site. This project resulted in the establishment of several vegetative communities native to southwest Ohio, including three forest types and a tall-grass savanna. Several small ponds and wetlands were also established.

- Wetland mitigation monitoring began in the Area 1, Phase I wetland during 2000. Data from this effort will be used as a baseline to monitor the health and progress of the wetland over time. Mortality counts of vegetation planted in 1999 were also conducted in 2000, and results show that deer browsing pressure and the 1999 drought resulted in a survival rate of approximately 70 percent. The required survival rate is 80 percent, and as a result, replacement plantings were undertaken in the fall of 2000.

- The four ecological restoration research projects, conducted as part of the Operable Unit 4 dispute resolution agreement, continued in 2000. Preliminary findings from these projects will provide valuable information for future natural resource restoration efforts at the Fernald site.

Fernald also has a number of archeological and historical sites representative of the cultural resources of the area. To protect these valuable resources, a team conducts cultural resource surveys prior to soil excavation activities in designated areas of the site. During 2000 surveys conducted on or near the Fernald site identified four previously undocumented prehistoric archaeological sites, one of which may meet the criteria for inclusion on the National Registry of Historic Places.

Chapter 1
The Fernald Environmental Management Project



The Fernald Environmental Management Project

Abbreviated Timeline

1951 Construction of the Feed Materials Production Center began.
1952 Uranium production started.
1986 EPA and DOE signed the Federal Facilities Compliance Agreement, which initiated the remedial investigation/feasibility study process.
1989 Uranium production was suspended. The Fernald site was placed on the National Priorities List, which is the list of CERCLA sites most in need of cleanup.
1990 As part of the Amended Consent Agreement, the site was divided into operable units for characterization and remedy determination.
1991 Uranium production formally ended. The site mission changed from uranium production to environmental remediation and site restoration.
1996 The last operable unit's record of decision was signed, signifying the end of the 10-year remedial investigation/feasibility study process. (The Operable Unit 4 record of decision was later re-opened.)
1997 Environmental remediation activities continued at the FEMP, including construction of Cell 1 of the on-site disposal facility with the first waste placement beginning in December.
1998 Decontamination of nuclear buildings and facilities (Safe Shutdown) neared completion, operation of several aquifer restoration modules was implemented on or ahead of schedule, excavated soil volumes exceeded expectations, and cell construction at the on-site disposal facility continued.
1999 Excavation of the waste pits was initiated and the first rail shipment of waste material was transported to Envirocare of Utah, Inc. Safe shutdown was completed ahead of schedule.
2000 The Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions was signed by EPA in July. On-site disposal facility Cell 1 was filled to capacity. Southern waste units' excavation was completed to design grade.

In 1951 the Atomic Energy Commission (predecessor of the U.S. Department of Energy [DOE]) began building the Feed Materials Production Center on a 1,050 acre (425 hectare) tract of land outside the small farming community of Fernald, Ohio. The facility's mission was to produce "feed materials" in the form of purified uranium compounds and metal for use by other government facilities involved in the production of nuclear weapons for the nation's defense.

Uranium metal was produced at the Feed Materials Production Center from 1952 through 1989. During that time, over 500 million pounds (227 million kilograms [kg]) of uranium metal products were delivered to other sites and approximately 400,000 to 1,000,000 pounds (180,000 to 450,000 kg) of uranium were released to the environment. These releases resulted in contamination of soil, surface water, sediment, and groundwater on and around the site.

CERCLA Remedial Process

In broad terms, the remedial response process for remediating sites under CERCLA consists of the following three general phases:

Site Characterization – During this phase, contaminants are identified and quantified, and the potential impacts of those contaminants on human health are determined. This phase includes the remedial investigation and the baseline risk assessment.

Remedy Selection – During this phase, cleanup alternatives are developed and evaluated and, with the input of stakeholders, a remedy is selected. Activities include the feasibility study and proposed plan. After public comments are received, a remedial alternative is selected and documented in a record of decision.

Remedial Design and Remedial Action – This phase of the CERCLA process includes the detailed design and implementation of the remedy.

The CERCLA process ends with certification and site closure. A five-year review process is triggered by the onset of construction for the first operable unit remedial action that will result in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure. Of all the FEMP operable units, the site preparation construction to support the Waste Pits Remedial Action Project under the Operable Unit 1 Record of Decision (DOE 1995b) was the first such action. This construction began on April 1, 1996; consequently, the First Five-Year Review Report for the FEMP (DOE 2001a) was submitted on April 1, 2001. The reviews ensure that the remedy remains effective and continues to be protective of human health and the environment.

Long-Term Stewardship - This refers to the monitoring and maintenance of the FEMP that DOE will assume after site closure in order to ensure continued protection of human health and the environment. Long-term stewardship will begin after the CERCLA process is complete. The previously mentioned five-year review process will continue in order to provide long-term stewardship information to the public.

In 1991 the mission of the site officially changed from uranium production to environmental remediation and site restoration under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. The site was renamed the Fernald Environmental Management Project (FEMP) to reflect the changing mission. Fluor Fernald, Inc. manages the remediation and restoration of the site under the terms of a prime contract with DOE. Regulatory oversight is provided by Region V of the U.S. Environmental Protection Agency (EPA) and the Southwest District Office of the Ohio Environmental Protection Agency (OEPA).

In the 1980s programmatic monitoring activities began at the site. The goal was to assess the impact of production operations and monitor the environmental pathways through which residents of the local community might be exposed to contaminants from the site (exposure pathways). The environmental monitoring program provided comprehensive on- and off-property surveillance of contaminant levels in surface water, groundwater, air, and biota. The goal was to continuously measure and report the levels of contaminants associated with uranium production operations to the regulatory agencies and the FEMP stakeholders.

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With the conclusion of the FEMP's uranium production mission and completion of the CERCLA remedy selection process, focus is now being directed to the safe and efficient implementation of FEMP environmental remediation activities and facility decontamination and dismantling operations. In recognition of this shift in emphasis toward remedy implementation, the environmental monitoring program was revised in 1997 to align with the remediation activities planned for the FEMP.

The site's current environmental monitoring program is described in the Integrated Environmental Monitoring Plan (IEMP), Revision 2 (DOE 2001b). The IEMP is updated at a minimum of every two years to keep pace with the site's monitoring needs as remediation progresses. The preceeding IEMP, Revision 1 (DOE 1999a), described sampling activities for 1999 and 2000. The 2000 Integrated Site Environmental Report summarizes the findings from the IEMP monitoring program and provides a status on the progress toward final site restoration. This report consists of the following:

Summary Report This summary report (Chapters 1 through 7) documents the results of environmental monitoring activities at the FEMP in 2000. It includes a discussion of remediation activities and summaries of environmental data from groundwater, surface water and treated effluent, sediment, air, biota (produce), and natural resources.

Appendices The appendices provide the 2000 environmental monitoring data for the various media, primarily in graphs and tables. The National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 Code of Federal Regulations 61 Subpart H) (EPA 1985) compliance report is also included. This detailed information is summarized in the Summary Report, because the appendices are generally distributed only to the regulatory agencies. However, a complete copy of the appendices is available at the Public Environmental Information Center, which is located a half mile south of the FEMP on Oakridge Drive in the Delta Building.

The remainder of this chapter provides:

- A brief overview of the FEMP's current environmental remediation operations and a description of its current cleanup mission, organization, and major remediation activities
- A description of environmental monitoring activities at the FEMP
- A description of the physical, ecological, and human characteristics of the area.

The Path to Site Restoration

In 1986 the FEMP began working through the CERCLA process to characterize the nature and extent of contamination at the site, establish risk-based cleanup standards, and select the appropriate remediation technologies to achieve those standards. To facilitate this process, the FEMP was organized into five operable units in 1991. The operable units were defined based on their location and/or the potential for similar technologies to be used for environmental remediation. The remedy selection process culminated in 1996 with approval of the final records of decision for the operable units. However, the Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions was issued in July of 2000, and an Explanation of Significant Differences for Silo 3 was issued in March 1998.

Following approval of the initial records of decision, work began on the design and implementation of the operable unit remedies. In order to align sitewide responsibilities and regulatory obligations across the operable units and to efficiently execute remedial design and remedial action, the FEMP established integrated project organizations in 1996. Realignment into project organizations reflected the actual work processes and operations necessary to complete remediation while meeting the requirements of the records of decision. Table 1-1 describes each operable unit and its associated remedy and provides a crosswalk between each operable unit and the project organizations responsible for implementing each remedy. For purposes of this document, references to a project organization also include the references to the applicable operable unit, as included in the Table 1-1 description.

Environmental Monitoring Program

Characterization activities were conducted at the Fernald site for nearly 10 years through the remedial investigation phase of the CERCLA process. The initial environmental evaluations performed during the remedial investigation/feasibility study process were used to select the final remedy for Operable Unit 5, which addressed contamination in soil, groundwater, surface water, sediment, air, and biota (produce) – in short, all environmental media and contaminant exposure pathways affected by past uranium production operations at the site. The selected remedy for Operable Unit 5 defined the site's final contaminant cleanup levels and established the areal extent of on- and off-property remedial actions necessary to provide permanent solutions to environmental concerns posed by the site.

The Operable Unit 5 remedy included plans for both removing the contamination that might be released via these exposure pathways, and monitoring the pathways to measure the site's continuing impact on the environment as remediation progresses. The characterization data used to develop the final remedy were also used to focus and develop the environmental monitoring program documented in the IEMP. The key elements of the IEMP are described below:

<u>Exposure Pathways</u>

An **exposure pathway** is a route by which materials could travel between the point of release (a source) and the point of delivering a radiation or chemical dose (a receptor). At the FEMP, two **primary exposure pathways (liquid and air)** have been identified. A primary pathway is one that may allow pollutants to directly reach the public and/or the environment. Therefore, the liquid and air pathways provide a basis for environmental sampling and information useful for evaluating potential dose to the public and/or the environment.

Secondary exposure pathways have been thoroughly evaluated under previous environmental monitoring programs. Secondary exposure pathways represent indirect routes by which pollutants may reach receptors. An example of a secondary pathway is biota, or produce. Through the food chain, one organism may accumulate a contaminant and then be consumed by humans or other animals. The contaminant travels through the air to the soil, where it is absorbed into produce through the roots, and is consumed by humans or animals. An evaluation of past monitoring data has shown that secondary exposure pathways at the FEMP are insignificant routes of exposure to off-site receptors. Therefore, the IEMP focuses on the primary exposure pathways.

Refer to Chapter 6 for information pertaining to 2000 dose calculations from all pathways.

- The IEMP defines monitoring activities for environmental media, such as groundwater, surface water and treated effluent, sediment, air (including air particulate, radon, and direct radiation), biota (produce), and natural resources. In general, the primary exposure pathways (liquid and air) are monitored and the program focuses on assessing the collective effect of sitewide emissions on the surrounding environment.

- The plan establishes an integrated data evaluation and decision-making process for each environmental medium. Through this process, environmental conditions at the site are continuously evaluated. These evaluations sometimes affect decisions made about the implementation of remediation activities. For example, environmental data are routinely evaluated to identify any significant trends that may indicate the potential for an unacceptable future impact to the environment if action is not taken. This information is communicated to the remediation project organization(s) so that corrective actions can be taken before conditions become unacceptable.

TABLE 1-1
FEMP OPERABLE UNIT REMEDIES AND ASSOCIATED PROJECT RESPONSIBILITIES

Operable Unit	Description	Remedy Overview[a]	Project Organization/Responsibilities
1	• Waste Pits 1 – 6 • Clearwell • Burn pit • Berms, liners, caps, and soil within the boundary	Record of Decision Approved: March 1995 Excavation of materials with constituents of concern above FRLs, waste processing and treatment by thermal drying (as necessary), off-site disposal at a permitted facility, and FEMP remediation	Waste Pits Remedial Action Project is responsible for rail upgrades, excavation of Operable Unit 1 waste units, waste processing and drying, loading, rail transport, and off-site disposal of contaminated soil and debris that exceed the waste acceptance criteria for the on-site disposal facility. (Note: Some of the activities with this project are being performed by International Technology Corporation.) Soil and Disposal Facility Project is responsible for directing excavation and certification of contaminated soil beneath the waste pits, as well as at- and below-grade remediation facilities, including the railroad. Aquifer Restoration Project is responsible for final treatment of contaminated runoff, perched water collected during waste pit excavation, and processing wastewater discharges. Each project is responsible for transporting remediation wastewater to the head works of the advanced wastewater treatment facility for treatment. Decontamination and Demolition Project is responsible for decontamination and dismantling of Operable Unit 1 remediation facilities not specifically the responsibility of the Waste Pits Remedial Action Project subcontractor.
2	• Solid waste landfill • Inactive flyash pile • Active flyash pile (now inactive) • North and south lime sludge ponds • Other South Field disposal areas • Berms, liners, and soil within the operable unit boundary	Record of Decision Approved: May 1995 Excavation of all materials with constituents of concern above FRLs, treatment for size reduction and moisture control as required, on-site disposal in the on-site disposal facility, off-site disposal of a small fraction of excavated material that exceeds the waste acceptance criteria for the on-site disposal facility and lead-contaminated soil from the South Field firing range, and FEMP remediation	Soil and Disposal Facility Project is responsible for excavating and disposing of waste from all Operable Unit 2 subunits and certifying the footprints. This project is also responsible for the ongoing design, construction, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes; Operable Unit 5 soil and debris, and Operable Unit 3 debris. Waste Acceptance Organization is responsible for field oversight of soil excavations, for reviewing and signing manifests for impacted material delivered to the on-site disposal facility for placement, and for rejecting any unacceptable shipments. Aquifer Restoration Project is responsible for treating contaminated runoff and perched water collected during excavation of Operable Unit 2 subunit wastes. This project is also responsible for leachate and leak detection monitoring at the on-site disposal facility and for treating leachate from the on-site disposal facility. Each project is responsible for transporting remediation wastewater to the head works of the advanced wastewater treatment facility for treatment. This project is also responsible for monitoring leachate within the facility and perched groundwater in the till below the facility.
3	Former production area, associated facilities, and equipment (includes all above- and below-grade improvements) including, but not limited to: • All structures, equipment, utilities, effluent lines, and K-65 transfer line • Wastewater treatment facilities • Fire training facilities • Scrap metals piles • Drums, tanks, solid waste, waste product, feedstocks, and thorium	Record of Decision Approved: September 1996 Adoption of Operable Unit 3 Interim Record of Decision; alternatives to disposal through the unrestricted or restricted release of materials, as economically feasible for recycling, reuse, or disposal; treatment of material for on- or off-site disposal; required off-site disposal for process residues, product materials, process-related metals, acid brick, concrete from specific locations, and any other material exceeding the on-site disposal facility waste acceptance criteria; and on-site disposal for material that meets the on-site disposal facility waste acceptance criteria	Decontamination and Demolition Project is responsible for decontamination and dismantling of all above-grade portions of buildings and facilities at the FEMP. Soil and Disposal Facility Project is responsible for excavation and certification of soil beneath facilities and for removal of at- and below-grade structures. This project is also responsible for design, construction, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes, Operable Unit 5 soil, and Operable Unit 3 debris. Waste Acceptance Organization is responsible for reviewing facility decontamination and dismantling planning documents. This organization is also responsible for field oversight of debris sizing, segregation of on-site disposal facility material categories, and prohibited items; completing field tracking logs; completing manifests for material bound for the on-site disposal facility; and compiling final records of decontamination and dismantling debris placed in the on-site disposal facility. Aquifer Restoration Project is responsible for treating decontamination and other wastewaters during decontamination and dismantling activities and processing wastewater discharges; each decontamination and dismantling project is responsible for transporting remediation wastewater to the head works of the advanced wastewater treatment facility for treatment.

TABLE 1-1
(Continued)

Operable Unit	Description	Remedy Overview[a]	Project Organization/Responsibilities
4	• Silos 1 and 2 (containing K-65 residues) • Silo 3 (containing cold metal oxides) • Silo 4 (empty and never used) • Decant tank system • Berms and soil within the operable unit boundary	Record of Decision Approved: December 1994 Record of Decision Amendment for Silos 1 and 2 Approved: July 2000 Silo 3: Explanation of Significant Differences Approved: March 1998 Removal of Silo 3 materials and Silos 1 and 2 residues and decant sump tank sludges with on-site stabilization of materials, residues, and sludges followed by off-site disposal; demolition and decontamination, to the extent possible, of silos and remediation facilities; excavation of contaminated soil above the FRLs with on-site disposal for contaminated soils and debris that meet the on-site disposal facility waste acceptance criteria; and site restoration. Concrete from Silos 1 and 2, and contaminated soil and debris that exceed the on-site disposal facility waste acceptance criteria will be disposed of off site.	Silos 1 and 2 Project is responsible for transfer of Silos 1 and 2 residues to temporary transfer tanks, treatment, and transport off site. Infrastructure and support systems such as roads and utilities will be completed to support the final remediation of the silos. Silo 3 Project is responsible for Silo 3 content removal, treatment, and transport off site. Soil and Disposal Facility Project is responsible for certification, excavation, and disposition of contaminated soil beneath the silos and for removal of subsurface structures (i.e., sub-grade silo decant system). The project is also responsible for design, construction, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes, Operable Unit 5 soil, and Operable Unit 3 debris. Aquifer Restoration Project is responsible for treating decontamination and other wastewaters during decontamination and demolition activities; each project is responsible for capturing and transporting remediation wastewater to the head works of the advanced wastewater treatment facility for treatment. Decontamination and Demolition Project is responsible for decontamination and dismantling of all Operable Unit 4 remediation facilities and associated above ground pipings.
5	• Groundwater • Surface water and sediments • Soil not included in the definitions of Operable Units 1 through 4 • Flora and fauna	Record of Decision Approved: January 1996 Extraction of contaminated groundwater from the Great Miami Aquifer to meet FRLs at all affected areas of the aquifer. Treatment of contaminated groundwater, storm water, and wastewater to attain concentration and mass-based discharge limits and FRLs in the Great Miami River. Excavation of contaminated soil and sediment to meet FRLs. Excavation of contaminated soil containing perched water that presents an unacceptable threat, through contaminant migration, to the underlying aquifer. On-site disposal of contaminated soil and sediment that meet the on-site disposal facility waste acceptance criteria. Soil and sediment that exceed the waste acceptance criteria for the on-site disposal facility will be treated, when possible, to meet the on-site disposal facility waste acceptance criteria or will be disposed of at an off-site facility. Also includes site restoration, institutional controls, and post-remediation maintenance.	Aquifer Restoration Project is responsible for designing, installing, and operating the extraction/re-injection systems for Great Miami Aquifer groundwater restoration. This project is responsible for groundwater monitoring in the Great Miami Aquifer; reporting on the progress of aquifer restoration; designing, constructing, and operating all treated effluent discharge systems, and treating and discharging contaminated groundwater, storm water, and remediation wastewaters at the FEMP. This project is also responsible for operation, maintenance, and monitoring of the on-site disposal facility leachate collection system and leak detection system. Soil and Disposal Facility Project is responsible for certification of sitewide soil; excavation and disposition of contaminated soil, sediment, perched groundwater and at- and below-grade structures; and final site restoration. The project is also responsible for design, installation, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes, Operable Unit 5 soil, and Operable Unit 3 debris. Waste Acceptance Organization is responsible for reviewing Soils and Disposal Facility Project planning documents. This project is also responsible for oversight of field excavations, segregation on-site disposal facility material categories, and segregating prohibited items; completing field tracking logs; completing manifests for material bound for the on-site disposal facility; and compiling final records of soil and at- and below-grade debris placed in the on-site disposal facility. Decontamination and Demolition Project is responsible for decontamination and dismantling of all Operable Unit 5 remediation facilities.

[a]Source of information is each operable unit's record of decisions and remedial design documents.

- Recognizing that the dominant types and pace of remediation activities will change over the life of the cleanup effort, the IEMP was developed as a "living document" allowing for adjustment of the program as site remediation progresses. Under the living document concept, the IEMP will be reviewed annually and revised every two years to ensure that the monitoring program adequately addresses changing remediation activities.

- The IEMP consolidates routine reporting of environmental data under a system consisting of quarterly data summary reports and a comprehensive annual report.

Characteristics of the Site and Surrounding Area

The natural setting of the site and nearby human communities were important factors in selecting the final remedy, and remain important in the continuous evaluation of the environmental monitoring program. Land use and demography, local geography, geology, surface hydrology, meteorological conditions, and natural resources all impact monitoring activities and the implementation of the site remedy.

Land Use and Demography

Economic activities in the area of the site rely heavily on the physical environment. Land in the area is used primarily for livestock and crop farming and gravel pit excavation operations. There is also a private water utility pumping groundwater, primarily for industrial use, aproximately 2 miles (3.2 km) east of the FEMP.

Downtown Cincinnati is approximately 18 miles (29 km) southeast of the FEMP, as shown in Figure 1-1. The cities of Fairfield and Hamilton are 6 and 8 miles (10 and 13 km) to the northeast, respectively, as shown in Figure 1-2. Scattered residences and several villages including Fernald, New Baltimore, New Haven, Ross, and Shandon are located near the site. There is an estimated population of 14,600 within 5 miles (8 km) of the FEMP and an estimated 2.74 million within 50 miles (80 km).

Geography

Figure 1-3 depicts the location of the major physical features of the site, such as the buildings and supporting infrastructure. The former production area and various administrative buildings dominate this view. The former production area occupies approximately 136 acres (55 hectares) in the center of the site. The waste pit area and K-65 Silos are located adjacent to the western edge of the former production area. The Great Miami River cuts a terraced valley to the east of the FEMP while Paddys Run, an intermittent stream, flows from north to south along the FEMP's western boundary. In general, the FEMP lies on a terrace that slopes gently between vegetated bedrock outcroppings to the north, southeast, and southwest.

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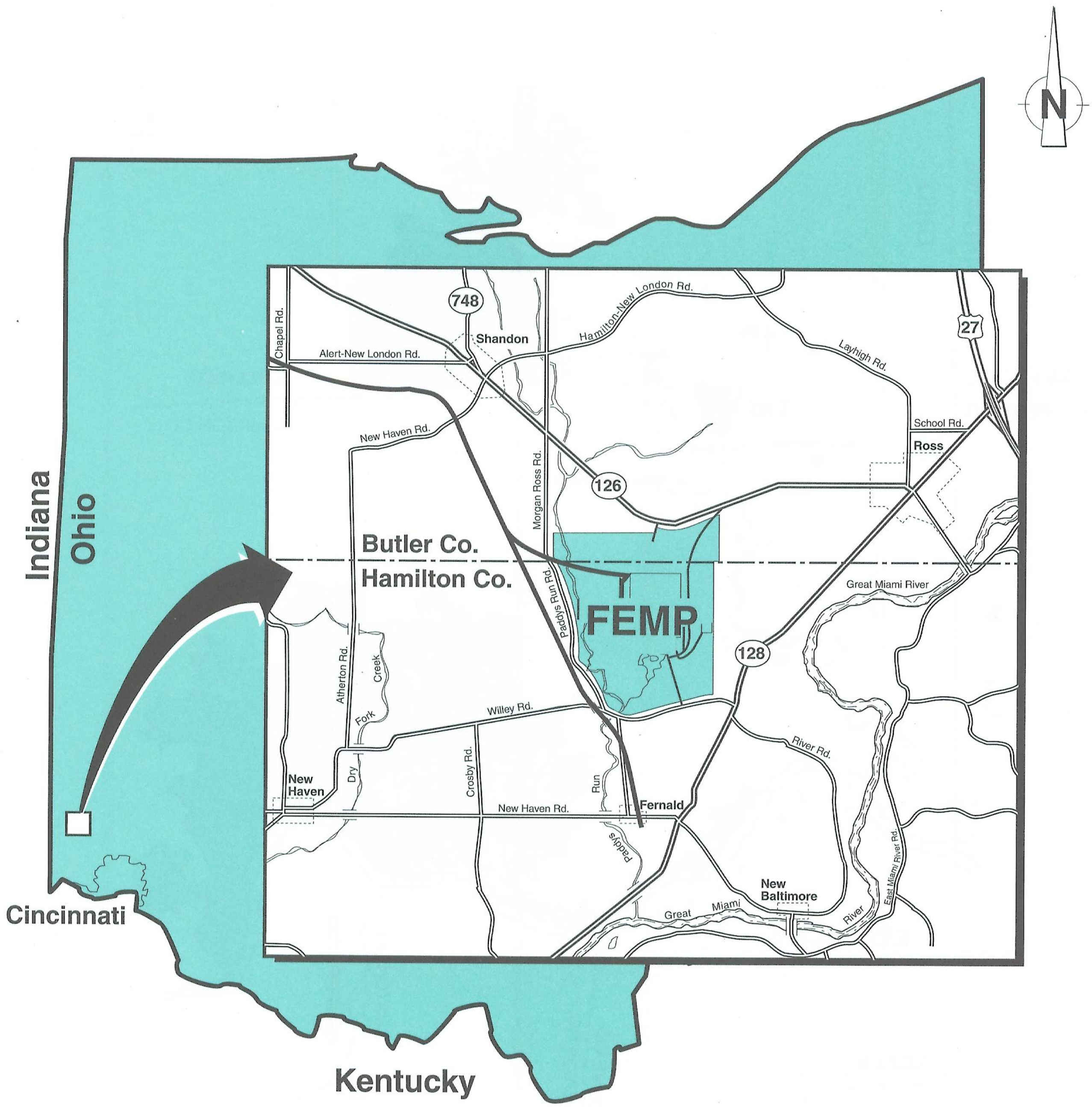

The FEMP covers about 1,050 acres (425 hectares).

Figure 1-1. FEMP and Vicinity

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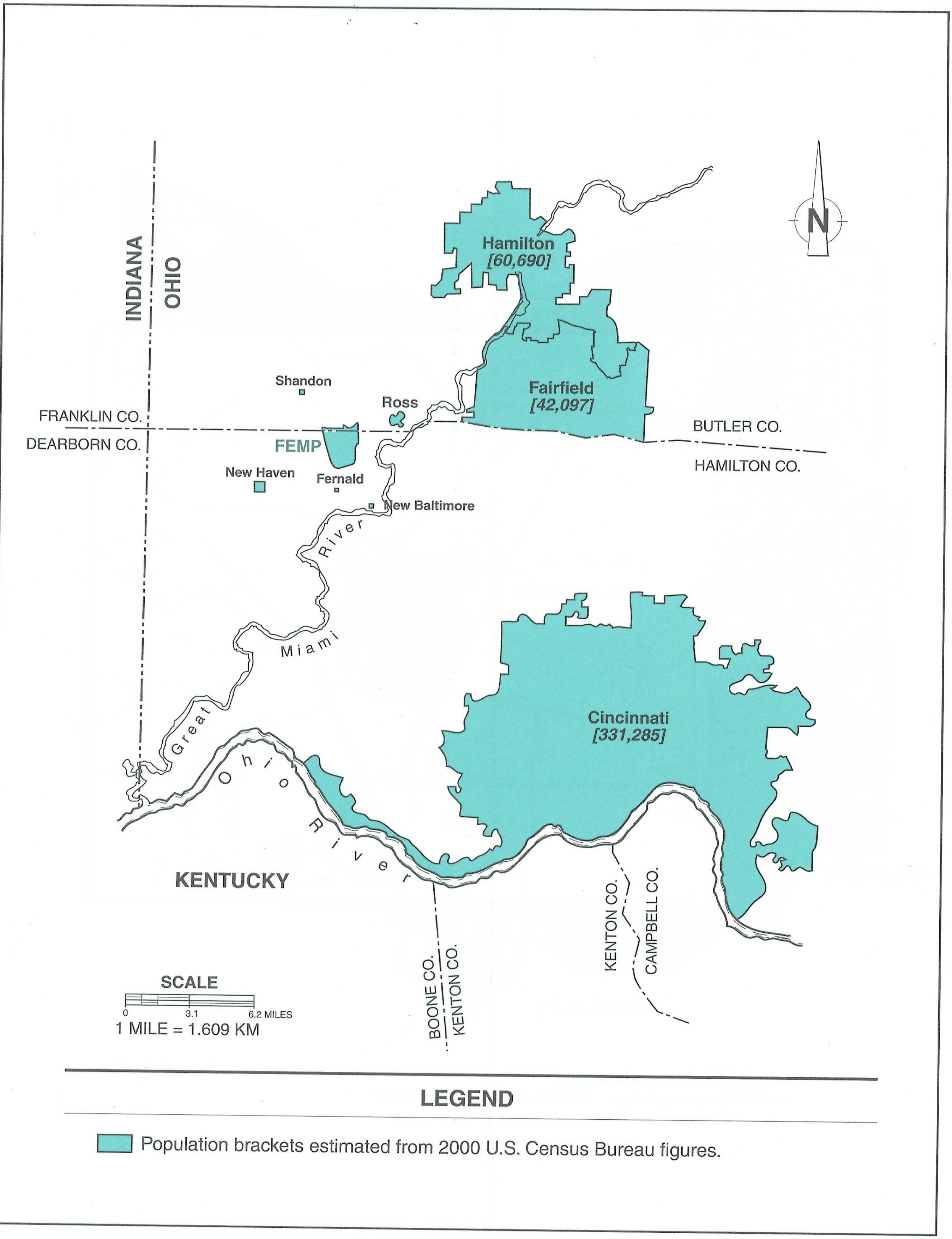

Figure 1-2. Major Communities in Southwestern Ohio

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Figure 1-3. Fernald Site Perspective

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Geology

Bedrock in the area indicates that approximately 450 million years ago a shallow sea covered the Cincinnati area. Sediments that later became flat-lying shale with interbedded limestone were deposited in the shallow sea as evidenced by the abundance of marine fossils in the bedrock. In the more recent geologic past, the advance and retreat of three separate glaciers shaped the southwestern Ohio landscape. A large river drainage system south of the glaciers created river valleys up to 200 feet (61 meters) deep, which were then filled with sand and gravel when the glaciers melted. These filled river valleys are called buried valleys.

The last glacier to reach the area left an impermeable mixture of clay and silt with minor amounts of sand and gravel deposited across the land surface, called glacial overburden. The site is situated on a layer of glacial overburden that overlies portions of a 2 to 3 mile (3 to 5 km) wide buried valley. This valley, known as the New Haven Trough, makes up part of the Great Miami Aquifer. The impermeable shale and limestone bedrock that define the edges and bottom of the New Haven Trough confine the groundwater to the sand and gravel within the buried valley. Where present, the glacial overburden limits the downward movement of precipitation and surface water runoff into the underlying sand and gravel of the Great Miami Aquifer.

The Great Miami River and its tributaries have eroded significant portions of the glacial overburden and exposed the underlying sand and gravel of the Great Miami Aquifer. Thus, in some areas where the glacial overburden has been eroded away, precipitation and surface water runoff can easily migrate into the underlying Great Miami Aquifer, permitting contaminants to be transported to the aquifer as well. Natural and man-made breaches of the glacial overburden were key pathways where contaminated water entered the aquifer, causing the groundwater plumes that are being addressed by the FEMP's aquifer restoration activities. Figure 1-4 provides a glimpse into the structure of subsurface deposits in the region along an east-west cross section through the site, while Figure 1-5 presents the regional groundwater flow patterns in the Great Miami Aquifer.

Surface Hydrology

The site is located in the Great Miami River drainage basin (refer to Figure 1-6). Natural drainage from the FEMP to the Great Miami River occurs primarily via Paddys Run. This intermittent stream begins losing flow to the underlying sand and gravel aquifer south of the waste pit area. Paddys Run empties into the Great Miami River 1.5 miles (2.4 km) south of the site.

In addition to natural drainage through Paddys Run, FEMP surface runoff from the former production area, waste pit area, and other selected areas is collected, treated, and discharged to the Great Miami River. Since January 1995, the majority of this runoff has been treated for uranium removal in the advanced wastewater treatment facility before being discharged. The Great Miami River, 0.6 mile (1 km) east of the FEMP, runs in a southerly direction and flows into the Ohio River about 24 miles (39 km) downstream of the FEMP. The segment of the river between the FEMP and the Ohio River is not used as a source of public drinking water.

The average flow rate for the Great Miami River in 2000 was 2,693 cubic feet per second (ft^3/sec) (76.26 cubic meters per second [m^3/sec]). This is based on daily measurements collected approximately 10 river miles (16 river km) upstream of the FEMP's effluent discharge.

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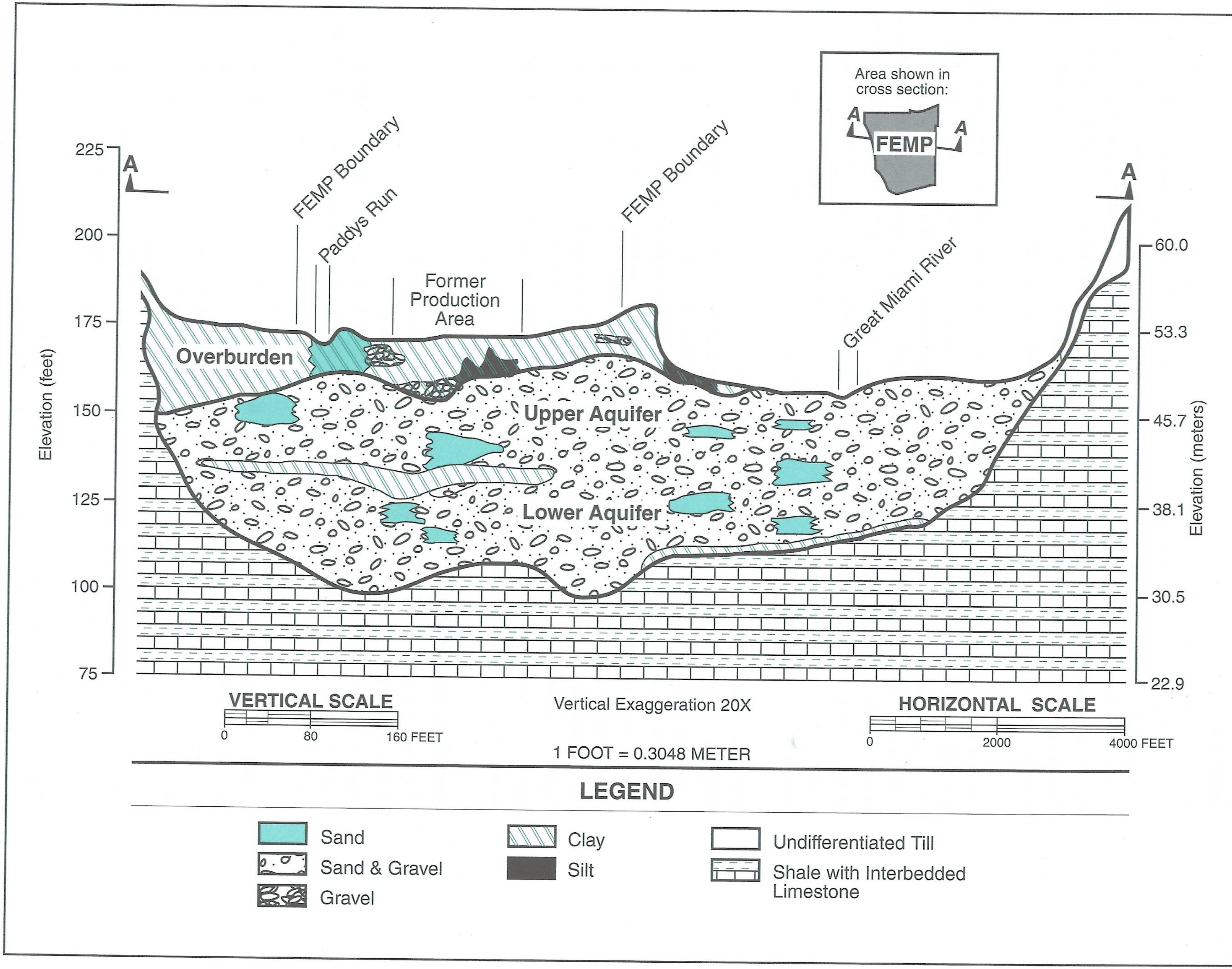

Figure 1-4. Cross-Section of the New Haven Trough, Looking North

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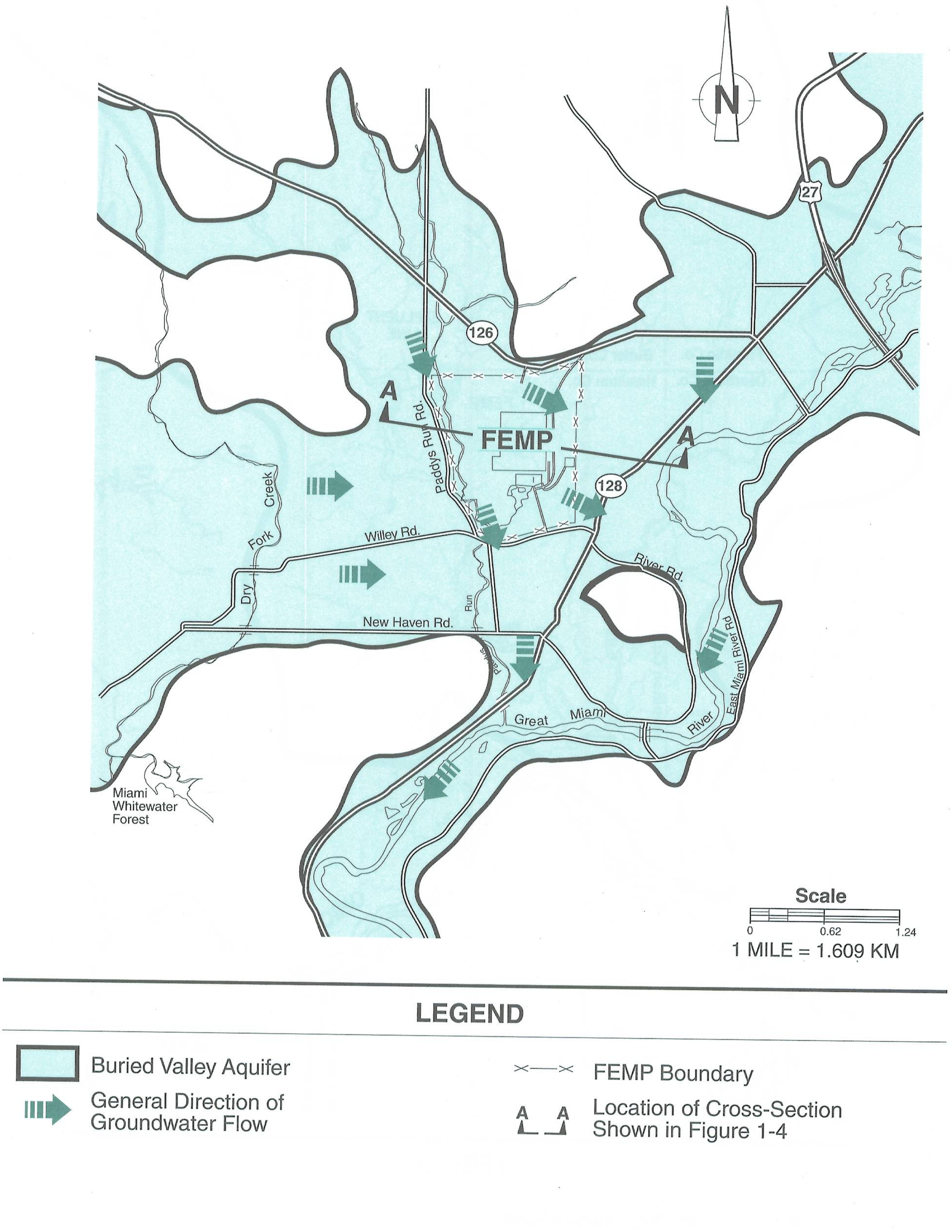

Figure 1-5. Regional Groundwater Flow in the Great Miami Aquifer

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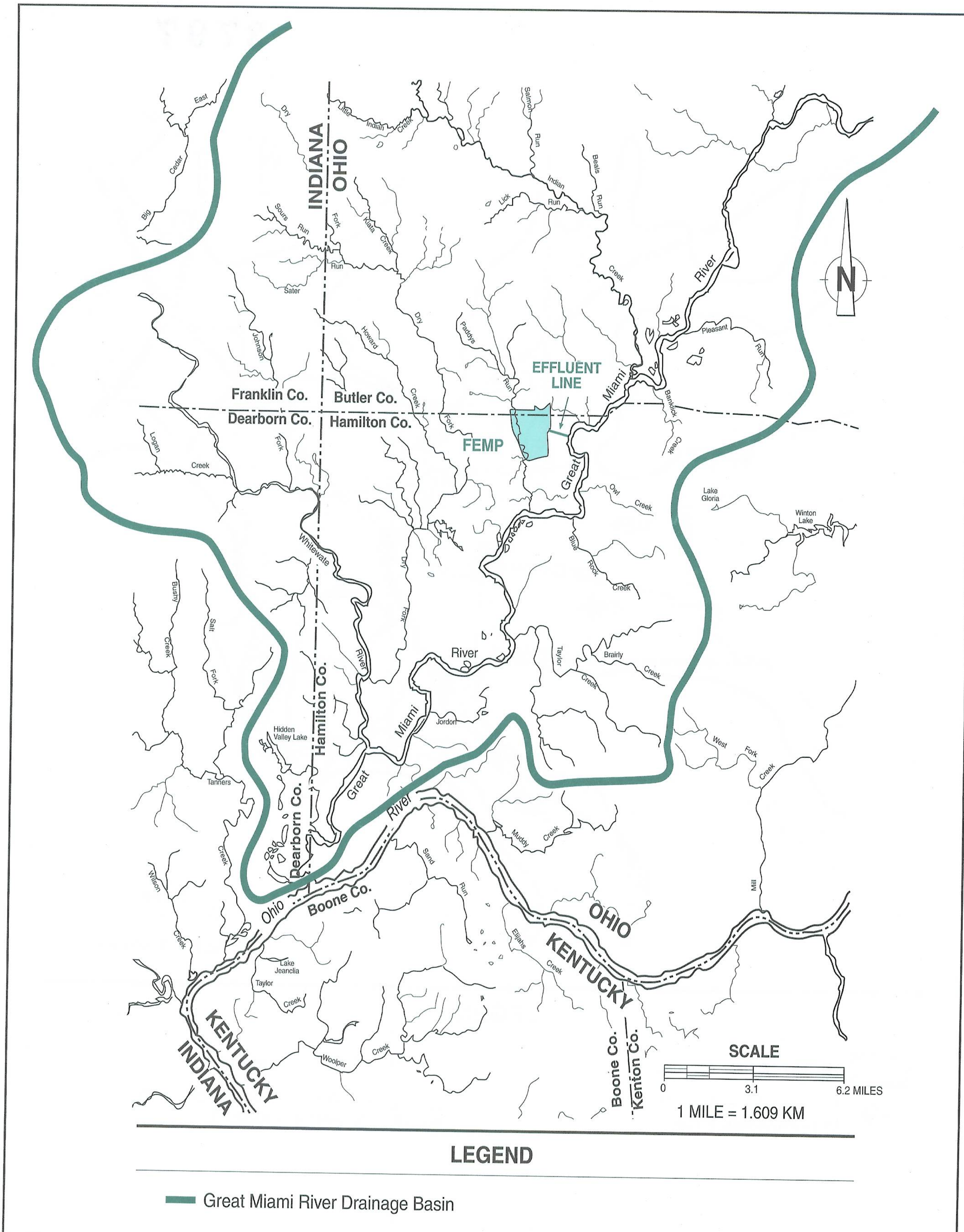

Figure 1-6. Great Miami River Drainage Basin

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Meteorological Conditions

Meteorological data gathered at the FEMP are primarily used to evaluate climatic conditions. The environmental monitoring program uses atmospheric models to determine how airborne effluents are mixed and dispersed. These models are then used to assess the impact of operations on the surrounding environment, in accordance with DOE requirements. Airborne pollutants are subject to weather conditions. Wind speed and direction, precipitation, and atmospheric stability play a key role in predicting how pollutants are distributed in the environment and in interpreting environmental data.

Figures 1-7 and 1-8 illustrate the average wind speed and general direction for 2000 measured at the 33-foot (10-meter) and 197-foot (60-meter) levels, respectively, in wind rose format. The prevailing winds were from the west through south-southwest approximately 40 percent of the time at both the 33- and 197-foot (10- and 60-meter) levels. Tables in Appendix C, Attachment 5, of this report present meteorological data for 2000, including wind direction and average speed.

In 2000, 44.75 inches (113.7 centimeters [cm]) of precipitation were measured at the FEMP. This is slightly higher than the average annual precipitation of 41.08 inches (104.3 cm) for 1950 through 1999. Figure 1-9 shows 2000 total precipitation for the area in relation to the annual precipitation amounts recorded from 1990 through 2000. (Precipitation totals from 1990 through 1992 were taken from the measurements made at the Greater Cincinnati/Northern Kentucky International Airport because of a computer software problem at the FEMP's meteorological tower. This problem was corrected, and the 1993 through 2000 totals were obtained from measurements made at the FEMP.) In addition, Figure 1-10 shows 2000 precipitation by month at the FEMP compared to the Cincinnati area average precipitation by month from 1950 through 1999, based on data collected at the Cincinnati/Northern Kentucky International Airport.

Natural Resources

Natural resources have important aesthetic, ecological, economic, educational, historical, recreational, and scientific value to the United States. Their protection will be an ongoing process throughout federal ownership of the Fernald site. Studies such as wildlife surveys (Facemire 1990) and the Operable Unit 5 Ecological Risk Assessment provided as Appendix B of the Remedial Investigation Report for Operable Unit 5 (DOE 1995d) show that terrestrial and aquatic flora and fauna at the site are diverse, healthy, and similar in abundance and species composition to those populations of surrounding ecological communities. Chapter 7 provides a detailed discussion of the site's diverse ecological habitats and cultural resources.

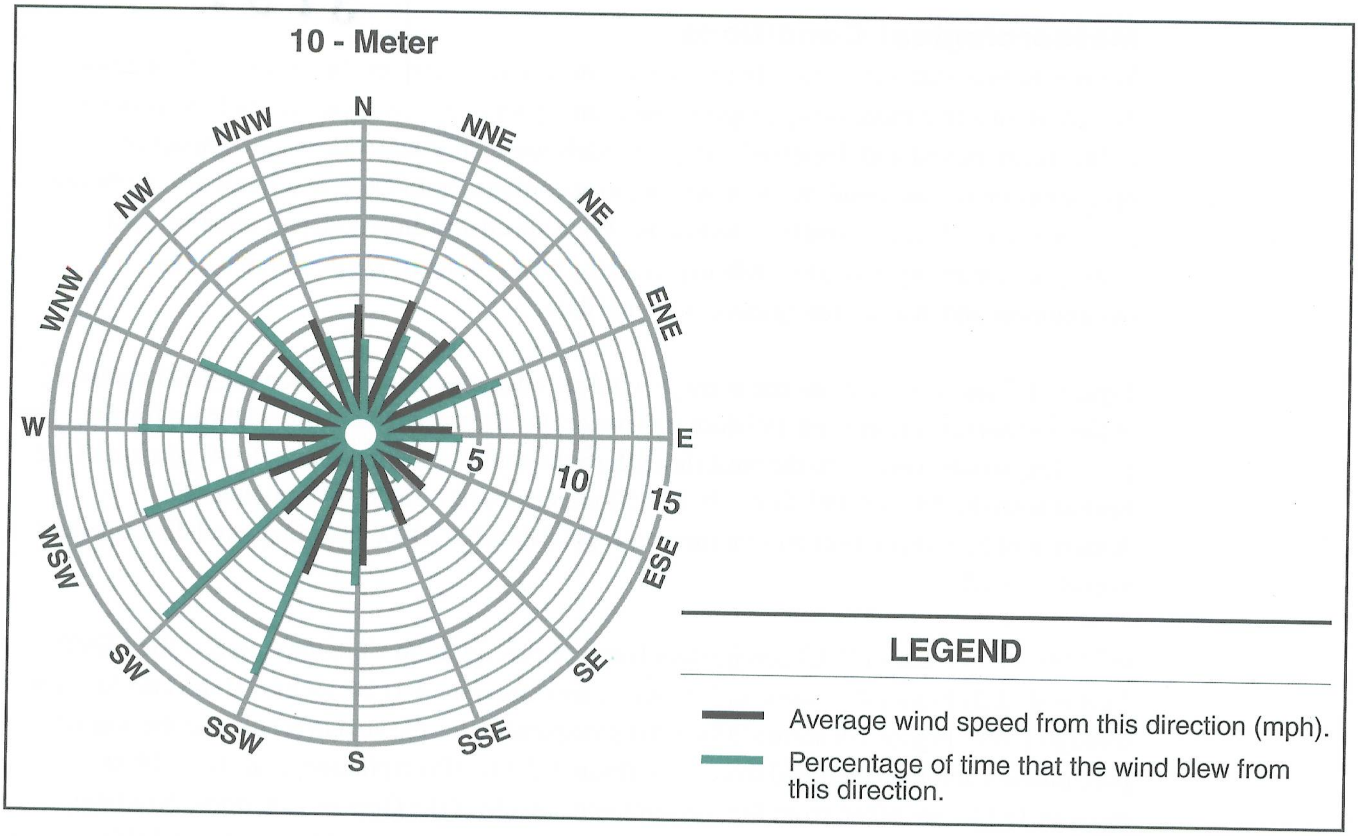

Figure 1-7. 2000 Wind Rose Data, 33 Foot (10 Meter) Height

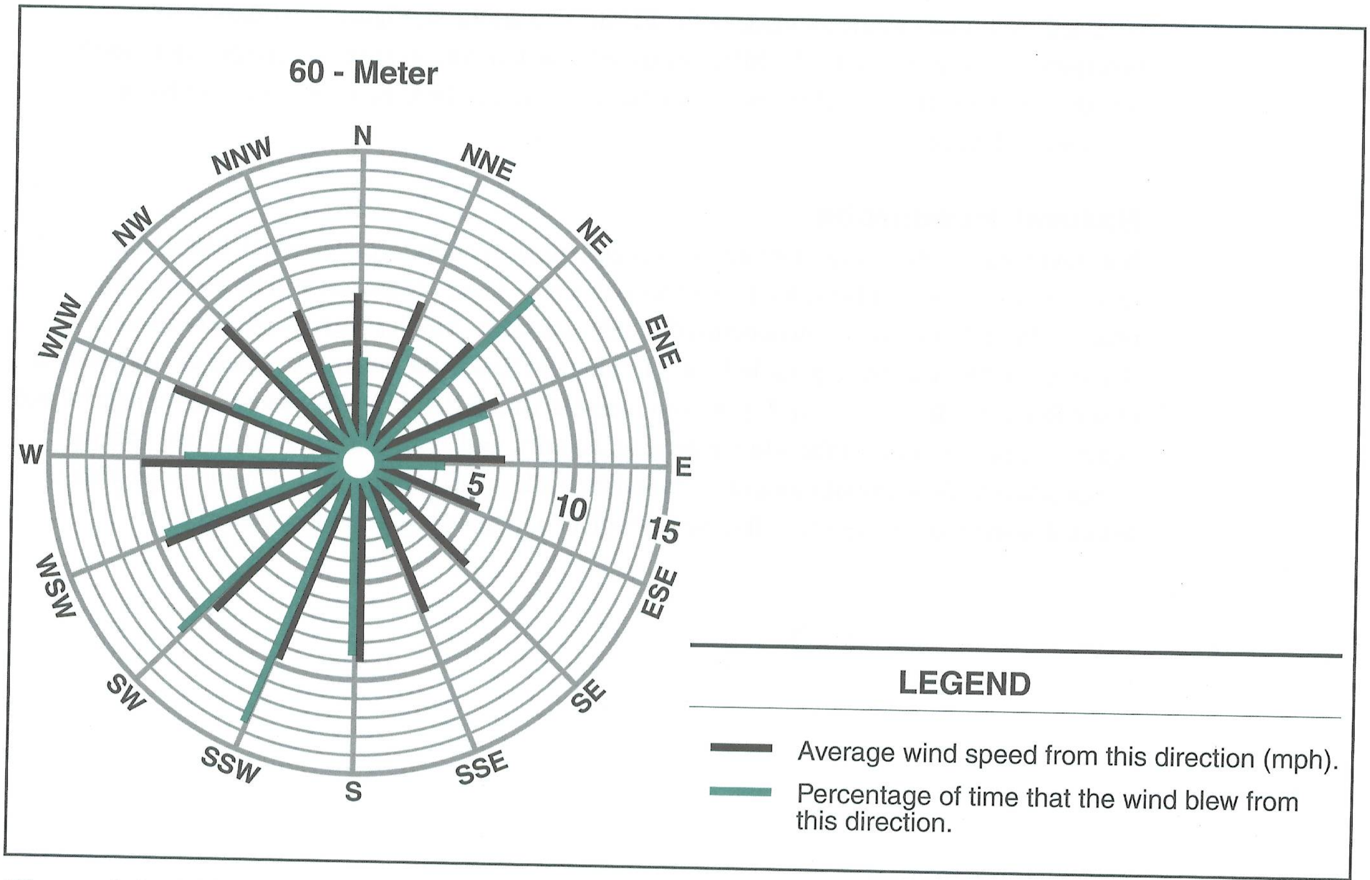

Figure 1-8. 2000 Wind Rose Data, 197 Foot (60 Meter) Height

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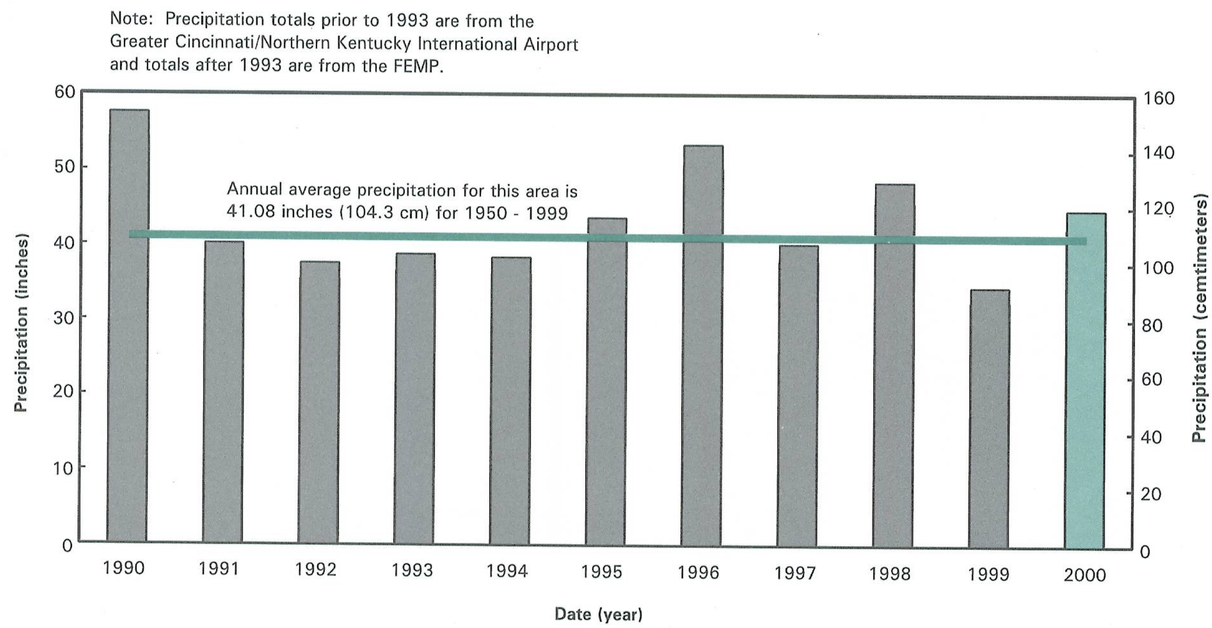

Figure 1-9. Annual FEMP Precipitation Data, 1990 - 2000

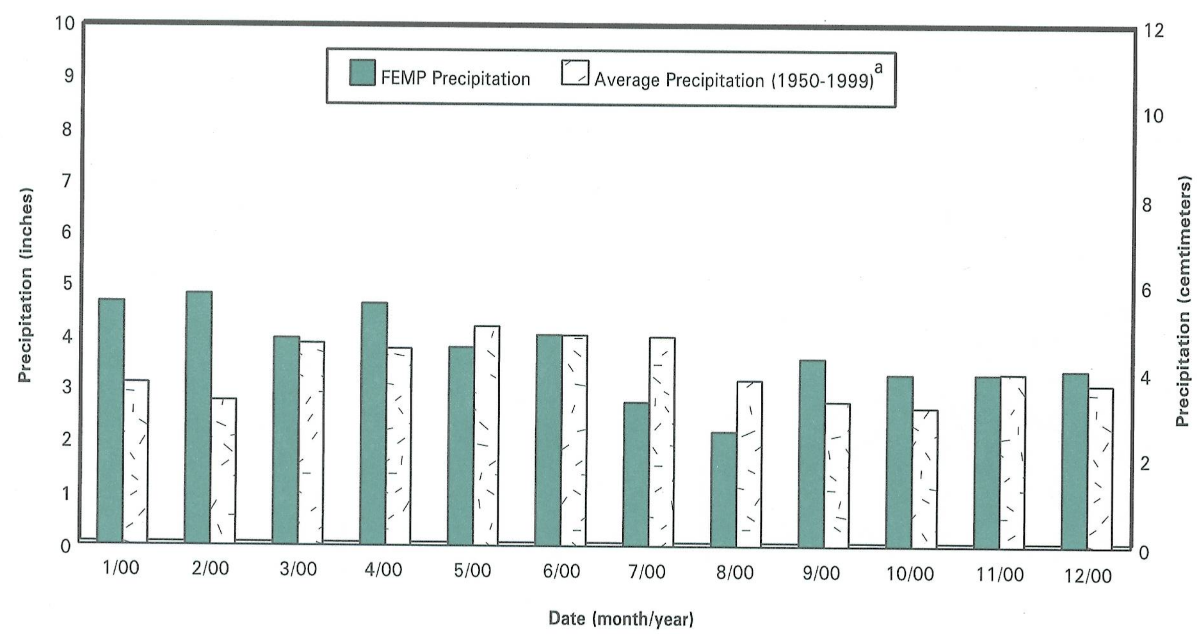

Figure 1-10. 2000 FEMP Monthly Precipitation Data

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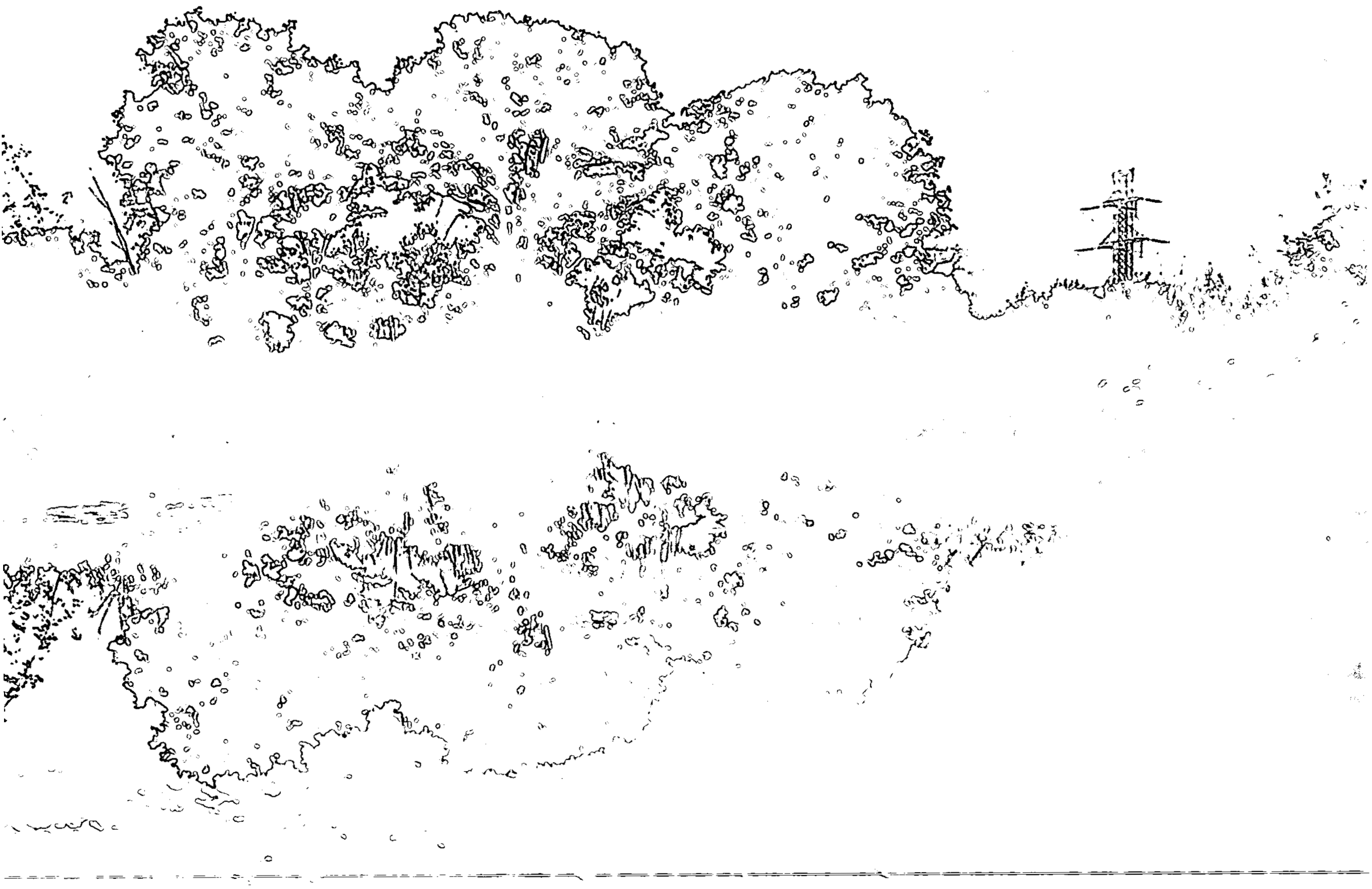
Chapter 2
Remediation Status and Compliance Summary



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Remediation Status and Compliance Summary

This chapter provides a summary of CERCLA remediation activities in 2000 for each project, and summarizes compliance activities with other applicable environmental laws, regulations, and legal agreements. CERCLA is the primary driver for environmental remediation of the FEMP.

The EPA and OEPA enforce the environmental laws, regulations, and legal agreements governing work at the FEMP. The EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards. EPA regional offices and state agencies enforce these regulations and standards by review of data collected at the FEMP. Region V of the EPA has regulatory oversight of the CERCLA process at the FEMP, with active participation from OEPA.

For some programs, such as those under the Resource Conservation and Recovery Act (RCRA), as amended, the Clean Air Act, as amended (excluding NESHAP compliance), and the Clean Water Act, as amended, EPA has authorized the State of Ohio to act as the primary enforcement authority. For these programs, Ohio promulgates state regulations that must be at least as stringent as federal requirements. Several legal agreements between DOE and EPA Region V and/or OEPA identify FEMP specific requirements for compliance with the regulations. As part of complying with these regulations, DOE Headquarters issues directives to its field and area offices and conducts audits to ensure compliance with all regulations.

CERCLA Remediation Status

The process for remediating sites under CERCLA consists of three phases, site characterization, remedy selection, and implementation. The FEMP has completed the first two phases, as the regulatory agencies have now approved remedy selection documents (i.e., Records of Decision) for all operable units. The Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions (DOE 2000a) was approved by the regulatory agencies in June of 2000.

The FEMP is currently involved in the implementation phase of CERCLA remediation, which includes remedial design, remedial action (construction and implementation of the remedy), certification of soil and groundwater to verify that the remedy was effective, and ultimately, site closure. Remediation activities, documents, and schedules are identified in each operable unit's remedial design and remedial action work plan. Progress has been made toward certification of soil remediation areas, as the Soil and Disposal Facility Project certified several more areas during 2000, as described later in this chapter under the Soil and Disposal Facility Project section.

Each phase of the CERCLA remediation process requires documentation. The documents produced reflect the input of stakeholders who have helped form the remediation strategy at the FEMP. Many documents that describe specific remediation activities were issued and/or approved in 2000, as mentioned throughout this report and identified in Table 2-1. All clean-up related CERCLA documentation is available to the public at the Public Environmental Information Center located near the FEMP. The administrative record is located at EPA's Region V office in Chicago, Illinois. The progress made by each remedial project toward CERCLA cleanup is summarized later in this chapter.

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TABLE 2-1
MAJOR FEMP DOCUMENTS FOR 2000

Project[a]	Documents	Status (on December 31, 2000)
Soil and Disposal Facility Project	Permanent Leachate Transmission System – Conceptual Design Report	Approved by Regulatory Agencies
	On-Site Disposal Facility Borrow Area Strategy Report	Approved by Regulatory Agencies
	90 Percent Title I/II Design for Areas 3A/4A	Submitted to Regulatory Agencies
	Certification Report for Area 2, Phase 3 Part 2	Approved by Regulatory Agencies
	Area 8, Phase III South Certification Report	Approved by Regulatory Agencies
	Certification Report for Area 1, Phase II	Submitted to Regulatory Agencies
Natural Resources	FEMP Master Plan for Public Use	Approved by Regulatory Agencies
	Area 8, Phase II Natural Resource Restoration Design Plan	Approved by Regulatory Agencies
Demolition Projects	Interim Report on D&D of Maintenance/Tank Farm Structures	Approved by Regulatory Agencies
	Operable Unit 3 Miscellaneous Small Structures D&D Project, Task Order #464 Completion Report	Submitted to Regulatory Agencies
Silos Project	Remedial Design Work Plan for the Silos 1 & 2 Accelerated Waste Retrieval Project	Approved by Regulatory Agencies
	Revised Feasibility Study Report for Silos 1 & 2	Approved by Regulatory Agencies
	Revised Proposed Plan for Remedial Actions at Silos 1 & 2	Approved by Regulatory Agencies
	Remedial Design Work Plan Silos 1 & 2 Accelerated Waste Retrieval Project Site Preparation	Submitted to Regulatory Agencies
	Silos 1 & 2 Accelerated Waste Retrieval (AWR) Project Remedial Design Package	Submitted to Regulatory Agencies
	Remedial Design Work Plan for Operable Unit 4 Silos 1 & 2	Approved by Regulatory Agencies
	Record of Decision Amendment for Operable Unit 4 Silos 1 & 2 Remedial Actions	Approved by Regulatory Agencies
Aquifer Restoration and Wastewater Project	Monthly Re-Injection Operation Reports	Submitted to Regulatory Agencies
	NPDES Discharge Monitoring Reports	Submitted to Regulatory Agencies
	Conceptual Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas	Submitted Informally to Regulatory Agencies
	Re-Injection Demonstration Test Report for the Aquifer Restoration and Wastewater Project	Approved by Regulatory Agencies
Environmental Monitoring	Integrated Environmental Monitoring Quarterly Status Reports	Submitted to Regulatory Agencies
	1999 Annual Integrated Site Environmental Report	Submitted to Regulatory Agencies
	Integrated Environmental Monitoring Plan, Revision 2, Draft Final	Submitted to Regulatory Agencies

[a]No major documents were submitted by the Waste Pits Remedial Action Project in 2000.

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CERCLA also requires a five-year review process of remedial actions implemented under the signed Record of Decision for each operable unit. The purpose of a five-year review is to determine whether the selected remedy at a site remains protective of human health and the environment through evaluation of performance of the remedy. The First Five-Year Review Report for the FEMP (DOE 2001a) was submitted to the EPA in April of 2001.

Cleanup levels for the FEMP for surface water, sediment, and groundwater were established in the Record of Decision for Remedial Actions at Operable Unit 5 (DOE 1996). These final remediation levels (FRLs) were established for constituents of concern, or those constituents at the FEMP determined, through risk assessment, to present risk to human health and/or the environment. Table 2-2 lists FRLs identified for constituents in groundwater, surface water, and sediment; these constituents are all monitored under the IEMP. FRLs represent the maximum allowable residual levels (the maximum concentrations which may remain in the environment following remediation), and these levels drive excavation and cleanup.

Benchmark Toxicity Values originated from the Operable Unit 5 Sitewide Ecological Risk Assessment. These concentrations for sediment and surface water are used to determine if a constituent may have a detrimental effect on a particular ecological receptor. For surface water and sediment, ecological receptors include fish and animals that inhabit the surface water body or use surface water as a source of drinking water.

Acceptable levels for constituents of ecological concern were established in the Operable Unit 5 Sitewide Ecological Risk Assessment (Appendix B of the Operable Unit 5 Remedial Investigation Report). The Sitewide Ecological Risk Assessment established benchmark toxicity values (BTVs) for protection of ecological receptors. Through the BTV screening process presented in Appendix C of the Final Sitewide Excavation Plan (DOE 1998b), three constituents of ecological concern (barium, cadmium, and silver) were selected to be evaluated in the surface water pathway to be protective of aquatic receptors. Chapter 4 discusses BTVs for surface water.

TABLE 2-2
FINAL REMEDIATION LEVELS
FOR GROUNDWATER, SURFACE WATER, AND SEDIMENT

	FRL[a]		
Constituent	Groundwater	Surface Water	Sediment
General Chemistry	(mg/L)	(mg/L)	(mg/kg)
Cyanide	NA[b]	0.012	NA
Fluoride	4[c]	2.0	NA
Nitrate[d]	11	2,400	NA
Inorganics	(mg/L)	(mg/L)	(mg/kg)
Antimony	0.0060	0.19	NA
Arsenic	0.050	0.049	94
Barium	2	100	NA
Beryllium	0.0040	0.0012	33
Boron	0.33	NA	NA
Cadmium	0.014	0.0098	71
Chromium VI[d]	0.022	0.010	3,000
Cobalt	0.17	NA	36,000
Copper	1.3	0.012	NA
Lead	0.015[c]	0.010	NA
Manganese	0.900	1.5	410
Mercury	0.0020	0.00020	NA
Molybdenum	0.10	1.5	NA
Nickel	0.10	0.17	NA
Selenium	0.050	0.0050	NA
Silver	0.050	0.0050	NA
Thallium	NA	NA	88
Vanadium	0.038	3.1	NA
Zinc	0.021	0.11	NA
Radionuclides	(pCi/L)	(pCi/L)	(pCi/g)
Cesium-137	NA	10	7.0
Neptunium-237	1.0	210	32
Lead-210	NA	11	390
Plutonium-238	NA	210	1,200
Plutonium-239/240	NA	200	1,100
Radium-226	20	38	2.9
Radium-228	20	47	4.8
Strontium-90	8.0	41	7,100
Technetium-99	94	150	200,000
Thorium-228	4.0	830	3.2
Thorium-230	15	3500	18,000
Thorium-232	1.2	270	1.6
	(µg/L)	(µg/L)	(mg/kg)
Total Uranium[e]	20	530	210

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TABLE 2-2
(Continued)

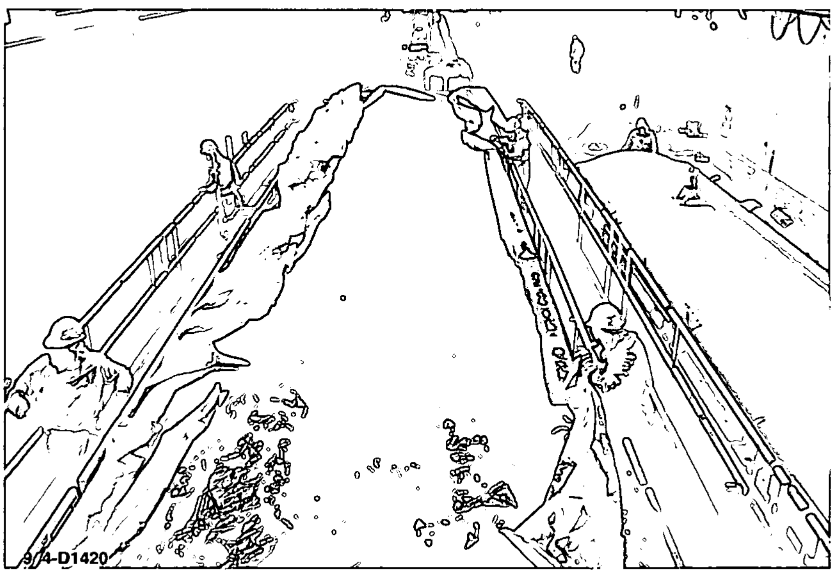
Constituent	FRL[a]		
	Groundwater	Surface Water	Sediment
Organics	(µg/L)	(µg/L)	(µg/kg)
Alpha-chlordane	2.0	0.31	NA
Aroclor-1254	0.20	0.20	670
Aroclor-1260	NA	0.20	670
Benzene	5.0	280	NA
Benzo(a)anthracene	NA	1.0	190,000
Benzo(a)pyrene	NA	1.0	19,000
Benzo(b)fluoranthene	NA	NA	190,000
Benzo(k)fluoranthene	NA	NA	1,900,000
Bis(2-chloroisopropyl)ether	5.0	280	NA
Bis(2-ethylhexyl)phthalate	6.0	8.4	5,000,000
Bromodichloromethane	100	240	NA
Bromoform	NA	NA	160,000
Bromomethane	2.1	1300	NA
Carbazole	11	NA	63,000
Carbon disulfide	5.5	NA	NA
Chloroethane	1.0	NA	NA
Chloroform	100	79	NA
Chrysene	NA	NA	19,000,000
Dibenzo(a,h)anthracene	NA	1.0	NA
3,3'-Dichlorobenzidene	NA	7.7	NA
1,1-Dichloroethane	280	NA	NA
1,1-Dichloroethene	7.0	15	NA
1,2-Dichloroethane	5.0	NA	NA
Dieldrin	NA	0.020	NA
Di-n-butylphthalate	NA	6,000	NA
Di-n-octylphthalate	NA	5.0	NA
Methylene chloride	5.0	430	NA
4-Methylphenol	29	2,200	NA
4-Methyl-2-pentanone	NA	NA	2,100,000
4-Nitrophenol	320	7,400,000	NA
N-nitrosodiphenylamine	NA	NA	260,000
Octachlorodibenzo-p-dioxin	0.0001	NA	NA
Phenanthrene	NA	NA	3
2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.010	NA	NA
Tetrachloroethene	NA	45	NA
1,1,1-Trichloroethane	NA	1.0	NA
1,1,2-Trichloroethane	NA	230	NA
Trichloroethene	5.0	NA	NA
Vinyl Chloride	2.0	NA	NA

[a]From Record of Decision for Remedial Actions at Operable Unit 5, Tables 9-4 through 9-6, January 1996
[b]NA = not applicable because no FRL was required for this constituent in this particular environmental media.
[c]The groundwater FRLs for fluoride and lead were changed from 0.89 mg/L and 0.002 mg/L, respectively, to be consistent with the FRL selection process outlined in the Operable Unit 5 Feasibility Study. The changes were documented in the Operable Unit 5 Record of Decision by change pages.
[d]Because of holding time considerations, nitrate/nitrite is analyzed for nitrate and total chromium is analyzed for hexavalent chromium. This is acceptable because total chromium and nitrate/nitrite provide a more conservative result.
[e]Uranium consists of several isotopes. The common isotopes of uranium include uranium-234, uranium-235, uranium-236, and uranium-238. This report interchangeably uses the terms uranium and total uranium. Either of these terms is defined as the sum of the various isotopic components.

Waste Pits Remedial Action Project

The Waste Pits Remedial Action Project (Operable Unit 1) is responsible for the excavation, drying (as required), loading, and rail transport of the contents of waste pits 1 through 6, the burn pit, and the clearwell to an off-site disposal facility. Sampling and analysis of the waste pit material and the off-site disposal of contaminated soil and debris that exceed the waste acceptance criteria (physical, chemical, and radiological standards) for the on-site disposal facility is part of this scope of work. The project is also responsible for collecting wastewater and storm water associated with the Waste Pits Remedial Action Project activities and, as needed, pre-treating and transporting this remediation water to the advanced wastewater treatment facility. In addition, the project is responsible for implementing dust control measures, and for implementing point source emission controls for dryer operations.

IT Corporation, the subcontractor for the Waste Pits Remedial Action Project, is responsible for the pre-treatment (e.g., crushing, sorting, and shredding) of waste pit materials, drying (as necessary), and the loadout of railcars with pit material for shipment to Envirocare of Utah, Inc. During 2000, 16 trains left the FEMP carrying a total of 104,209 tons (94,538 metric tons) of material. Since the first rail shipment in April of 1999, the Waste Pits Remedial Action Project has shipped 32 trains carrying approximately 193,836 tons (175,848 metric tons) of material to Envirocare of Utah, Inc. for disposal. As of December 31, 2000, the excavation of the waste pits was approximately 30 percent complete.



Waste Pits Remedial Action Project - a loaded railcar is prepared for shipment

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Soil and Disposal Facility Project

The Soil and Disposal Facility Project, which includes components of both Operable Units 2 and 5, is responsible for soil characterization sampling, excavation of contaminated soil, natural resource restoration, and the construction of on-site disposal facility cells and waste placement into those cells. Of note, the on-site disposal facility's leachate and leak detection monitoring, as well as operation, maintenance and monitoring of the leachate transmission system is the responsibility of the Aquifer Restoration Project.

For purposes of excavating contaminated soil, the FEMP has been divided into 10 main soil remediation areas. Figure 2-1 depicts Remediation Areas 1 through 9. Area 10, which is not shown on Figure 2-1, consists of potentially contaminated corridors such as haul routes, utility corridors and access roads. Area 10 will not be addressed until the end of both soil and aquifer remediation.

Prior to remediation, real-time scanning and soil sampling are performed to support engineering designs to determine the extent of contaminated soil for remediation, and to identify the materials that meet the waste acceptance criteria for the on-site disposal facility. Materials that cannot be placed in the on-site disposal facility are stockpiled, monitored, and tracked for off-site disposal. When contaminated soil and debris have been excavated from each area, pre-certification real-time scanning and certification sampling are performed to demonstrate that the residual levels of the constituents of concern for that area are below the site's FRLs. After the laboratory results are reviewed to confirm that constituents of concern are below the site's FRLs, the area is certified as meeting the soil remediation goal, and natural resource restoration can begin.

Soil and Disposal Facility Project - contaminated debris is placed in the on-site disposal facility

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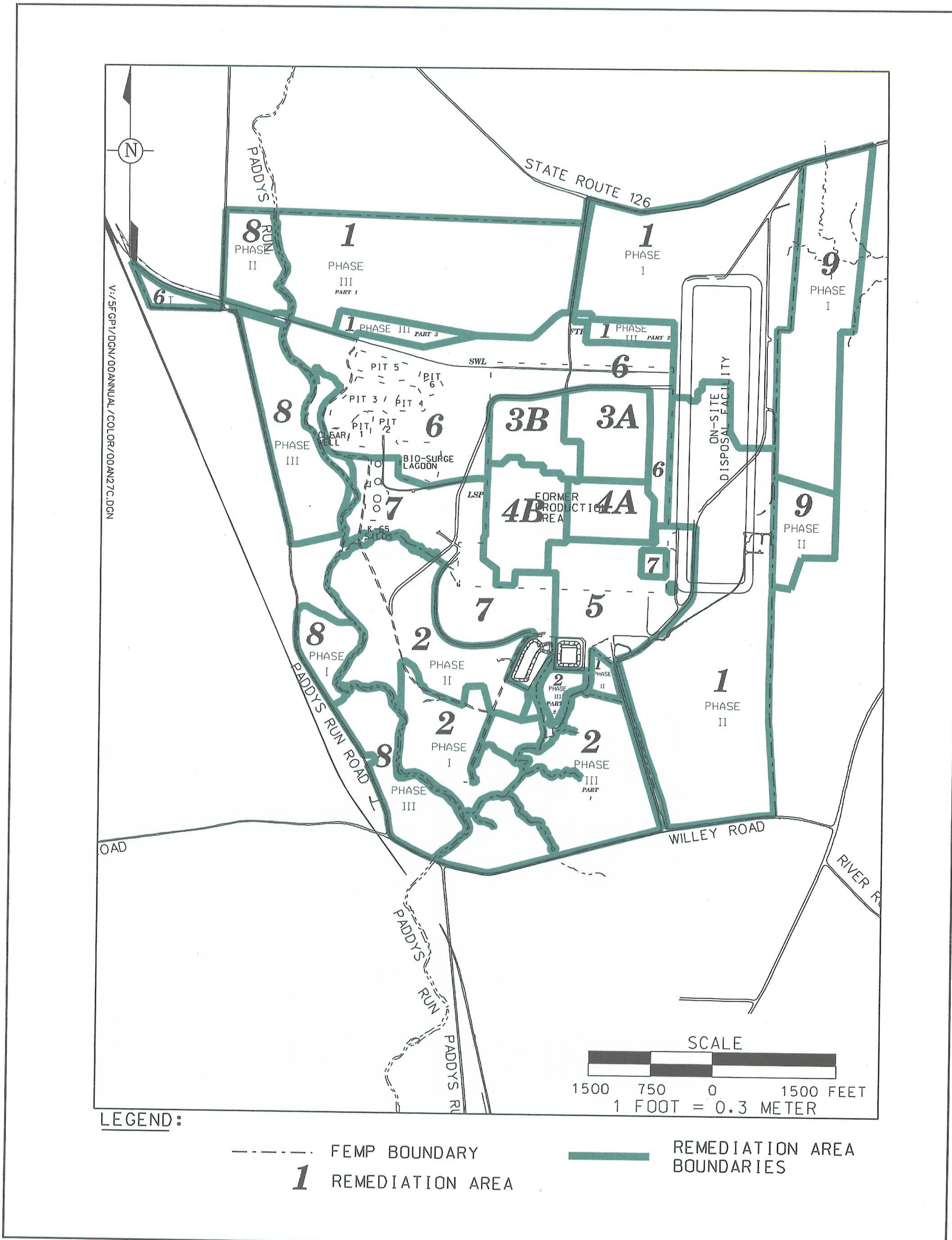

Figure 2-1. Sitewide Remediation Areas

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The Soil and Disposal Facility Project continued soil and debris excavation and placement in 2000. Soil excavation and/or certification activities activities took place in the following remediation areas in 2000:

- Area 1, Phase II (former sewage treatment plant, trap range, additional area and facilities in the southeast corner of the FEMP): In 1999 soil in the vicinity of the former trap range was treated to stabilize the lead, and as a result, allow the soil to be placed in the on-site disposal facility. In 2000 a small volume (4 cubic yards [yd^3]) (3 cubic meters [m^3]) of soil required further lead stabilization and excavation. After certification sampling and analysis took place in this area, the Certification Report for Area 1, Phase II was submitted to the EPA and OEPA. Also, clay to be used as on-site disposal facility liner material was stockpiled in the borrow area.

- Area 1, Phase III (areas north of the former production area and the waste pits): Part 1 includes the 100-plus acre (40.5 hectare) area north of the production area and waste pits. Certification sampling and analysis in Area 1, Phase III, Part 1 took place during the spring of 2000. Also, a ground penetrating radar scan took place in portions of this area to identify any buried man-made materials. A certification report will be issued in 2001 after removal of some identified construction debris, and subsequent certification of that soil. Part 2 is the 7-acre (2.8-hecare) field north of the railyard and east of the former fire training facility. Pre-certification scanning and certification sampling were conducted in the summer of 2000 for Part 2. A small remedial excavation was required to remove 625 yd^3 (478 m^3) of contaminated soil adjacent to the former fire training facility.

- Area 2, Phase I (southern waste units, southwest corner of the FEMP): Excavation and real-time radiological monitoring of the South Field and the Active Flyash Pile continued during 2000, and the excavation reached the design grade. A ground penetrating radar scan was performed in an area adjacent to the southern waste units, and 10,000 yd^3 (7,650 m^3) of material were excavated to remove all identified man-made objects. Excavation took place to remove approximately 5,000 yd^3 (3,800 m^3) of radium contaminated soil from Area 2, Phase III, Part 2, just south of the Storm Water Retention Basin. Soil Pile 3 was also excavated in 2000.

- Areas 3, 4, and 5 (former production area): The 90 Percent Title I/II Design for Areas 3A/4A was submitted to EPA and OEPA.

- Area 6 (waste pits area): No Soil and Disposal Facility Project activities took place in Area 6 during 2000.

- Area 7 (Silos Project area and advanced wastewater treatment facility vicinity): Soil sampling to determine attainment of on-site disposal facility waste acceptance criteria was completed in support of soil excavations that took place in the vicinity of the silos (Operable Unit 4) for the project's infrastructure development.

- Area 8 (west of Paddys Run): Area 8, Phase III-South (the southwestern corner of the site) was certified, and the certification report was approved by the regulatory agencies. No excavation of this area was required.

- Area 9 (off-property soil adjacent to the FEMP): Area 9, Phase I includes off-property soil adjacent to remediated portions of Area 1, Phase I. Real-time scanning and soil sampling was performed in 2000 within Area 9, Phase I in preparation for the certification of this area. Also, additional subsurface background soil samples were collected from off-property areas north and east of the FEMP to fill the data gap in the 1992 soil background study.

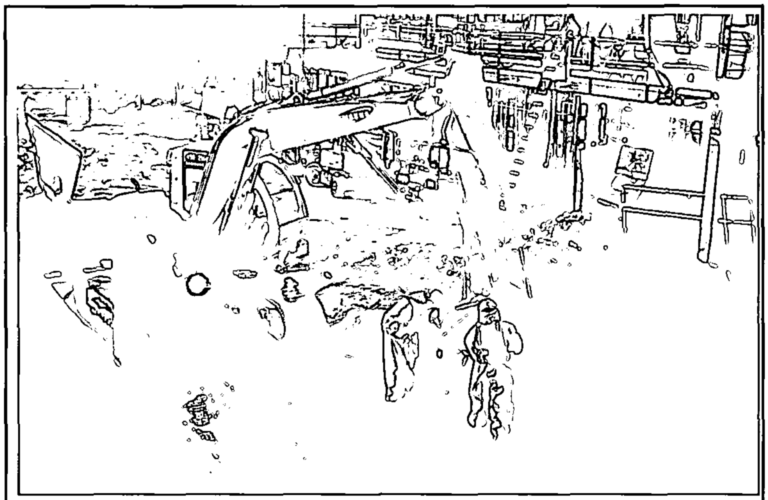
At the on-site disposal facility, waste placement into Cells 1, 2, and 3 continued throughout 2000. Over 227,600 yd^3 (174,023 m^3) of contaminated soil and debris were placed in the on-site disposal facility during the year. In September of 2000, an important milestone in the Fernald site clean up was achieved when Cell 1 reached 100 percent capacity. Also, following the award of a contract to the Staver Group, construction began on the enhanced permanent leachate transmission system in the summer of 2000. Chapter 3 discusses the activities associated with the monitoring of the on-site disposal facility.

Activities associated with natural resources closely parallel the activities of the Soil and Disposal Facility Project. Chapter 7 discusses specific 2000 natural resources activities.

Decontamination and Demolition Project

The Decontamination and Demolition Project (Operable Unit 3) is responsible for decontamination and dismantling of the above-grade portion of structures and facilities associated with production operations and remedial action facilities. This includes decontamination of facilities, isolation of utilities, demolition of buildings, equipment, and other facilities, and removing uranium and other material from former processing equipment and shipping material and equipment off site. The scope includes the collection and proper management of associated decontamination wastewater.

Facilities Shutdown is part of the Decontamination and Demolition Project, and this project's closure activities during 2000 included the following:



Decontamination and Demolition Project

- Isolated the services building (complete)
- Plant 5 ball mill holdup removal (complete)
- 28A electrical isolation (complete)
- 28B electrical isolation (complete)
- Plant 6 removal of holdup material (complete)
- Area 3 utility isolations except the utilities that support 64/65 (complete)
- T-85 isolated for relocation
- Completed removal of sediment from the Nuclear Fuel Services tanks 2E
- Isolated 4B fire water system.

Decontamination and dismantlement activities that took place in 2000 included:

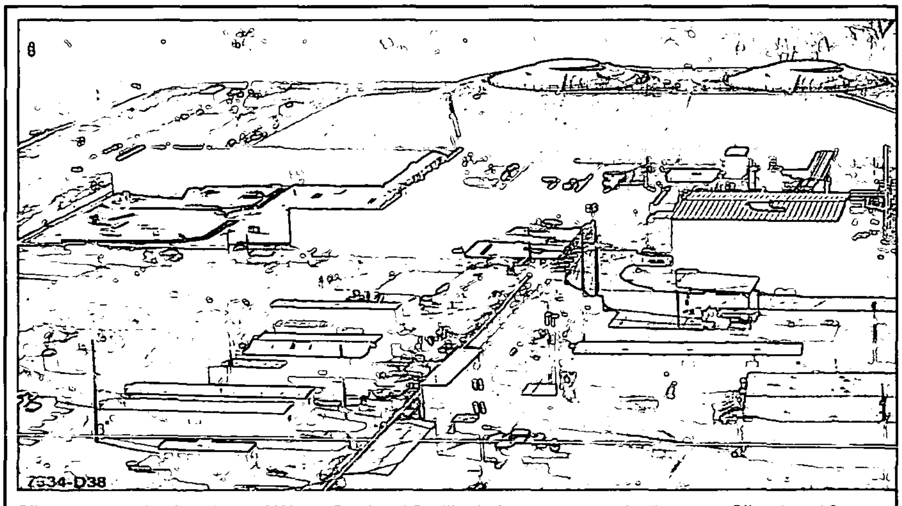
- 28N main gate guard post
- 2E Nuclear Fuel Services storage and pump house
- 28B industrial relations building
- 28A security building
- 20H process water storage tank
- 55B slag recycling pit/elevator
- 55A slag recycling building
- 4B Plant 4 Warehouse
- Plant 6 covered storage area
- 6F Plant 6 salt oil heat treatment building
- 6C electrostatic precipitator south.

Demolition Projects dismantled a total of 13 structures in 2000, bringing the total number of structures demolished at the FEMP to 90.

Silos Projects

The Silos Project (Operable Unit 4) is located on the western edge of the site and includes Silos 1 and 2, also known as the K-65 Silos, Silos 3 and 4, and several nearby structures. Silos 1 and 2 contain low-level radium-bearing residues dating back to the 1950s. Silo 3 contains cold metal oxides, and Silo 4 has never been used. Silos Project remediation activities include the retrieval, stabilization, and off-site disposal of the residues stored in the silos, as well as decontamination and dismantling of the silo structures and associated facilities. A re-evaluation of the remedy for Silos 1 and 2 was completed in 2000, as discussed later in this section.

During 1997 the decision was reached among DOE, EPA, and OEPA to separate the remediation of Silo 3 material from remediation of Silos 1 and 2 material and to re-evaluate the treatment remedies for both materials. In addition, the Silos 1 and 2 Accelerated Waste Retrieval Project was initiated to provide control of radon in Silos 1 and 2 headspace and safe storage of the Silos 1 and 2 material during the interim period until treatment and disposal can be implemented. Following is a summary of each project's major activities during the year.



Silos Project - the Accelerated Waste Retrieval Facility being constructed adjacent to Silos 1 and 2

Silos 1 and 2 Remediation

In 1999, "Proof-of-principle" testing was conducted on four potential treatment processes to provide technical and cost data to support detailed evaluation of potential treatment alternatives. The results of this testing were used to support preparation of a revised Feasibility Study for Silos 1 and 2, documenting the detailed analysis of the alternatives against criteria specified by CERCLA.

The Silos 1 and 2 Draft Feasibility Study/Proposed Plan (DOE 1999b) was submitted to EPA and OEPA for review and approval in December 1999. Based upon the evaluation documented in the Feasibility Study, the Proposed Plan suggested on-site chemical stabilization followed by off site disposal as the revised remedy for Silos 1 and 2 material. EPA approved the revised Feasibility Study/Proposed Plan for Silos 1 and 2 on March 22, 2000 (DOE 2000f), and the Proposed Plan was then issued for a formal public comment period from April 3 through May 15, 2000. Public hearings were conducted in the vicinity of both the FEMP and the Nevada Test Site during this comment period. Responses to all comments received during the comment period were documented in a Responsiveness Summary that was included in the Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions. On July 13, 2000, EPA approved the Record of Decision Amendment, which documents the final revised remedy for treatment of Silos 1 and 2 material. The final revised remedy consists of on-site chemical stabilization of the Silos 1 and 2 material followed by off site disposal at the Nevada Test Site. Design of the necessary facilities for implementation of the revised remedy for Silos 1 and 2 will be initiated in 2001.

The Silos 1 and 2 Project initiated the Accelerated Waste Retrieval Project in 1998. The purpose of this project is to address the increasing radon concentrations in the Silos 1 and 2 headspace, issues with silo integrity, and heterogeneity of the material for the final treatment facility. The project scope includes design, construction, testing, and operation of interim storage facilities to hold the Silos 1 and 2 material until treatment is implemented. The project also includes design, construction, and startup of a radon control system to provide control of radon emissions during construction and operation phases of the Accelerated Waste Retrieval Project, as well as during interim storage and operation of the Silos 1 and 2 full-scale treatment facility. A contract for implementation of the Silos 1 and 2 Accelerated Waste Retrieval Project was awarded to Foster Wheeler Environmental Corporation in 1999. During 2000 design of the necessary equipment and facilities, and initial construction activities took place. Final design will be completed in early 2001. Construction of the radon control system, the transfer tank area, and the full-scale mockup system will take place during 2001.

Silo 3 Project

A contract for the Silo 3 stabilization/solidification facility was awarded to Rocky Mountain Remediation Services in December 1998. Design of the facility, and initial construction activities took place during 2000. Primary construction activities during 2000 consisted of site preparation and grading, installation of the foundations for the retrieval gantry, and installation of the interim storage area pad. During late 2000, Fluor Fernald's contract with Rocky Mountain Remedial Services was terminated by agreement of both parties. Evaluation of alternatives for implementation of Silo 3 remediation was initiated and a revised path forward will be developed with input from DOE, regulators, and FEMP stakeholders during 2001.

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Supplemental Environmental Projects

As a result of missed Operable Unit 4 enforceable milestones in 1996, the dispute resolution agreement with EPA required DOE to perform the following supplemental environmental projects:

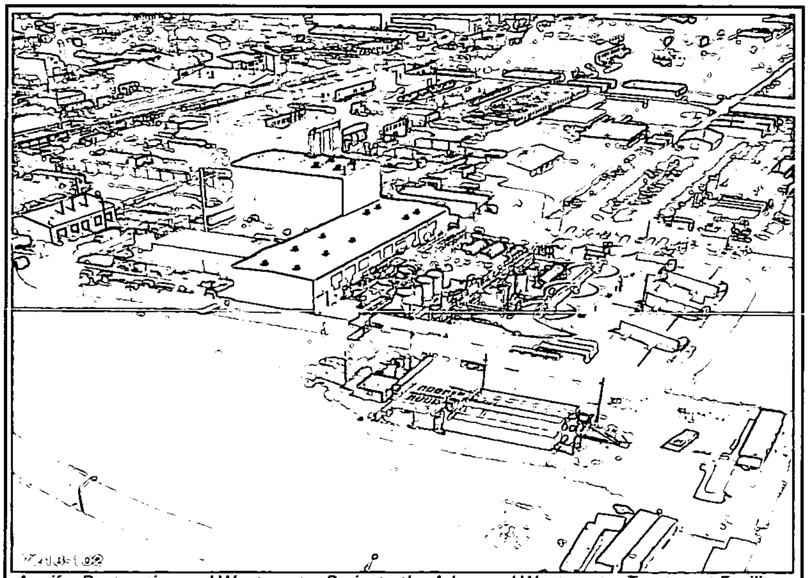
- Grants for ecological restoration research
- Creation of a wild bird/wildflower habitat area
- Railroad track recycling
- Structural steel debris recycling.

Originally this dispute resolution agreement also called for the establishment of a conservation area near the FEMP, however this project could not be finalized. Funds identified for the conservation area were instead directed to the recycling projects.

These supplemental environmental projects are being performed under the scopes of other projects. The wild bird/wildflower habitat area and recycling projects are now complete. Chapter 7 reports the progress on the ecological restoration research in 2000.

Aquifer Restoration and Wastewater Project

The Aquifer Restoration and Wastewater Project (Operable Unit 5) is responsible for the restoration of water quality in the affected portions of the Great Miami Aquifer and treating the FEMP's extracted groundwater, storm water, sanitary wastewater, and remediation wastewater. These activities include the design, construction, operation, monitoring, and reporting for the groundwater restoration and wastewater treatment systems at the FEMP. This project is also responsible for managing the on-site disposal facility's leachate and leak detection monitoring program, as well as operation, maintenance and monitoring of the leachate transmission system.



Aquifer Restoration and Wastewater Project - the Advanced Wastewater Treatment Facility

In 2000 the Aquifer Restoration and Wastewater Project continued to operate the South Plume Module (including the South Plume Optimization Module), the South Field (Phase I) Extraction Module, and the Re-Injection Module. Direct push sampling activities were conducted with a Geoprobe® in the South Field, the waste storage area, and the Plant 6 area. The South Field activities support the groundwater remedy performance monitoring and design of the South Field Phase II Modules, while the waste storage area and Plant 6 area activities support the design of the planned aquifer restoration modules for those areas.

In 2000 a total of 1,879 million gallons (7,112 million liters) of groundwater were extracted from the Great Miami Aquifer, 845 pounds (384 kg) of uranium were removed from the aquifer, and 299 million gallons (1,132 million liters) of water were re-injected into the aquifer. Chapter 3 discusses groundwater monitoring.

Phases 1 and 2 of the advanced wastewater treatment facility and the interim advanced wastewater treatment facility provide final treatment of FEMP contaminated storm water and wastewater. The advanced wastewater treatment facility Phase 3 and the South Plume interim treatment facility are dedicated to treatment of contaminated groundwater associated with FEMP groundwater remediation. In 2000 the following improvements to the site's wastewater storage, conveyance, and treatment systems were made:

- Modified the method of operating the Storm Water Retention Basin to maximize the hydraulic capacity by continuously treating low flows (continuous treatment versus batch treatment)
- Continued to refine the ion exchange resin regeneration system operation
- Changed from the use of caustic (sodium hydroxide) to lime (calcium carbonate) in the operation of the advanced wastewater treatment facility slurry de-watering facility to optimize performance
- Began the construction of the enhanced permanent leachate transmission system for the on-site disposal facility
- Began construction of the alternative remedial action subcontractor aproach Basin Re-Route Project that will provide the ability to route storm water from the waste pit area to the Storm Water Retention Basin.

Summary of Compliance with Other Requirements

CERCLA requires compliance with other laws and regulations as part of remediation of the FEMP. These other requirements are referred to as applicable or relevant and appropriate requirements, or ARARs. ARARs that are pertinent to remediation of the site are specified in the record of decision for each operable unit. This section highlights some of the major requirements related to environmental monitoring and waste management and how the FEMP complied with these requirements in 2000.

The regulations discussed in this section have been identified as ARARs within the FEMP's records of decision. The FEMP must comply with these regulations while site remediation under CERCLA is underway; EPA and OEPA enforce compliance. Some of these requirements include permits for controlled releases, which are also discussed in this section.

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Resource Conservation and Recovery Act (RCRA)

RCRA, as amended, regulates treatment, storage, and disposal of hazardous waste and the hazardous part of mixed waste (mixed waste contains both radioactive and hazardous waste components). Hazardous and mixed waste now generated at the site result from such activities as CERCLA remedial actions, laboratory analyses, and maintenance activities. The FEMP also has an inventory of mixed waste generated from former production activities. These wastes are regulated under RCRA and Ohio hazardous waste management regulations; thus, the site must comply with legal requirements for managing hazardous and mixed wastes. OEPA has been authorized by EPA to enforce its hazardous waste management regulations in lieu of the federal RCRA program. In addition, hazardous waste management is subject to the 1988 Consent Decree and the first (1993) and second (1998) Stipulated Amendment entered into between the State of Ohio and DOE, as well as a series of Director's Final Findings and Orders issued by OEPA.

The FEMP completed several administrative activities related to mixed waste storage and treatment during 2000, including:

- Submittal of the 1999 RCRA Annual Report (DOE 2000c), which describes hazardous waste activities for 1999
- Revisions to several sections of the RCRA Part A and B permit application
- Submittal of the Fiscal Year 2000 Annual Update to the Site Treatment Plan (DOE 2000g) as required in the 1992 Federal Facility Compliance Act and the implementing Director's Findings and Orders issued by OEPA in October 1995.

Additional details on projects involving treatment of mixed wastes are provided in the Mixed Waste Treatment subsection.

RCRA Property Boundary Groundwater Monitoring

The Director's Findings and Orders, which were signed September 10, 1993, described an alternate groundwater monitoring system. This document was revised during 2000 and approved on September 7, 2000, to coincide with the groundwater monitoring strategy identified in the IEMP. This is discussed in Chapter 3 and is called Property Boundary Monitoring.

RCRA Closures

The first (1993) Stipulated Amendment to Consent Decree required that DOE identify all hazardous waste management units at the site. As a result, burners, incinerators, furnaces, stills, process equipment, tank units, dust collectors, and other potential waste containment units were evaluated in the early 1990s to determine if they were hazardous waste management units or solid waste management units. This evaluation was completed in 1994. In 1996 OEPA issued a Director's Findings and Orders to integrate RCRA closure requirements with CERCLA response actions for FEMP hazardous waste management units. In 2000 the FEMP completed the remediation of two hazardous waste management units under the integrated RCRA/CERCLA process: the sludge drying beds located at the former sewage treatment plant and the uranyl nitrate hexahydrate tanks in the Nuclear Fuel Services storage area. Plans were developed for the remediation of a third unit, a storage pad located north of Plant 6.

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Thorium Management

A thorium management strategy and a schedule to complete RCRA determinations of thorium materials and to improve the storage of thorium materials at the FEMP were developed as part of the Stipulated Amendment to the Consent Decree signed in 1991. This strategy is based on three primary objectives:

- To maintain environmentally stable interim storage of the thorium inventory while minimizing personnel radiation exposure
- To implement actions required to complete RCRA evaluations of the thorium materials
- To implement long-term storage and disposal alternatives.

The Thorium Overpacking Project, in which the FEMP removed 3,400 containers of thorium material and shipped 10,875 drum-equivalents, or 80,480 ft^3 (2,279 m^3), of thorium material to the Nevada Test Site for disposal, was completed in 1997. The characterization documentation and formal RCRA waste determinations for the remaining estimated 8,500 containers of thorium legacy waste continued in 1999. In 2000 over 6,000 of these containers were shiped to Nevada Test Site for disposal. The following activities are planned for the future:

- Low-level radioactive, non-RCRA thorium legacy waste will continue to be prepared and shipped to the Nevada Test Site for disposal.
- The thorium legacy waste determined to be hazardous under RCRA will be prepared and shipped for treatment to meet land disposal restrictions and, upon analytical confirmation, will be shipped from the treatment facility to an approved disposal facility.
- Non-RCRA throium waste that contains free liquids and hydrogen-generating waste will require treatment and repackaging to meet Nevada Test Site waste acceptance criteria and will then be shipped to the Nevada Test Site for disposal.

The treatment activities for thorium legacy waste are planned for completion by December 31, 2002.

Mixed Waste Treatment

The FEMP stores mixed wastes that are subject to RCRA land disposal restrictions. These restrictions currently prohibit the storage of certain hazardous waste streams for longer than one year, unless OEPA approves an extension.

> **Mixed waste** is defined under RCRA as waste containing both a hazardous waste subject to RCRA, and a source, special nuclear, or radioactive byproduct material subject to the Atomic Energy Act, as amended. RCRA mixed wastes at the FEMP are stored in consolidation tanks until they are shipped to the incinerator at Oak Ridge, Tennessee. The consolidation tanks at the FEMP hold approximately 20,000 gallons of material, which constitutes a "batch". Batches may contain oils, solvents or a combination of the two.
>
> Depending on how liquid mixed wastes are classified under RCRA, they are reported either as liquids or as solids.

The 1992 amendment to RCRA, the Federal Facility Compliance Act, provided DOE with an exemption from enforcement under the land disposal restrictions storage prohibition; as long as DOE sites complied with the plans and schedules for mixed waste treatment, as identified in the Site Treatment Plan and the implementing Director's Findings and Orders issued by OEPA on October 4, 1995. The FEMP submitted the first Site Treatment Plan Annual Update to OEPA in December 1996. These updates are due by December 31 each calendar year. Since then, four additional annual updates have been submitted. The annual update describes the status of mixed waste treatment projects developed under the Site Treatment Plan. It also adds newly generated/newly identified mixed waste streams, and certifies that the FEMP met all regulatory milestone dates for the treatment of mixed wastes identified in the plan and in the implementing Director's Findings and Orders.

In 2000, 18,102 gallons (68,516 liters) of liquid mixed waste were bulked into batch 10 storage tanks, and 50 gallons (190 liters) of liquid mixed waste were bulked into batch 11 storage tanks. The following mixed wastes were shipped during 2000:

- 14,947 gallons (56,574 liters) of liquid mixed waste from batch 9 were shipped to the K-25 Toxic Substances Control Act Incinerator in Oak Ridge, Tennessee.
- 2,034 ft^3 (58 m^3) of below-treatment-standard mixed waste was shipped to Envirocare of Utah, Inc. for disposal.
- 2,636 ft^3 (75 m^3) of mixed waste soils from the fire training facility, which met the waste acceptance criteria, were disposed at the on-site disposal facility.
- 3,267 ft^3 (93 m^3; under specific Waste Generator Services treatment campaigns) of liquid aqueous low level radioactive and mixed wastes meeting National Pollutant Discharge Elimination System (NPDES) Permit requirements were treated at the advanced wastewater treatment facility.

The following hazardous/recyclable wastes were shipped to approved recycle centers and/or treatment facilities in 2000:

- 1,152 ft^3 (33 m^3) of lead acid batteries
- 237 ft^3 (7 m^3) of lab packs
- 788 ft^3 (22 m^3) of electrical waste (fluorescent light tubes)
- 21 ft^3 (less than 1 m^3) of photographic waste
- 247 ft^3 (7 m^3) of water treatment chemicals
- 1,134 ft^3 (32 m^3) of asbestos
- 3,750 ft^3 (106 m^3) of used rubber tires.

Clean Water Act

Under the Clean Water Act, as amended, the FEMP is governed by NPDES regulations that require the control of discharges of non-radiological pollutants to waters of the State of Ohio. The NPDES Permit, issued by the State of Ohio, specifies discharge and sample locations, sampling and reporting schedules, and discharge limitations. The FEMP submits monthly reports on NPDES activities to OEPA.

OEPA issued a new NPDES Permit, Permit No. 1IO00004*FD on January 28, 2000, which became effective on March 1, 2000. Therefore, NPDES reporting for 2000 reflects those requirements of the old NPDES Permit (1IO00004*ED) from January 1, 2000 through February 28, 2000, and the requirements under the new permit from March 1, 2000 through December 31, 2000. Chapter 4 discusses the surface water and treated effluent information in detail.

Clean Air Act

NESHAP Subpart H imposes a limit of 10 millirem (mrem) per year on the effective dose equivalent to the maximally exposed individual as a result of all air emissions (with the exception of radon) from the facility in a single year. For 2000 the FEMP was in compliance with the NESHAP dose limit, as determined by ambient air monitoring at the FEMP fenceline boundary.

EPA regulates the FEMP's radionuclide emission sources through the NESHAP; OEPA has authority to enforce the State of Ohio's air standards including particulate, chemical, and toxic emission sources. In 2000 the FEMP complied with all emissions standards, as discussed in Chapter 5. The NESHAP Annual Report for 2000 is included as Appendix D.

Several remediation activities, including the waste pits remediation, decontamination and dismantling, soil excavation, and on-site disposal facility construction and waste placement, may result in the generation of fugitive dust, which is also regulated by OEPA. Compliance is accomplished by implementing the Fugitive Dust Control Policy negotiated between DOE and OEPA in 1997. This policy is implemented in the Best Available Technology Determination for Remedial Construction Activities on the Fernald Environmental Management Project (DOE 1997b), the requirements of which are incorporated into each operable unit's remedial design and remedial action deliverables. The policy allows for visual observation of fugitive dust and implementation of dust control measures to determine compliance during remediation activities.

Superfund Amendments and Reauthorization Act of 1986

The Superfund Amendments and Reauthorization Act of 1986 (SARA) amended CERCLA and was enacted, in part, to clarify and expand CERCLA "Superfund" requirements. SARA Title III is also known as the Emergency Planning and Community Right-to-Know Act (EPCRA). SARA Title III, Section 312, Emergency and Hazardous Chemical Inventory Report (DOE 2000e) for 2000 was submitted to OEPA and other local emergency planning/response organizations in February 2001. The report lists the amount and location of hazardous chemicals/substances stored or used in amounts greater than the minimum reporting threshold at any time during the previous year.

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The SARA Title III, Section 313, Toxic Chemical Release Inventory Report will be submitted, as required, to OEPA and EPA before July 1, 2001. This report, called Form R, is required if the FEMP meets certain criteria and an applicable threshold for any SARA 313 chemical is reached.

The Toxic Chemical Release Inventory Report lists routine and accidental releases, as well as information about the activities, uses, and waste for each reported toxic chemical. For 2000 an evaluation is currently underway to determine if the FEMP has any chemicals that meet the SARA 313 manufactured, processed, or otherwise used reporting threshold requirements. The regulatory reporting threshold has changed for several chemicals; thus, a thorough review of chemicals at the FEMP will be conducted. The evaluation will be completed in June of 2001, and will be reported prior to the July 1, 2001 compliance date.

Any off-site release meeting or exceeding a reportable quantity as defined by SARA Title III, Section 304, requires immediate notifications to local emergency planning committees and the state emergency response commission. Depending on the respective requirements, notifications are made to the National Response Center and to the appropriate federal, state, and local regulatory entities. All releases occurring at the FEMP are evaluated and documented to ensure that proper notifications are made in accordance with SARA. In addition to SARA, releases are also evaluated for notification under CERCLA Section 103, RCRA, the Toxic Substances Control Act, the Clean Air Act, the Clean Water Act, and Ohio environmental laws and regulations. In 2000 no releases occurred at the FEMP that required reporting to regulatory or other agencies, under any of the above regulations. Table 2-3 summarizes the FEMP's compliance with SARA Title III (i.e., EPCRA) reporting requirements during 2000.

TABLE 2-3
SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT, TITLE III (EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT) COMPLIANCE REPORTING, 2000[a]

Sections of the Act	Yes	No	Not Required
302-303: Planning notification	X		
304: Extremely hazardous substances release notification			X
311-312: Material safety data sheet/chemical inventory	X		
313: Toxic chemical release inventory reporting (for calendar year 1999)	X		

[a]"Yes" indicates that notifications were provided and/or reports were issued under the applicable provisions. "No" indicates that notifications or reports should have been provided but were not. "Not required" indicates that no actions were required under the applicable provisions, either because triggering thresholds were not exceeded or no releases occurred.

Other Environmental Regulations

The FEMP is also required to comply with other environmental laws and regulations in addition to those described above. Table 2-4 summarizes compliance with each of these requirements for 2000.

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TABLE 2-4
COMPLIANCE WITH OTHER ENVIRONMENTAL REGULATIONS

Regulation and Purpose	Background Compliance Issues	2000 Compliance Activities
Toxic Substances Control Act (TSCA)		
Regulates the manufacturing, use, storage, and disposal of toxic materials, including polychlorinated biphenyl (PCBs) and PCB items	The last routine TSCA inspection of the FEMP's program was conducted by EPA Region V on September 21, 1994. No violations of PCB regulations were identified during the inspection.	Non-radiologically contaminated PCBs and PCB items were shipped to TSCA-approved commercial disposal facilities for incineration on an "as-needed basis". Radiologically contaminated PCB liquids were bulked for later shipment to the TSCA permitted DOE incinerator in Oak Ridge, TN. Most radiologically contaminated PCB solids currently had no treatment or disposal options and remain in storage on site.
Ohio Solid Waste Act		
Regulates infectious waste	The FEMP was registered with OEPA as a generator of infectious waste (generating more than 50 pounds [23 kg] per month) until December 6, 1999, when OEPA concurred with the FEMP's qualification as a small quantity generator.	All infectious wastes generated in the medical department were transported to a licensed treatment facility for incineration.
Federal Insecticide, Fungicide, and Rodenticide Act		
Regulate the registration, storage, labeling, and use of pesticides (such as insecticides, herbicides, and rodenticides)	The last inspection of the Federal Insecticide, Fungicide, and Rodenticide Act program conducted by EPA Region V on September 21, 1994, found the FEMP to be in full compliance with the requirements mandated by Federal Insecticide, Fungicide, and Rodenticide Act.	An inappropriate application of the pesticide diazinon took place in June of 2000 within the Area 1, Phase I wetland. This was reported to the EPA and OEPA, and measures have been taken to prevent a reoccurrence. All other pesticide applications at the FEMP were conducted according to Federal and State regulatory requirements.
National Environmental Policy Act (NEPA)		
Requires the evaluation of environmental, socio-economic, and cultural impacts before any action, such as a construction or cleanup project, is initiated by a federal agency	An environmental assessment for proposed final land use was issued for public review in 1998. It was prepared under DOE's guidelines for implementation of NEPA, 10 Code of Federal Regulations 1021. It also addresses previous DOE commitments to consult with the public prior to any decisions on land use.	No NEPA activities were conducted in 2000.
Endangered Species Act		
Requires the protection of any threatened or endangered species found at the site as well as any critical habitat that is essential for the species' existence	Ecological surveys conducted by Miami University and DOE, in consultation with the Ohio Department of Natural Resources and U.S. Fish and Wildlife Service, have established the following list of threatened and endangered species and their habitats existing on site: Cave salamander, state-listed endangered -- marginal habitat, none found; Sloan's crayfish, state-listed threatened – found on northern sections of Paddys Run; Indiana brown bat, federally listed endangered – species found in riparian areas along Paddys Run.	No surveys were conducted in 2000.

TABLE 2-4
(Continued)

Regulation and Purpose	Background Compliance Issues	2000 Compliance Activities
Floodplains/ Wetlands Review Requirements		
DOE regulations require a floodplain/wetland assessment for DOE construction and improvement projects.	A wetlands delineation of the FEMP, completed in 1992 and approved by the U.S. Army Corps of Engineers in August 1993, identified 36 acres (15 hectares) of freshwater wetland on the FEMP property. Updated delineations are conducted approximately every five years.	No assessments were performed in 2000.
National Historic Preservation Act		
Mandates protection of historic and prehistoric cultural resources	The FEMP is within an area rich in historic and prehistoric cultural resources. These cultural resources include 148 prehistoric sites within 1.24 miles (2 km) of the FEMP and 40 historic sites.	Activities were conducted to avoid and address impacts to cultural resources (refer to Chapter 7).
Native American Graves Protection and Repatriation Act		
Requires the identification and preservation of cultural resources on federal lands, and consultation with Native American Tribes on removal and management of inadvertently discovered Native American cultural items	Historical remains and artifacts were discovered during a 1994 construction project. The Native American remains which included an adolescent boy and his dog were discovered during installation of pipelines for the Public Water Supply project. Partial remains of approximately 20 more people and numerous artifacts were also found.	No Native American remains were discovered or interred in 2000. Cultural resources were identified as a result of surveys performed (refer to Chapter 7).
Natural Resource Requirements Under CERCLA and Executive Order 12580		
Requires DOE to act as a Trustee (i.e., guardian) for natural resources at its federal facilities.	DOE and the other Trustees, which include U.S. Department of the Interior, U.S. Fish and Wildlife Service, OEPA, Ohio Attorney General's Office, and EPA, meet regularly to discuss potential impact to natural resources and to coordinate Trustee activities. The Trustees also interact with the Fernald Citizens Advisory Board and Community Reuse Organization.	The Trustees and stakeholders continued to discuss the scope of Natural Resource Restoration activities at the FEMP, and the integration of public use and long-term stewardship at the FEMP.

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Other Permits

Permits are the means by which some environmental laws are implemented. The FEMP has permits for controlled releases to surface water and air. The FEMP's permit for discharging water under the NPDES regulations is discussed in the Clean Water Act section of this chapter. The active Permits to Install remaining for the FEMP wastewater treatment system include those for the Storm Water Retention Basin and Bio-Surge Lagoon. Permits to Install govern the installation (and to a lesser degree, the operation) of specific wastewater treatment and control devices.

The FEMP has 10 current air Permits to Operate and five associated Permits to Install. These permits cover boilers, diesel storage tanks, clothes dryers, the respirator washing facility, maintenance shop facilities, a laboratory hood system, and a gasoline dispensing facility. EPA and OEPA approve other air emission sources and wastewater systems related to remedial activities through the review and approval of CERCLA remedial design packages or CERCLA-allowed permit information summaries.

Site-Specific Regulatory Agreements

Federal Facility Compliance Agreement

In July 1986 DOE entered into a Federal Facility Compliance Agreement (FFCA) with the EPA, which requires the FEMP to:

- Maintain a continuous sample collection program for radiological constituents at the FEMP's treated effluent discharge points and report the results quarterly to EPA, OEPA, and the Ohio Department of Health. The sampling program to address this requirement has been modified over the years and is currently governed by an agreement reached with EPA and OEPA that became effective May 1, 1996. This agreement requires sampling at the Parshall Flume (PF 4001) and the Storm Water Retention Basin spillway for radiological constituents. These data are reported through quarterly and annual reports (refer to Appendix B of this report) under the IEMP.

- Maintain a sampling program for daily flow and total uranium at the South Plume extraction wells and report the results quarterly to EPA, OEPA, and Ohio Department of Health. The sampling program conducted to address this requirement has also been modified over the years and is currently governed by the agreement reached with EPA and OEPA on May 1, 1996.

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Federal Facility Agreement, Control and Abatement of Radon-222 Emissions

The Federal Facility Agreement (FFA) between DOE and EPA, signed on November 19, 1991, ensures that DOE takes all necessary actions to control and abate radon-222 emissions at the FEMP, under the authority of 40 Code of Federal Regulations 61, Subpart Q. This agreement acknowledges that Silos 1 and 2 exceed the radon flux rate of 20 picoCuries per square meter per second (pCi/m^2/sec), but allowed the FEMP to address this exceedance by implementing a removal action (installation of a bentonite cap in 1991) to bring radon emissions from the silos to a level as low as reasonably achievable (ALARA), and to attain the NESHAP Subpart Q standard upon completion of final remediation. The FFA also requires demonstration of compliance with the Subpart Q standard (upon completion of remedial actions) for the waste pits, clearwell, and any other sources found to emit radon in excess of 20 pCi/m^2/sec. Chapter 5 further discusses the results of the FEMP Radon Monitoring Program for 2000.

As Low As Reasonably Achievable

The ALARA process ensures the selection of the optimum physical design features and administrative controls, which will eliminate, control, or mitigate radiological exposure of general employees, the public, and the environment with respect to what is reasonably achievable.

Split/Co-Located Sampling Program

In 2000 DOE and OEPA cooperated in a program in which samples of groundwater, surface water, and sediment, were "split" and sent to different analytical laboratories, or "co-located," meaning samples were collected from the same location but at different times. Split samples are obtained when technicians alternately add portions of a sample to two individual sample containers. This collection method helps ensure that both samples are as identical as possible. Split samples are then submitted to two independent laboratories for analysis. The FEMP has participated in this program with the state since 1987.

This program allows for an independent comparison of data to ascertain laboratory analysis and field quality assurance. The data from the split/co-located sampling program show reasonable agreement between DOE and OEPA results for groundwater, surface water, and sediment samples. The slight differences in DOE and OEPA sample results presented for 2000 do not impact the FEMP's compliance with federal or state regulations. The detailed results for the 2000 split/co-located samples are presented in Appendix E of this report.

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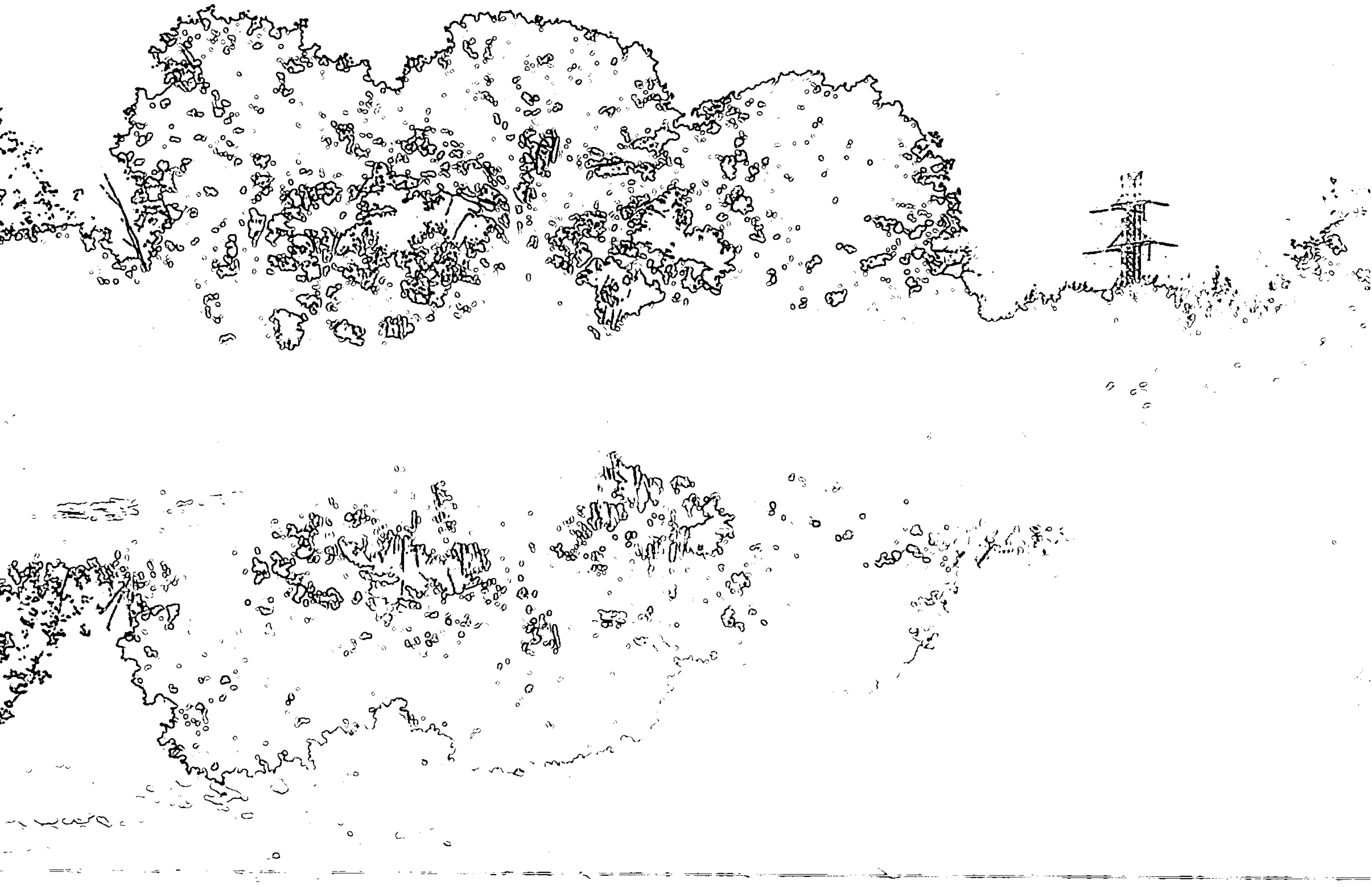
Chapter 3
Groundwater Pathway



Groundwater Pathway

Results in Brief: 2000 Groundwater Pathway

Enhanced Groundwater Remedy - During 2000 active restoration of the Great Miami Aquifer continued at the following four groundwater restoration modules:

- South Plume Module, which became operational on August 27, 1993
- South Field (Phase I) Extraction Module, which became operational on July 13, 1998
- South Plume Optimization Module, which became operational on August 9, 1998
- Re-Injection Module, which became operational on September 2, 1998.

Since 1993

- 7,516 million gallons (28,448 million liters) of water have been pumped from the Great Miami Aquifer.
- 859 million gallons (3,251 million liters) of water have been re-injected into the Great Miami Aquifer.
- 2,356 pounds (1,070 kg) of total uranium have been removed from the Great Miami Aquifer.

During 2000

- 1,879 million gallons (7,112 million liters) of water were pumped from the Great Miami Aquifer.
- 299 million gallons (1,132 million liters) of water were re-injected into the Great Miami Aquifer.
- 845 pounds (384 kg) of total uranium were removed from the Great Miami Aquifer.

Pumping of two new South Field extraction wells (32446 and 32447) began in February 2000. The wells were installed in response to a newly defined area of uranium contamination.

Director's Findings and Orders were issued by OEPA on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process, without issuance of a new order.

Groundwater re-injection was adopted as part of the groundwater remedy at the FEMP.

The designs for aquifer restoration modules in the waste storage and Plant 6 areas were revised significantly based on groundwater characterization efforts completed in 1999 and 2000.

Groundwater Monitoring Results - Geoprobe® sampling data, along with routine IEMP monitoring well data in the South Field area continue to indicate that surface source removal, flushing of the contaminants toward the extraction wells by infiltrating surface water, and pumping the extraction wells are all contributing to reducing the total uranium concentration in the western portion of this plume, particularly beneath the former Inactive Flyash Pile. However, some monitoring wells in the eastern portion of the South Field Module area have steady or increasing total uranium concentrations. Options for increasing the flushing of the aquifer in the eastern portion of the South Field area are scheduled to be evaluated in 2001.

On-Site Disposal Facility Monitoring - Leak detection monitoring during 2000 indicated that the liner systems for Cells 1, 2, and 3 are performing within the specifications outlined in the approved on-site disposal facility design documents.

This chapter provides background information on the nature and extent of groundwater contamination in the Great Miami Aquifer due to past operations at the FEMP and summarizes:

- Significant achievements realized by the Operable Unit 5 Aquifer Restoration and Wastewater Project in 2000
- Groundwater monitoring activities and results for 2000.

Restoration of the affected portions of the Great Miami Aquifer and continued protection of the groundwater pathway are primary considerations in the accelerated remediation strategy for the FEMP. The FEMP will continue to monitor the groundwater pathway throughout remediation to ensure the protection of this primary exposure pathway.

Groundwater Modeling at the FEMP

The FEMP uses computer models to make predictions about how the contaminants in the aquifer will look in the future. Because the model contains simplifying assumptions about the aquifer and the contaminants, the predictions about future behavior must be verified with field measurements obtained from groundwater monitoring activities.

If groundwater monitoring data indicate the need for operational changes to the groundwater remedy, then the groundwater model is run to predict the effect those changes might have on the aquifer and the contaminants. If the predictions indicate the proposed changes would increase clean-up efficiency and reduce the clean-up time and cost, then the operational changes are made and monitoring data are collected after the changes to verify whether model predictions were correct. If model predictions prove to be incorrect, then modifications are made to the model to improve its predictive capabilities.

Summary of the Nature and Extent of Groundwater Contamination

The nature and extent of groundwater contamination from operations at the FEMP has been investigated, and the risk to human health and the environment from those contaminants has been evaluated in the Operable Unit 5 Remedial Investigation Report (DOE 1995d). As documented in that report, the primary groundwater contaminant at the FEMP is uranium. Approximately 230 acres (93 hectares) of the Great Miami Aquifer are contaminated above the 20 μg/L groundwater FRL for total uranium.

Contamination of the groundwater resulted from infiltration through the bed of Paddys Run, the Storm Sewer Outfall Ditch, and the Pilot Plant Drainage Ditch. In these areas, the glacial overburden is eroded, and the sand and gravel of the aquifer are in direct contact with uranium-contaminated surface water from the FEMP. To a lesser degree, groundwater contamination also resulted where past excavations, such as the waste pits, removed some of the protective clay contained in the glacial overburden and exposed the aquifer to contamination.

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Selection and Design of the Groundwater Remedy

After the nature and extent of groundwater contamination was defined, various remediation technologies were evaluated in the Feasibility Study Report for Operable Unit 5 (DOE 1995). Remediation cost, efficiency, and various land-use scenarios were considered during the development of the preferred remedy for restoring the quality of the groundwater in the aquifer.

The Operable Unit 5 Feasibility Study Report recommended a pump-and-treat remedy for the groundwater contaminated with uranium. The remedy consisted of 28 groundwater extraction wells located on and off property. Computer modeling suggested that the 28 extraction wells pumping at a combined rate of 4,000 gpm (15,000 L/min) would remediate the aquifer within 27 years. The recommended groundwater remedy was presented to EPA, OEPA, and FEMP stakeholders in the Proposed Plan for Operable Unit 5 (DOE 1995c).

Once the preferred groundwater remedy was identified and approved in the Operable Unit 5 Proposed Plan, the Operable Unit 5 Record of Decision was presented to FEMP stakeholders and subsequently approved by EPA and OEPA in January 1996. The Operable Unit 5 Record of Decision formally defined the selected groundwater remedy and established FRLs for all constituents of concern. The Operable Unit 5 Record of Decision committed to ongoing evaluation of innovative remediation technologies so that remedy performance could be improved as such technologies become available. As a result of this commitment, an enhanced groundwater remedy was presented in the Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1) (DOE 1997a).

The enhanced groundwater remediation strategy, which relies on pump-and-treat and re-injection technology is being used to conduct a concentration-based clean up of the Great Miami Aquifer. The restoration strategy focuses primarily on the removal of uranium, but also has been designed to limit the further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impacts beyond the FEMP property.

Re-Injection at the FEMP

Re-injection is an enhancement to the groundwater remedy. Groundwater pumped from the aquifer is treated to remove contaminants and then re-injected back into the aquifer at strategic locations. The re-injected groundwater increases the speed at which contaminants move through the aquifer and are pulled by extraction wells, thereby decreasing the overall remediation time.

A groundwater re-injection demonstration was conducted at the FEMP from September 2, 1998, to September 2, 1999. Following completion of the re-injection demonstration in September of 1999, the Re-Injection Demonstration Test Report (DOE 2000c) was issued to EPA and OEPA in May 2000. This report details the demonstration and recommends its incorporation into the FEMP's aquifer restoration strategy. Based on the results of the demonstration, re-injection will continue at the FEMP. Accordingly, the Re-Injection Demonstration Module has been renamed the Re-Injection Module to reflect completion of the demonstration. The Re-Injection Module Operational Summary section within this chapter provides more discussion of this topic.

The enhanced groundwater remedy also included additional extraction wells in on-site areas of aquifer contamination. Groundwater modeling studies conducted in support of the enhanced groundwater remedy suggest that, with the early installation of additional extraction wells and re-injection technology, the remedy could potentially be reduced to 10 years. EPA and OEPA approved the enhanced groundwater remedy.

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While the remedial investigation and feasibility study process was in progress and a groundwater remedy was being selected, off-property contaminated groundwater was being pumped from the South Plume area by the South Plume Removal Action System (referred to as the South Plume Module). In 1993 this system was installed south of Willey Road and east of Paddys Run Road to stop the total uranium plume in this area from migrating any further to the south. Figure 3-1 shows the South Plume Module Extraction Wells 3924, 3925, 3926, and 3927. These extraction wells have successfully stopped further southern migration of the total uranium plume beyond the wells and have contributed to significantly reducing total uranium concentrations in the off-property portion of the plume.

During 1998 significant portions of the enhanced groundwater remedy infrastructure were completed. By the end of June 1998, construction was complete on the pipeline distribution network and associated electronic controls for three groundwater restoration modules: South Plume Optimization Module, South Field (Phase I) Extraction Module, and Re-Injection Demonstration Module. By September 1998, all three modules were on line and, in combination with the South Plume Module, were pumping 3,500 gpm (13,000 L/min) from the aquifer and re-injecting 1,000 gpm (3,800 L/min).

During 2000 active remediation of the Great Miami Aquifer continued at the following groundwater restoration modules: South Plume/South Plume Optimization Module, South Field (Phase I) Extraction Module, and Re-injection Module. As identified in the 1999 Integrated Site Environmental Report (DOE 2000b), Extraction Wells 32446 and 32447 were installed during the fourth quarter of 1999 to supplement the South Field (Phase I) Extraction Module. The location of these wells was based on refined total uranium plume interpretations and groundwater modeling. These two wells began pumping in February 2000. Figure 3-1 depicts the current extraction and re-injection well locations. The operational information associated with these modules is presented in subsequent subsections.

As a result of a conceptual design groundwater characterization program conducted in the waste storage and Plant 6 areas in late 1999 and early 2000, a total uranium plume in the Plant 6 area exceeding 20 μg/L was not detected. It is believed that the plume has dissipated to concentrations that are below 20 μg/L as a result of the shutdown of plant operations in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action in the early 1990s. Because a total uranium plume with concentrations above 20 μg/L is no longer present in the Plant 6 area, a restoration module for this area is no longer planned. However, groundwater monitoring will continue in the Plant 6 area until the groundwater in this area is certified as clean. The conceptual design groundwater characterization also indicated the total uranium plume in the waste storage area is smaller than what was estimated during the remedial investigation/feasibility study (approximately 55 acres [22 hectares] versus 70 acres [28 hectares]). However, a portion of the waste storage area total uranium plume in the vicinity of the confluence of Paddys Run and the Pilot Plant Drainage Ditch has been re-defined as extending farther to the east than previously estimated. In addition, total uranium concentrations up to 566 μg/L have been found in this area.

Figure 3-2 identifies current and future extraction and re-injection well locations based on the 1997 Baseline Remedial Strategy Report. The actual location of future extraction wells will be based on the most up-to-date characterization and modeling efforts. The actual locations of the initial wells in the waste storage area will be defined as part of the detailed design of the Waste Storage Area Module to be completed in 2001.

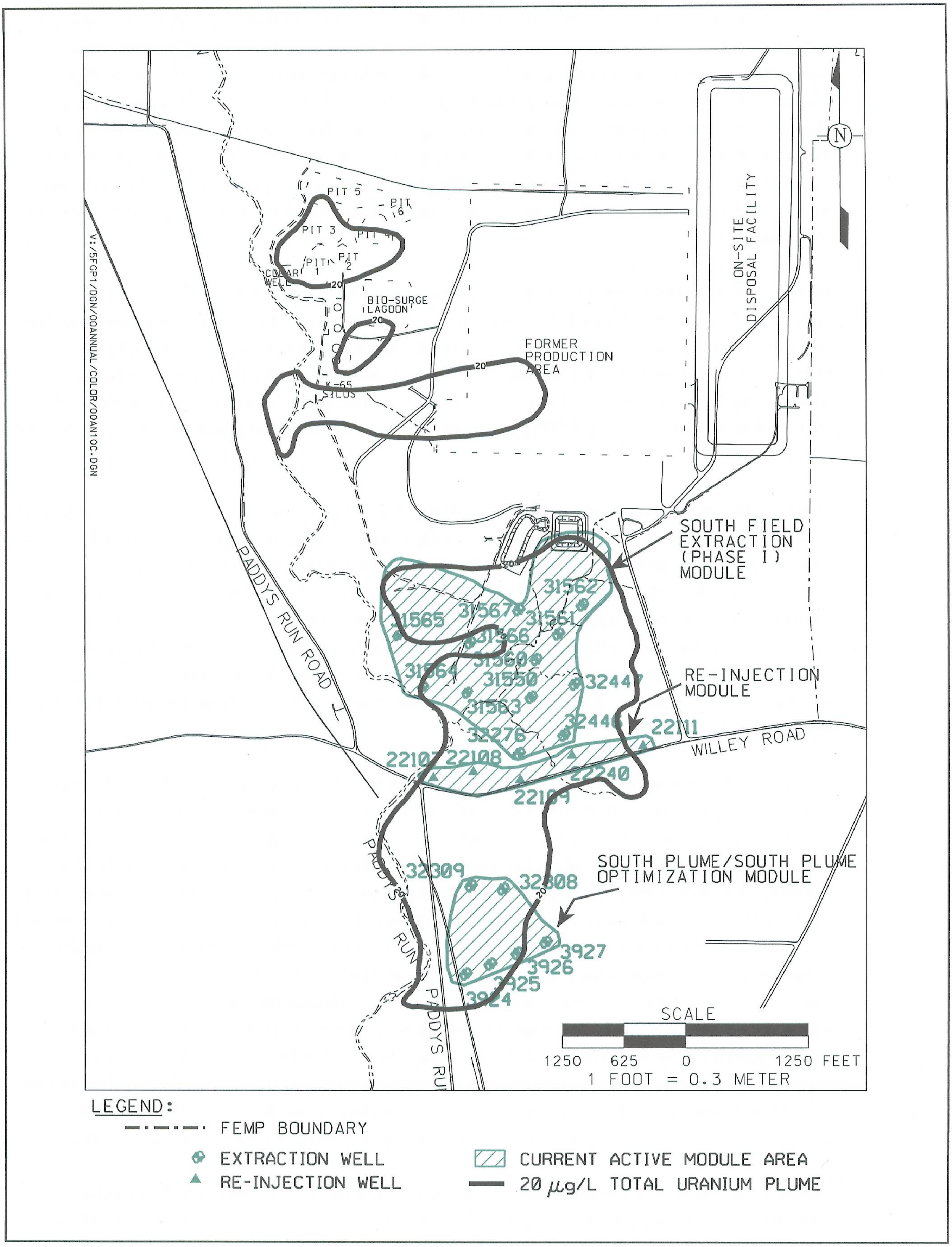

Figure 3-1. Current Extraction and Re-Injection Wells

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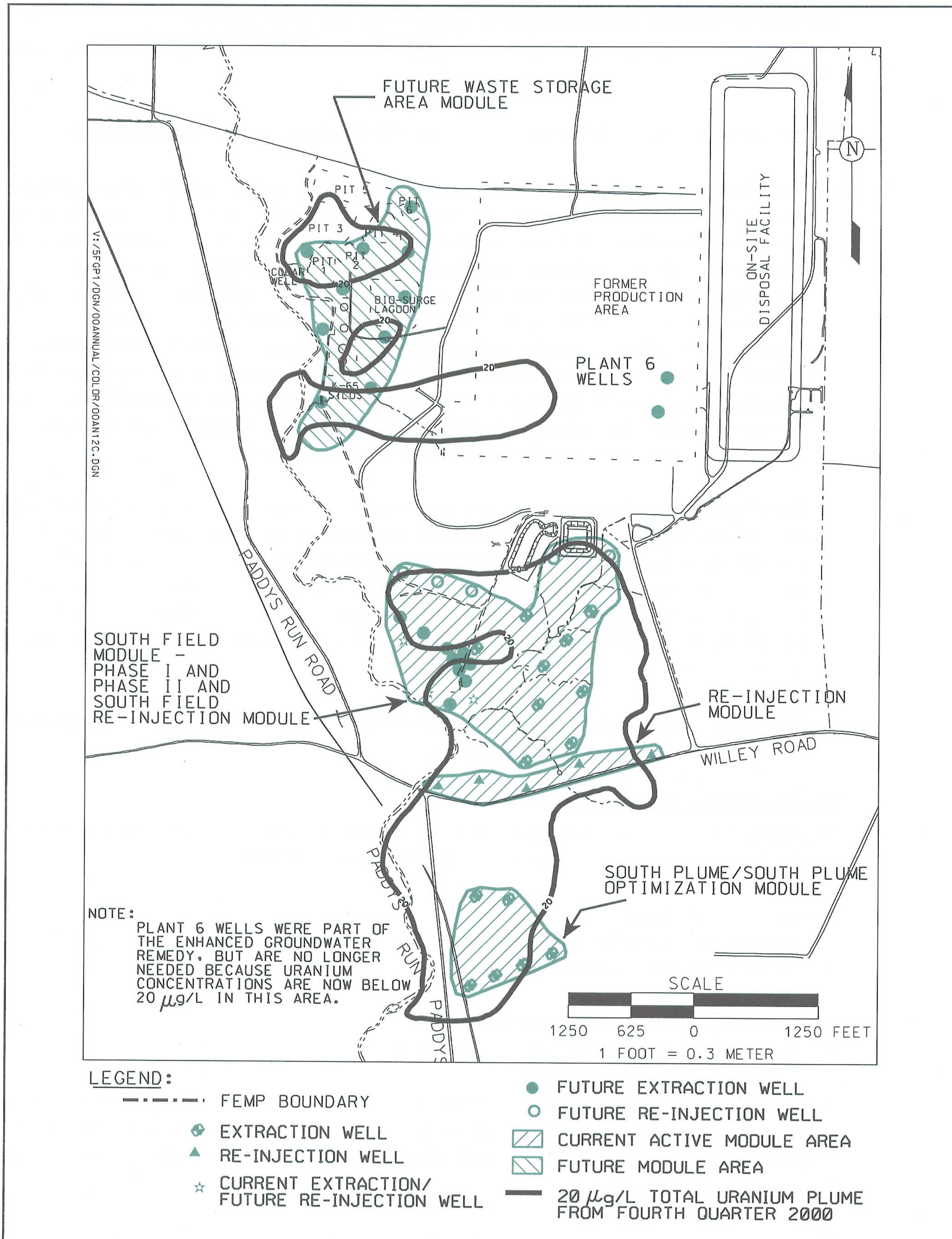

Figure 3-2. Current and Future Extraction and Re-Injection Wells for the Enhanced Groundwater Remedy

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Groundwater Monitoring Highlights for 2000

For this report, groundwater monitoring results are discussed in terms of restoration and compliance monitoring.

The key elements of the FEMP groundwater monitoring program design are described below:

- **Sampling** - Sample locations, frequency, and the constituents were selected to address operational assessment, restoration assessment, and compliance requirements. Selected wells are monitored for up to 50 groundwater FRL constituents as identified in Table 2-2. Monitoring is conducted to ascertain groundwater quality and groundwater flow direction. Figure 3-3 shows a typical groundwater monitoring well at the FEMP and Figure 3-4 identifies the relative placement depths of groundwater monitoring wells at the FEMP. As part of the comprehensive IEMP groundwater-monitoring program, approximately 140 wells were monitored for water quality in 2000. Figure 3-5 identifies the location of the current IEMP water quality monitoring wells, including extraction wells. In addition to water quality monitoring, approximately 184 wells were monitored quarterly for groundwater elevations. Figure 3-6 depicts the IEMP routine water-level (groundwater elevation) monitoring wells, including extraction wells.

- **Data Evaluation** - The integrated data evaluation process looks at the data collected from wells to determine: capture and restoration of the total uranium plume, capture and restoration of non-uranium FRL constituents, water quality conditions in the aquifer that indicate a need to modify the design and installation of restoration modules, and the impact of on-going groundwater restoration on the Paddys Run Road Site plume (a separate contaminant plume south of the FEMP property along Paddys Run Road resulting from independent industrial activities in the area).

- **Reporting** - Groundwater reporting requirements are combined into IEMP quarterly reports and annual integrated site environmental reports.

Restoration Monitoring

In general, restoration monitoring tracks the progress of the groundwater remedy and water quality conditions. Restoration monitoring is discussed in the following subsections:

- Operational Summary
  - South Plume/South Plume Optimization Module
  - South Field (Phase I) Extraction Module
  - Re-Injection Module
- Monitoring Results for Total Uranium
- Monitoring Results for Non-Uranium Constituents.

All operational modules are evaluated quarterly. The evaluation is done by collecting and mapping groundwater quality and groundwater elevation data and then analyzing the results. Concentration maps are developed from analytical data and compared with groundwater elevation maps depicting the location of the capture zone.

More detailed information on the above can be found in Appendix A of this report. Each subsection below identifies the specific Attachment of Appendix A where the detailed information can be found.

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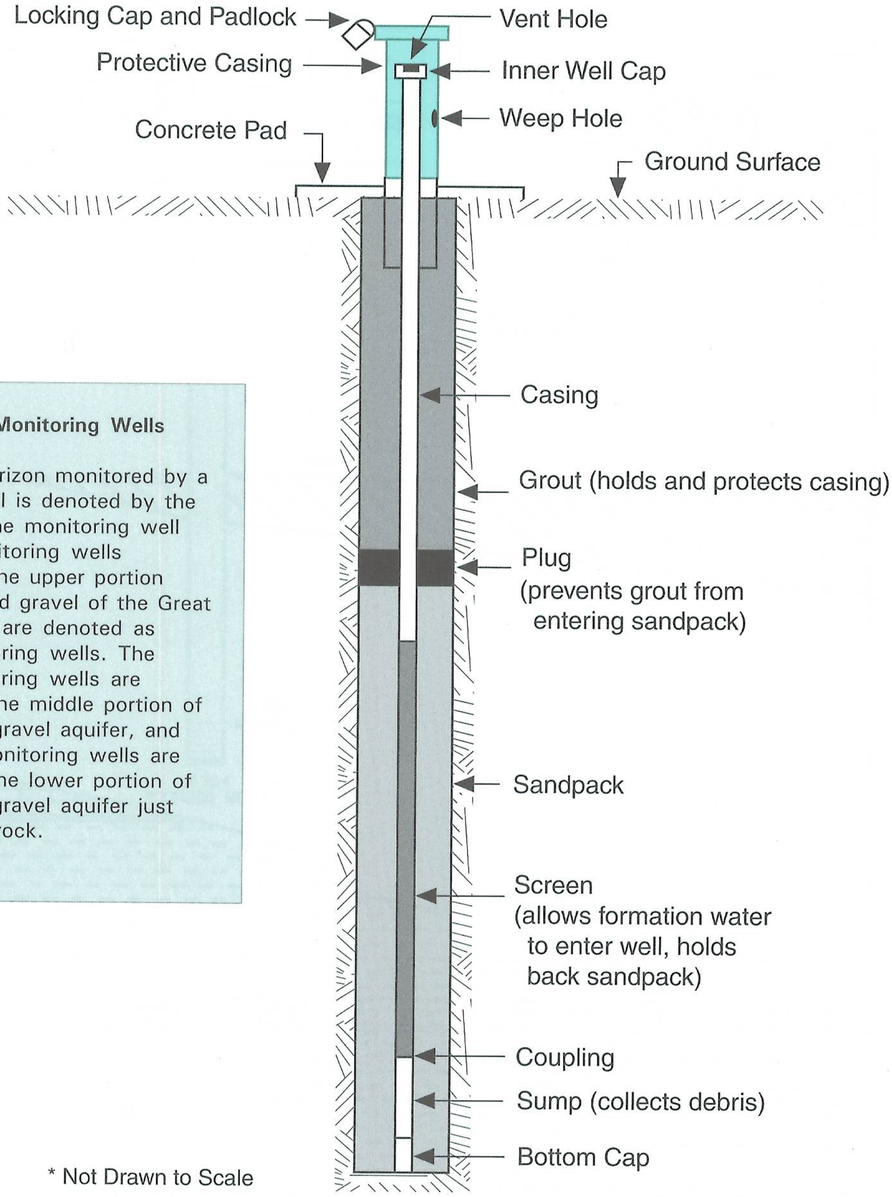

Groundwater Monitoring Wells

The aquifer horizon monitored by a monitoring well is denoted by the first digit of the monitoring well number. Monitoring wells completed in the upper portion of the sand and gravel of the Great Miami Aquifer are denoted as Type 2 monitoring wells. The Type 3 monitoring wells are completed in the middle portion of the sand and gravel aquifer, and the Type 4 monitoring wells are completed in the lower portion of the sand and gravel aquifer just above the bedrock.

* Not Drawn to Scale

Figure 3-3. Monitoring Well Diagram

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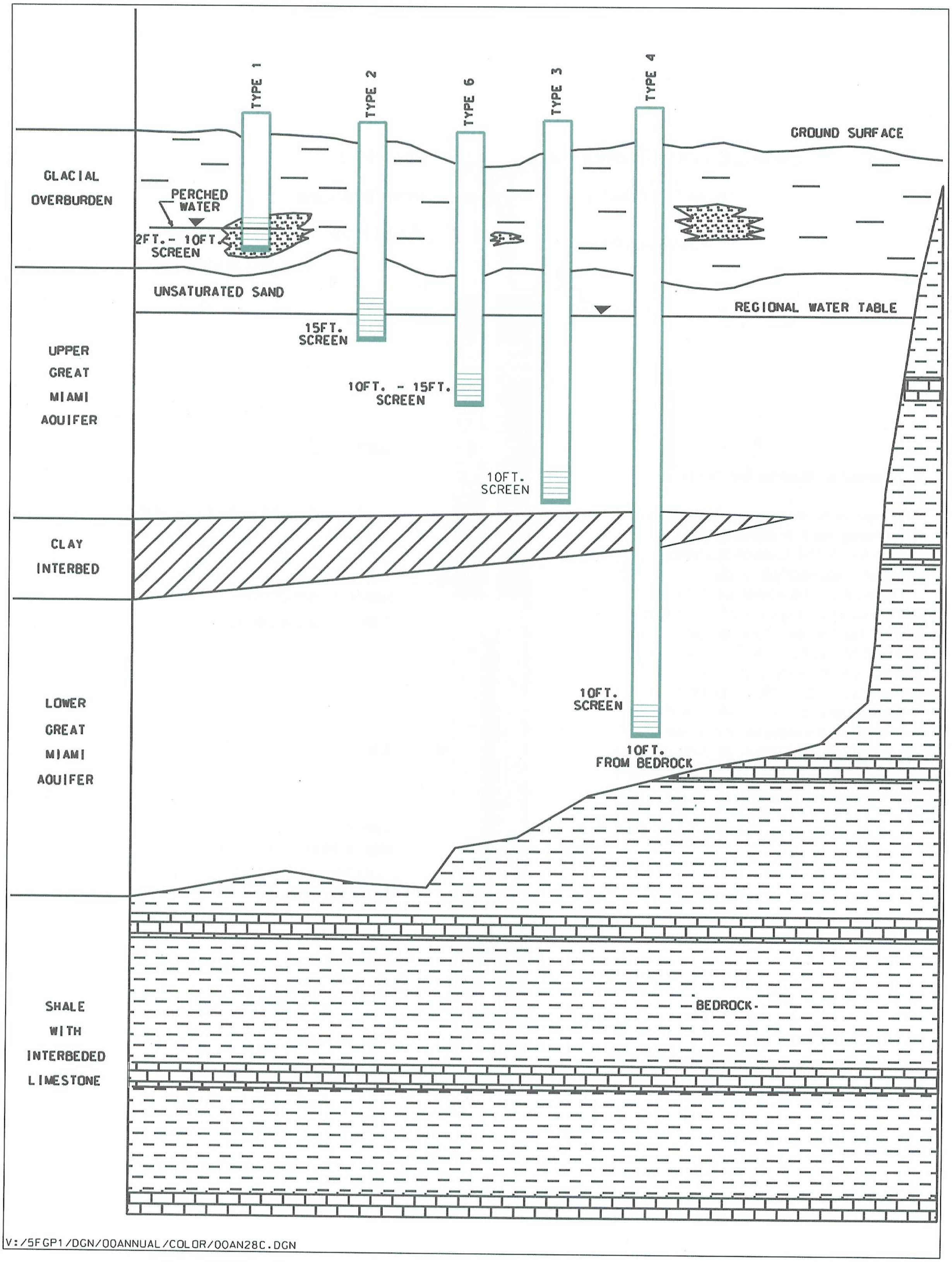

Figure 3-4. Monitoring Well Relative Depths and Screen Locations

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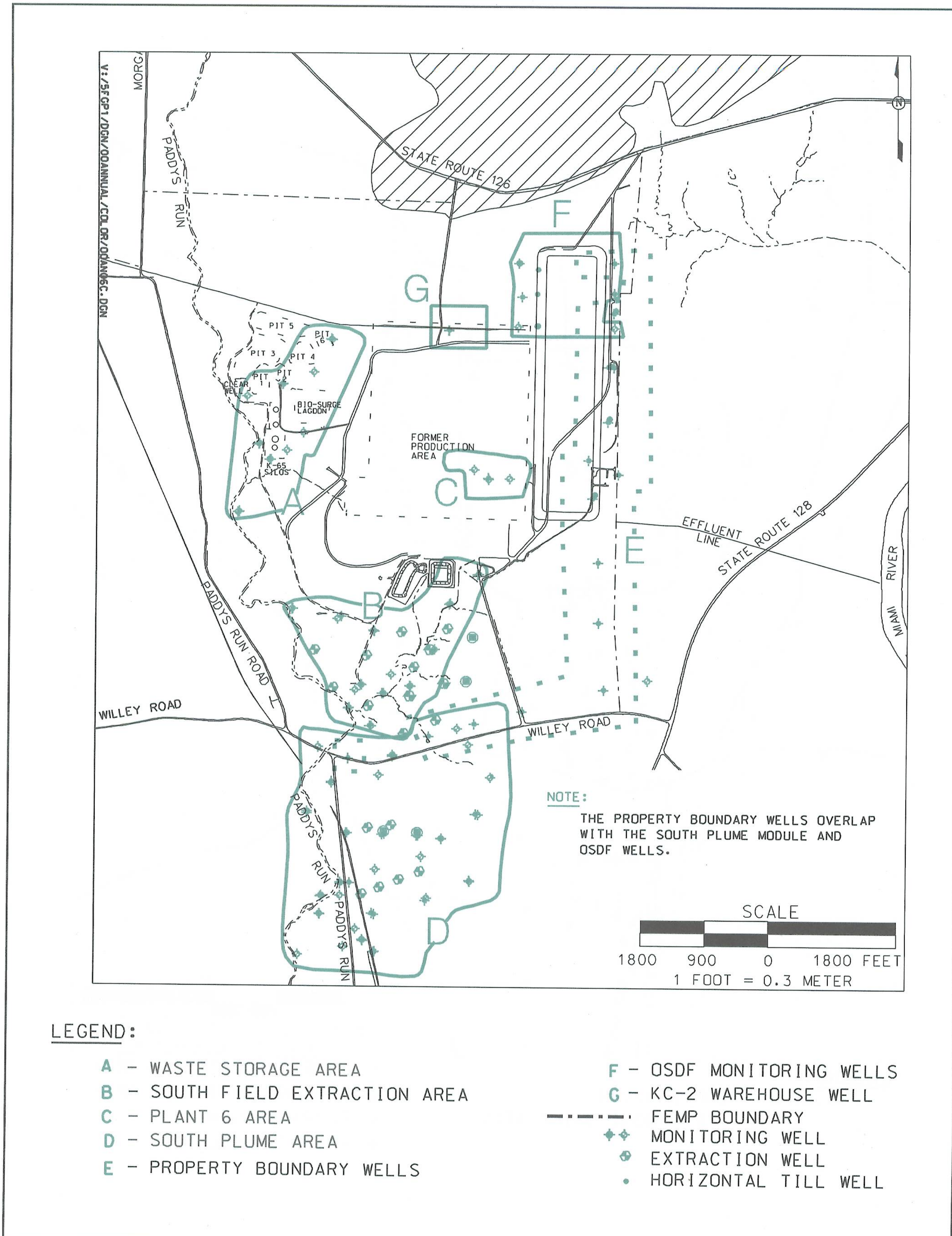

Figure 3-5. IEMP Water Quality Monitoring Wells

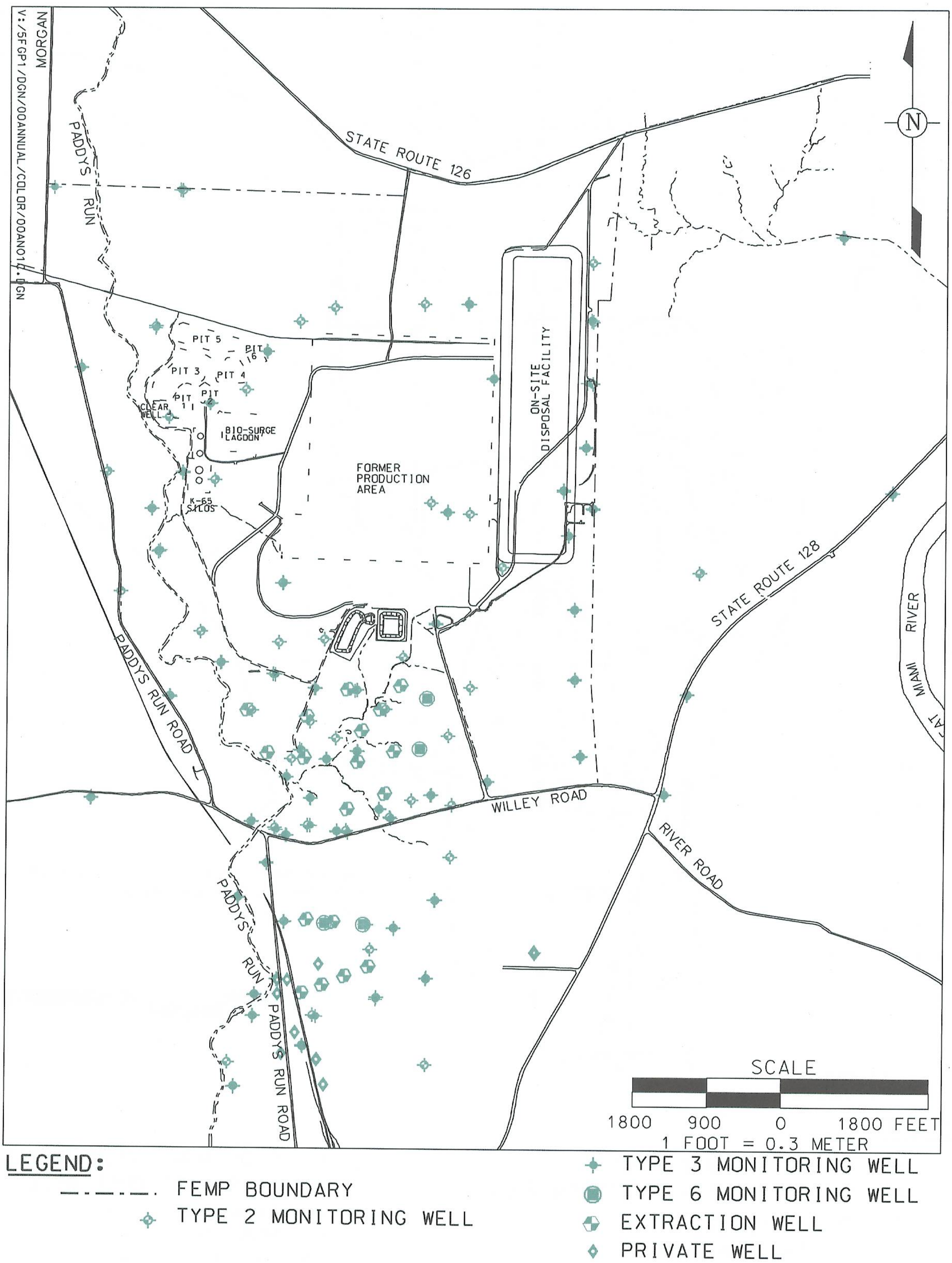

Figure 3-6. IEMP Groundwater Elevation Monitoring Wells

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Operational Summary

Figure 3-2 shows the extraction and re-injection well locations associated with the current restoration modules. Table 3-1 summarizes the pounds of uranium removed and the amount of groundwater pumped by the three restoration modules active during 2000. Figure 3-7 identifies the yearly and cumulative pounds of uranium removed from the Great Miami Aquifer from 1993 through 2000. Since 1993:

- 7,516 million gallons (28,448 million liters) of water have been pumped from the Great Miami Aquifer.
- 859 million gallons (3,251 million liters) of treated water have been re-injected into the Great Miami Aquifer.
- 2,356 net pounds (1,070 kg) of uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment 1, of this report provides detailed operational information on each extraction and re-injection well, such as pumping and re-injection rates, uranium removal indices, and total uranium concentration graphs. The following subsections provide information on the individual modules.

TABLE 3-1
2000 GROUNDWATER RESTORATION MODULE STATUS

			Target Pumping Rate		Gallons Pumped/ Re-Injected		Uranium Removed/ Re-Injected	
Module	Restoration Wells	Operational Status	Gpm	Lpm	M gal.	M Liters	lbs	kg
South Plume/ South Plume Optimization Module	3924 3925 3926 3927	Operating since August 1993	1,500	5,700	921	3,486	226	103
	32308 32309	Operating since August 1998	500	1,900				
South Field (Phase I) Extraction Module	31550 31560 31561 31562 31563 31564 31565 31566 31567 32276 32446 32447	Operating since July 1998	1,900	7,200	958	3,626	628	285
Re-Injection Module	22107 22108 22109 22111 22240	Operating since September 1998	1,000	3,800	299	1,132	9.58	4.35
Aquifer Restoration System Totals								
(pumped)			3,900	14,762	1,879	7,112	854	388
(re-injected)			1,000	3,785	299	1,132	10	4
(net)			2,900	10,977	1,580	5,980	845	384

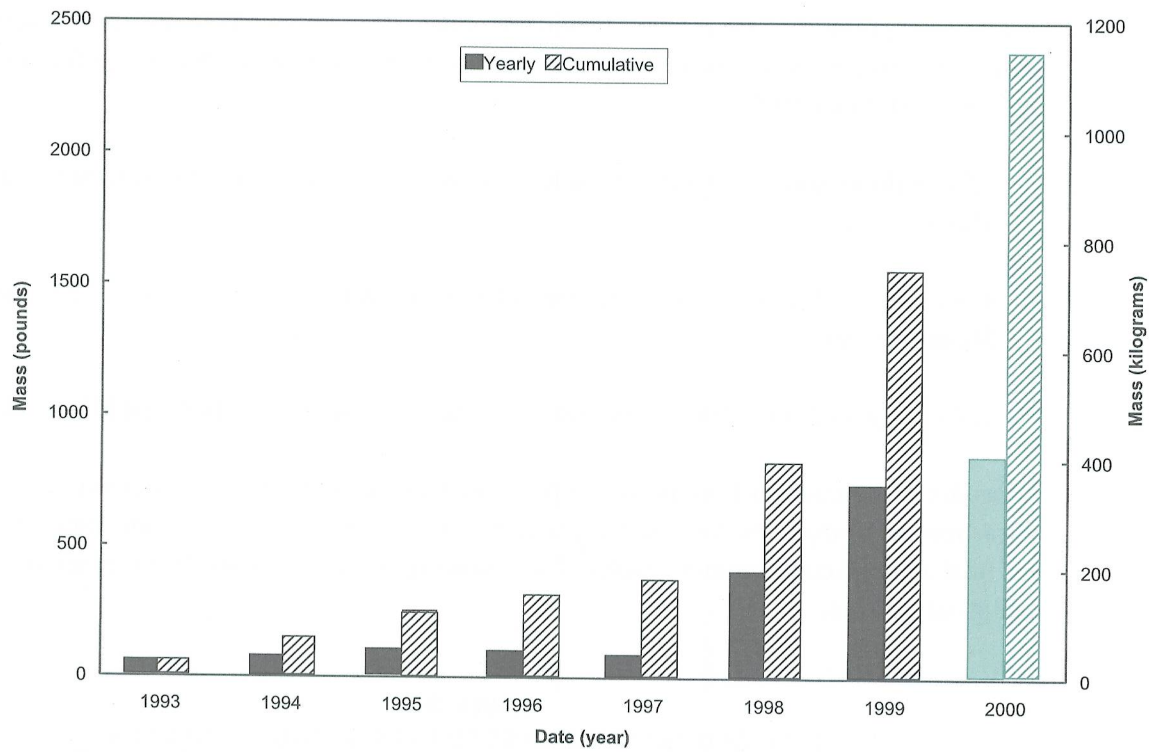

Figure 3-7. Net Pounds of Uranium Removed from the Great Miami Aquifer 1993 - 2000

South Plume/South Plume Optimization Module Operational Summary

Figure 3-8 illustrates capture zones associated with the South Plume/South Plume Optimization Module. Based on analysis of the data in 2000, the module continues to meet its primary objectives in that:

- Southward movement of the total uranium plume beyond the extraction wells has not occurred.
- Active remediation of the central portion of the off-property total uranium plume continues
- The Paddys Run Road Site plume, located south of the extraction wells, is not being adversely affected by the pumping.

The Paddys Run Road Site plume is a result of separate industrial activities along Paddys Run Road that are not associated with the FEMP.

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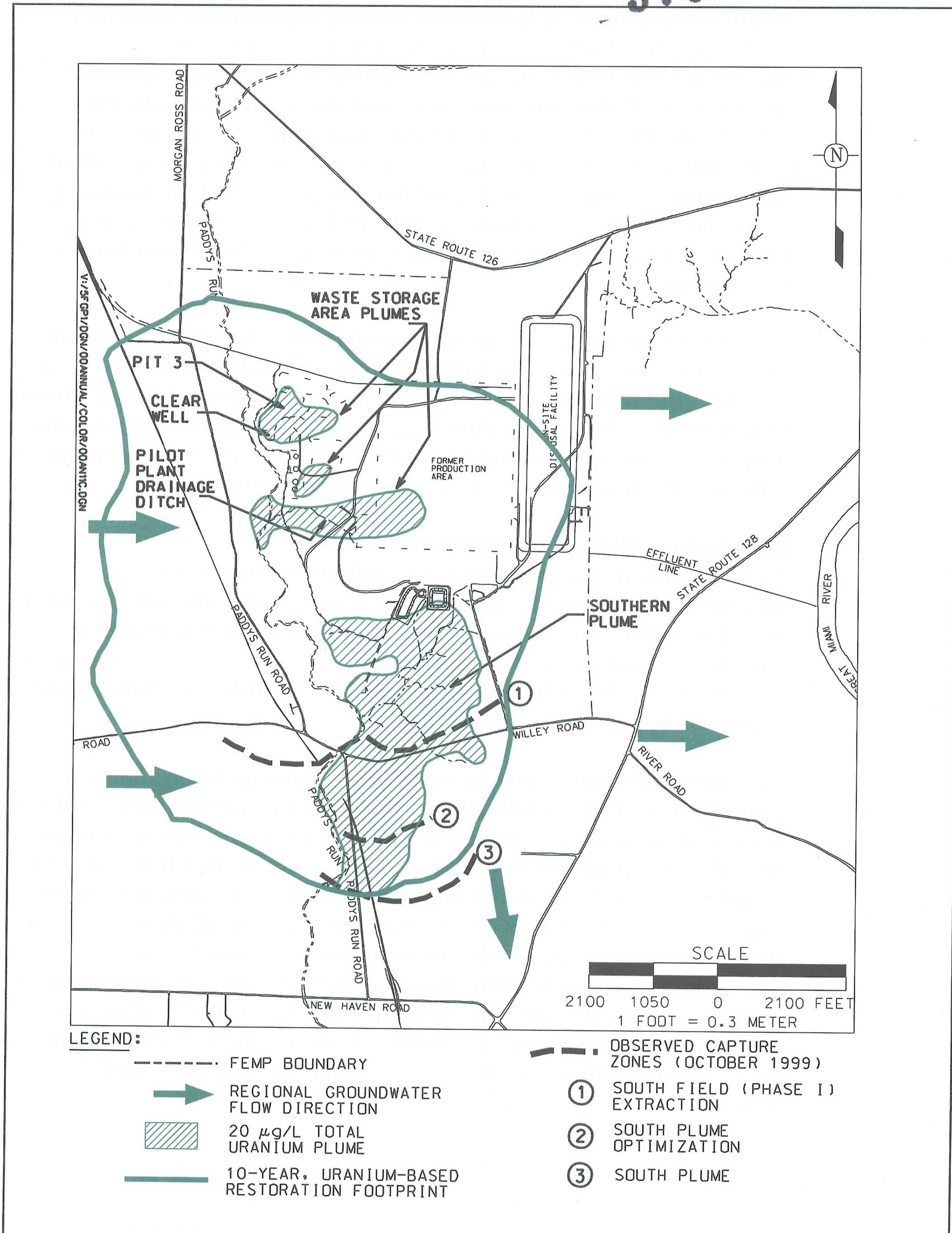

Figure 3-8. Total Uranium Plume in the Aquifer with Concentrations Greater than 20 µg/L at the End of 2000

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South Field (Phase I) Extraction Module Operational Summary

The 10 extraction wells of the South Field (Phase I) Extraction Module (Extraction Wells 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276) began operating on July 13, 1998. After evaluating the total uranium concentrations from Extraction Well 31566 in 1998 and finding the concentrations averaging much less than the 20 µg/L total uranium FRL, DOE decided to discontinue operation of this well, effective August of 1998. To compensate for the decreased total system flow with Extraction Well 31566 turned off, pumping rates were increased at Extraction Wells 31562 and 32276. Monthly sampling for total uranium was continued at Extraction Well 31566 in April of 2000 upon installation of a new sampling pump.

Figure 3-8 illustrates the capture zone associated with the South Field (Phase I) Extraction Module. As a result of groundwater remedy performance monitoring, Extraction Wells 32446 and 32447 were installed during the fourth quarter of 1999 as part of the South Field (Phase I) Extraction Module. The locations of these wells were based on refined total uranium plume interpretations in the South Field area and groundwater modeling. The wells began pumping in February 2000. Figure 3-2 identifies the location of these new extraction wells.

Re-Injection Module Operational Summary

A groundwater re-injection demonstration was conducted at the FEMP from September 2, 1998, to September 2, 1999. The Re-Injection Module consists of Re-Injection Wells 22107, 22108, 22109, 22111, and 22240. Following completion of the re-injection demonstration in September of 1999, it was decided to incorporate re-injection technology into the aquifer remedy. The Re-Injection Demonstration Test Report detailing the demonstration was issued to EPA and OEPA on May 30, 2000.

The evaluation indicated that the testing results were favorable regarding the viability of re-injection at the FEMP, that a reliable source of injection water can be maintained, and that an acceptable injection rate can be sustained without negative effects on the plume or aquifer. However, residual plugging of the re-injection wells became a concern in the last half of 2000. As of the close of 2000, the increased plugging had precipitated the need for more aggressive treatment of the re-injection wells. A revised treatment method utilizing concentrated hydrochloric acid, sodium hypochlorite, and calcium hypochlorite was approved and implemented in early December 2000. Although initial results of the aggressive treatment were encouraging, by early 2001, only one of three wells treated with the aggressive method was rehabilitated such that re-injection could resume at the design rate of 200 gallons per minute. Therefore, additional treatment methods to address this plugging are being researched.

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Monitoring Results for Total Uranium

Total uranium is the primary FRL constituent because it is the most prevalent site contaminant and has impacted the largest area of the aquifer.

Figure 3-8 shows general groundwater flow directions and the interpretation of the total uranium plume in the aquifer, as updated with data collected through 2000. The shaded areas represent the interpreted size of the total uranium plume that is above the 20 µg/L groundwater FRL for total uranium. The fourth quarter 2000 observed capture zones for the South Field (Phase I) Extraction, South Plume, and South Plume Optimization Modules are also identified on Figure 3-8. These capture zones indicate that the southern plume is being captured by the existing system and that further movement of uranium to the south of the extraction wells is being prevented. Figure 3-8 also depicts that the total uranium concentrations greater than the FRL are within the 10-year, uranium-based restoration footprint which was defined in the 1997 Baseline Remedial Strategy Report.

> **Geoprobe®**
>
> The Geoprobe® is a hydraulically powered, direct push sampling tool that is used at the FEMP to obtain groundwater samples at specific intervals without installing a permanent monitoring well. Direct push means that the tool employs the weight of the vehicle it is mounted on and percussive force to push into the ground without drilling (or cutting) to displace soil in the tool's path. DOE uses this technique to collect data on the progress of aquifer restoration and to determine the optimal location and depth of additional monitoring and extraction wells that may be installed in the future.

The interpreted 20 µg/L total uranium plume boundary in the area of the South Field has changed in shape from 1999. The plume shape and concentration contours have been modified to better reflect the Geoprobe® sampling data in the western, on-property area of the southern plume (refer to Figure 3-8). These data were collected as part of South Field Phase II Module pre-design characterization effort. The Geoprobe® data, along with routine IEMP monitoring well data in the South Field area, continue to indicate that surface source removal, flushing of the contaminants toward the extraction wells by infiltrating surface water, and pumping the extraction wells are all contributing to reducing the total uranium concentration in the western portion of this plume, particularly beneath the former Inactive Flyash Pile. However, some monitoring wells in the eastern portion of the South Field (Phase I) Extraction Module area have steady or increasing total uranium concentrations. Options for increasing the flushing of the aquifer in the eastern portion of the South Field area are scheduled to be evaluated in 2001. These options currently include additional extraction wells, increasing the pumping rate of some existing wells (with the existing pumps) and increasing the pumping rate in some of the existing extraction wells by installing larger capacity pumps.

In the northeast portion of the South Field Module area, Geoprobe® sampling data were used to confirm the lack of a plume upgradient of Monitoring Well 3068. A camera survey, along with a pumping action at Monitoring Well 3068 confirmed the source for the uranium contamination in the well was perched water leakage into the well, rather than a uranium plume at the well. The concentration contour maps were redrawn to reflect this analysis and Appendix A, Attachment 2, provides additional detail.

As previously noted in the Selection and Design of the Groundwater Remedy section, the Plant 6 plume appears to have dissipated to concentrations below the 20 µg/L total uranium FRL and the waste storage area plume interpretation has been revised based on the pre-design characterization completed. These revised interpretations are reflected in the total uranium plume outline on Figure 3-8.

Appendix A, Attachment 2, of this report provides individual monitoring well total uranium results and quarterly total uranium plume maps for 2000. Appendix A, Attachment 3, of this report provides capture zone evaluations based on groundwater flow directions from groundwater elevation data. It includes quarterly groundwater elevation maps and graphical displays of groundwater elevation data.

Monitoring Results for Non-Uranium Constituents

Although the enhanced groundwater remedy is primarily targeting remediation of the total uranium plume, other FRL constituents (Table 2-2) contained within the total uranium plume are also being monitored.

Table 3-2 summarizes the results of monitoring for non-uranium FRL constituents, and Figure 3-9 identifies the locations of the wells that had FRL exceedances in 2000. Included in the table for each FRL constituent are the number of wells with FRL exceedances, the number of wells with FRL exceedances outside the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint, and the range of 2000 data above the FRL from wells inside or outside the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint.

TABLE 3-2
NON-URANIUM CONSTITUENTS WITH RESULTS ABOVE FINAL REMEDIATION LEVELS DURING 2000

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint	Groundwater FRL	Range of 2000 Data Inside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint above the FRL[b]	Range of 2000 Data Outside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint above the FRL[b]
General Chemistry			(mg/L)	(mg/L)	(mg/L)
Nitrate/Nitrite	3	0	11[c]	11.4 to 48.4	NA
Inorganics					
Arsenic	4	2	0.050	0.0609 to 0.0633	0.0595 to 0.082
Boron	2	0	0.33	0.339 to 0.857	NA
Lead	4	2	0.015	0.0191 to 0.0224	0.0157 to 0.201
Manganese	17	4[d]	0.900	0.916 to 105	0.918 to 1.3
Molybdenum	1	0	0.10	0.275	NA
Nickel	4	0	0.10	0.104 to 0.906	NA
Zinc	19	6[d]	0.021	0.0216 to 0.235	0.0252 to 0.077
Volatile Organics			(μg/L)	(μg/L)	(μg/L)
Trichloroethene	1	0	5.0	70.7	NA
Radionuclides			(pCi/L)	(pCi/L)	(pCi/L)
Technetium-99	1	0	94	181.533 to 685.581	NA

[a]Baseline Remedial Strategy Report (DOE 1997a)

[b]NA = not applicable

[c]FRL based on nitrate, from Operable Unit 5 Record of Decision, Table 9-4; however, the sampling results are for nitrate/nitrite.

[d]Additional 2001 data are needed from Monitoring Wells 22198, 2426, and 3426 before a determination of persistence can be made.

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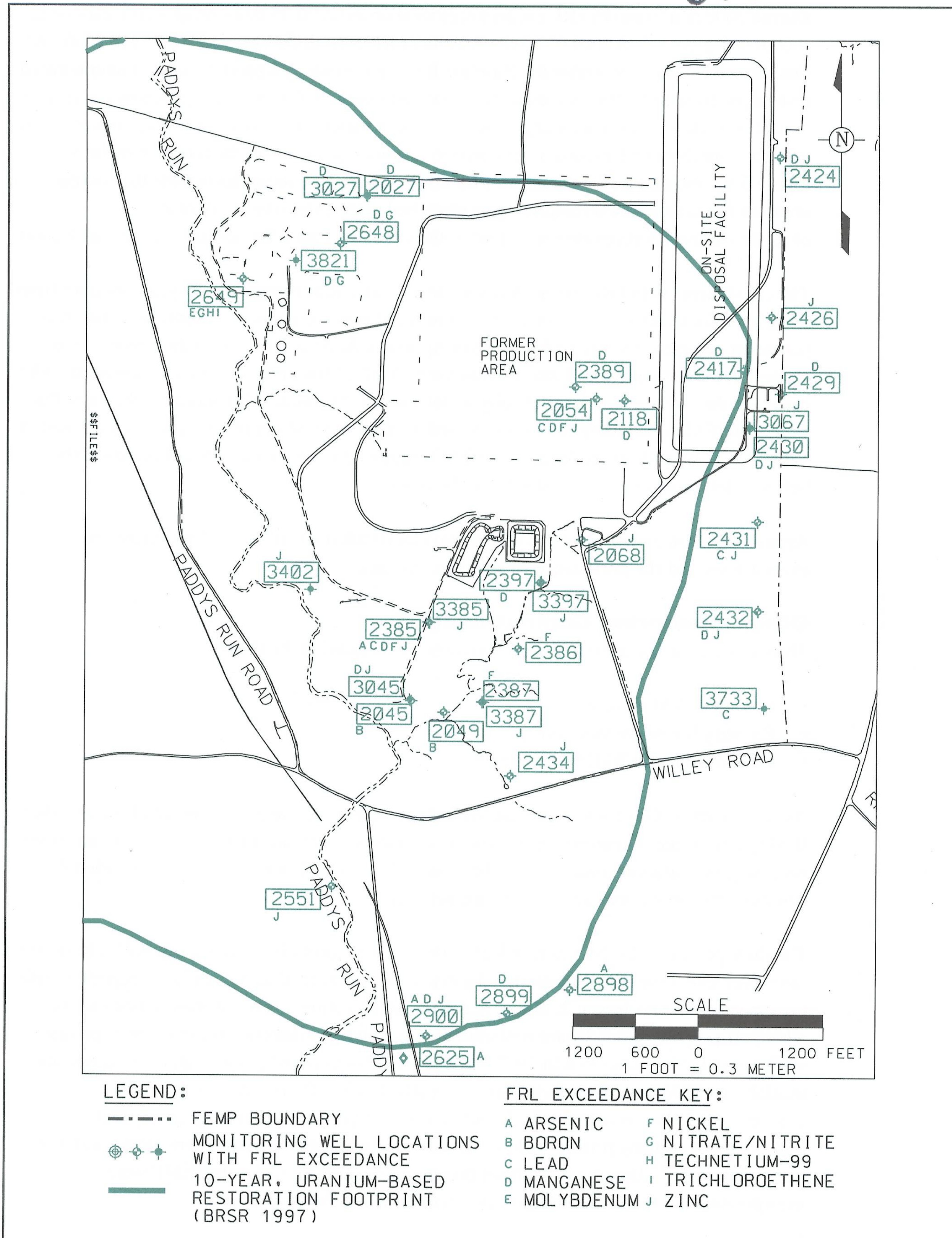

Figure 3-9. Non-Uranium Constituents with 2000 Results Above Final Remediation Levels

During 2000 non-uranium FRL exceedances were observed at 35 monitoring well locations as shown in Figure 3-9. A total of 10 non-uranium FRL constituents exceeded FRLs in 2000. All these exceedances were within the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint. They are expected to be addressed by the enhanced groundwater remedy, except exceedances for lead, manganese, and zinc at various monitoring well locations along the eastern property boundary, and arsenic in two locations just south of the footprint (refer to Figure 3-9). No plumes for the above FRL constituents at the locations outside the 10-year, uranium-based restoration footprint were identified in the extensive groundwater characterization efforts evaluated as part of the Operable Unit 5 Remedial Investigation Report.

The constituents with FRL exceedances at the well locations outside the 10-year, uranium-based restoration footprint were further evaluated to see if they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment 4, of this report. Two exceedances (manganese and zinc at Monitoring Well 2430) were classified as persistent. The cause for these exceedances is not fully understood at this time. All former exceedances that were classified as persistent have disappeared with subsequent sampling. Also, as footnoted in Table 3-2, some FRL exceedances from 2000 require additional data to be collected in 2001 before a determination of persistence can be made.

Appendix A, Attachment 4, of this report provides detailed information of non-uranium FRL exceedances and the persistence of these exceedances.

Other Monitoring Commitments

Three other groundwater monitoring activities are included in the IEMP:

- Private Well Monitoring
- Property Boundary Monitoring
- KC-2 Warehouse Well Monitoring.

As stated earlier, the groundwater data from these activities, along with the data from all other IEMP groundwater monitoring activities, are collectively evaluated for total uranium, and where necessary, non-uranium constituents of concern. The discussion below provides additional details on the three compliance monitoring activities.

The three private wells (Monitoring Wells 2060 [12], 13, and 14) located along Willey Road are monitored under the IEMP to assist in the evaluation of the total uranium plume migration (refer to Appendix A, Attachment 2, Figure A.2-1 for well locations). One of these private wells is where off-property groundwater contamination was initially detected in 1981. Other private wells ceased to be monitored in 1997 because a DOE-sponsored public water supply became available to FEMP neighbors who have been affected by off-property groundwater contamination. The availability of the public water supply resulted in the plugging and abandonment of many private wells in the affected off-property areas where groundwater is being remediated. Data from the three private wells sampled under the IEMP were incorporated into the total uranium plume map shown in Figure 3-8.

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Property Boundary Monitoring is comprised of 33 monitoring wells located downgradient of the FEMP, along the eastern and southern portions of the property boundary. These wells are monitored quarterly for 27 of the most mobile FRL constituents in order to determine if contaminant excursions at the property boundary are occurring during the remediation process. During 2000, the frequency of monitoring the property boundary Type 4 wells was decreased to once every five years due to lack of contamination in the aquifer at the depth these wells monitor. Data from the property boundary wells were integrated with other IEMP data for 2000 and were incorporated into the total uranium plume map shown in Figure 3-8. Non-uranium data from these wells were included above in the section on monitoring results for non-uranium constituents. Director's Findings and Orders were issued by OEPA on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process (subject to OEPA approval), without issuance of a new order. As determined by OEPA, the IEMP will remain in effect throughout the duration of remedial actions.

The KC-2 Warehouse well (Figure 3-5) monitoring was also to be included as part of the IEMP until such time that it could be plugged. Monitoring of this well (Well 67) was conducted on an annual basis as a result of the presence of what appeared to be contaminated sediment at the bottom of the well. As reported in the 1999 Integrated Site Environmental Report, the KC-2 Warehouse well has been removed from the IEMP sampling program. The KC-2 Warehouse well was sampled in March of 2000 and plugged and abandoned in April 2000. The March 2000 sampling results were generally lower than the historical averages. Although cyanide and sodium concentrations exceeded the historical average, there is no groundwater FRL for either constituent. The monitoring results for this well and additional detail in the sampling events are presented in Appendix A, Attachment 5, of this report.

On-Site Disposal Facility Monitoring

Groundwater monitoring for the cells of the on-site disposal facility is conducted in the glacial till (perched water) and in the Great Miami Aquifer. Groundwater monitoring in support of the on-site disposal facility continued in 2000. This monitoring program is designed to accomplish the following:

- Establish a baseline of groundwater conditions in both the perched groundwater and the Great Miami Aquifer beneath each cell of the on-site disposal facility. The baseline data will be used to evaluate future changes in perched groundwater and Great Miami Aquifer groundwater quality to help determine if the changes are due to on-site disposal facility operations.

- Continue routine groundwater sampling following waste placement and cell capping as part of the comprehensive leak detection monitoring program for the on-site disposal facility. This information will be used to help verify the ongoing performance and integrity of the on-site disposal facility.

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Table 3-3 summarizes the groundwater monitoring information associated with the on-site disposal facility. Table 3-3 also summarizes leachate collection system and leak detection system monitoring information. Sampling of the leachate collection system and the leak detection system is generally initiated after waste placement, while groundwater sampling is initiated before waste is placed in a particular cell. Table 3-3 provides information for Cells 1, 2, and 3, along with sample information and range of total uranium concentrations. During 2000, design was completed on an enhanced permanent leachate transmission system, which is scheduled to replace the existing system in 2001. Construction of the new system began in May 2000.

TABLE 3-3
ON-SITE DISPOSAL FACILITY GROUNDWATER, LEACHATE, AND LEAK DETECTION SYSTEM MONITORING SUMMARY

Cell (Waste Placement Start Date)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a] (µg/L)
Cell 1	22201	Great Miami Aquifer	March 31, 1997	27	ND – 6.384
(December 1997)	22198	Great Miami Aquifer	March 31, 1997	40	0.557 – 8.365
	12338	Glacial Till	October 30, 1997	32	ND – 19
	12338C	Leachate Collection System	February 17, 1998	12	ND – 119
	12338D	Leak Detection System	February 18, 1998	11	1.5 - 20.17
Cell 2	22200	Great Miami Aquifer	June 30, 1997	22	ND - 1.11
(November 1998)	22199	Great Miami Aquifer	June 25, 1997	22	0.259 -12.1
	12339	Glacial Till	June 29, 1998	31	ND - 3.607
	12339C	Leachate Collection System	November 23, 1998	9	4.51 – 39.299
	12339D	Leak Detection System	December 14, 1998	9	9.334 - 71[b]
Cell 3	22203	Great Miami Aquifer	August 24, 1998	20	ND – 2.522
(November 1999)	22204	Great Miami Aquifer	August 24, 1998	20	ND – 5.924
	12340	Glacial Till	July 28, 1998	24	ND – 9.14
	12340C	Leachate Collection System	October 13, 1999	6	9.27 – 37.854
	12340D	Leak Detection System	NS[c]		

[a]ND = not detectable

[b]Data not considered reliable due to malfunction in the leachate pipeline and the resultant mixing of individual flows.

[c]NS = not sampled due to lack of water yield

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At the end of 2000, baseline groundwater sampling of perched water and the Great Miami Aquifer concluded for Cells 1, 2, and 3. These data will be used to establish the initial groundwater conditions against which future sample results will be compared as part of the leak detection data evaluation process. A technical memorandum to document the baseline conditions for Cells 1, 2, and 3 is scheduled to be prepared in 2001. Starting in January 2001, the first three cells were sampled to determine post-baseline groundwater conditions. Figure 3-10 identifies the on-site disposal facility footprint and monitoring well locations.

Placement of contaminated soil and debris in Cell 1 concluded at the end of December 2000 (Cell 1 was 100 percent full). Soil and debris placement continued in Cells 2 and 3 during 2000. As of the end of December 2000, Cell 2 was approximately 51 percent full and Cell 3 was approximately 24 percent full. Based on 2000 leak detection monitoring data associated with the on-site disposal facility, the liner systems for Cells 1, 2, and 3 are performing within the specifications outlined in the approved cell design.

In all the samples collected from the horizontal till wells and Great Miami Aquifer wells, none of the constituents analyzed exceeded the groundwater FRLs. For additional information on the groundwater, leak detection and leachate sampling results for the on-site disposal facility, refer to Appendix A, Attachment 6, of this report.

Guide to Aquifer Restoration and Wastewater Project Documents

Numerous studies and reports have been issued by the FEMP during the CERCLA process to document the progress of the aquifer restoration. Table 3-4 is a reference for the reader to consult when seeking additional information about any phase of the site CERCLA process related to groundwater which has been completed to date. The dates during which the major accomplishments under the CERCLA process were performed are shown on the left. The middle column identifies the major CERCLA process, which was in progress at the time. The last column indicates the documents where significant findings, results, and recommendations can be located. These documents are available for public viewing in the FEMP Public Environmental Information Center, which is located a half mile south of the FEMP on Oakridge Drive in the Delta Building.

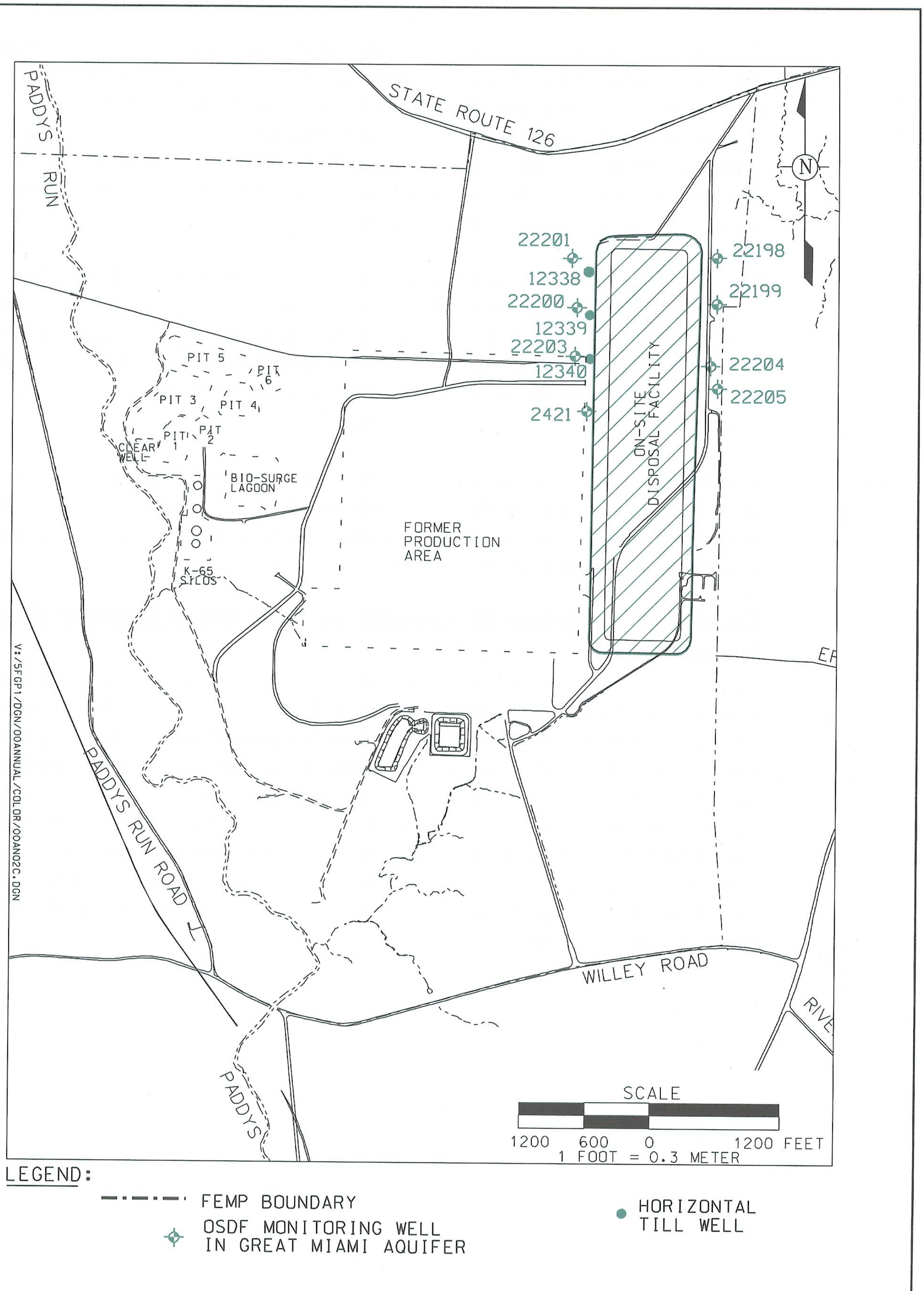

Figure 3-10. On-Site Disposal Facility Footprint and Monitoring Well Locations

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TABLE 3-4
CHRONOLOGICAL SUMMARY OF KEY AQUIFER RESTORATION ACTIVITIES

Date	Activity	Documentation
1988 - 1995	Determine the Scope of the Problem and Select a Solution	
	Determine the nature and extent of groundwater contamination and investigate the risk posed to human health and/or the environment	**Remedial Investigation Report for Operable Unit 5** (1995)
	Evaluate various remediation technologies; consider efficiency, land use scenarios, and cost	**Feasibility Study Report for Operable Unit 5** (1995)
	Establish remediation goals for site contaminants in environmental media; commit to a selected cleanup remedy	**Record of Decision for Remedial Actions at Operable Unit 5** (1996)
1996 - 1997	Design and Construct a System to Clean Up the Aquifer	
	Define how and when needed construction drawings, specifications, plans, and procurement documents will be prepared	**Remedial Design Work Plan for Remedial Actions at Operable Unit 5** (1996)
	Develop a strategy and schedule for completing restoration of the aquifer	**Remedial Action Work Plan for Aquifer Restoration at Operable Unit 5** (1997)
	Design the aquifer restoration system (e.g., number of wells, pumping rates, well locations, etc.)	**Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)** (1997)
	Develop a plan to monitor progress of the clean up	Chapter 3 of the **Integrated Environmental Monitoring Plan (IEMP)** (1997)
	Develop operational strategy for the aquifer system	**Operations and Maintenance Master Plan for the Aquifer Restoration and Wastewater Treatment Project** (1997)
1993	South Plume Module begins operating as a removal action.	**South Plume Removal Action Design Monitoring Evaluation Program Plan** (1993)
1997	IEMP Monitoring Begins	**Design Monitoring Evaluation Program Plan System Evaluation Report** (various dates through September 1997)
		Integrated Environmental Monitoring Plan (IEMP); Integrated Environmental Monitoring Quarterly Reports
1998	South Field (Phase I) and South Plume Optimization Modules become operational	**Start-Up Monitoring Plan for the South Field Extraction and South Plume Optimization Modules** (1998)
	Re-Injection Demonstration begins	**Re-Injection Demonstration Test Plan** (1997)
1999	Re-Injection Demonstration ends	**Monthly Re-Injection Report** (September 1999) and **Integrated Environmental Monitoring Status Report for Third Quarter 1999** (December 1999)
	Revised the operational strategy for the project	**Operations and Maintenance Master Plan** (December 1999)
	Began a pre-design characterization of uranium plumes in the waste storage area and Plant 6 area	**Integrated Environmental Monitoring Status Report for Fourth Quarter 1999** (March 2000)
2000	Completed a Conceptual Design for plumes in the waste storage and Plant 6 areas	**Conceptual Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas** (May 2000)
	Issued Re-Injection Demonstration Test Report and added re-injection to the aquifer remedy	**Re-Injection Demonstration Test Report for the Aquifer Restoration and Wastewater Project** (May 2000)

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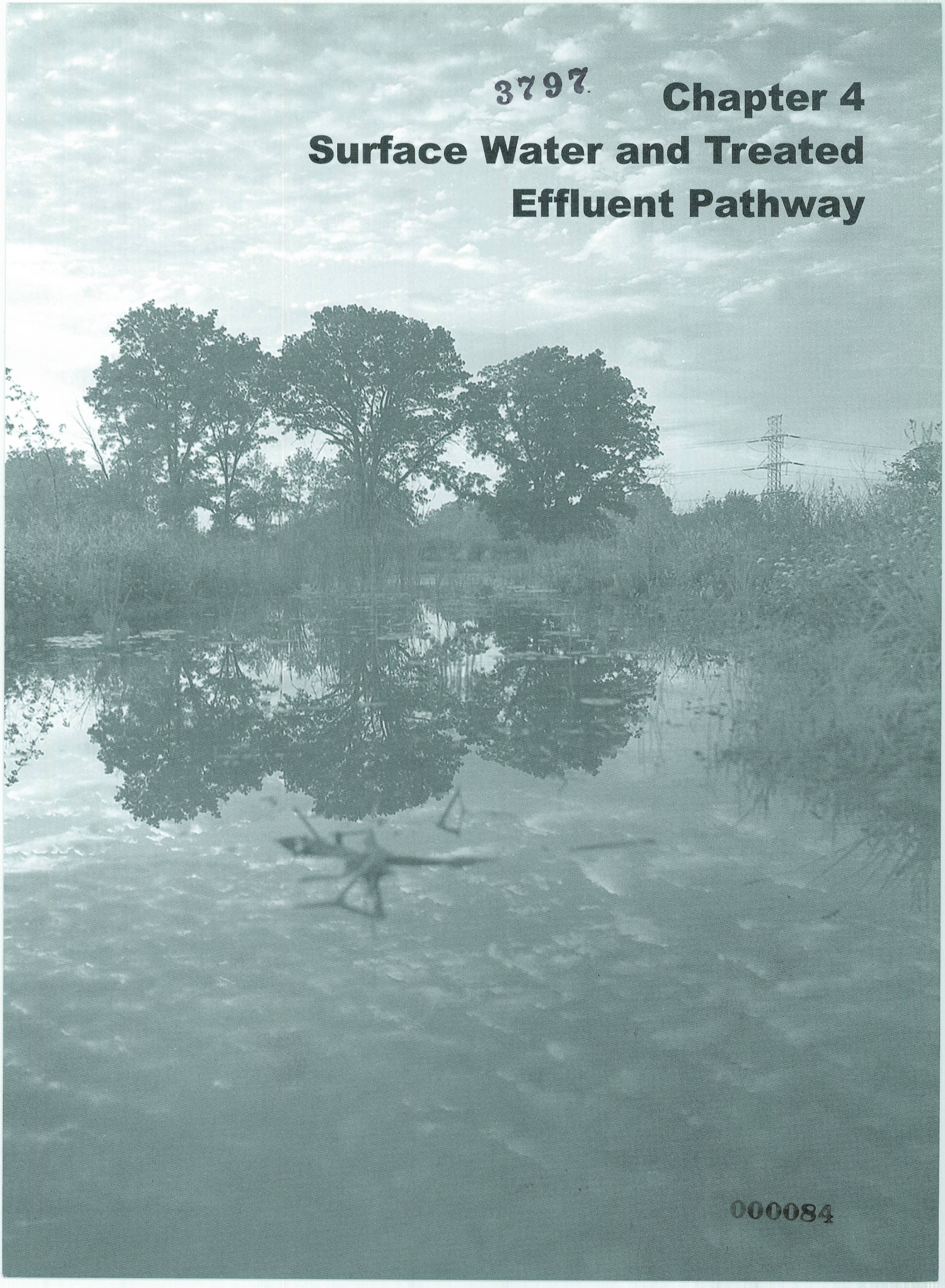
Chapter 4
Surface Water and Treated Effluent Pathway



Surface Water and Treated Effluent Pathway

Results in Brief: 2000 Treated Effluent and Surface Water Pathway

Surveillance Monitoring - No surface water or treated effluent analytical results from samples collected in 2000 exceeded the surface water FRL for total uranium, the primary site contaminant. FRL exceedances that may be attributable to the FEMP were limited to four constituents and three locations while one BTV exceedance occurred. Occasional, sporadic FRL and BTV exceedances are to be expected until site remediation is complete.

NPDES - Permitted discharges were in compliance with the current NPDES Permit requirements 99.8 percent of the time.

Uranium Discharges - In 2000, 252 pounds (114 kg) of uranium were discharged in treated effluent to the Great Miami River. Approximately 124 pounds (56 kg) of uranium were released to the environment through uncontrolled storm water runoff. The estimated total pounds of uranium released through the surface water and treated effluent pathway (approximately 376 pounds [171 kg]) decreased 10 percent from the 1999 estimate.

Sediment - The 2000 sediment results are within the range of historical concentrations. In addition, there were no FRL exceedances for any sediment result in 2000.

This chapter presents the 2000 monitoring activities and results for surface water, treated effluent, and sediment to determine the effects of remediation activities on the surface water pathway.

In general, low levels of contaminants enter the surface water pathway at the FEMP by two primary mechanisms: treated effluent that is monitored as it is discharged to the Great Miami River, and through uncontrolled runoff entering the site's drainages from areas of the site containing low levels of soil contamination. Because these discharges will continue throughout remediation, the surface water and sediment pathways will continue to be monitored. Effective use of the site's wastewater treatment capabilities and implementation of runoff and sediment controls minimize the site's impact on the surface water pathway.

To assist in the understanding of this chapter, the following key definitions are provided:

- **Controlled runoff** is contaminated storm water that is under normal circumstances, collected, treated and eventually discharged to the Great Miami River as treated effluent.
- **Uncontrolled runoff** is storm water that is not collected by the site for treatment, but enters the site's natural drainages.
- **Treated effluent** is water from numerous sources at the site, which is treated through one of the FEMP's wastewater treatment facilities and discharged to the Great Miami River.
- **Surface water** is water that flows within natural drainage features.

Summary of Surface Water and Treated Effluent Pathway

The treated effluent pathway is comprised of those flows discharged to the Great Miami River via the Parshall Flume (PF 4001). Discharges through this point are considered under the control of FEMP wastewater operations. Under normal operation this combined flow is comprised of:

- Storm water runoff collected from the former production area, waste pit area and the southern waste unit excavation area
- Treated and untreated groundwater from the South Plume and South Field (Phase I) Aquifer Restoration Modules
- Remediation wastewater, such as on-site disposal facility leachate, decontamination rinse water generated during building decontamination and dismantling activities, and wastewater generated from the operation of the Waste Pits Remedial Action Project dryer facility
- Treated sanitary wastewater from the sewage treatment plant.

During periods of heavy, sequential rainfall events, untreated storm water, which exceeds the capacity of FEMP treatment systems, is bypassed directly to the Great Miami River.

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The volume and flow rate of uncontrolled runoff depends on the amount of precipitation within any given period of time. Figure 1-10 in Chapter 1 shows monthly precipitation totals for 2000. Figure 4-1 shows the site's natural drainage features and defines the areas from which runoff is either controlled or uncontrolled. The site's natural surface water drainages include several tributaries to Paddys Run (e.g., Pilot Plant Drainage Ditch, Storm Sewer Outfall Ditch) as well as the northeast drainage that flows to the Great Miami River. The arrows on this figure indicate the general flow direction of uncontrolled runoff that is determined from the topography. Uncontrolled runoff from the FEMP leaves the property via two drainage pathways, Paddys Run and the northeast drainage.

Remediation Activities Affecting Surface Water Pathway

Major remediation activities in 2000 that affected (or had the potential to affect) the surface water pathway included:

- Construction activities associated with the on-site disposal facility including excavation, screening, and hauling activities in the on-site disposal facility borrow area
- Waste hauling and placement activities associated with the on-site disposal facility
- Soil excavation activities conducted by the Soil and Disposal Facility Project (refer to Chapter 2)
- Activities associated with the Waste Pits Remedial Action Project including dryer operation, pit excavation and waste material handling, and railcar loading
- Construction activities associated with site preparation activities for the Accelerated Waste Retrieval and Silo 3 Projects.

To minimize the effects of remediation on the environment, engineered and administrative controls are used at the FEMP to reduce the amount of sediment entering the surface water drainages during rainfall events. As water flows over soil, contaminants typically move with the water either by being adsorbed to sediment eroded from the land surface or dissolved in the water itself. The chosen sediment control method varies based on the contaminants expected during excavation, the topography of the area, and the size and duration of the excavation.

Engineered sediment controls can include the construction of sedimentation basins (lined or unlined), silt fences, check dams, and permanent or temporary seeding. Diversion ditches are also constructed as an engineered control to divert clean water from upgradient areas away from areas of remediation. Ditches are sometimes lined with riprap and/or synthetic liners to control erosion. In areas where remediation activities may expose contaminated materials (e.g., the southern waste units), contaminated runoff is collected in lined basins and routed for treatment at one of the FEMP's wastewater treatment facilities. Administrative controls include limiting the duration of open excavations, as well as routinely inspecting each of the engineered controls used.

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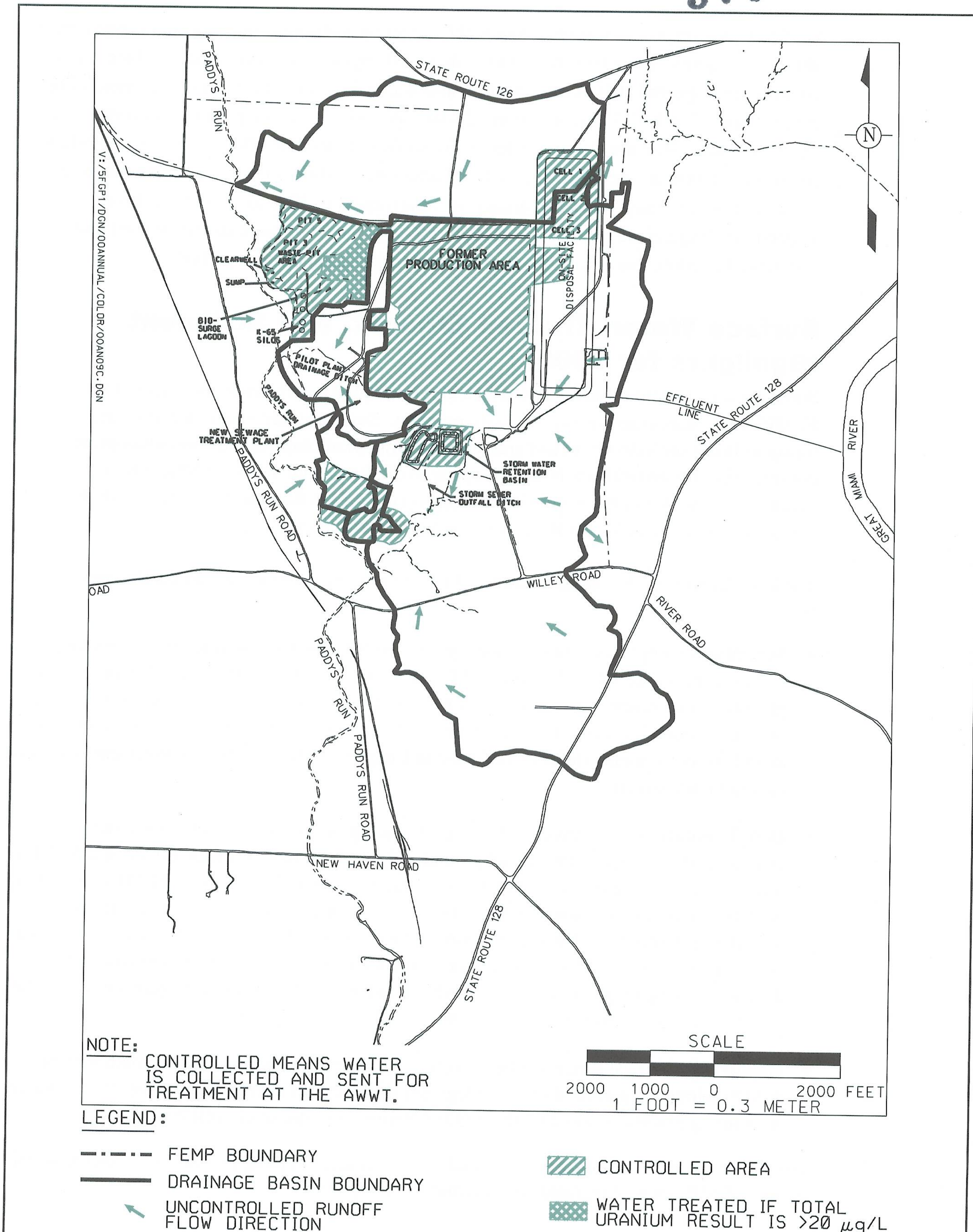

Figure 4-1. Controlled Surface Water Areas and Uncontrolled Runoff Flow Directions

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Each remediation project is responsible for constructing and maintaining the engineered control structures required under their remedial design. All engineered sediment and surface water controls are inspected at least once a week, and within 24 hours of any rain event measuring greater than 0.5 inch (1.3 cm) of rain in a 24-hour period. Discharge points for uncontrolled runoff to Paddys Run are also inspected periodically to assess the effectiveness of upgradient controls in preventing significant impacts to Paddys Run. Minor maintenance activities (e.g., silt fence repairs, reseeding of eroded areas) were performed in 2000 as a result of these inspections. Engineered controls installed during 1997 and 1998 continued to be used and maintained in 2000. No new storm water controls were installed during 2000.

Surface Water, Treated Effluent, and Sediment Highlights for 2000

Surface water, treated effluent, and sediment are sampled to determine the effect of the FEMP's remediation activities on the environment. Surface water is sampled at several locations in the site's drainages and analyzed for various radiological and non-radiological constituents. Treated effluent is sampled prior to discharge into the Great Miami River. Sediment is sampled in the major site drainages (i.e., Paddys Run and Storm Sewer Outfall Ditch) and in the Great Miami River for radiological constituents.

The key elements of the surface water and treated effluent program design are described below:

- **Sampling** - Sample locations, frequency, and constituents were selected to address the requirements of the NPDES Permit, FFCA, and Operable Unit 5 Record of Decision, and to provide a comprehensive assessment of surface water quality at 16 key locations including two background locations (refer to Figures 4-2 and 4-3). Surface water is monitored for up to 55 FRL constituents (refer to Table 2-2 in Chapter 2) and three BTV constituents (barium, cadmium, and silver).

- **Data Evaluation** - The integrated data evaluation process focuses on tracking and evaluating data compared with background and historical ranges, FRLs, BTVs, and NPDES limits. This information is used to assess impacts to surface water due to FEMP remediation activities affecting uncontrolled runoff or treated effluent. The assessment also includes identifying the potential for impacts from surface water to the groundwater in the underlying Great Miami Aquifer. The ongoing data evaluation is designed to support remedial action decision-making by providing timely feedback to the remediation project organizations on the effectiveness of storm water runoff controls and treatment processes.

- **Reporting** - Surface water and treated effluent reporting requirements are combined into IEMP quarterly reports and annual integrated site environmental reports. Monthly discharge monitoring reports required by the NPDES Permit are submitted to OEPA.

The IEMP sediment sampling program includes an annual sampling program with data reported through IEMP annual integrated site environmental reports.

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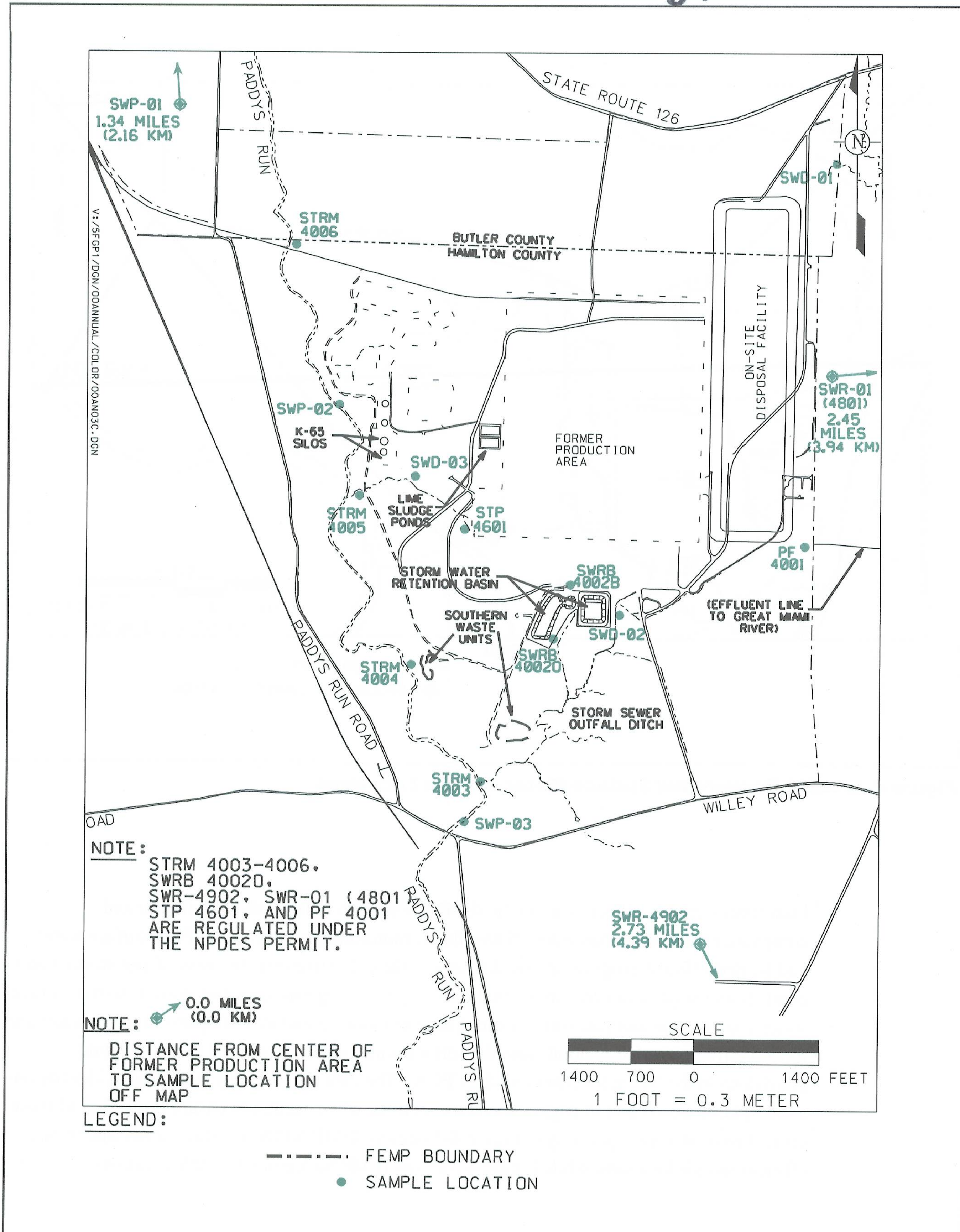

Figure 4-2. IEMP/NPDES Surface Water and Treated Effluent Sample Locations

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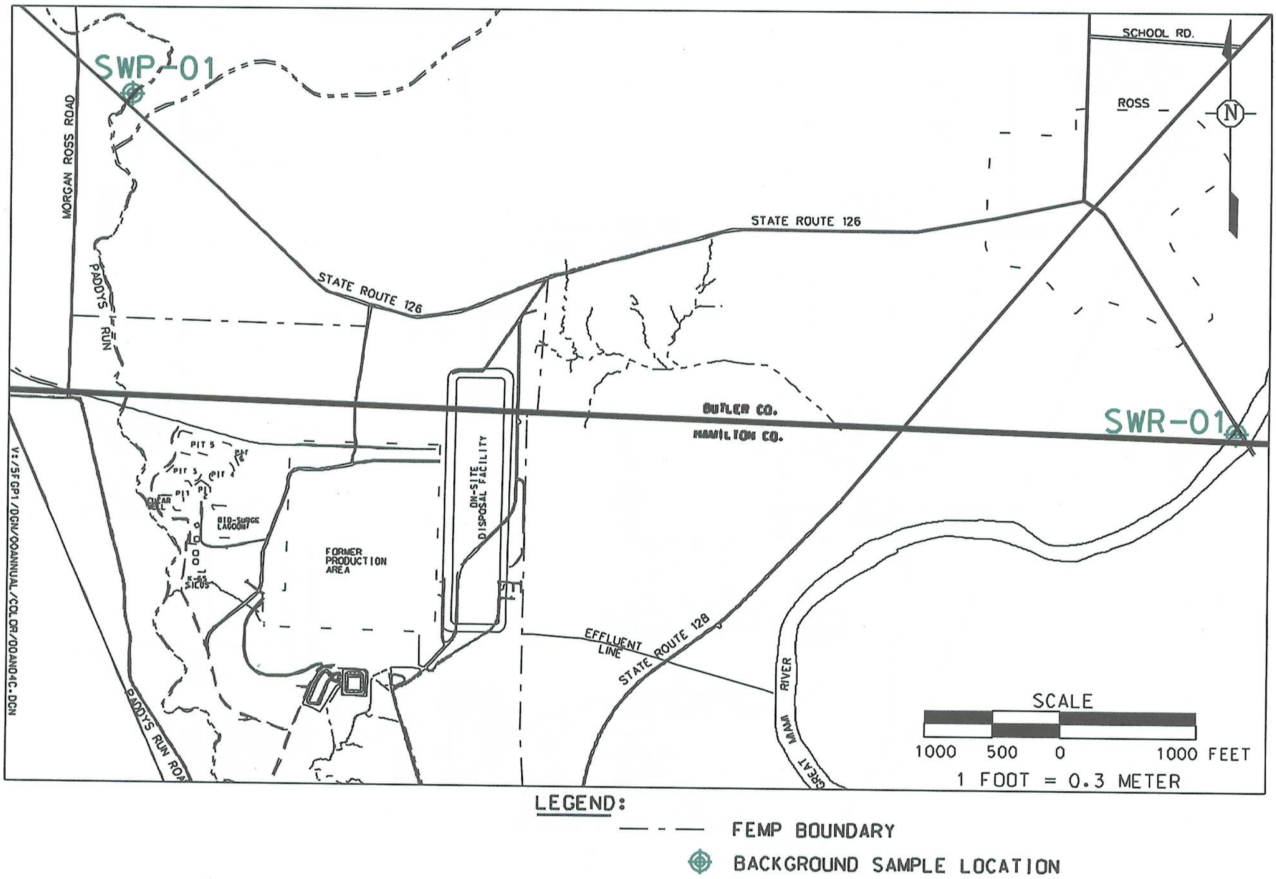

Figure 4-3. IEMP Background Surface Water Sample Locations

Data from samples collected under the IEMP are used to fulfill both surveillance and compliance monitoring functions. Surveillance monitoring results of the IEMP surface water and treated effluent program are used to assess the collective effectiveness of site storm water controls and wastewater treatment processes in preventing unacceptable impacts to the surface water and groundwater pathways. Compliance monitoring includes sampling at storm water and treated effluent discharge points into the surface water and is conducted to comply with provisions in the NPDES Permit and the FFCA. The data are routinely evaluated to identify any unacceptable trends and to trigger corrective actions when needed to ensure protection of these critical environmental pathways. Figure 4-2 depicts IEMP/NPDES surface water and treated effluent sample locations, while Figure 4-3 shows IEMP background sample locations.

> **Treated effluent** is discharged to the Great Miami River through the effluent line, identified on Figure 4-1. Samples of the treated effluent are collected at the Parshall Flume (PF 4001). The resulting data are used to calculate the concentration of each FRL constituent after the water mixes with effluent water in the Great Miami River.

Surveillance Monitoring

Data resulting from 2000 sampling efforts were evaluated to provide surveillance monitoring of remediation activities. This evaluation showed that during 2000, there were no exceedances of the surface water total uranium FRL (530 μg/L) detected in any of the surface water and treated effluent samples. There were six non-uranium constituents with FRL exceedances, along with one BTV exceedance. Table 4-1 summarizes these exceedances and Figure 4-4 identifies the locations of the exceedances.

There were three FRL exceedances in 2000 at location SWR-01: one for lead, one for mercury, and one for zinc. Background sample location SWR-01 is located upstream of the FEMP effluent line on the Great Miami River. Background monitoring locations are situated upstream and outside the influence of FEMP discharges. The background data are used to distinguish impacts from FEMP activities against upstream water quality conditions.

The remaining FRL/BTV exceedances which may be attributable to FEMP activities were sporadic in nature and do not indicate any significant impacts to the environment or operational problems with the FEMP's storm water and sediment control systems. There was one result above an FRL at the Storm Water Retention Basin overflow location (SWRB 4002O) for copper. While this result is reported as an exceedance, it is likely that after accounting for the mixing within the entire reach of the Storm Sewer Outfall Ditch, followed by mixing within Paddys Run, there would be no FRL exceedance in Paddys Run. There were two FRL exceedances at location SWD-03, one for silver and one for zinc. The silver exceedance also resulted in the one BTV exceedance. Finally there were three FRL exceedances (two for chromium and one for copper) at location SWP-03. This is the point at which Paddys Run leaves FEMP property, as discussed later in this chapter.

TABLE 4-1

CONSTITUENTS WITH RESULTS ABOVE SURFACE WATER FRLs OR BTVs DURING 2000

Constituent	Number of Locations Exceeding FRL	Number of Locations Exceeding BTV[a]	Surface Water FRL	Surface Water BTV[a]	Range of 2000 Data above FRL	Range of 2000 Data above BTV[a]
Inorganics			(mg/L)	(mg/L)	(mg/L)	(mg/L)
Chromium	1	NA	0.010[b]	NA	0.0121 - 0.0153	NA
Copper	2	NA	0.012	NA	0.0159 - 0.016	NA
Lead	1	NA	0.010	NA	0.0151	NA
Mercury	1	NA	0.00020	NA	0.00021	NA
Silver	1	1	0.0050	0.0013	0.0106	0.0106
Zinc	2	NA	0.11	NA	0.114 - 0.126	NA

[a]NA = not applicable

[b]FRL based on hexavalent chromium, from Operable Unit 5 Record of Decision, Table 9-5; however, due to holding time considerations, total chromium is analyzed which is acceptable because total chromium provides a more conservative result.

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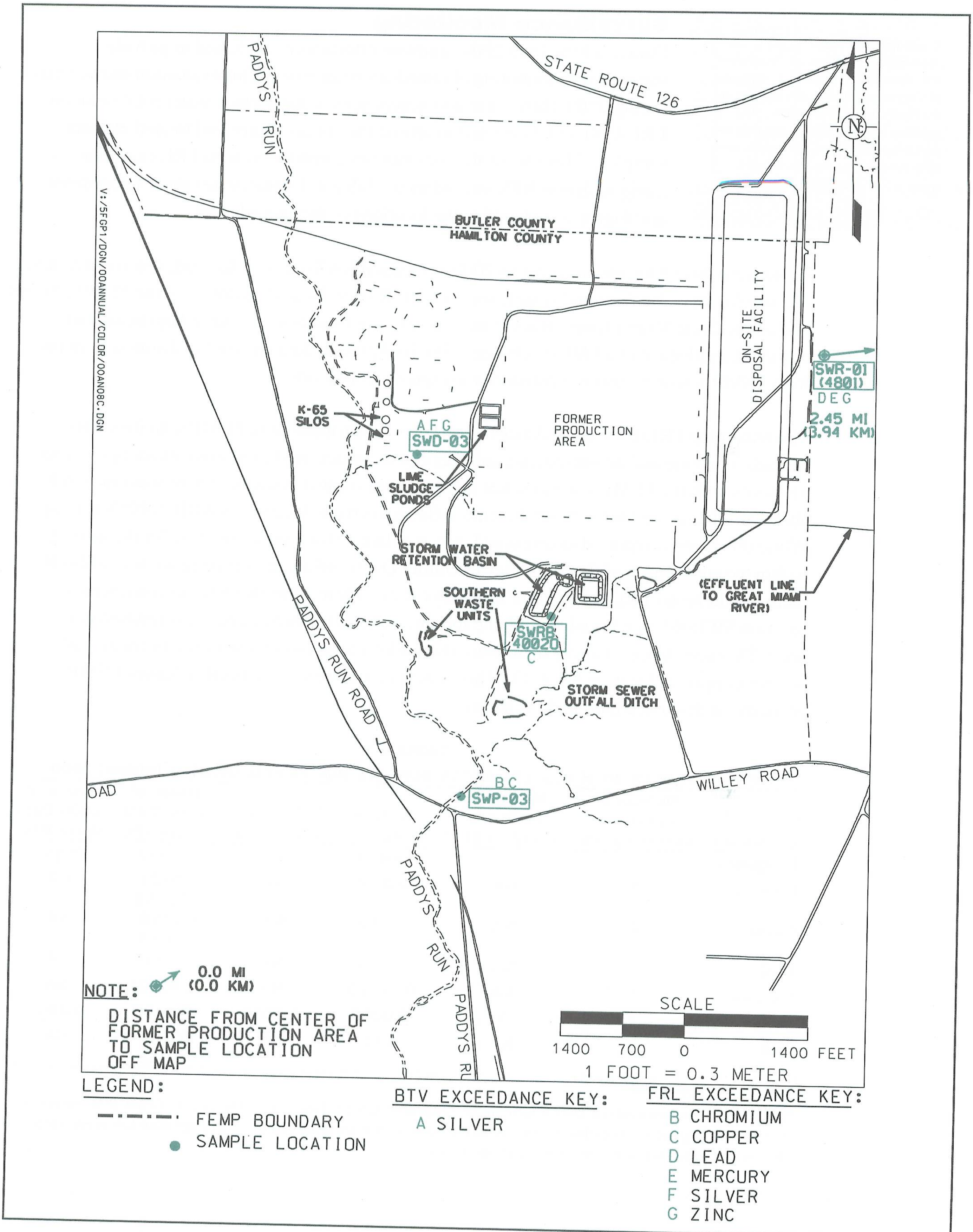

Figure 4-4. Constituents with 2000 Results Above FRLs or BTVs

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Even with the FEMP's implementation of storm water and sediment controls, sporadic FRL and BTV exceedances can be expected to occur until final remediation of contaminated source areas (soils and sediments) are complete. A Mann-Kendall statistical test for trends was run for each 2000 FRL exceedance at each location where the exceedance occurred, and no statistically significant trends were identified. The FRL and BTV exceedances will continue to be evaluated for persistence and increasing trends through the IEMP sampling program throughout remediation. This information will be used to provide feedback to the remediation projects on the collective effectiveness of their storm water and sediment controls. Additional details of the FRL and BTV exceedances are presented in Appendix B, Attachment 1, of this report.

The following two key sample locations represent points where surface water or treated effluent leaves the site:

- Paddys Run at the Willey Road property boundary (sample location SWP-03)
- Parshall Flume (PF 4001) located at the entry point of the effluent line leading to the Great Miami River.

Evaluation of the data from these locations is especially important because it represents points beyond which direct exposure to the public is possible.

As previously mentioned, there were three FRL exceedances at location SWP-03. On September 25, 2000, there were FRL exceedances for chromium and copper, followed by one additional exceedance for chromium on October 5, 2000. The total chromium results on September 25 and October 5, 2000 were 0.0153 and 0.0121 mg/L, respectively. The FRL for hexavalent chromium is 0.010 mg/L. Hexavalent chromium is some fraction of total chromium, but because hexavalent chromium samples can only be held in the laboratory a short time before analysis, the analysis is performed for total chromium and the result is conservatively compared to the hexavalent chromium FRL. The copper result on September 25, 2000 was 0.0159 mg/L compared to the established FRL of 0.012 mg/L.

Investigation of these FRL exceedances has revealed no discernable causes. During the September 25, 2000 sampling event, no other drainages to Paddys Run were sampled. With no upstream results and no specific activity identified that would cause these exceedances, a specific cause cannot be identified. There were other drainages sampled during the sampling event on October 5, 2000. The total chromium result (0.00853 mg/L) at the Paddys Run background location (SWP-01) was in fact elevated compared to previous results. The other drainage location sampled on October 5, 2000 was SWD-03 with a chromium result of 0.0049 mg/L. These results fail to identify a cause for the October 5, 2000 chromium exceedance.

Given the data available and the field activities that occurred in 2000, no specific circumstance can be discerned that would explain these exceedances at SWP-03. Based on this information and the fact that there was no statistically significant trend, these exceedances are considered isolated events and do not indicate any significant impacts to the environment or operational problems with the FEMP's storm water and sediment control systems.

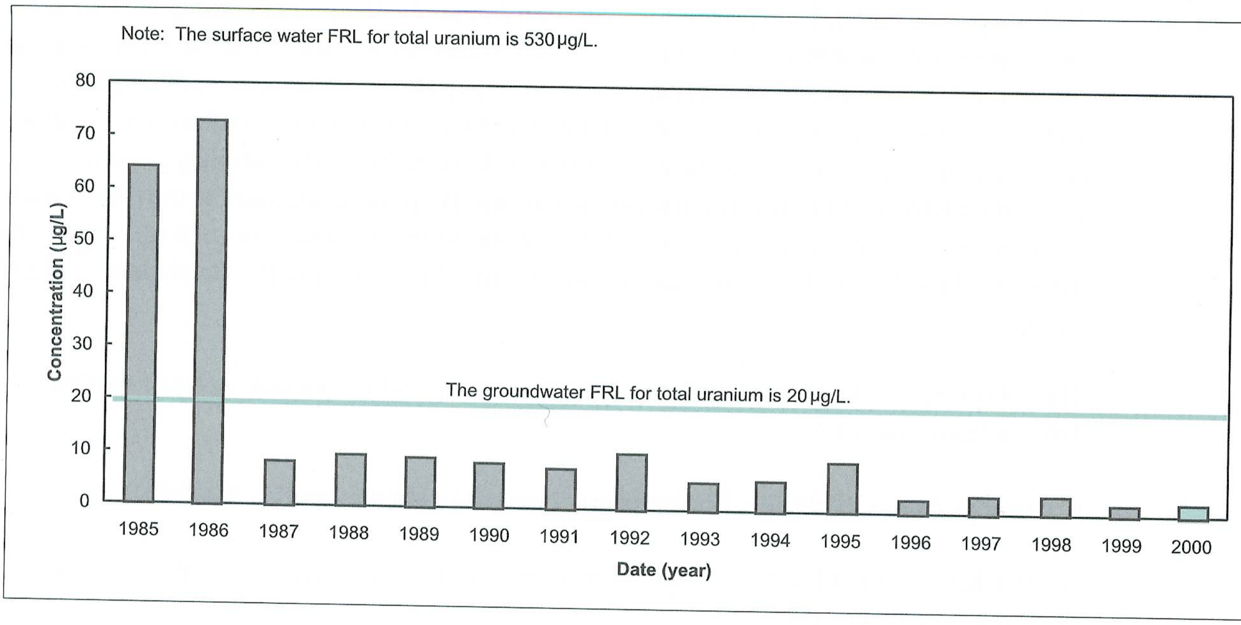

Figure 4-5. Annual Average Total Uranium Concentrations in Paddys Run at Willey Road (SWP-03) Sample Location, 1985 - 2000

The maximum total uranium concentration at SWP-03 during 2000 was 3.81µg/L, which was well below the surface water total uranium FRL of 530 µg/L. Figure 4-5 shows the annual average total uranium concentration in Paddys Run at Willey Road for the period 1985 through 2000. This figure illustrates the decrease of the total uranium concentration in Paddys Run from 1986 following completion of the Storm Water Retention Basin, which collects contaminated storm water from the former production area.

Samples collected at the Parshall Flume (PF 4001) are used in the surveillance evaluation because this is the last point treated effluent is sampled prior to discharge to the Great Miami River. Data collected from this location cannot directly be compared to the surface water FRL without considering the effect of the effluent waters mixing with the Great Miami River. This is done through the use of a mixing equation. There were six results at the Parshall Flume (PF 4001) for four constituents (chromium, copper, cyanide, and lead) that were above the established surface water FRL. After applying the mixing equation, these six results did not exceed their respective surface water FRL.

There were no surface water FRL or BTV exceedances in the Great Miami River outside the FEMP mixing zone during 2000. The maximum daily total uranium concentration at the Parshall Flume (PF 4001) prior to discharge through the effluent line to the Great Miami River was 174.1 µg/L. After the water from the Parshall Flume (PF 4001) mixed with the water in the Great Miami River, the concentration would have been approximately 5 µg/L. Both concentrations, those from the Parshall Flume (PF 4001) and after mixing with the Great Miami River, were well below the surface water total uranium FRL of 530 µg/L. Contaminant concentrations observed at the Parshall Flume (PF 4001) in 2000 are further discussed in the compliance monitoring section.

Evaluation of surface water data is also performed to provide an ongoing assessment of the potential for cross-media impacts from surface water to the underlying Great Miami Aquifer. In areas where there is no glacial overburden, a direct pathway exists for contaminants to reach the aquifer. This contaminant pathway to the aquifer was considered in the design of the groundwater remedy and includes placing groundwater extraction wells downgradient of these areas where direct infiltration occurs to mitigate any potential cross-media impacts during surface remediation. To provide this assessment, sample locations were selected to evaluate contaminant concentrations in surface water just upstream of, or within those areas where site drainages have eroded through the protective glacial overburden. Prior to 2000, these sample locations were SWP-02, SWD-02, and the Storm Water Retention Basin overflow (SWRB 4002O). However, locations SWD-03 and STRM 4005 have been added to this evaluation as they are considered to be in areas where infiltration to the aquifer is occurring. The significance of these locations was identified during the pre-design investigation for the waste storage area groundwater restoration module.

During 2000, four (STRM 4005, SWD-02, SWD-03, and SWRB 4002O) of the five surface water locations evaluated exceeded the total uranium groundwater FRL. Table 4-2 summarizes the total uranium cross-media exceedances. Only one (SWD-03) of the locations evaluated exceeded groundwater non-uranium FRLs, one for technetium-99 and two for zinc. The technetium-99 result of 113 pCi/L exceeded the groundwater FRL of 94 pCi/L while two results for zinc (0.126 mg/L and 0.0469 mg/L) exceeded the respective FRL of 0.02 mg/L.

TABLE 4-2
SURFACE WATER TOTAL URANIUM RESULTS EXCEEDING GROUNDWATER FRL AT CROSS-MEDIA IMPACT LOCATIONS DURING 2000

Location	Number of Surface Water Results Exceeding the Groundwater FRL for Total Uranium[a]	Total Number of Samples	Range of 2000 Data above FRL (μg/L)
STRM 4005	3	4	56.0 - 374
SWD-02	2	11	24.8 - 39.2
SWD-03	9	11	24.0 - 173
SWRB 4002O	1	1	253

[a]The surface water result is compared to the groundwater FRL of 20 μg/L for the purpose of evaluating potential cross-media impacts.

Both surface water and groundwater data from monitoring wells will continue to be collected at these sensitive areas under the IEMP to address the cross-media concern. Additional details concerning the cross-media impacts are presented in Appendix B, Attachment 1, of this report.

Compliance Monitoring

FFCA and Operable Unit 5 Record of Decision Compliance

The FEMP is required to monitor treated effluent discharges at the Parshall Flume (PF 4001) for total uranium mass discharges and total uranium concentrations. These requirements are identified in the July 1986 FFCA and the Operable Unit 5 Record of Decision. The Operable Unit 5 Record of Decision requires treatment of effluent so that the mass of total uranium discharged to the Great Miami River through the Parshall Flume (PF 4001) does not exceed 600 pounds (272 kg) per year. The Operable Unit 5 Record of Decision also requires that the monthly average total uranium concentration in the effluent must be at or below 20 μg/L. This 20 μg/L concentration limit became effective January 1, 1998. 000095

The Operable Unit 5 Record of Decision remedy allows the FEMP to discharge water from the Storm Water Retention Basin directly to the Great Miami River during periods of heavy precipitation. This is allowed in order to reduce the possibility of an overflow condition for the Storm Water Retention Basin. An overflow condition has the potential to generate cross-media impacts as described above. To comply with the 20 µg/L limit during these types of bypasses, the FEMP is allowed to deduct the concentration of uranium from the monthly average total uranium at the Parshall Flume (PF 4001) calculation for up to 10 significant precipitation bypass days per year. However, the mass of total uranium discharged during these 10 days per year is still considered in the total discharge mass to ensure the 600 pound (272 kg) per year discharge limit is not exceeded.

In addition to "significant precipitation" related bypasses, the FEMP is also allowed to bypass water from the Storm Water Retention Basin during certain scheduled wastewater treatment plant maintenance activities. The total uranium concentration in the discharge related to maintenance activities may be deducted from the monthly average calculation demonstrating compliance with the 20 µg/L concentration limit. However, the mass of total uranium discharged during these maintenance bypasses is still considered in the discharge mass to ensure compliance with the 600 pound (272 kg) discharge limit. These maintenance bypasses must be pre-approved by the regulatory agencies.

During 2000 there were two bypasses as a result of excessive precipitation, while no bypass events for maintenance were required. The storm water bypass event of January 3, 2000 also resulted in an overflow of the Storm Water Retention Basin. Table 4-3 summarizes these Storm Water Retention Basin treatment bypass events during 2000. Figure 4-6 shows that the cumulative mass of total uranium discharged to the Great Miami River during 2000 was 252 pounds (114 kg), which is well below the 600 pound (272 kg) annual limit. Figure 4-7 shows that the 20 µg/L concentration limit was met every month during 2000. Appendix B, Attachment 1, of this report provides more detail on the bypass days deleted from the monthly average calculation to determine compliance with the 20 µg/L limit.

TABLE 4-3
2000 STORM WATER RETENTION BASIN OVERFLOWS AND TREATMENT BYPASS EVENTS

Event	Duration (hours)	Number of Bypass Days[a]	Cumulative Number of Bypass Days	Total Uranium Discharged (pounds)	Total Water Discharged (millions of gallons)
Overflows				**(to Paddys Run)**	**(to Paddys Run)**
January 4	16.16	1	1	8.53	4.041
Significant Precipitation Bypasses				**(to Great Miami River)**	**(to Great Miami River)**
January 3 through January 5	39.67	1	1	4.19	2.455
February 18 through February 19	30.50	1	2	5.87	2.064

[a]Days are counted according to the definition provided in the Operations and Maintenance Master Plan for the Aquifer Restoration and Wastewater Project (DOE 1999).

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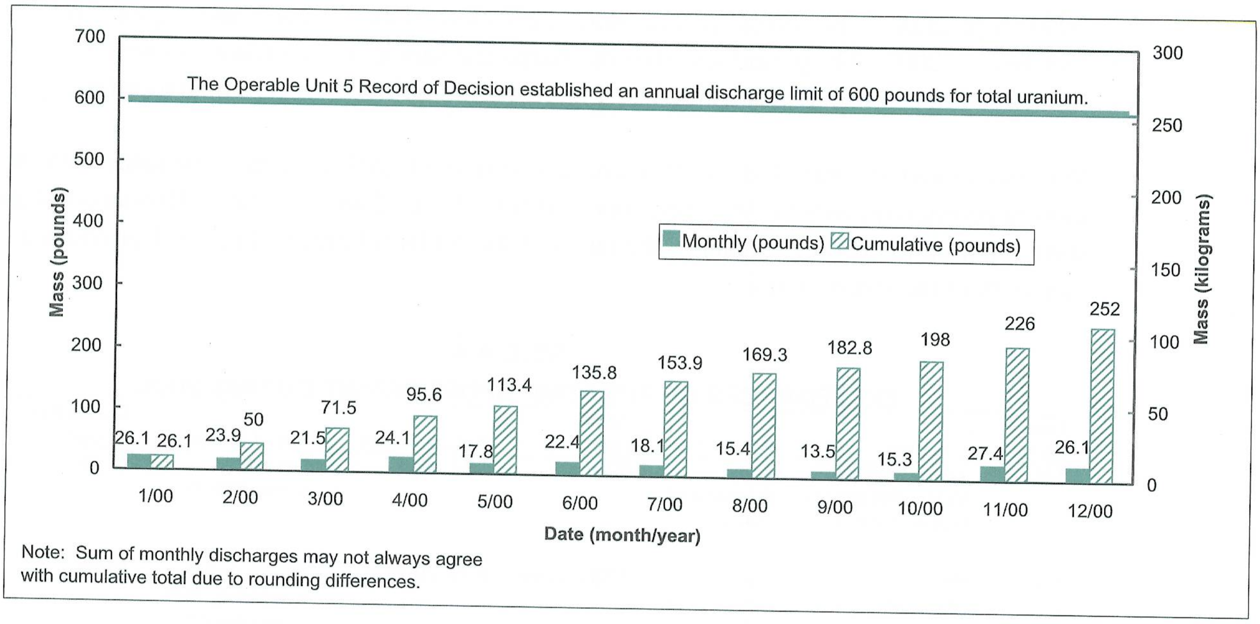

Figure 4-6. Pounds of Uranium Discharged to the Great Miami River from the Parshall Flume (PF 4001) in 2000

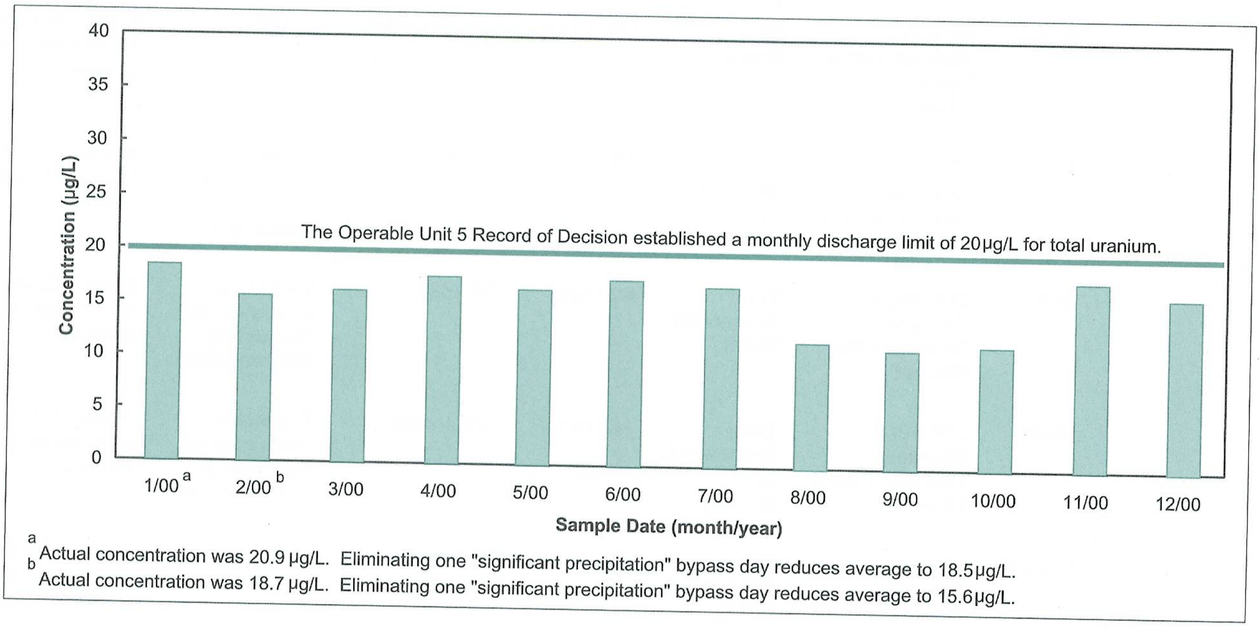

Figure 4-7. 2000 Monthly Average Total Uranium Concentration in Water Discharged from the Parshall Flume (PF 4001) to the Great Miami River

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NPDES Permit Compliance

Compliance sampling, consisting of sampling for non-radiological pollutants from uncontrolled runoff and treated effluent discharges from the FEMP, is regulated under the state-administrated NPDES program. The current permit became effective March 1, 2000, and expires on October 31, 2002. The permit specifies discharge and sample requirements, as well as discharge limits for several constituents. Figure 4-2 identifies NPDES sample locations.

Wastewater and uncontrolled runoff discharges from the FEMP were in compliance with the current permit requirements 99.8 percent of the time during 2000. A total of 10 noncompliances were reported to OEPA pursuant to the terms of the NPDES Permit. Table 4-4 provides a summary of these noncompliances.

TABLE 4-4

EXCEEDANCES OF THE FEMP NPDES PERMIT DURING 2000

Date/ Month	Location	Parameter	Permit Limit	Actual Result	Possible Cause	Corrective Action
1/3	40020 (Storm Water Retention Basin Overflow)	Total Suspended Solids	50 mg/L	134 mg/L	Excessive precipitation	None
1/4	PF 4001 (Parshall Flume-Treated Effluent)	Total Suspended Solids	473 kg/day	933.79 kg/day	Storm water bypassing due to excessive precipitation	None
3/17	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	105 kg/day	177.4 kg/day	Unknown	None. Continue to monitor and observe
3/20	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	42 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
3/22	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	105 kg/day	120.8 kg/day	Unknown	None. Continue to monitor and observe
March	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (average)	20 mg/L	28.3 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
4/3	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	55 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
April	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (average)	20 mg/L	23.3 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
10/26	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	41 mg/L	Unknown	None. Continue to monitor and observe
12/6	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	48.8 mg/L	Operator error in valve adjustment	Corrected valve alignment

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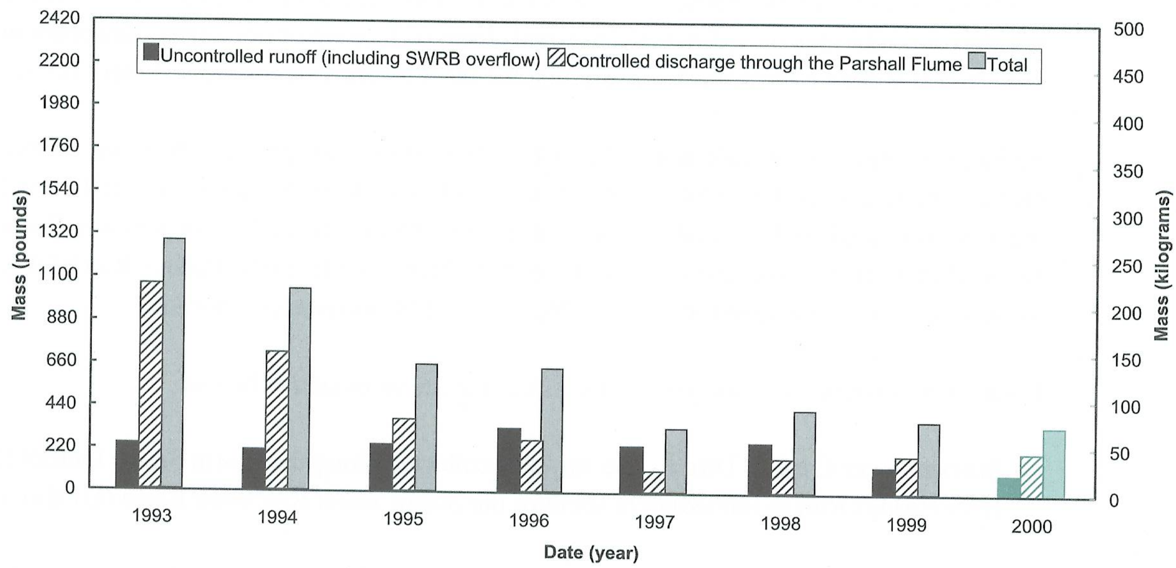

Figure 4-8. Uranium Discharged from the FEMP Via the Surface Water Pathway, 1993 - 2000

Uranium Discharges in Surface Water and Treated Effluent

As identified in Figure 4-6, 252 pounds (114 kg) of uranium in treated effluent were discharged to the Great Miami River through the Parshall Flume (PF 4001) in 2000. In addition to the treated effluent, uncontrolled runoff is also contributing to the amount of uranium entering the environment. Figure 4-8 presents the pounds of uranium from the uncontrolled runoff and controlled discharges from 1993 through 2000.

Beginning in 1999, estimates of uncontrolled runoff have been calculated using a loading term of 2.6 pounds (1.2 kg) of uranium discharged to Paddys Run for every inch (2.54 cm) of rainfall. This term was revised in 1999 based on analytical data reflecting the decreasing total uranium concentrations measured at points discharging to Paddys Run. Total uranium concentrations have been decreasing due to significant improvements in the capture of contaminated storm water by the Pilot Plant Drainage Sump, southern waste unit surface water control system, and excavation and placement of contaminated soils into the on-site disposal facility.

During 2000, 44.75 inches (113.7 cm) of precipitation fell at the FEMP; therefore, it is estimated that approximately 116 pounds (53 kg) of uranium entered the environment through uncontrolled runoff. (This significant reduction in uranium in uncontrolled runoff is largely attributed to using the revised loading term for the entire year. The 1999 estimate of 186 pounds was based on using the previous loading term of 6.25 pounds [2.84 kg] of uranium per inch of rainfall for nine of the 12 months in 1999). In addition, there was one overflow at the Storm Water Retention Basin during 2000, resulting in an additional 8.5 pounds (3.9 kg) of uranium contributed by this source.

The estimated total amount of uranium discharged to the surface water pathway for the year, including both controlled treated effluent discharges and uncontrolled runoff, was approximately 376 pounds (171 kg).

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Sediment Monitoring

Sediment is a secondary exposure pathway and is monitored annually to assess the impact of remediation activities on sediments deposited along surface water drainages. Sediment is collected at strategic locations to ensure that the most recently deposited sediment is collected.

Sediment samples were collected in August at 16 locations along Paddys Run, the Storm Sewer Outfall Ditch, and the Great Miami River (refer to Figure 4-9). Samples collected at each location were analyzed for total uranium. Samples collected from the Storm Sewer Outfall Ditch, Paddys Run (north and south of the outfall ditch), and from the Paddys Run background location were also analyzed for radium-226, radium-228, and isotopic thorium.

Figure 4-9 illustrates specific sample locations that are summarized below:

- **Storm Sewer Outfall Ditch**: five samples collected along the Storm Sewer Outfall Ditch from Paddys Run to immediately south of the Storm Water Retention Basin (D1 through D5)

- **Paddys Run**: five samples collected north of the confluence with the Storm Sewer Outfall Ditch (PN1 through PN5), three samples collected south of the confluence (PS1 through PS3), and one background sample collected north of the site (P1)

- **Great Miami River**: one sample collected north of the effluent line (background location, G2) and one sample collected south of the effluent line (G4).

Analytical results of samples collected from the Storm Sewer Outfall Ditch, Paddys Run, and the Great Miami River from 2000 are presented in Table 4-5 and were below the FRL for total uranium, isotopic thorium, radium-226, and radium-228. In comparison to 1999 data, there was a slight increase in average concentrations of thorium-228, thorium-230, thorium-232, and total uranium at the northern locations in Paddys Run. However, there was also an increase in radium-226, thorium-230, and thorium-232 at the Paddys Run background location. Furthermore, all results are within the range of historical background levels.

Monitoring of sediment will continue under the IEMP to determine the effectiveness of the engineered controls designed to reduce erosion from the FEMP and sedimentation of Paddys Run and its tributaries. Appendix B, Attachment 2, of this report contains additional details of the sediment monitoring results.

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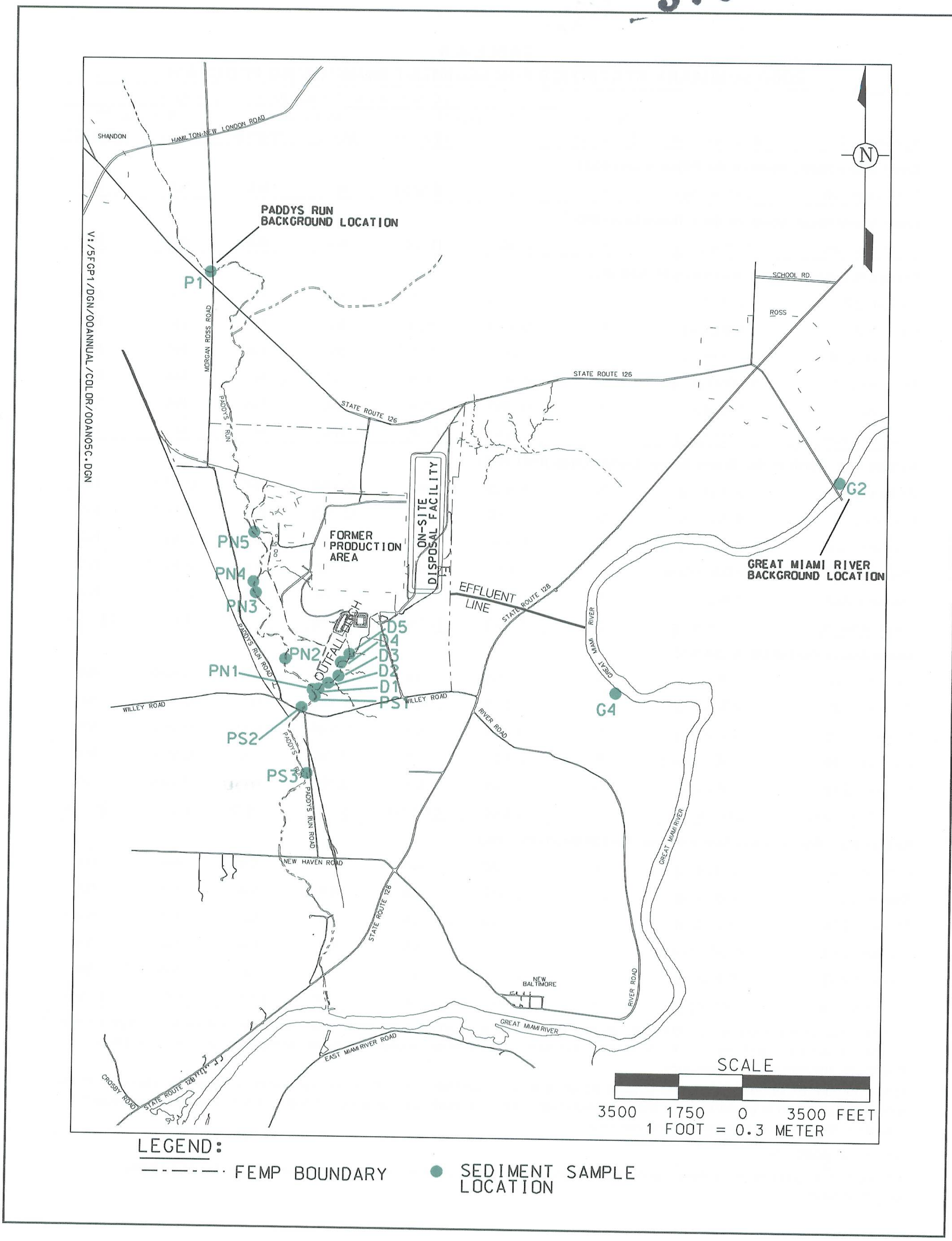

Figure 4-9. 2000 Sediment Sample Locations

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TABLE 4-5
2000 SUMMARY STATISTICS FOR SEDIMENT MONITORING PROGRAM

			2000 Results - Concentration (dry weight)					
		No. of	Minimum[a,b,c,d]		Maximum[a,b,c]		Average[a,b,c,d]	
Radionuclide	Sediment FRL	Samples[a]	pCi/g	(mg/kg)	pCi/g	(mg/kg)	pCi/g	(mg/kg)
Great Miami River, North of the Effluent Line (G2)								
Total Uranium	210 mg/kg	1	1.353	(2.002)	NA	NA	NA	NA
Great Miami River, South of the Effluent Line (G4)								
Total Uranium	210 mg/kg	1	0.909	(1.34)	NA	NA	NA	NA
Paddys Run Background, North of S.R. 126 (P1)								
Radium-226	2.9 pCi/g	1	0.504	NA	NA	NA	NA	NA
Radium-228	4.8 pCi/g	1	0.373	NA	NA	NA	NA	NA
Thorium-228	3.2 pCi/g	1	0.383	NA	NA	NA	NA	NA
Thorium-230	18,000 pCi/g	1	0.930	NA	NA	NA	NA	NA
Thorium-232	1.6 pCi/g	1	0.381	NA	NA	NA	NA	NA
Total Uranium	210 mg/kg	1	0.944	(1.40)	NA	NA	NA	NA
Paddys Run, North of the Storm Sewer Outfall Ditch (PN1-PN5)								
Radium-226	2.9 pCi/g	5	0.523	NA	0.786	NA	0.670	NA
Radium-228	4.8 pCi/g	5	0.289	NA	0.745	NA	0.500	NA
Thorium-228	3.2 pCi/g	5	0.344	NA	0.999	NA	0.529	NA
Thorium-230	18,000 pCi/g	5	0.637	NA	1.12	NA	0.924	NA
Thorium-232	1.6 pCi/g	5	0.214	NA	1.06	NA	0.538	NA
Total Uranium	210 mg/kg	5	1.043	(1.544)	8.056	(11.92)	2.651	(3.923)
Storm Sewer Outfall Ditch (D1-D5)								
Radium-226	2.9 pCi/g	5	0.498	NA	0.924	NA	0.630	NA
Radium-228	4.8 pCi/g	5	0.271	NA	0.769	NA	0.442	NA
Thorium-228	3.2 pCi/g	5	0.114	NA	0.585	NA	0.352	NA
Thorium-230	18,000 pCi/g	5	0.621	NA	1.38	NA	0.912	NA
Thorium-232	1.6 pCi/g	5	0.154	NA	0.688	NA	0.320	NA
Total Uranium	210 mg/kg	5	1.086	(1.607)	5.035	(7.452)	2.090	(3.093)
Paddys Run, South of the Storm Sewer Outfall Ditch (PS1-PS3)								
Radium-226	2.9 pCi/g	1	0.538	NA	NA	NA	NA	NA
Radium-228	4.8 pCi/g	1	0.317	NA	NA	NA	NA	NA
Thorium-228	3.2 pCi/g	1	0.263	NA	NA	NA	NA	NA
Thorium-230	18,000 pCi/g	1	0.933	NA	NA	NA	NA	NA
Thorium-232	1.6 pCi/g	1	0.325	NA	NA	NA	NA	NA
Total Uranium	210 mg/kg	3	0.982	(1.45)	1.055	(1.562)	1.02	(1.52)

[a]If more than one sample is collected per sample location (e.g., split or duplicate), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, and average).

[b]If the number of samples is greater than or equal to three, then the minimum, maximum, and average are reported. If the number of samples is equal to two, then the minimum and maximum are reported. If the number of samples is equal to one, then the result is reported as the minimum.

[c]NA = not applicable

[d]Where concentrations are below the detection limit, each result used in the summary statistics is set at half the detection limit.

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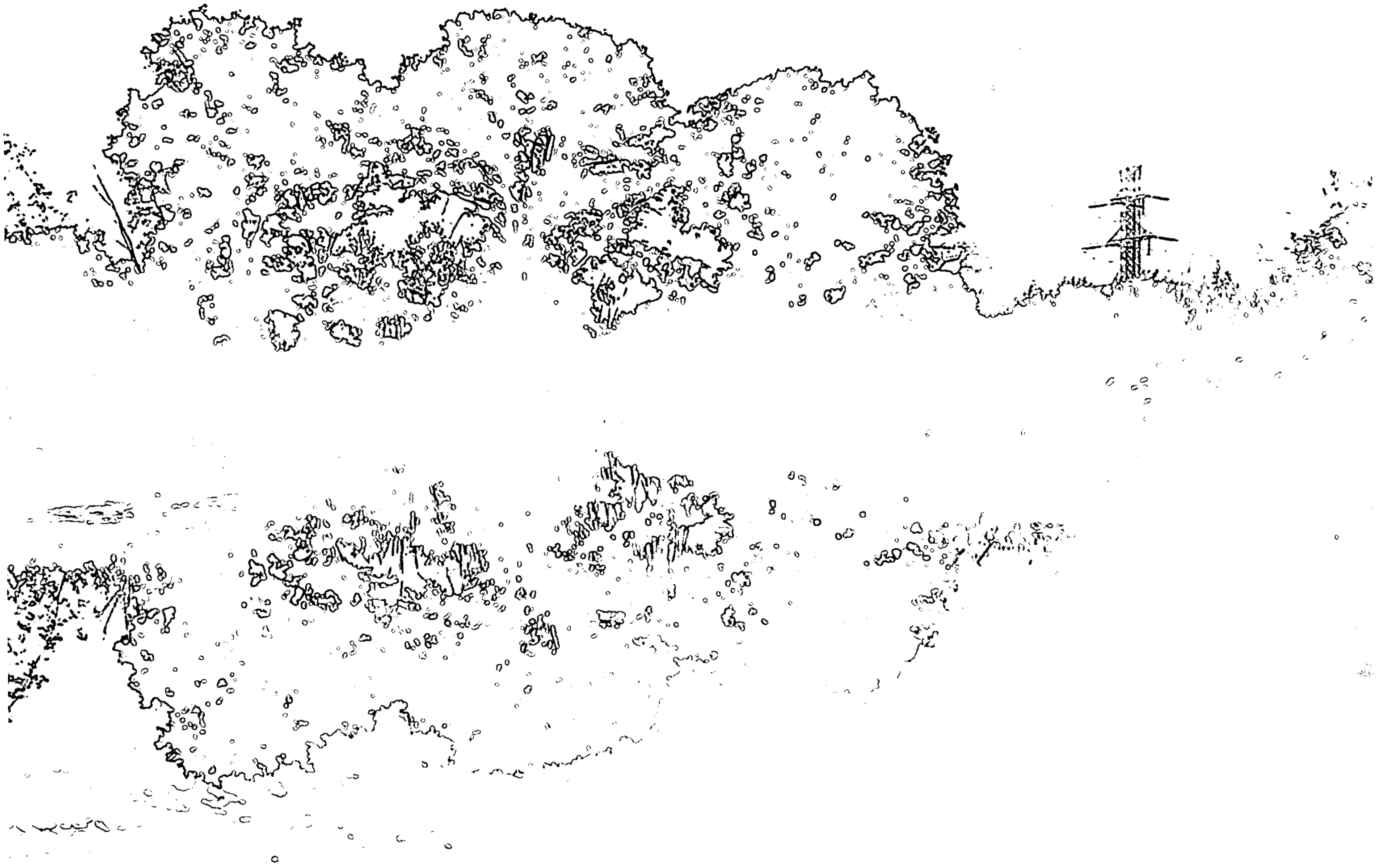
Chapter 5
Air Pathway



Air Pathway

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This chapter describes the air pathway components used to track and trend airborne emissions from the FEMP. It includes a discussion of radiological air particulates, radon, direct radiation, and biota (produce) monitoring. In addition, this chapter provides a summary of radiological emissions from stacks and vents, as well as non-radiological emissions associated with boiler plant operations at the FEMP.

Results in Brief: 2000 Air Pathway

Radiological Air Particulates - Data collected from fenceline air monitoring stations show that average concentrations for each radionuclide monitored were less than one percent of the corresponding DOE-derived concentration guide.

Radon - There were no exceedances of the DOE standard (3 pCi/L annual average above background) at the FEMP fenceline and off-property locations. The maximum annual average concentration at the FEMP fenceline measured by continuous radon monitors was 0.4 pCi/L above background.

Direct Radiation - Direct radiation measurements increased slightly at the FEMP fenceline and the K-65 Silos boundary when compared to 1999. However, these levels are still approximately 53 percent lower than the radiation levels measured in 1991 prior to the addition of the bentonite layer within the K-65 Silos. These measurements are consistent with the fact that the K-65 Silos contain radium and its decay products, which contribute to direct radiation levels.

Produce - Total uranium concentrations in produce were consistent with previous years' data. Radium-226 and radium-228 were not detectable in any samples, and thorium-230 was not detectable in the majority of samples. The results suggest that there is no substantial impact from past or current FEMP emissions on produce grown in the area.

Boiler Plant - There were no opacity excursions reported during 2000.

As discussed in Chapter 1, the public may be exposed to radiation from the FEMP through the air pathway. This pathway includes emissions from specific point sources, such as plant stacks, as well as fugitive dust from soil excavations and other remediation activities. When production operations were suspended in July of 1989, the major point source emissions from the FEMP were eliminated. Since then, the principal sources of airborne emissions have been fugitive dust from environmental remediation activities, laboratory fume hoods, which contain low levels of uranium, and wind blown fugitive dust.

Air pathway monitoring focuses on airborne pollutants that may be carried from the FEMP as a particulate or gas and how these pollutants are distributed in the environment. The physical form and chemical composition of pollutants influence how they are dispersed in the environment and how they may deliver radiation doses. For example, fine particles and gases remain suspended, while larger, heavier particles tend to settle and deposit on the ground. Chemical properties determine whether the pollutant will dissolve in water, be absorbed by plants and animals, or settle in sediment and soil.

Monitoring the air pathway is critical to ensuring the continued protection of the public and environment during the remediation process because airborne contaminants can potentially migrate from the FEMP quickly and affect a large number of people. The FEMP's air monitoring approach (presented in the IEMP) provides an ongoing assessment of the collective emissions originating from remediation activities. The results of this assessment are used to provide feedback to remediation project organizations regarding the sitewide effectiveness of project-specific emission controls relative to DOE, EPA, and OEPA standards. In response to this feedback, project organizations modify or maintain emission controls.

Remediation Activities Affecting the Air Pathway

When the mission of the FEMP changed from production to remediation, work activities also changed. This change in work scope changed the characteristics of sources that emit pollutants in the environment via the air pathway. During the production years, the primary emission sources were point source]s (i.e., stacks and vents) from process facilities. Today, the dominant emission sources are associated with remediation activities (i.e., excavation and hauling of contaminated soil, demolition of production facilities, and general construction activities supporting the remediation process) and the storage of radon generating waste materials.

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The following primary emission sources were active during 2000:

- Excavation of contaminated soil and debris (Operable Units 2 and 5)
- Construction activities associated with the on-site disposal facility including excavation, screening, and hauling activities in the on-site disposal facility borrow area (Operable Unit 2)
- Transportation and placement of contaminated material in the on-site disposal facility and interim storage at the on-site material transfer area (Operable Unit 2)
- Plant 5 Decontamination and Dismantlement Project (Operable Unit 3)
- Radon and direct radiation emissions from the K-65 Silos (Operable Unit 4)
- Excavation of the waste pits and the associated waste processing and rail car load-out operations at the Waste Pits Remedial Action Project (Operable Unit 1).

Each project is responsible for designing and implementing administrative and engineered controls for each remediation activity. The FEMP fugitive emissions control policy mandates that fugitive emissions be visually monitored and controls be implemented as necessary. The following types of controls are used at the FEMP to keep point source and fugitive emissions to a minimum.

- Administrative Controls - typical administrative controls include management and control procedures, record keeping, periodic assessments, and establishing speed limits; control zones; and construction zones.
- Engineered Controls - typical engineered controls include physical barriers; wetting agents; control, collection, and treatment systems; filtration; fixatives; sealants; and dust suppressants. Engineered designs help reduce point source and fugitive emissions by using the best available technology. The selection of the best available technology for controlling project emissions is conducted during the design process and frequently includes the evaluation of several treatment alternatives.

Air Highlights for 2000

The FEMP's air monitoring program, as defined in the IEMP, is comprised of three distinct components:

- Radiological air particulate monitoring
- Radon monitoring
- Direct radiation monitoring.

Each component of the air monitoring program is designed to address a unique aspect of air pathway monitoring, and as such, reflects distinct sampling methodologies and analytical procedures. The key elements of the air monitoring program design are:

- **Sampling** - Sample locations, frequency, and the constituents were selected to address DOE and EPA requirements for assessing radiological emissions from the site. Key considerations in the design of the sampling program included prevailing wind directions, location of potential sources of emissions, and the location of off-property receptors. The IEMP program includes monitoring radiological air particulates at 19 locations, radon measurements at 34 locations, and direct radiation at 32 locations on and off the FEMP property.

- **Data Evaluation** - The data evaluation process focuses on tracking and trending data against historical ranges and DOE, EPA, and OEPA standards. Each section in this chapter presents an evaluation of data and a comparison to applicable standards and guidelines.

- **Reporting** - All data are reported through IEMP quarterly reports and annual integrated site environmental reports. The addition of quarterly reporting provides more timely information to the remediation projects, regulatory agencies, and FEMP stakeholders.

Radiological Air Particulate Sampling Results

As described in the IEMP, the FEMP utilizes a network of 19 high volume air particulate monitoring stations to measure the collective contributions from all fugitive and point source particulate emissions from the site. This monitoring network includes 16 monitoring locations on the FEMP fenceline and two background locations. In addition, two thorium monitors were operated through September 2000. With the inclusion of biweeky isotopic thorium sampling at all fenceline monitors beginning in the fourth quarter of 2000, one thorium monitor became redundant and was removed from service. Figure 5-1 provides the locations of the IEMP air monitoring stations.

The sampling and analysis program for the 16 fenceline and two background locations consists of biweekly total uranium, isotopic thorium, and particulate analyses and a quarterly composite sample analyzed for the expected major contributors (i.e., uranium, thorium, and radium) to the radiological air inhalation dose from the site. The analytical data from this program are used to assess the effectiveness of the FEMP's emission control practices throughout the year to ensure particulate emissions remain below health protective standards.

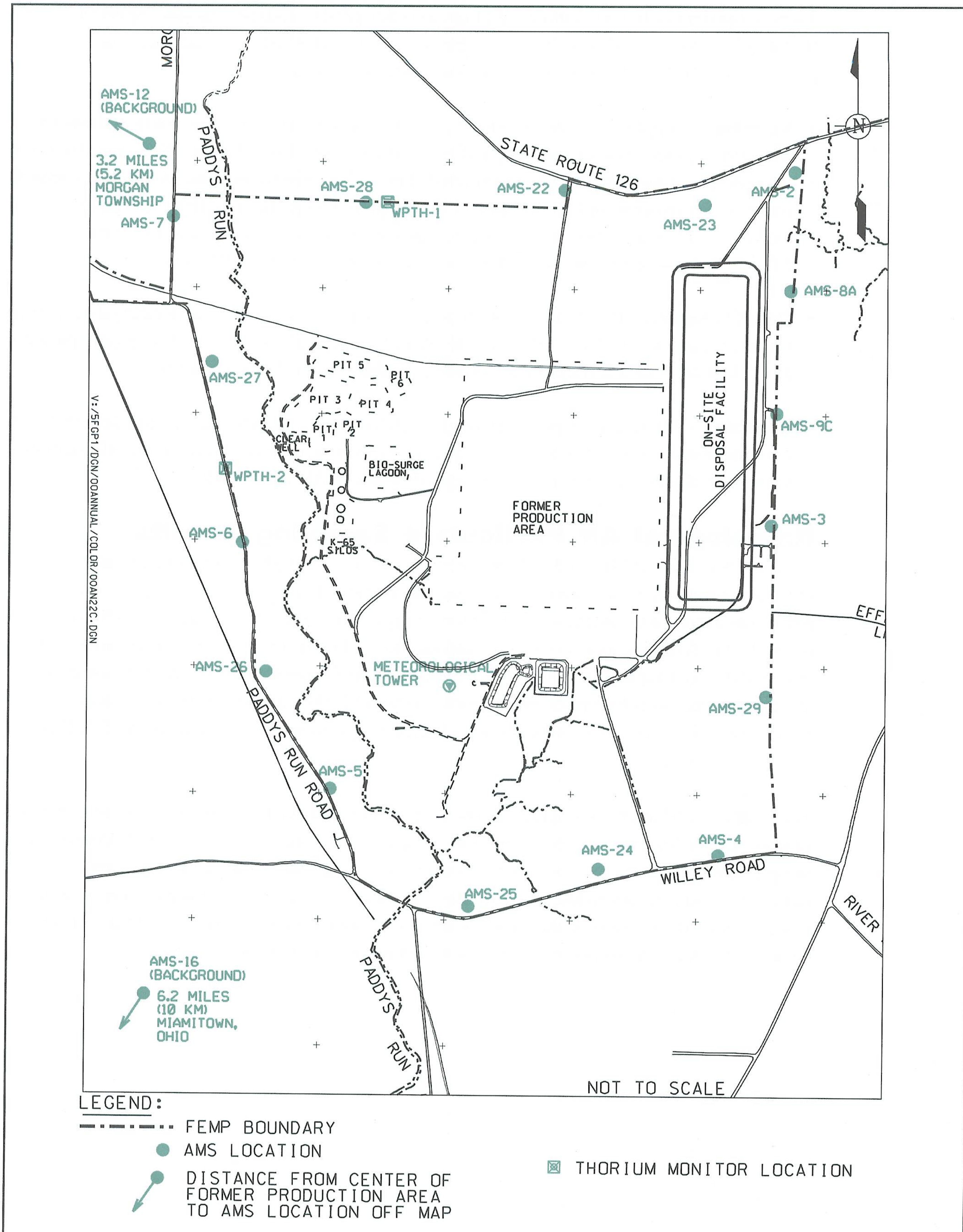

Figure 5-1. Radiological Air Monitoring Locations

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The radiological air particulate monitoring program is designed to demonstrate compliance with the following:

- National Emissions Standards for Hazardous Air Pollutant (NESHAP) Subpart H requirements which stipulate that radionuclide emissions to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem in a year above background. This dose is reported in the annual NESHAP Subpart H compliance report and is included as Appendix D of this report.

- DOE Order 5400.5, Radiation Protection of the Public and Environment, establishes guidelines for concentrations of radionuclides in air emissions. These guidelines, referred to as derived concentration guide values, are concentrations of radionuclides that, under conditions of continuous exposure for one year by one exposure mode (e.g., inhalation, ingestion) would result in a dose of 100 mrem to the public. These derived concentration guide values are not limits, but serve as reference values to assist in evaluating the radiological air particulate data.

Table 5-1 presents a summary of the minimum, maximum, and average concentrations for total uranium, thorium-230 and total particulate in 2000 and 1999. The annual average concentrations of total uranium at all fenceline air monitoring stations were less than one percent of the DOE-derived concentration guide value (0.1 picoCuries per cubic meter [pCi/m^3]). In 2000 total uranium at all air monitoring locations ranged from less than detectable concentrations to a maximum concentration of 9.9E-04 pCi/m^3 at AMS-3. For comparison, background locations ranged from less than detectable to 1.4E-04 pCi/m^3 at AMS-16.

TABLE 5-1
TOTAL URANIUM, TOTAL PARTICULATE, AND THORIUM-230 CONCENTRATIONS IN AIR FOR 1999 AND 2000

Location	2000 Total Uranium (pCi/m^3)	1999 Total Uranium (pCi/m^3)	2000 Total Particulate (μg/m^3)	1999 Total Particulate (μg/m^3)	2000 Thorium-230[a] (pCi/m^3)	1999 Thorium-230[a] (pCi/m^3)
Fenceline Locations						
Minimum	0.0E+00	0.0E+00	5.4	11	2.4E-05	1.1E-05
Maximum	9.9E-04	1.1E-03	72	92	1.9E-04	2.5E-05
Average	8.5E-05	5.3E-05	31	35	6.1E-05	1.8E-05
Background Locations						
Minimum	0.0E+00	0.0E+00	17	16	6.1E-06	6.4E-06
Maximum	1.4E-04	4.5E-05	52	61	8.9E-06	1.4E-05
Average	1.6E-05	1.2E-05	33	36	7.5E-06	1.0E-05

[a]Data from composite results.

Biweekly thorium analysis was initiated in the fourth quarter of 2000 in response to evolving work activities and dose contributions from thorium isotopes generated from the Waste Pits Remedial Action Project. Biweekly thorium monitoring at the fenceline provides timely feedback on project engineering and administrative controls that are implemented to control fugitive emissions. The fenceline annual average concentrations of thorium-230, the primary thorium isotope of concern in the waste pit material excavated to date, ranged from 2.4E-05 to 1.9E-04 pCi/m^3, which was detected at the AMS-3 monitoring location.

In addition to the total uranium and isotopic thorium analyses, total particulate measurements are obtained from each filter every two weeks as summarized in Table 5-1. Total particulate concentrations ranged from 5.4 micrograms per cubic meter (μg/m^3) to a maximum of 72 μg/m^3 at AMS-27. There are no general or site-specific regulatory limits associated with total particulate measurements used in the data evaluation process.

Total particulate, total uranium, and thorium-230 data were collectively evaluated to identify any increasing trends that may be related to remediation activities. Several temporary increases of these three constituents were observed at various monitoring locations, however the short-lived increases did not pose a potential exceedance of the NESHAP dose limit or DOE guidelines. The majority of increases in total uranium and thorium-230 concentrations were detected at some of the air monitoring stations on the eastern fenceline (AMS-3, AMS-8A, and AMS-9C) during the last quarter of 2000, but also throughout the year on a less frequent basis. Figures 5-2 and 5-3 show total uranium and thorium concentrations, respectively, at the selected eastern fenceline locations. These temporary increases were due to the remediation activities associated with the Waste Pits Remedial Action Project, on-site disposal facility and its associated material transfer area, and the Plant 5 Decontamination and Dismantlement Project. The radiological air particulate data are routinely discussed with the remediation projects to ensure that emission controls are operating as expected and to consider actions as necessary. Appendix C, Attachment 1, of this report provides graphical displays of the 2000 total uranium, thorium-230, and total particulate data.

Quarterly composite air filter samples were formed from the biweekly samples at each air monitoring station during 2000 to determine the radiological air inhalation dose for each location. The samples were analyzed for isotopes of radium, thorium, and uranium. The quarterly results were used to track compliance with the NESHAP 10 mrem dose limit throughout the year and to demonstrate compliance with the limit at the end of 2000. The maximum dose associated with the quarterly composite results for 2000 was 1.1 mrem, compared to the 10 mrem limit, and occurred at AMS-3. Chapter 6 and Appendix D of this report provide more detailed information on the dose associated with the composite results.

The annual average radionuclide concentrations at each air monitoring station, which were determined from the quarterly composite results, were compared to the DOE-derived concentration guide values. At each monitoring station, the annual average radionuclide concentrations were below one percent of the corresponding DOE-derived concentration guide values. The results from the fenceline monitors show that, on average, uranium isotopes contribute 25 percent of the dose from 2000 airborne emissions. Isotopes of thorium and radium account for 52 and 22 percent of the dose, respectively. This is a departure from historical FEMP emission patterns in which uranium was the major dose contributor, typically contributing greater than 62 percent of the dose. The decrease in the percentage of dose from uranium is a result of thorium-230 becoming the major dose contributor through fugitive emissions from the Waste Pits Remedial Action Project operations. Given the methods required to excavate, transport, and process waste pit material, fugitive emissions were expected to increase the average concentration of thorium-230 at the fenceline. Although the project employs several environmental compliance-based dust abatement practices and controls, some fugitive emissions are expected to be generated from the project based on the large-scale waste handling operations.

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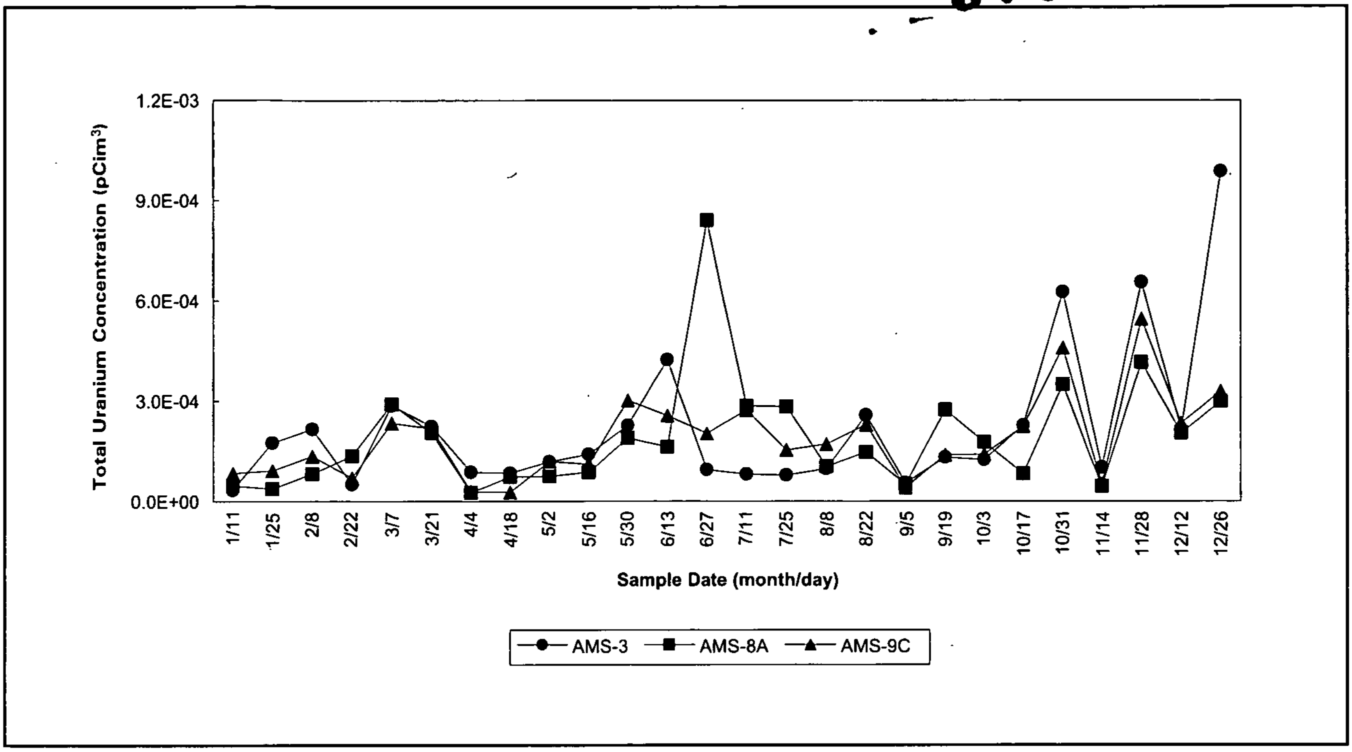

Figure 5-2. 2000 Total Uranium Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

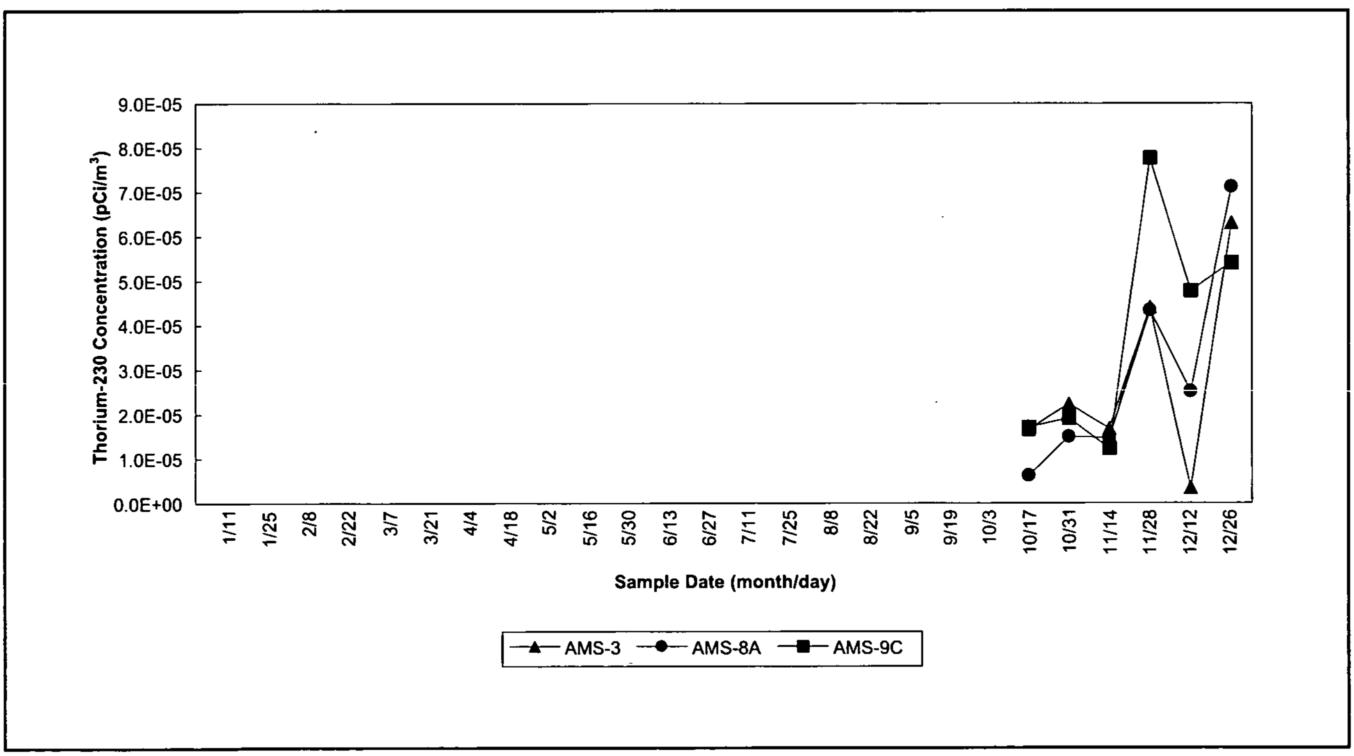

Figure 5-3. 2000 Thorium-230 Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

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The WPTH-1 and WPTH-2 fenceline monitoring locations were installed in 1998 to specifically monitor thorium emissions from the Waste Pits Remedial Action Project on a biweekly basis. Airborne concentrations of thorium-228 and thorium-232 measured at WPTH-1 and WPTH-2 were comparable to background concentrations throughout 2000. This fenceline data reflect the fact that, in comparison to thorium-230, the concentrations of thorium-228 and thorium-232 in the waste pit material are relatively low thus far into the excavation of waste. The Waste Pits Remedial Action Project operations are not expected to significantly impact the fenceline concentrations of thorium-228 and thorium-232. With the initiation of biweekly thorium measurements at all fenceline monitors in October 2000, the WPTH-1 monitor was removed since biweekly thorium measurements were started at AMS-28, which was adjacent to WPTH-1. Appendix C, Attachment 1, of this report provides graphical displays of the isotopic thorium data from the WPTH-1 and WPTH-2 monitors.

Radon Monitoring

Radon-222 (referred to in this section as radon) is a naturally occurring radioactive gas. It is produced by radioactive decay of radium-226, which can be found in varying concentrations in the earth's crust. Radon is also chemically inert, and tends to diffuse from the earth's crust to the atmosphere. The concentration of radon in the environment is dynamic and exhibits daily, seasonal, and annual variability.

Many factors influence the concentration of radon in the environment, including the distribution of radium-226 in the ground, porosity of the soil, weather conditions, etc. For instance, radon diffusion from the ground is minimized by the presence of precipitation and snow cover. Alternatively, elevated temperatures and the absence of precipitation can produce cracks in the ground and changes in porosity that increase the rate at which radon escapes. Summary level meteorological data from 2000 are presented in Appendix C, Attachment 5, and Figures 1-7 through 1-10 of this report.

Environmental radon concentrations are also influenced by atmospheric conditions. During periods of calm winds and temperature inversions (the air near the earth's surface is cooler than the air above it), air is held near the earth's surface, minimizing the mixing of air. Consequently, when these inversions occur, radon's movement is limited vertically, and concentrations tend to increase near the ground.

Waste material that produces radon is also stored at the FEMP. This waste was generated from uranium extraction processes performed decades ago and contains radium-226. This material is contained in K-65 Silos 1 and 2 and Silo 3 (part of the Operable Unit 4 remediation) and waste pits (presently being remediated per the Operable Unit 1 Record of Decision).

DOE Order 5400.5, Radiation Protection of the Public and the Environment, defines radiological protection requirements, guidelines for cleanup of residual radioactive material, management of resulting wastes and residues, and the release of radiological property. Radon limits above interim storage facilities (such as the FEMP) are also defined under DOE Order 5400.5 and must not exceed:

- 100 pCi/L at any given location and any given time
- Annual average concentration of 30 pCi/L (above background) over the facility
- Annual average concentration of 3 pCi/L (above background) at and beyond the facility fenceline.

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In 2000 an expanded continuous radon-monitoring network was used for determining compliance with the above limits. Figure 5-4 illustrates the radon-monitoring network. The continuous radon-monitoring network was expanded in preparation for the Accelerated Waste Retrieval Project which focuses on removing and temporarily storing the contents of the K-65 Silos and also includes construction of a new radon control system. These changes to the radon-monitoring network were approved by the EPA and OEPA and documented in the IEMP. The continuous monitoring network provides for more frequent feedback to remediation projects, regulatory agencies, and FEMP stakeholders on trends in ambient radon concentrations, while providing sufficient radon monitoring to ensure compliance with DOE Order 5400.5 requirements. Access to real-time radon monitoring data from selected continuous radon monitoring locations is available at the FEMP Public Environmental Information Center.

In general, monitoring locations were selected near radon-emitting sources, at the FEMP property fenceline, and at background locations. The FFA identifies additional environmental radon monitoring locations, as well as continuous measurement of radon concentrations in the headspace of the K-65 Silos. DOE guidance and EPA air monitor siting criteria were considered when selecting monitoring locations.

Continuous Alpha Scintillation Detectors

Alpha scintillation detectors use scintillation cells to continuously monitor environmental radon concentrations based on an hourly average. Radon gas in ambient air diffuses into the scintillation cell through a foam barrier without the aid of a pump (this technique is called passive sampling). Inside the cell, radon decays into more radioactive material (daughter products), which give off alpha particles. The alpha particles interact with the scintillation material inside the cell, producing light pulses. The light pulses are amplified and counted. The number of light pulses counted is proportional to the radon concentration inside the cell.

Continuous monitors reveal important information regarding the dynamics of radon concentrations at different times during the day and at various locations on and off site. These monitors allow for timely review of radon concentrations, which may indicate concentrations are significantly changing from day to day and week to week. However, the use of these monitors is restricted by certain conditions. For example, potential monitoring sites are limited by the availability of electricity.

Table 5-2 provides monthly average radon concentration data from the continuous radon monitors for 2000. The data are used to track radon concentrations through the year to ensure the DOE limits are not exceeded. In addition to the summary data presented here, Appendix C, Attachment 2, of this report provides graphical displays of monthly average radon concentrations from continuous radon monitors during 2000 and 1999.

Results from the fenceline monitoring locations indicate radon levels for 2000 were within historical ranges and well below the DOE limit of 3 pCi/L above background. The range of annual average concentrations at the fenceline was 0.2 to 0.6 pCi/L. The range of annual average background radon concentrations was 0.2 to 0.3 pCi/L. A review of site fenceline data suggests that during 2000, the Waste Pits Remedial Action Project operations did not significantly impact the radon concentrations at the site fenceline (refer to Table 5-2).

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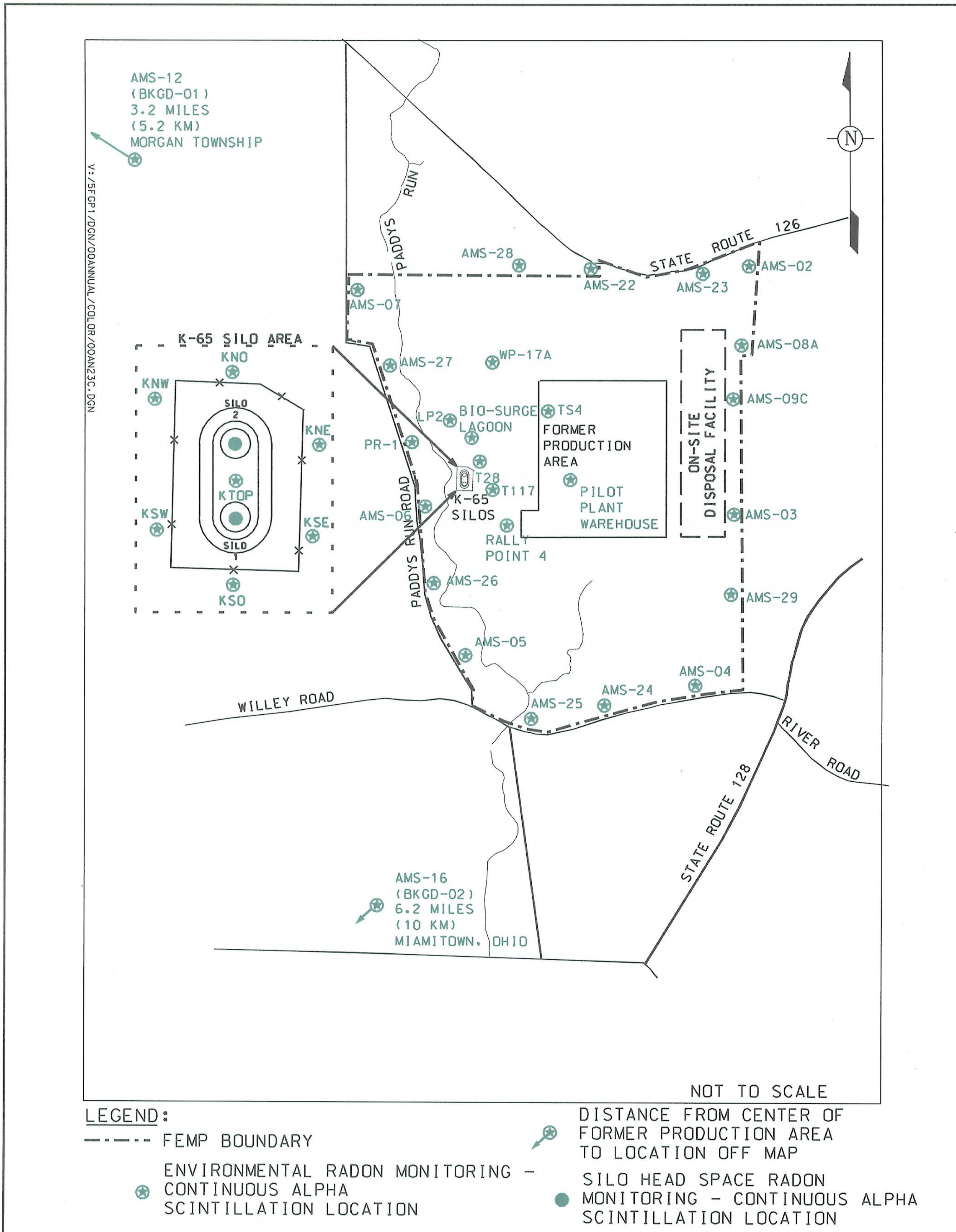

Figure 5-4. Radon Monitoring - Continuous Alpha Scintillation Locations

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TABLE 5-2
CONTINUOUS ENVIRONMENTAL RADON MONITORING
MONTHLY AVERAGE CONCENTRATIONS[a]

Location[b]	2000 Summary Results[c] (Instrument Background Corrected) (pCi/L) Min.	Max.	Avg.	1999 Summary Results[c,d] (Instrument Background Corrected) (pCi/L) Min.	Max.	Avg.
Fenceline						
AMS-02	0.2	0.6	0.4	0.2	1.0	0.5
AMS-03	0.3	1.0	0.6	0.1	1.0	0.5
AMS-04	0.2	0.8	0.4	0.1	0.8	0.4
AMS-05	0.2	0.7	0.4	0.2	1.4	0.7
AMS-06	0.2	0.7	0.4	0.2	0.8	0.5
AMS-07	0.3	0.9	0.5	0.3	1.5	0.8
AMS-08A	0.2	0.6	0.4	0.1	0.8	0.4
AMS-09C	0.1	0.8	0.4	0.2	0.8	0.5
AMS-22	0.1	0.5	0.3	0.1	0.5	0.3
AMS-23	0.1	0.3	0.2	0.1	0.6	0.3
AMS-24	0.2	0.8	0.4	0.2	1.1	0.6
AMS-25	0.2	0.6	0.3	0.2	0.8	0.5
AMS-26	0.2	0.7	0.4	0.2	0.8	0.5
AMS-27	0.2	0.8	0.4	0.2	1.1	0.6
AMS-28	0.2	0.6	0.3	0.1	0.8	0.4
AMS-29	0.2	0.7	0.4	0.1	0.8	0.4
Background						
AMS-12	0.1	0.5	0.3	0.1	0.5	0.2
AMS-16	0.1	0.4	0.2	0.1	0.5	0.3
On Site						
KNE	1.5	3.6	2.2	1.7	18.3	9.6
KNO[e]	1.3	3.7	2.7	NA	NA	NA
KNW	1.0	4.2	1.9	2.1	8.2	3.8
KSE	1.3	4.7	2.8	1.2	9.9	4.9
KSO[e]	0.3	0.9	0.5	NA	NA	NA
KSW	1.0	2.4	1.6	1.7	4.8	3.1
KTOP	1.8	11.8	4.7	3.4	15.8	8.4
LP2[f]	0.4	0.5	0.4	NA	NA	NA
Pilot Plant Warehouse	0.1	1.1	0.4	0.3	0.8	0.4
PR-1[g]	0.3	1.0	0.6	NA	NA	NA
Rally Point 4	0.3	0.8	0.4	0.5	1.3	0.8
Surge Lagoon	0.2	0.6	0.4	0.4	1.0	0.7
T117[f]	0.2	0.4	0.3	NA	NA	NA
T28	0.7	1.2	1.0	1.1	3.8	2.2
TS4	0.1	0.7	0.3	0.2	0.9	0.5
WP-17A	0.2	1.0	0.4	0.1	1.1	0.6

[a]Monthly average radon concentrations are calculated from daily average concentrations. Daily average concentrations are calculated by summing all hourly count data, treating the sum as a single daily measurement, and then converting the sum to a (daily average) concentration.
[b]Refer to Figure 5-4 for sample locations
[c]Instrument background changes as monitors are replaced.
[d]NA = not applicable
[e]Unit was placed in service in April 2000.
[f]Unit was placed in service in November 2000.
[g]Unit was placed in service in March 2000.

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In accordance with the FFA, radon concentrations within the headspace of K-65 Silos 1 and 2 are continuously monitored to assess the effectiveness of control measures in reducing radon emissions. Over the past seven years (1993 to 2000), radon concentrations in the silo headspace have been trending upward. These increases in headspace concentration are attributable to degradation of the 1991 application of bentonite clay to the surface of the K-65 Silo residues. Appendix C, Attachment 2, of this report provides a graphical display of quarterly average heaspace radon concentrations from 1992 to 2000. Concurrent with the increases in headspace radon concentrations, increases in radon levels at the K-65 Silo exclusion fence had been observed until 1999 when actions were taken to repair the surface seal on the silo domes.

In an attempt to reduce the high radon concentrations that were observed at the K-65 Silos exclusion fence during 1998 and 1999, silo dome re-sealing activities were initiated in late May 1999 and were completed on June 4, 1999. Following the re-sealing of the silo domes, radon data from the K-65 Silo area have been closely monitored in order to gauge the effectiveness in reducing radon emissions. A review of the 2000 and 1999 radon concentrations at the K-65 Silos exclusion fence shows that the 1999 dome re-sealing measures continue to be effective (refer to Table 5-2 and Figure 5-5). There were only six exceedances of the 100 pCi/L DOE limit measured on site during 2000 (refer to Table C.2-1) compared with 47 recorded in 1999. As in past years, the exceedances were observed at monitoring locations adjacent to the K-65 Silos and occurred during periods of atmospheric inversions.

Long-term comparisons are performed on average radon concentrations recorded at the K-65 Silos exclusion fence locations (historical alpha track-etch and alpha scintillation detector data were used for this comparison). The results indicate a measurable increase at the K-65 Silos exclusion fence through 1999 (Figure 5-5), although 2000 showed a substantial decrease at these monitors. This is attributable to the dome re-sealing measures and the relocation of the KNW and KSW monitors approximately 35 feet farther from the silos. The monitors were relocated in October 2000 in order to remove them from the Accelerated Waste Retrieval Project construction area. It is important to note that the average concentrations adjacent to the K-65 Silos are still below the levels observed prior to the addition of bentonite to the K-65 Silos in 1991.

Long-term comparisons are also performed on average radon concentrations at western property fenceline locations and background locations as a basis for comparison to the 3 pCi/L annual average limit. In 2000 a marginal difference in radon concentrations was observed between background and western property fenceline monitoring locations (refer to Figure 5-6). The on-property monitoring locations near the K-65 Silos also recorded radon levels well below the applicable DOE limit of 30 pCi/L annual average.

To better monitor radon levels in the K-65 Silos area during the Accelerated Waste Retrieval Project, five radon-monitoring locations were added to the existing IEMP radon network in 2000. Four of the monitors are located in the vicinity of the silos (KNO, KSO, LP2, and T117) while the other monitor (PR1) is located along the western fenceline of the FEMP. The data and specific locations of the additional radon monitors were reported in the 2000 IEMP quarterly status reports. Figure 5-4 illustrates the locations of all radon monitors.

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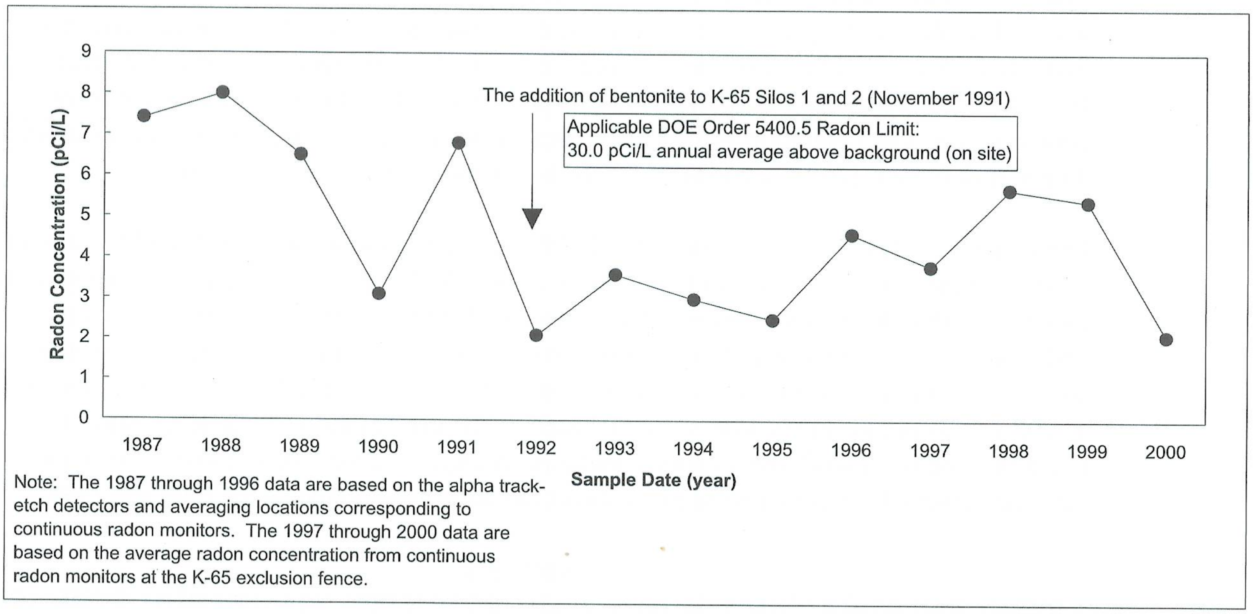

Figure 5-5. Annual Average Radon Concentrations at K-65 Silos Exclusion Fence, 1987 - 2000

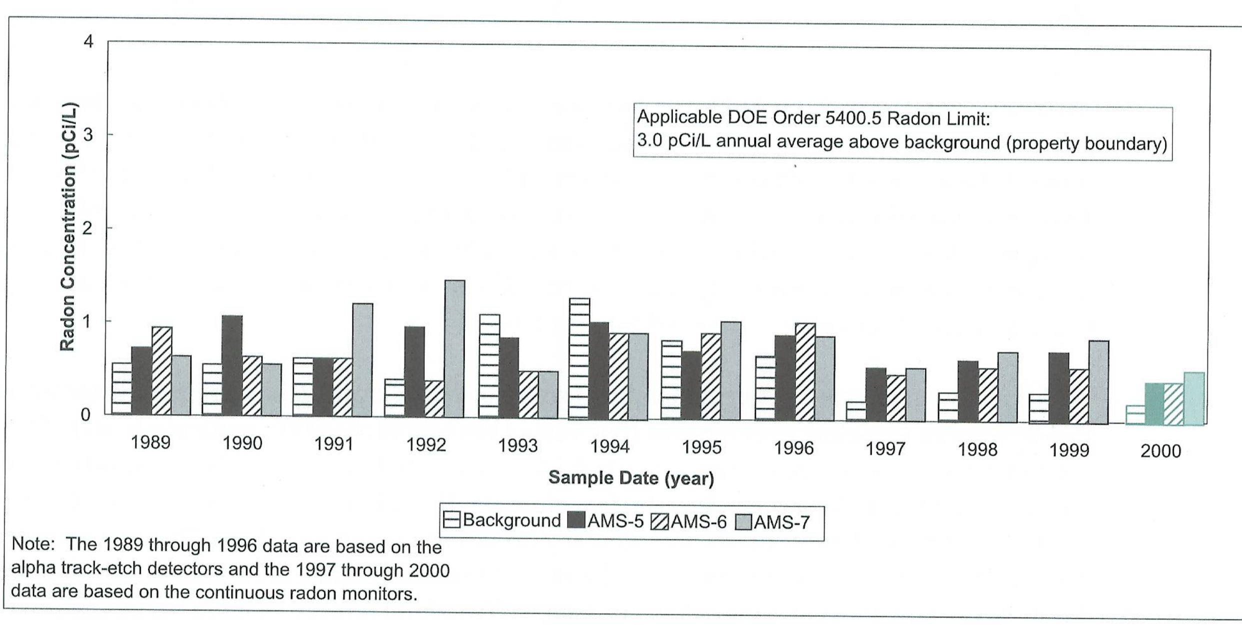

Figure 5-6. Annual Average Radon Concentrations at Selected Radon Locations, 1989 - 2000

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Monitoring for Direct Radiation

Direct radiation (i.e., x-rays, gamma rays, energetic beta particles, and neutrons) originates from sources such as cosmic radiation, naturally occurring radionuclides in soil, as well as radioactive materials at the FEMP. The largest source of direct radiation at the FEMP is the material stored in the K-65 Silos 1 and 2. Gamma rays and x-rays are the dominant types of radiation emitted from the silos. Energetic beta particles, alpha particles, and neutrons are not a significant component of direct radiation at the FEMP because uranium, thorium, and their decay products do not emit these types of radiation at levels that create a public exposure concern.

Direct radiation levels at and around the FEMP were continuously measured at 32 locations with thermoluminescent dosimeters (TLDs) during 2000. TLDs absorb and store the energy of direct radiation within the thermoluminescent material. By heating the thermoluminescent material under controlled conditions in a laboratory, the stored energy is released as light, measured, and correlated to the amount of direct radiation. Figure 5-7 identifies the TLD monitoring locations. These monitoring locations were selected based on the need to monitor the K-65 Silos, the FEMP fenceline, and several off-site locations, including background locations. Table 5-3 provides summary level information pertaining to direct radiation measurements for 2000 and 1999.

TABLE 5-3
DIRECT RADIATION (THERMOLUMINESCENT DOSIMETER) MEASUREMENT SUMMARY

	Direct Radiation (mrem)	
TLD Location	Summary of 2000 Results	Summary of 1999 Results
Fenceline (21 locations)		
Minimum	65	63
Maximum	85	81
On Site (6 locations)		
Minimum (Health & Safety Bldg.)	58	55
Maximum (K-65 Silo area)	1084	904
Background (6 locations)		
Minimum	62	62
Maximum	77	77

All monitoring results from TLDs for 2000 were within historical ranges. However, there is an increasing trend in direct radiation measurements in the immediate area of the K-65 Silos and some of the western fenceline locations which will continue to be monitored (refer to Figure 5-8). This trend is attributable to a corresponding increase in radon concentrations (from 1993 through 2000) and associated decay products within the K-65 Silos' headspace. The increased direct radiation measurements adjacent to K-65 Silos are still well below the levels observed prior to the addition of bentonite to the K-65 Silos in 1991.

Additionally, an increase in direct radiation levels above background has also been detected at the FEMP western fenceline over the past four years (1997 through 2000), particularly at TLD location 6 which is located closest to the K-65 Silos (refer to Figure 5-9). The relatively small increases in direct radiation levels at the fenceline are difficult to measure consistently due to small variations in the sensitivity and accuracy of the environmental TLDs. These increases at the fenceline are partially attributable to the increase in radon concentrations and associated decay products within the K-65 Silos' headspace. The slight upward trend in background radiation levels shown in Figure 5-9 is attributed to changes in the laboratory processing of the TLDs. These trends will continue to be monitored and presented in IEMP quarterly summaries and annual integrated site environmental reports.

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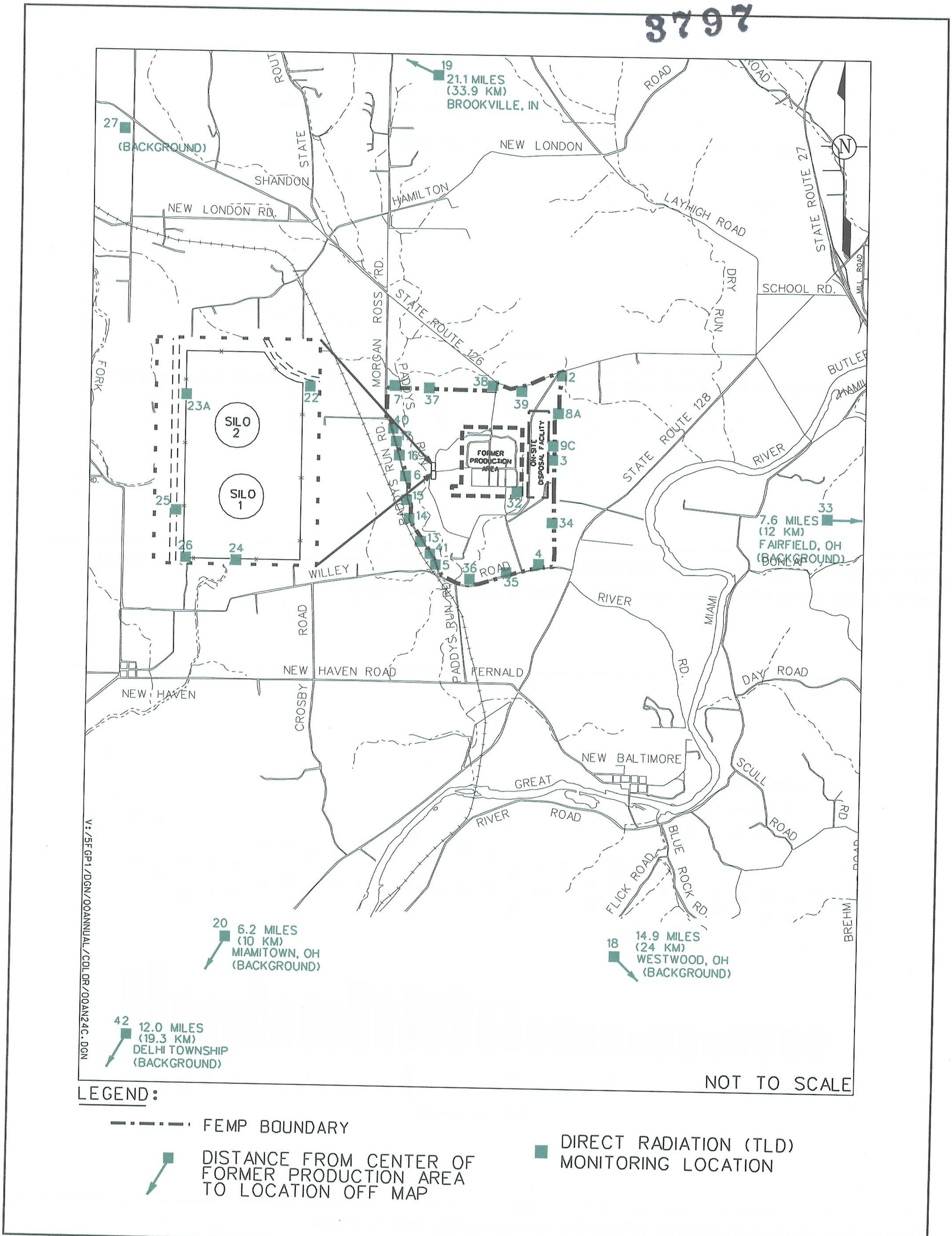

Figure 5-7. Direct Radiation (TLD) Monitoring Locations

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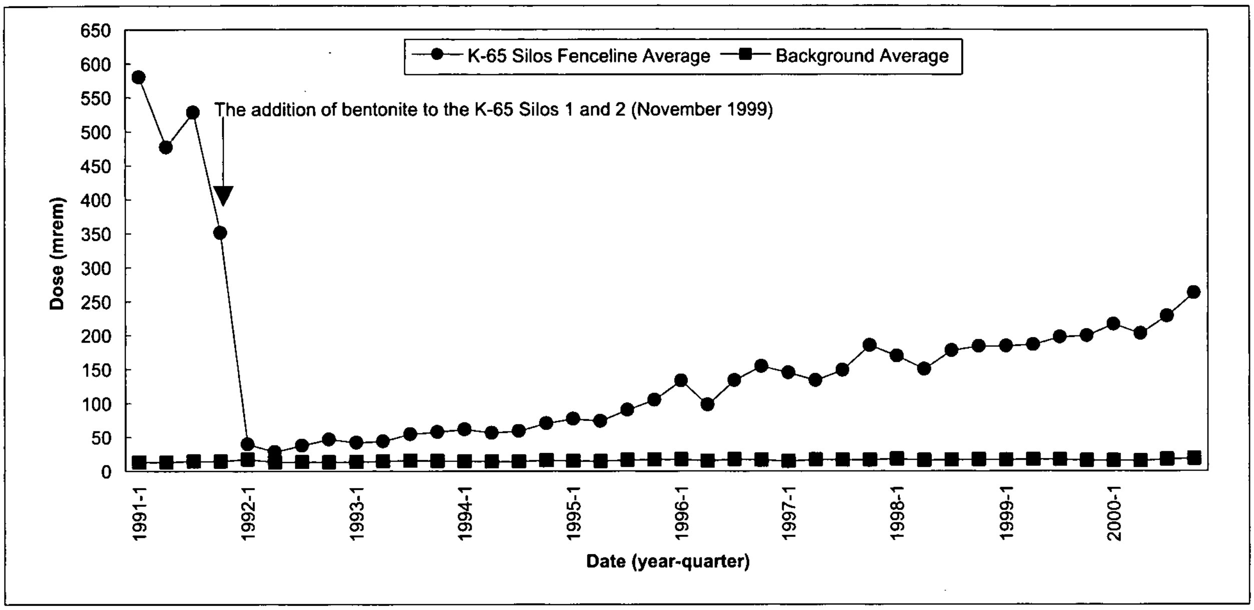

Figure 5-8. Direct Radiation (TLD) Measurements at K-65 Silos Boundary, 1991 - 2000 (K-65 Silos Fenceline Average Versus Background Average)

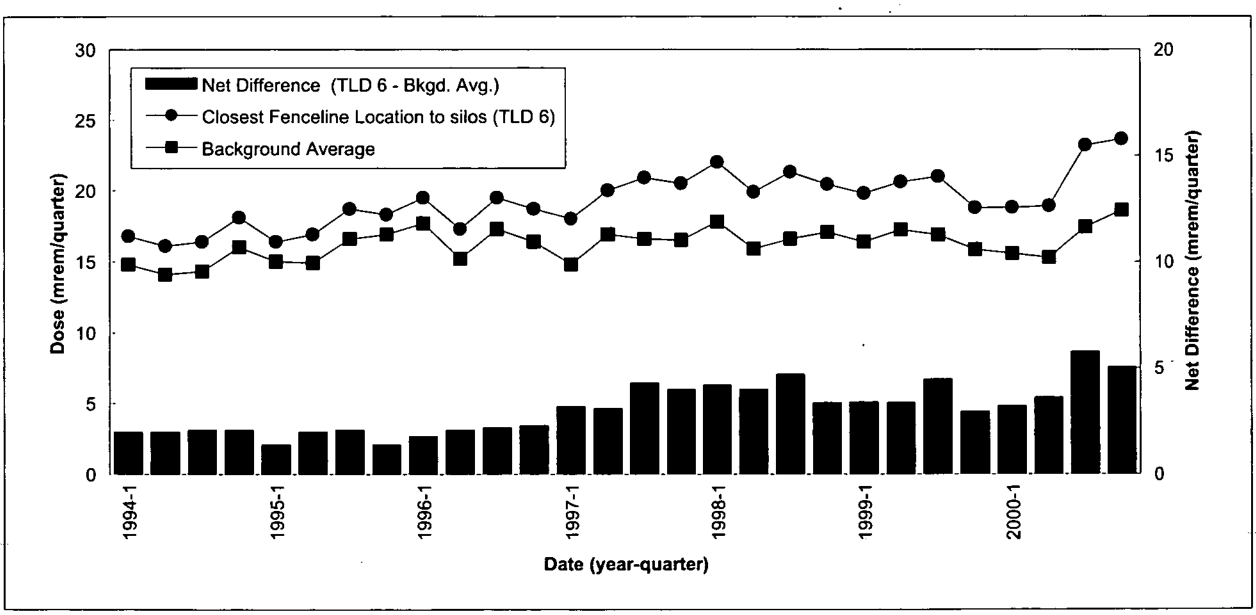

Figure 5-9. Direct Radiation (TLD) Measurements, 1994 - 2000 (Location 6 Versus Background Average)

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Stack Monitoring for Radionuclide Emissions

With the transition from uranium production to full-scale remediation activities, there was a significant reduction in the number of stacks and vents (point sources) which require monitoring. Three stack monitors were in operation during 2000: Laundry, Building 71, and the Waste Pits Remedial Action Project dryer stack. No significant changes in source operations associated with the Building 71 stack were noted during 2000. The on-site laundry function and the use of the stack were concluded during 2000.

The Waste Pits Remedial Action Project dryer stack operated periodically in 2000. The stack particulate filters were analyzed for isotopes of uranium, thorium, and radium. The results confirmed that Waste Pits Remedial Action Project stack particulate emissions are very low and are not the primary source of the increases in thorium-230 concentrations at the fenceline. The stack also contains a continuous radon monitor (i.e., radon-220 and radon-222). The maximum daily release of radon (radon-220 and radon-222) for 2000 was 27,946 μCi. This equates to 1,164 μCi/hr, which is below the estimated maximum hourly release rate of 13,000 μCi/hr (DOE 1998a) for radon-222. The average daily release rate for 2000 was 507 μCi radon. Table 5-4 summarizes the FEMP stack emissions for 2000 and Figure 5-10 illustrates the monitored stack locations.

Typically, post-production monitoring data have shown stack emissions of uranium and thorium to be very low or not detectable. The 2000 stack emissions are consistent with historically low stack emission data for the post-production period.

TABLE 5-4
2000 NESHAP STACK EMISSIONS

Radionuclide (Unit)	Laundry Stack[a]	WPRAP Dryer Stack[a]	Building 71 Stack[a]
Uranium, Total (lbs/yr.)	1.9E-05	NS	1.8E-05
Uranium-238 (lbs/yr.)	NS	4.2E-05	NS
Uranium-235/236 (lbs/yr.)	NS	2.5E-07	NS
Uranium-234 (lbs/yr.)	NS	2.1E-09	NS
Thorium-232 (lbs/yr.)	1.5E-04	1.0E-05	3.4E-05
Thorium-230 (lbs/yr.)	3.0E-09	1.1E-09	8.2E-10
Thorium-228 (lbs/yr.)	NS	1.3E-15	NS
Radium-226 (lbs/yr.)	NS	3.3E-11	NS
Particulates, Total (lbs/yr.)	1.1E-01	NS	4.6E-02
Radon, Total (μCi)	NS	507[b]	NS

[a]NS = not sampled

[b]Value represents a daily average.

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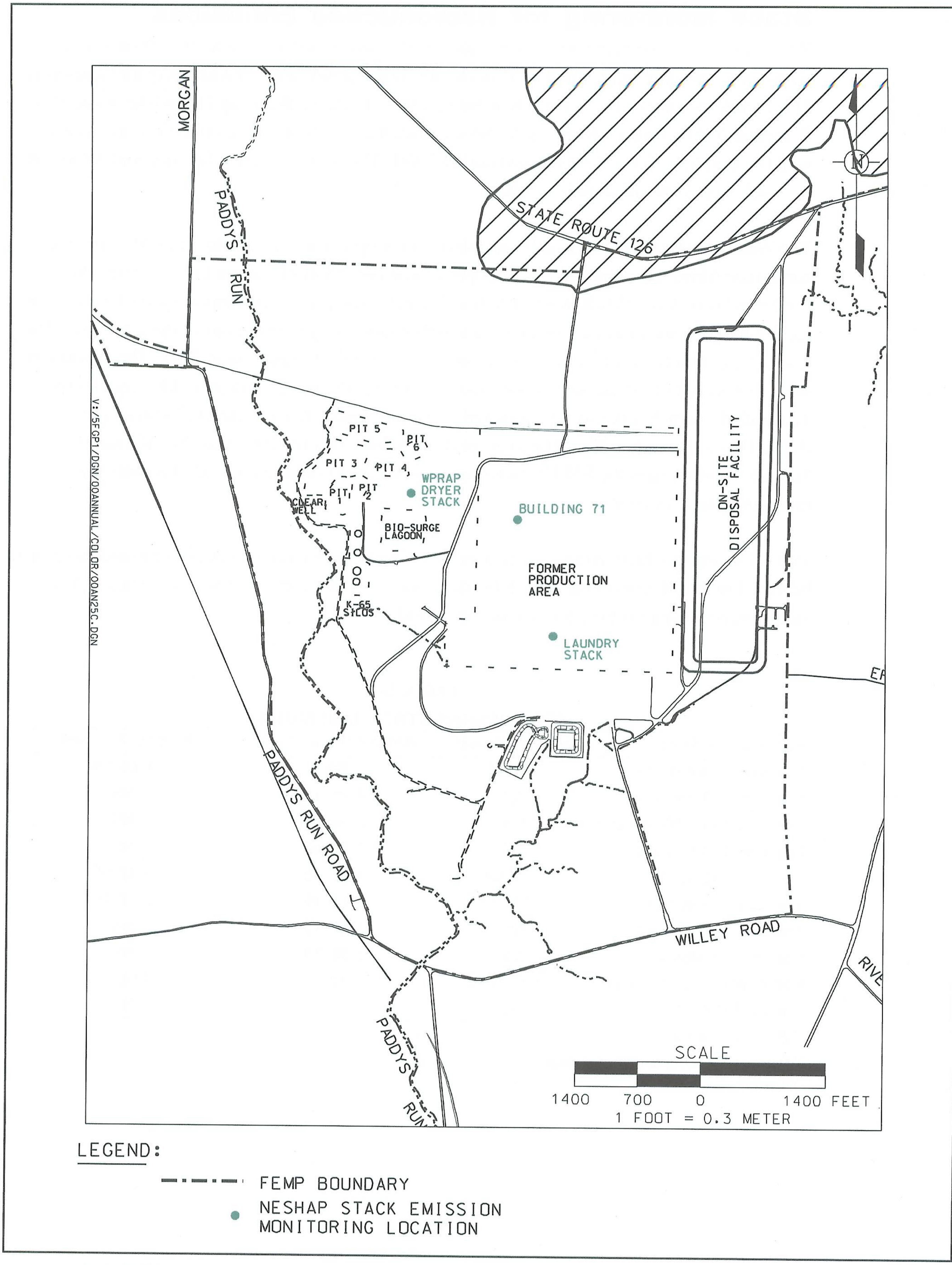

Figure 5-10. NESHAP Stack Emission Monitoring Locations

Monitoring for Non-Radiological Pollutants

OEPA requires an estimate of boiler emissions from the FEMP in order to demonstrate compliance with the Clean Air Act. The FEMP estimated the amount of non-radiological pollutants, including particulate matter, sulfur dioxide, nitrogen oxides, and carbon monoxide, and measured the opacity of particulate emissions from the FEMP boilers. Opacity is a measure of how much light is blocked by particulate matter present in stack emissions. There were no exceedances of the opacity limits for the boilers in 2000 and there have been no exceedances since 1996. The reduction in opacity exceedances since 1996 is due to the FEMP's conversion from coal-fired boilers to natural gas/diesel-fired boilers in 1996. Table 5-5 provides a comprehensive list of 2000 boiler plant emissions.

TABLE 5-5
BOILER PLANT EMISSIONS

Chemical Name	Type of Release	Quantity Released (lb/kg)	Major Release Sources	Basis of Estimate
Particulates	Stack Emissions	1,534/697	Fossil Fuels Combustion	AP-42 Emission Factors[a]
Sulfur Dioxide	Stack Emissions	72/33	Fossil Fuels Combustion	AP-42 Emission Factors[a]
Nitrogen Oxide	Stack Emissions	15,072/6,843	Fossil Fuels Combustion	AP-42 Emission Factors[a]
Carbon Monoxide	Stack Emissions	4,187/1,901	Fossil Fuels Combustion	AP-42 Emission Factors[a]
Non-Methane Volatile Organic Compounds	Stack Emissions	648/294	Fossil Fuels Combustion	AP-42 Emission Factors[a]

[a]Compilation of Air Pollution Emission Factors, Vol. 1; Stationary Point and Area Sources, 5[th] edition, January 1995 (USEPA 1995)

In order to estimate sulfur dioxide emissions, scientists determine the sulfur and heat content of the fuel. Using this information and the total amount of fuel burned, the amount of sulfur dioxide emissions can be calculated. For 2000 sulfur dioxide emissions from all boilers were calculated to be 72 pounds (33 kg). This was below the allowable limit of 79 tons (72 metric tons) per year calculated from information in the permits issued by OEPA.

The nitrogen oxide and carbon monoxide emissions are estimated using data obtained from published emission factors. Nitrogen oxide emissions for all boilers for 2000 were estimated to be 15,072 pounds (6,843 kg). Carbon monoxide emissions for all boilers in 2000 were estimated to be 4,187 pounds (1,901 kg). To date, OEPA has not set nitrogen oxide or carbon monoxide limits for the FEMP boilers.

The FEMP operated two Waste Pits Remedial Action Project gas-fired dryers during 2000. The estimated emissions from the dryer operation are based on calculations from dryer operation. The sulfur dioxide emissions were estimated to be 59 pounds (27 kg). Nitrogen oxide emissions for 2000 were estimated to be 8,010 pounds (3,636 kg). Carbon monoxide emissions were estimated to be 6,032 pounds (2,739 kg). Estimates for particulate as PM10 (particles with an aerodynamic diameter less than or equal to a nominal 10 microns) was 1,355 pounds (615 kg). Total organic compound emissions for 2000 were estimated to be 574 pounds (260 kg).

Biota (Produce) Sampling

As mentioned in Chapter 1, the FEMP is surrounded by farmland. Locally grown sweet corn and tomatoes are two of the major crops sold from roadside stands within 3 miles (4.8 km) of the FEMP. Local residents also grow apples, beets, feed corn, cucumbers, lettuce, peppers, potatoes, soybeans, and squash.

Under the IEMP, produce is sampled once every three years to ensure that airborne emissions from the remediation of the site are not adversely affecting the produce grown near the FEMP. In 2000 produce and grain samples from 15 locations were collected and then analyzed for uranium, thorium, and radium. Figure 5-11 depicts produce monitoring locations. Historically, produce samples have only been analyzed for uranium because it has been the major contributor to dose from airborne emissions at the FEMP. With the start of the Waste Pits Remedial Action Project in late 1999, thorium and more specifically thorium-230, has become the major contributor to dose via the air inhalation pathway. Therefore, thorium-230 analysis of produce samples was initiated in 2000. Radium analysis of produce samples was also initiated in 2000 in response to a draft study conducted by the Agency for Toxic Substances and Disease Registry (ATSDR 2000) which suggested that radium may be a potentially significant contributor to dose based on their review of historical environmental monitoring data. Table 5-6 presents the summary results of the produce sampling program.

As indicated in Table 5-6, the total uranium results in 2000 remained within the range of historical background concentrations from produce samples collected from 1990 to 1997 and a majority of sample results were less than detectable. Radium-226 and radium-228 were less than detectable in all samples. Thorium-230 was not consistently detected in many of the samples. The large percentage of less than detectable concentrations, lack of historical thorium data for produce, and a limited number of background produce sample results makes it difficult to rigorously compare and evaluate the produce data with a high degree of confidence. However, the uranium results suggest that there is currently no substantial impact from past or current FEMP emissions on produce grown in the area.

The produce sample results are used to estimate the dose from this component of the air pathway. Chapter 6 provides more information on the dose associated with the consumption of locally grown produce. Detailed results of produce sampling for 2000 are provided in Appendix C, Attachment 4, of this report. Under the IEMP, produce will continue to be sampled once every three years. The next sampling round is scheduled for 2003.

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TABLE 5-6
2000 BIOTA (PRODUCE) SUMMARY RESULTS

Produce	Number of Samples	Minimum[a]	Maximum[a]	Background[a]	1990-1997 Historical Background Range[a] Minimum (pCi/g, dry weight)	Maximum (pCi/g, dry weight)
		(All Concentrations in pCi/g [dry weight])				
			Total Uranium			
Corn	6	ND	0.144[b]	NA	ND	0.2
Zucchini (squash)	1	ND	NA	NA	ND	0.34
Soybeans	7	ND	0.197[c]	NA	ND	1.2
Cucumbers	5	ND	NA	ND	0.00023	0.12
Tomatoes	8	ND	NA	ND	ND	0.61
			Thorium-230			
Corn	6	ND	0.045[b]	NA	NA	NA
Zucchini (squash)	1	ND	NA	NA	NA	NA
Soybeans	7	ND	0.066[b]	NA	NA	NA
Cucumbers	5	ND	0.054[c]	ND	NA	NA
Tomatoes	8	ND	0.062[b]	ND	NA	NA
			Radium-226			
Corn	6	ND	NA	NA	NA	NA
Zucchini (squash)	1	ND	NA	NA	NA	NA
Soybeans	7	ND	NA	NA	NA	NA
Cucumbers	5	ND	NA	ND	NA	NA
Tomatoes	8	ND	NA	ND	NA	NA
			Radium-228			
Corn	6	ND	NA	NA	NA	NA
Zucchini (squash)	1	ND	NA	NA	NA	NA
Soybeans	7	ND	NA	NA	NA	NA
Cucumbers	5	ND	NA	ND	NA	NA
Tomatoes	8	ND	NA	ND	NA	NA

[a]ND = non-detectable; NA = not applicable
[b]Value is an average of detectable results from multiple analyses of sample material.
[c]Value is an average of detectable and non-detectable results from multiple analyses of sample material. One half of MDC was used in place of non-detectable results.

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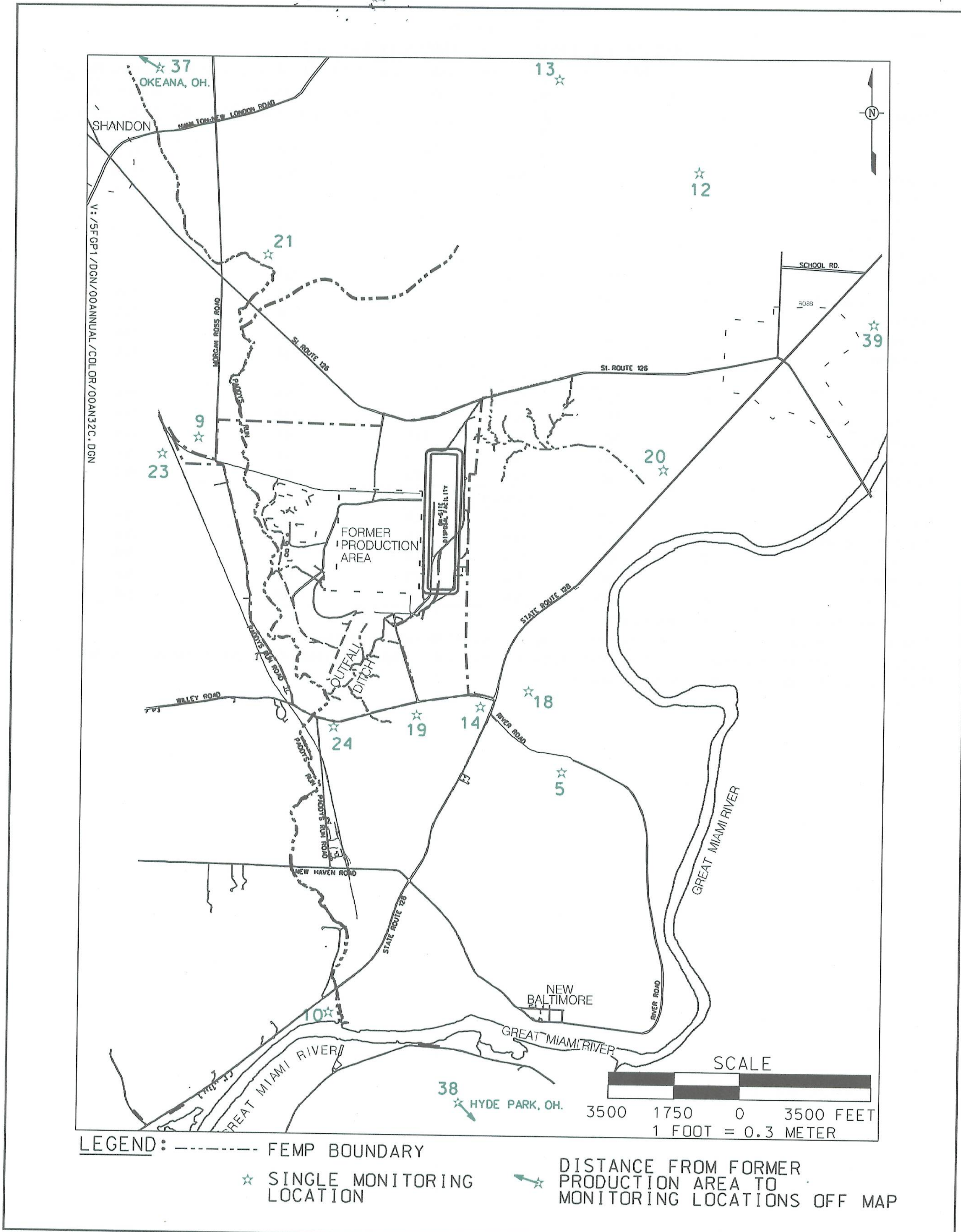

Figure 5-11. Produce Monitoring Locations

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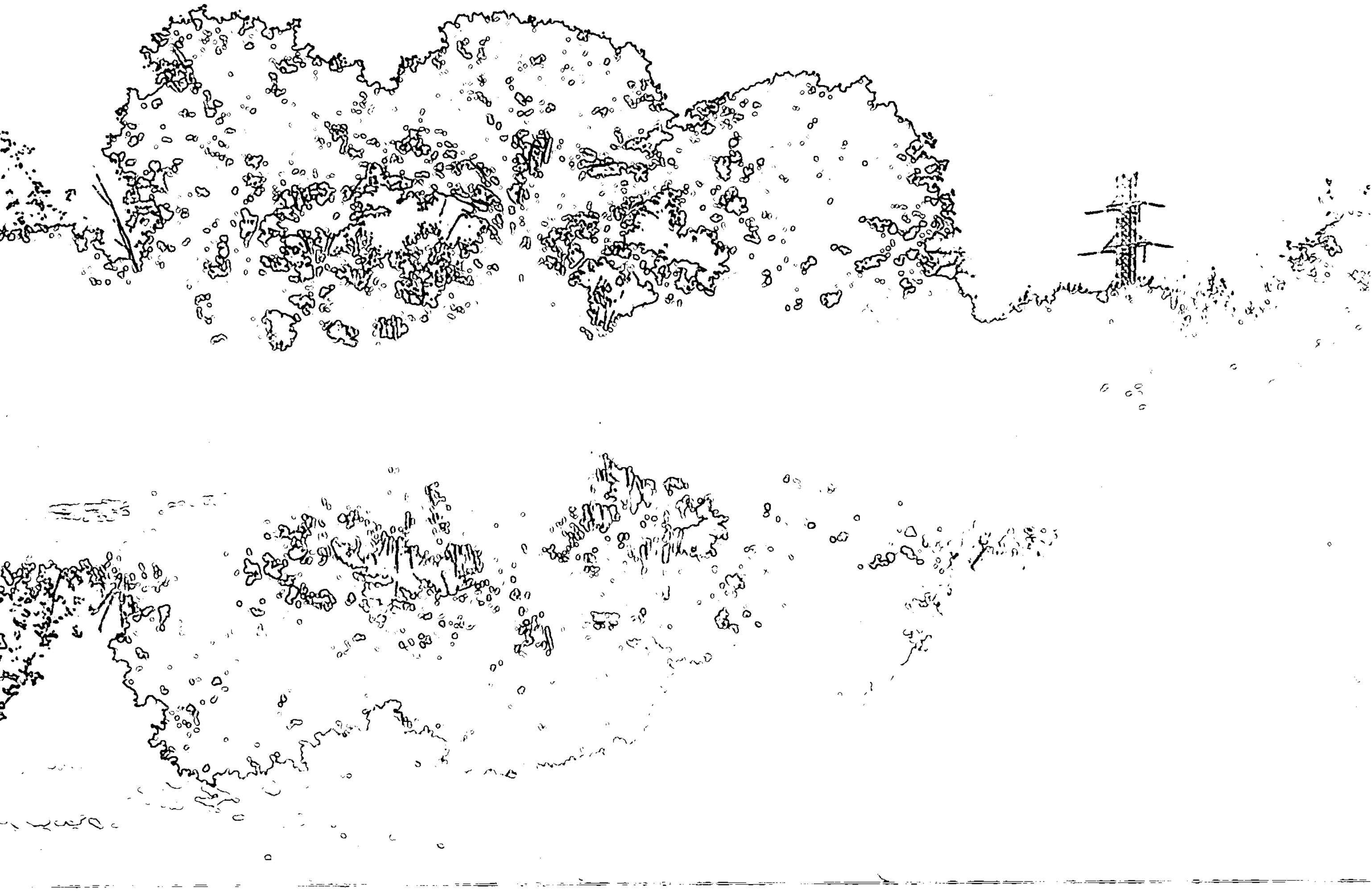
Chapter 6
Radiation Dose



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Radiation Dose

Results in Brief: 2000 Estimated Doses

Airborne Emissions - The estimated maximum effective dose at the site fenceline from 2000 airborne emissions (excluding radon) was calculated to be 1.1 mrem, which equals 11 percent of the EPA NESHAP 10 mrem annual dose limit.

Produce Consumption - The estimated maximum effective dose equivalent from consuming locally grown produce during 2000 is 0.9 mrem.

Direct Radiation - The estimated 2000 effective dose equivalent at an off-site receptor location near the western fenceline of the FEMP was 10 mrem.

Dose to the Maximally Exposed Individual - The dose to the maximally exposed individual for 2000 was estimated to be 11.2 mrem at an off-site receptor location near the western fenceline of the FEMP.

This chapter provides estimated doses to the public from the air, biota, and direct radiation pathways for 2000 as a result of remedial actions taken at the FEMP. EPA NESHAP regulations require the FEMP to demonstrate that its radionuclide airborne emissions are low enough to ensure that no one in the public receives an effective dose of 10 mrem or more in any one year. Moreover, to determine whether the FEMP is within the DOE effective dose limit of 100 mrem per year from all exposure pathways (excluding radon), estimates of dose due to direct radiation are combined with airborne emissions and consumption of locally grown produce to estimate the total dose to the maximally exposed individual. This estimate reflects the incremental dose above background that is attributable to the FEMP.

The DOE limits for radon and its decay products in air are provided in terms of concentrations and are addressed independently of the all-pathway dose limit. A concentration-based limit is used because dose calculations associated with radon and its decay products are highly sensitive to input parameters which are difficult to confirm with environmental measurements. Nonetheless, dose estimates for radon have been included in this section in response to FEMP stakeholders' interests in radon exposures. A number of different radon dose calculations are presented in this section to demonstrate the variation of radon doses based on each method of calculation. The radon dose estimates in this section can also be compared with radon dose estimates presented in previous annual site environmental reports and other radon dose studies (i.e., Fernald Dosimetry Reconstruction Project [RAC 1996]).

Estimated Dose from Airborne Emissions

The estimated dose from 2000 airborne emissions was calculated from annual average radionuclide concentrations measured at the 18 IEMP air particulate monitoring locations (two background and 16 fenceline locations [refer to Figure 5-1 in Chapter 5 for the location of the air particulate monitoring locations]). Annual average background concentrations were subtracted from the fenceline concentrations in order to account for the natural occurrence of airborne radionuclides. Dose estimates were determined by converting the net annual average radionuclide concentrations measured at each fenceline monitoring location to dose using values listed in 40 Code of Federal Regulations 61 (NESHAP) Subpart H, Appendix E, Table 2.

The maximum effective dose at the fenceline from 2000 airborne emissions was estimated to be 1.1 mrem per year and occurred at AMS-3 along the eastern fenceline of the site. The dose estimate is based on the conservative assumption that a person remains outdoors at the AMS-3 location for 100 percent of the time during the year. Recognizing that the nearest residence is located approximately 1,500 feet (450 meters) downwind from AMS-3 (east-southeast from the site), the actual dose received by this receptor would be substantially lower than 1.1 mrem per year.

The maximum fenceline dose of 1.1 mrem in 2000 is notably higher than the maximum fenceline dose of 0.29 mrem in 1999, although still well below the NESHAP annual limit of 10 mrem. The increase is attributable to increased emissions from remediation activities associated with the Waste Pits Remedial Action Project, on-site disposal facility and its associated material transfer area, and the Plant 5 Decontamination and Dismantlement Project. Fugitive emissions from the Waste Pits Remedial Action Project waste processing activities, and specifically thorium-230 emissions, is the major source of the increase in the maximum fenceline dose in 2000.

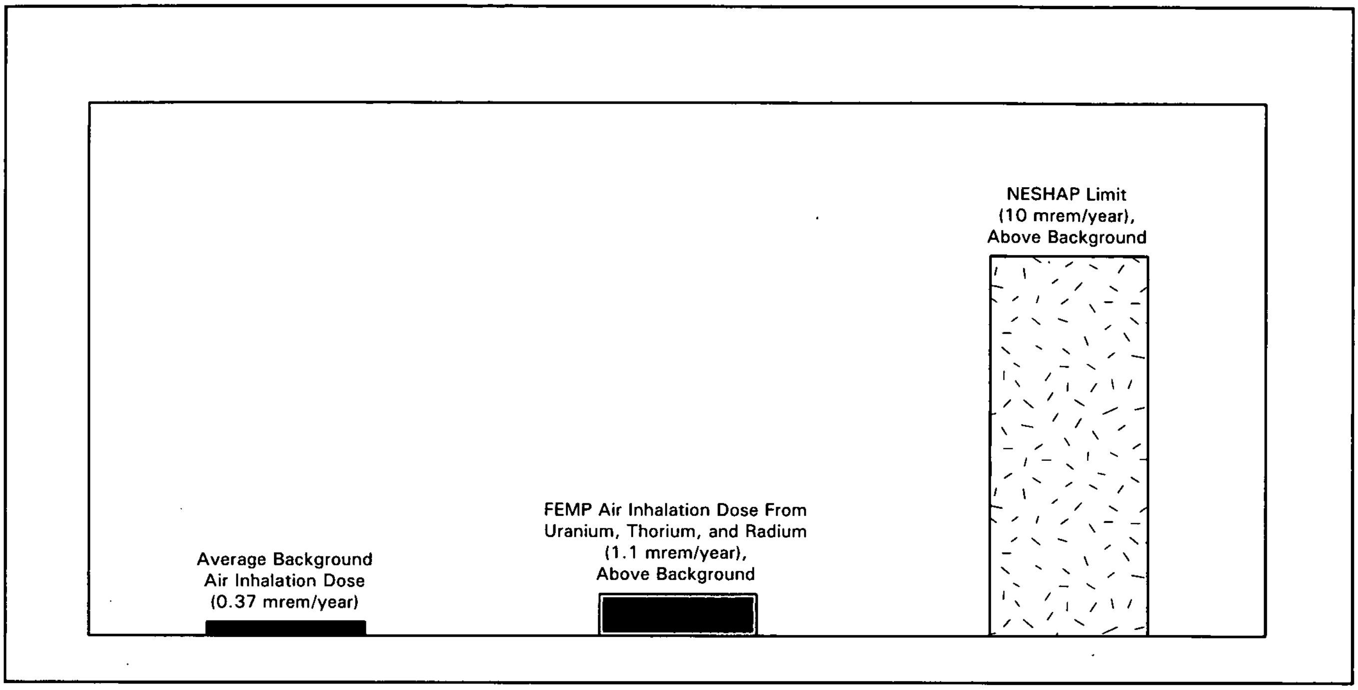

Figure 6-1. Comparison of 2000 Air Pathway Doses and Allowable Limits

Figure 6-1 provides a comparison between the air pathway doses at the average background and maximum fenceline locations with the annual NESHAP limit of 10 mrem. The average background and maximum fenceline doses shown in Figure 6-1 are attributable to the airborne concentration of uranium, thorium and radium and exclude contributions from radon (dose from radon is excluded from the annual NESHAP limit of 10 mrem). The maximum air pathway dose of 1.1 mrem (above background) which is in addition to the average air pathway background dose of 0.37 mrem, is 11 percent of the annual NESHAP limit. The estimated dose for each radionuclide from airborne emissions measured at each fenceline air monitor is provided in Appendix D of this report.

Direct Radiation Dose

Direct radiation dose is the result of gamma and x-ray radiation emitted from radionuclides stored on site. The largest source of direct radiation at the FEMP is the waste stored in the K-65 Silos. As the waste in the silos undergoes radioactive decay, gamma rays and x-rays are emitted. Direct radiation from the decay of radon progeny in the silo headspace contributes a major fraction of the direct radiation from the K-65 Silos. As the headspace radon concentrations have increased over the last eight years (1993 to 2000), the direct radiation from the silos has also increased. Direct radiation levels at the K-65 Silos and site fenceline are monitored by a network of environmental TLDs. Chapter 5 provides a description of the direct radiation monitoring.

The direct radiation dose for 2000 at the fenceline was estimated using the highest dose from the fenceline monitoring locations and subtracting the average dose measured at background TLD locations. This method provides a conservative estimate of direct radiation dose and measures the impact of increasing radiation levels near the silos and the fenceline due to increasing levels of radon and associated decay products in the silo headspace (refer to Chapter 5). From the data in Table 5-3, the maximum fenceline measurement was 85 mrem per year and occurred at TLD location 16. The average background dose from the six background TLD locations was 69 mrem. The difference in these values (16 mrem) is the estimated fenceline direct radiation dose for a hypothetical individual who stands at the fenceline, specifically TLD location 16, for the entire year.

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In accordance with DOE Order 5400.5, Radiation Protection of the Public and the Environment, which requires that realistic exposure conditions be used for conducting dose evaluations, an estimate of direct radiation dose was calculated for a residence nearest the K-65 Silos. This dose was estimated by using the net fenceline TLD measurement at TLD 16 and accounting for the distance between the fenceline TLD location and the residence (approximately 326 feet [99 meters]) which would lower the direct radiation dose to approximately 10 mrem. This estimate remains extremely conservative in that it assumes a resident at this location is present 24 hours per day for a full year and does not account for shielding provided by the structure of the house.

Estimated Dose from Consumption of Locally Grown Produce

There is a potential for low levels of radioactive particulate emissions to be deposited onto soil surrounding the FEMP and possibly absorbed by produce, thereby delivering a secondary pathway dose. This secondary pathway dose is estimated using the conservative assumption that a large fraction of a person's diet of vegetables comes from gardens and farms in the FEMP area. This modeled diet assumes an annual consumption of 100 pounds (45 kg) of grains (corn and soybeans) and 100 pounds (45 kg) of other vegetables (tomatoes and squash). To represent the foods in the diet, samples of corn, cucumbers, soybeans, tomatoes, and squash from local gardens and farms were collected and analyzed in 2000 for uranium, thorium, and radium.

As noted in Chapter 5, 2000 was the first year that produce samples were analyzed for thorium and radium. Analyzing produce samples for thorium, and more specifically thorium-230, was initiated as a result of thorium-230 becoming the major contributor to dose from airborne emissions in 2000. Radium analysis of produce samples was also initiated in response to a study conducted by the Agency for Toxic Substances and Disease Registry (ATSDR 2000) which suggested that radium may be a potentially significant contributor to dose based on their review of historical environmental monitoring data. Of the radionuclides analyzed in the produce samples, only the total uranium and thorium-230 analyses yielded detectable results of isotopes known to be present in the FEMP airborne emissions at levels that would potentially impact produce samples. Radium-226 and radium-228 were not detected in locally grown produce; therefore, these isotopes were not included in the calculation of estimated dose from produce.

For 2000 the estimated dose from the consumption of locally grown produce was 0.9 mrem. Of this 0.9 mrem, total uranium contributed 0.46 mrem and thorium-230 contributed 0.44 mrem. For comparison, in 1997 when produce was analyzed for only total uranium, the estimated dose from the consumption of locally grown produce was 0.1 mrem. The increase in the produce dose for 2000 is attributable to the addition of thorium analyses for the 2000 samples and other factors as discussed in Appendix C.4.

Although higher than previous years' produce dose estimates, the 2000 produce dose represents less than one percent of the DOE all-pathways dose limit of 100 mrem per year. Furthermore, the 2000 produce dose, in conjunction with the produce sample results, confirms that past and current emissions from the FEMP do not substantially impact produce grown in the area.

Total of Doses to Maximally Exposed Individual

The maximally exposed individual is the member of the public who receives the highest estimated effective dose equivalent based on the sum of the individual pathway doses. For 2000 the dose to the maximally exposed individual (Table 6-1) is the sum of the estimated doses from direct radiation dose, consumption of locally grown produce, and airborne emissions (excluding radon). The conservative assumptions used throughout the dose calculation process ensure that the dose to the maximally exposed individual is the maximum possible dose any member of the public could receive. The 2000 dose to the maximally exposed individual is estimated to be 11.2 mrem. The contributions to this all-pathway dose are:

- 10 mrem from direct radiation to an off-site receptor located near the western fenceline of the FEMP
- 0.9 mrem from locally grown produce
- 0.28 mrem from air inhalation dose, as measured at AMS-6, to an off-site receptor located near the western fenceline of the FEMP.

TABLE 6-1
DOSE TO MAXIMALLY EXPOSED INDIVIDUAL

Pathway	Dose Attributable to the FEMP	Applicable Limit
Air		
Airborne emissions at AMS-6 (excluding radon)	0.28 mrem	10 mrem (air pathway)
Direct radiation	10 mrem	100 mrem (total of all pathways)
Consumption of locally grown foodstuffs	0.91 mrem	100 mrem (total of all pathways)
Maximally exposed individual	11.2 mrem	100 mrem (total of all pathways)

This estimate represents the incremental dose above background attributable to the FEMP, exclusive of the dose received from radon. Figure 6-2 provides a comparison between the average background radiation dose at background (69.4 mrem) and the all-pathway dose to the maximally exposed individual (112 mrem). Figure 6-2 also provides graphical comparison to the annual DOE all-pathway limit of 100 mrem.

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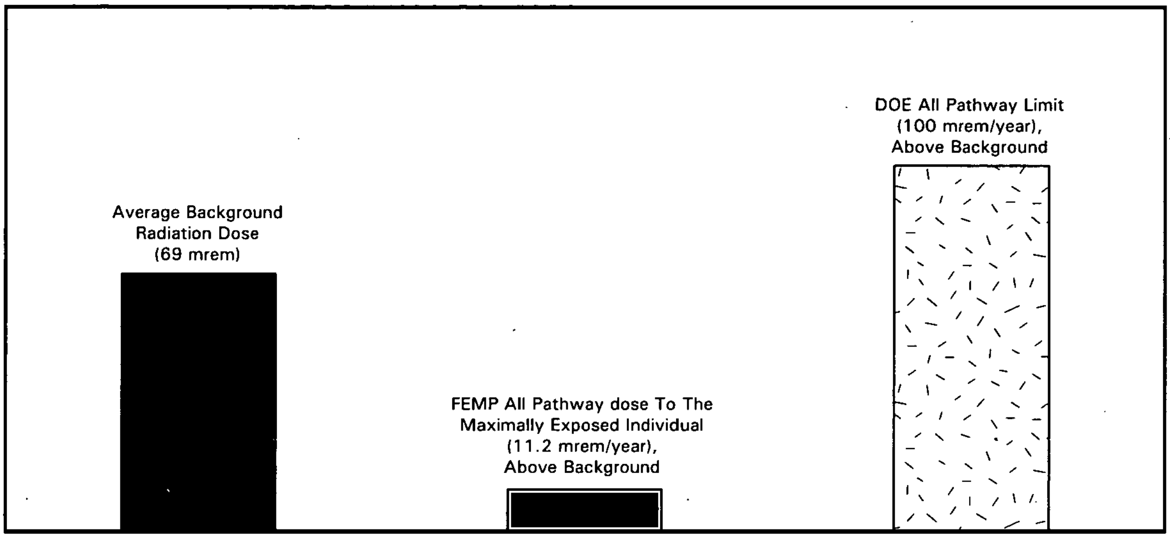

Figure 6-2. Comparison of 2000 All Pathway Doses and Allowable Limits

Significance of Estimated Radiation Doses for 2000

One method of evaluating the significance of the estimated doses is to compare them with doses received from background radiation. Background radiation yields approximately 100 mrem per year from natural sources, excluding radon. For example, the dose received each year from cosmic and terrestrial background radiation contributes approximately 26 and 28 mrem, respectively. In addition, the background radiation dose will vary in different parts of the country. Living in the Cincinnati area contributes an annual dose of approximately 110 mrem, whereas living in the Denver area would contribute approximately 125 mrem from background radiation (U.S. National Academy of Science 1980) (National Council on Radiation Protection and Measurements 1987). Comparing the maximally exposed individual dose to the background dose demonstrates that, even with the conservative estimates, the dose to a member of the public (nearest resident) from the FEMP is much less than the natural background radiation dose. Although the estimated dose will be received in addition to the background dose, this comparison provides a basis for evaluating the significance of the estimated doses.

Another method of determining the significance of the estimated doses is to compare them with dose limits developed to protect the public. The ICRP has recommended that members of the public receive no more than 100 mrem per year above background. As a result of this recommendation, DOE has incorporated 100 mrem per year above background as the limit in DOE Order 5400.5. The sum of all estimated doses from FEMP operations for 2000 (11.2 mrem) was significantly below this limit.

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Estimated Dose from Radon

Radon in the air decays to produce more radioactive material, known as daughter products. Airborne daughter products attach to dust particles that may be inhaled and deposited within the lungs. As the daughter products decay, they emit electrostatically charged particles (alpha and beta particles) that may damage sensitive tissues of the lung. For exposures to radon and its daughters, the target organ for the radiation dose is the lung.

Radon dose estimate methodologies from the ICRP and National Council on Radiation Protection (NCRP) have been revised and updated over the years with the primary effect being a decrease in the estimated health damage (detriment) per unit of radiation exposure. The revisions were based on re-evaluations of studies examining the detrimental health effects (i.e., epidemiological studies) on highly exposed worker populations (i.e., uranium miners). Therefore, radon dose estimates were generated for this report using the following four different calculation methods:

- <u>Working level-month determination</u>
  Historically, radon daughter exposure rates have been measured in the units of working levels, a measure of the activity concentration of the radon daughters in air. A working level is approximately equivalent to a radioactivity concentration of 100 pCi/L of radon in 100 percent equilibrium with its daughters. An individual exposure is then determined by multiplying the working level by the number of 170-hour periods (i.e., a work month) at that level, yielding the exposure unit working level-month. Working level-months of exposure are provided because all dose conversion factors and detriment coefficients used in estimating a dose from radon and its daughters are derived from this fundamental unit.

- <u>NCRP 78 report</u>
  This document, in part, provides equations for converting exposure resulting from inhalation of radon daughter products to an equivalent lung dose. This method considered the whole lung as the target organ for the radiation exposure. A number of dose conversion factors and assumptions are utilized to equate the lung dose to a whole body radiation dose (i.e., effective dose equivalent). Equations from this report were utilized in previous annual site environmental reports and are presented here for direct comparison to previous years' estimates.

- <u>ICRP 66 tissue weighting factor modification to NCRP 78 equation</u>
  ICRP 66 introduced a specific tissue-weighting factor representing the localized radiation exposure to the bronchial epithelium (a specific region of the lung thought to be the source for lung cancer) from inhalation of radon daughter products. Using the NCRP 78 equations, this new weighting factor results in a reduction of the effective dose by a factor of three. Incorporation of factors from this report allows comparison to dose estimates provided in the Fernald Dosimetry Reconstruction Project performed by Radiological Assessments Corporation under contract with the Centers for Disease Control.

- <u>ICRP 65 report</u>
  This report suggests the use of detriment coefficients for estimating dose from exposure to radon daughter products. These detriment coefficients are based on epidemiological studies of the lung cancer rates among uranium miners. The new coefficients result in a dose conversion factor of approximately 500 mrem per working level-month. This report was released in 1994 and represents a more recent methodology for calculating radon dose.

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Table 6-2 presents the 2000 radon dose estimates, which includes concentration values for fenceline and background locations, as well as DOE radon concentration limit values. Estimated working level-month exposures are given for each concentration value, as well as effective dose equivalents utilizing both the NCRP 78, ICRP 66, and ICRP 65 methods. Doses were calculated from annual average continuous radon data (assuming the suggested environmental radon daughter product equilibrium concentration of 70 percent). All dose estimates are for a hypothetical maximally exposed reference man of average body size and breathing rate who continuously breathed air at the FEMP western fenceline while engaged in light, physical activity 24 hours a day for the entire year. This exposure scenario is highly conservative, but suggests that in using the ICRP 65 methodology the dose at the nearest public receptor from FEMP radon emissions is 36 mrem per year above background.

Although there are no regulatory limits for dose from radon and its daughters, the radon concentration limits imposed by DOE Order 5400.5 provide a benchmark for evaluating the estimated doses from radon at the FEMP boundary. In DOE Order 5400.5, the annual average radon concentration limit at the facility boundary is 3 pCi/L above background. Using the ICRP 65 methodology, a concentration of 3 pCi/L equates to an effective dose equivalent of 547 mrem. As presented in Table 6-2, the maximum measured radon concentration and corresponding dose at the FEMP boundary are well below the limits associated with DOE Order 5400.5.

TABLE 6-2

2000 RADON DOSE ESTIMATE[a]

Location	Radon Concentration (pCi/L)	Exposure in Working Level-Months (WLM)	NCRP 78 Effective Dose Equivalent Equation (mrem)[b]	(mrem)[c]	ICRP 65 Effective Dose Equivalent (mrem)[d]
Average Background	0.2	0.072	144	48	36
FEMP Fenceline Nearest Receptor (net, above background)	0.2	0.072	144	48	36
Maximum Fenceline (net, above background)	0.4	0.144	288	96	73
DOE Order 5400.5 Limit (net, above background)	3	1.08	2,160	720	547

[a]Assuming the suggested environmental radon daughter product equilibrium concentration of 70 percent

[b]NCRP 78 suggests whole lung tissue weighting factor of 0.12

[c]NCRP 78 calculation using the ICRP 66 bronchial epithelium weighting factor of 0.04

[d]Utilizing the dose conversion factor for the maximally-exposed reference man

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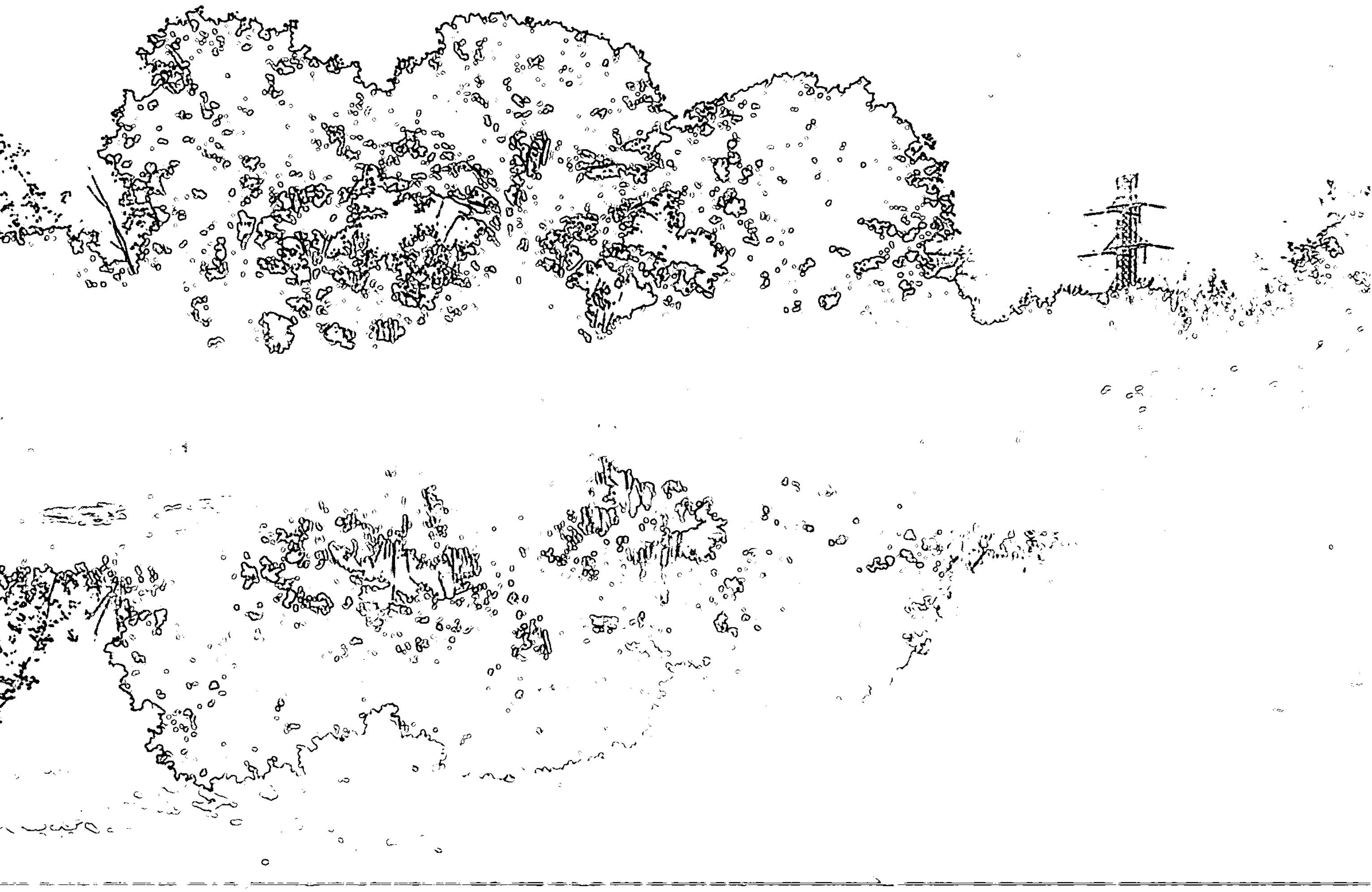
Chapter 7
Natural Resources



Natural Resources

This chapter provides background information on the natural resources associated with the FEMP and summarizes the activities in 2000 relating to these resources. Included in this chapter is a discussion of the following:

- Threatened and endangered species
- Impacted habitat areas
- Ecological restoration
- Ecological restoration research activities
- Cultural resources.

Much of the 1,050 acres (425 hectares) of the FEMP property is undeveloped land that provides habitat for a variety of animals and plants. Wetlands, deciduous and riparian (stream side) woodlands, old fields, grasslands, and aquatic habitats are among the FEMP's natural resources. Some of these areas provide habitat for state and/or federal endangered species. Cultural resources, such as prehistoric archaeological sites, can also be found at the FEMP. These resources are considered in the Natural Resource Monitoring Plan, which is included in the IEMP. This document presents an approach for monitoring and reporting the status of several priority natural resources in order to remain in compliance with the pertinent regulations and agreements.

Threatened and Endangered Species

The Endangered Species Act requires the protection of any federally listed threatened or endangered species, as well as any habitat critical for the species' existence. Several Ohio laws mandate the protection of state-listed endangered species as well. Since 1993 several surveys have been conducted to determine the presence of any threatened or endangered species at the FEMP. As a result of these surveys, the federally endangered Indiana brown bat and the state-threatened Sloan's crayfish have been found at the FEMP. In addition, suitable habitat exists at the FEMP for the federally endangered running buffalo clover and the state-threatened spring coral root. Neither of these species has been found on FEMP property, but their habitat ranges encompass the FEMP. Figure 7-1 shows the habitats and potential habitats of these species. Based on provisions set forth in the IEMP, any threatened or endangered species habitat will be surveyed prior to any remediation or restoration activities. If threatened or endangered species are present, appropriate avoidance or mitigation efforts will be undertaken. No surveys for endangered species were necessary in 2000. The IEMP specifies that surveys for the Indiana brown bat and the Sloan's crayfish will be conducted in 2002.

Sloan's Crayfish - The state-listed threatened Sloan's crayfish (*Orconectes sloanii*) is found in southwest Ohio and southeast Indiana. It prefers streams with constant (though not necessarily fast) current flowing over rocky bottoms. A large, well-established population of Sloan's crayfish is found at the FEMP in the northern reaches of Paddys Run.

Indiana Brown Bat - The federally listed endangered Indiana brown bat (*Myotis sodalis*) forms colonies in hollow trees and under loose tree bark along riparian (stream side) areas during the summer. Excellent habitat for the Indiana brown bat has been identified at the FEMP along the wooded banks of the northern reaches of Paddys Run. The habitat provides an extensive mature canopy of older trees and water throughout the year. One Indiana brown bat was captured and released on property in August of 1999.

Running Buffalo Clover - The federally listed endangered running buffalo clover (*Trifolium stoloniferum*) is a member of the clover family whose flower resembles that of the common white clover. Its leaves, however, differ from white clover in that they are heart-shaped and a lighter shade of green. Running buffalo clover has not been identified at the FEMP; however, because running buffalo clover is found nearby in the Miami Whitewater Forest, the potential exists for this species to become established at the FEMP. The running buffalo clover prefers habitat with well-drained soil, filtered sunlight, and limited competition from other plants, and periodic disturbance. Suitable habitat areas include partially shaded grazed areas along Paddys Run and the Storm Sewer Outfall Ditch.

Spring Coral Root - The state-listed threatened spring coral root (*Corallorhiza wisteriana*) is a white and red orchid which blooms in April and May and grows in partially shaded areas of forested wetlands and wooded ravines. This plant has not been identified at the FEMP; however, suitable habitat exists in portions of the northern woodlot.

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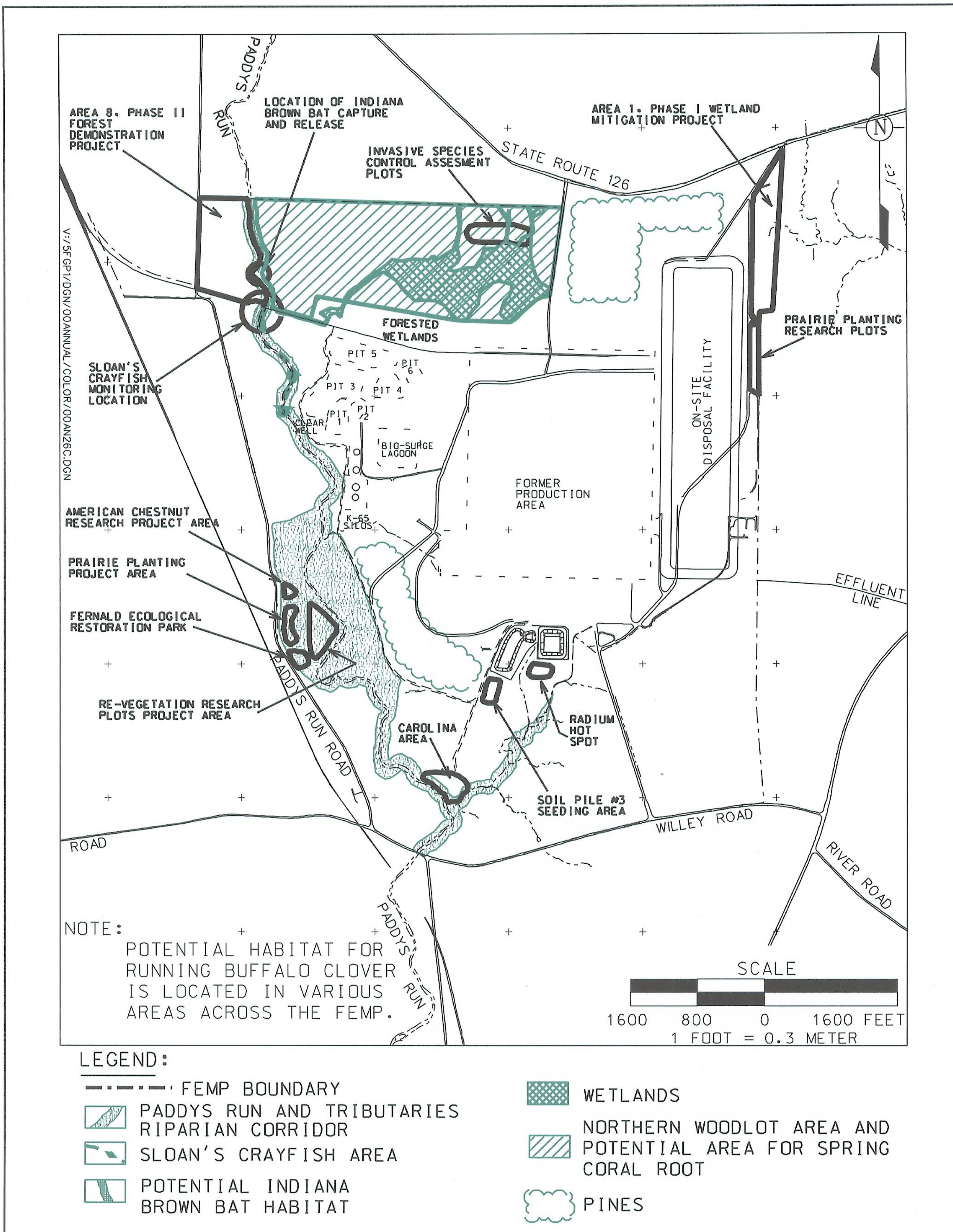

Figure 7-1. Priority Natural Resource Areas

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Sloan's Crayfish Monitoring and Provisions for Protection

The latest survey for the Sloan's crayfish, which was conducted in 1999, found a large, healthy population still residing in Paddys Run.

The IEMP requires that visual field inspections of sediment loading be conducted within 24 hours of a "significant rain event," which is considered to be 0.5 inch (1 cm) or more of rain in one storm event. The purpose for this field-inspection monitoring is to determine if there is an increase of sediment in the northern reaches of Paddys Run due to remediation activities. Sediment loading can adversely impact the Sloan's crayfish by restricting its ability to "breathe" in water. If remediation activities cause sustained (four to five days) increased sediment loading to Sloan's crayfish habitat in Paddys Run, then alternatives such as crayfish relocation are considered. Figure 7-1 identifies the Sloan's crayfish monitoring location.

The monitoring effort in 2000 yielded similar findings to previous years. Results of visual field inspections indicated that sediment loading from remediation activities has not impacted Sloan's crayfish habitat in Paddys Run. Four isolated instances of increased sediment loading from the northern drainage ditch were observed in 2000. As in previous years, it is unlikely that there was an impact because of their relatively short duration. However, an investigation was conducted to identify the cause of the increased turbidity in the northern drainage ditch. The investigation revealed that the rail yard sedimentation basin appears to be the source of the increased loading. However, the specific reason for increased turbidity in the basin could not be determined. Although several repairs and improvements to this basin were conducted in 2000, they appear to have had little effect in reducing turbidity. DOE is working with OEPA to resolve this issue. DOE will continue to observe the northern drainage ditch following rain events, and will notify OEPA when there is an increase in turbidity.

Impacted Habitat Areas

DOE and the Natural Resource Trustees tentatively agreed that it would not be necessary to quantitatively assess habitat impacted through remediation, because DOE will be conducting natural resource restoration on approximately 884 acres (358 hectares) of the site. Therefore, a summary of the year's habitat impacts is presented here.

Within Area 2, Phase I, approximately 3 acres (1 hectare) of riparian habitat were cleared to remove debris from an area south of the southern waste units. Habitat impacts from this activity were minimized by maintaining the existing overstory trees to the greatest extent possible, and by transplanting a number of great blue lobelia (*Lobelia siphilitica*) to Area 8, Phase II prior to soil disturbance. After debris removal, the area was re-graded to promote water retention in shallow depressions. Also, the area was seeded with native grasses and wildflowers.

Approximately 2 acres (0.8 hectare) of upland forest habitat were cleared in order to install a series of groundwater monitoring wells near the Pilot Plant Drainage Ditch. As with the Area 2, Phase I riparian area, large trees were marked and avoided during field activities. Early-successional black cherry (*Prunus serotina*) and hackberry (*Celtis occidentalis*) trees were removed for placement of the wells. The later-successional shingle oaks (*Quercus imbricaria*) were intentionally avoided.

One row of Austrian pine (*Pinus nigra*) was cleared along the southern edge of the northern pine plantation for construction of an access road to the on-site disposal facility laydown area. This impact was minimal because the Austrian pines are non-native, and because the northern pine plantation stands are severely stressed due to overcrowding and a tip blight fungal infection.

Three acres of pasture grasses were cleared during remediation of contaminated soil in Area 2, Phase III just south of the Storm Water Retention Basin. Grading work was completed so that the area would retain surface water, the area was re-seeded with a wet marsh prairie grass and wildflower mix, and willow cuttings were installed along the outfall.

A power line relocation project in the vicinity of the waste pits resulted in the clearing of approximately 0.5 acre (0.2 hectare) of small trees and underbrush along Paddys Run west of the waste pits. Originally, one utility pole was to be moved back from the vicinity of Paddys Run; however, this effort would have required extensive clearing of vegetation along the eastern bank of the stream. The removal of vegetation in this area could have destabilized the bank and accelerated erosion. Therefore, an additional utility pole was relocated in order to move the power lines away from the existing vegetation. By moving this additional pole, disturbances along Paddys Run were minimized.

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In preparation for the ground penetrating radar scan of several areas in Area 1, Phase III and Area 2, Phase II, approximately 3 acres (1.2 hectares) of underbrush were cleared. The impacts from this activity were minimal because the majority of the vegetation removed was the non-native, invasive shrub, amur honeysuckle (*Lonicera mackii*).

There was an inappropriate application of the pesticide diazanon around two air monitoring stations at the Area 1, Phase I Wetland Mitigation Project. Immediately after this problem was discovered, the diazanon was removed from the area. A subsequent field survey of benthic macroinvertebrates demonstrated that no impacts occurred to this population as a result of the pesticide. To prevent similar incidents from reoccurring, a more stringent review and approval process for field application of herbicides and pesticides has been implemented at the FEMP.

Ecological Restoration Activities

Several ecological restoration activities were undertaken at the FEMP in 2000. These projects consisted of the construction of the Area 8, Phase II Forest Demonstration Project and the initiation of wetland mitigation monitoring efforts in Area 1, Phase I. An additional seeding effort was conducted after Soil Pile 3 in Area 2, Phase I was excavated and the footprint area was certified. These projects are described in more detail below and are identified on Figure 7-1. Figure 7-1 also shows the restoration seeding efforts in Area 2, Phases I and III, as mentioned above, as well as the location for previous restoration projects undertaken at the FEMP.

The Area 8, Phase II Forest Demonstration Project involved the ecological restoration of a formerly grazed pasture located in the northwest corner of the FEMP along Morgan-Ross Road in Butler County. Over 1,300 sapling trees, 475 shrubs, and 2,300 seedlings were planted across the 18-acre (7.3-hectare) site, resulting in the restoration of several habitats native to southwest Ohio, including beech-maple, oak-maple, and mesophytic forests, a tallgrass savanna, and the enhancement of the existing riparian corridor along Paddys Run. Also, several ponds and wetlands, including a vernal pool, were constructed and planted with the appropriate wetland grasses and wildflowers. Bioengineering techniques were implemented to repair cow paths that were accelerating erosion along the western bank of Paddys Run. This project was essentially completed in 2000. A small number of seedlings will be planted during the spring of 2001.

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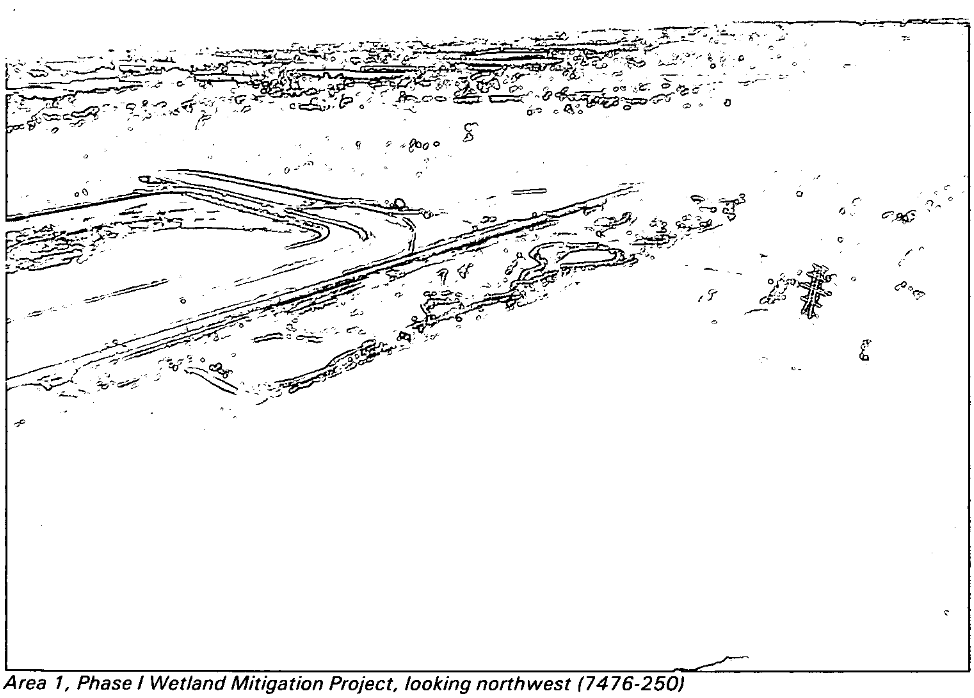
Wetland mitigation monitoring efforts began in Area 1, Phase I during 2000 to partially fulfill DOE's 16.5-acre (6.68-hectare) mitigation requirement. DOE must restore or create 16.5 acres (6.68 hectares) of wetlands in order to compensate for the loss of existing site wetlands during remediation. In 1999 a formerly grazed pasture was converted to a 12-acre (4.9-hectare) ecosystem containing eight wetland basins that are connected by gravity flow streams. The wetland portion of this ecosystem covers approximately 6 acres (2.5 hectares). Vegetative cover (i.e., forest, shrubland, prairie, and marsh) was installed for both wet and dry conditions. Monitoring of the Area 1, Phase I Wetland Mitigation Project was initiated in the first quarter of 2000. Pond and sub-surface water levels were determined in each of the basins that comprise the wetland ecosystem. Water quality samples were also collected and analyzed for pH, dissolved oxygen, conductivity, temperature, turbidity, odor, and color. This initial data set will be used to establish a baseline from which future data can be compared. By looking at these parameters over time, the health of the wetland system can be assessed. Results from the initial sampling effort show that the wetland is healthy and progressing as planned.



Area 1, Phase I Wetland Mitigation Project, looking northwest (7476-250)

Mortality counts of vegetation planted during 1999 were initiated in the spring of 2000. DOE is required to replace vegetation if survival drops below 80 percent. Due to deer pressure and the 1999 drought, survival was less than 80 percent within several areas of the wetland project. Therefore, replacement plantings were undertaken in the fall of 2000 to account for trees and shrubs lost. Approximately 200 trees and 400 shrubs were planted as replacements.

Approximately 3 acres (1.2 hectares) of certified soil remaining after the excavation of Soil Pile 3 in Area 2, Phase I were seeded with native grasses and wildflowers. Varying combinations of seed mixes, biological innoculants, and cover crops were used. This area will be monitored for the next several years to determine the optimal seeding approach for excavated areas.

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Ecological Restoration Research Projects

Monitoring continued in 2000 for the Invasive Plant Control Research Project, the Area 8, Phase I Re-vegetation Research Plots Project, the Prairie Plots Project, and the American Chestnut Research Project. These projects are being conducted under an ecological research grant as part of the Operable Unit 4 dispute resolution agreement. Results from these efforts will assist in the development of future ecological restoration designs at the FEMP. Research is still ongoing, but some preliminary findings are available. For the Invasive Plant Control Research Project, herbicide injection appears to be the best method for controlling honeysuckle. Preliminary data from the Re-vegetation Research Plots Project indicate that protective tree tubes provide different levels of protection for individual tree seedling species. Results from the Prairie Plots Project show that wood chip mulch seems to accelerate prairie establishment and retard weed growth. Results from the American Chestnut Research Project are not available yet, but are expected in the next several years.

Cultural Resources

Factors such as geologic setting, surface water, soil, vegetation, and climate determine the population and cultural growth of an area. The FEMP and surrounding area are located in a region of rich soil and many sources of water, such as the Great Miami River. Because of its advantageous location, the area was settled repeatedly throughout prehistoric and historic time, resulting in richly diverse cultural resources. The periods of occupation include the Paleo-Indian (12000 to 8000 B.C.), Archaic (8000 to 1000 B.C.), Woodland Tradition (1000 B.C. to 1000 A.D.), Mississippian Tradition (1000 to 1660 A.D.), and Historic Times (1660 A.D. to present).

The National Historic Preservation Act requires that DOE take into consideration the effects of its actions on sites that are listed or eligible for listing on the National Register of Historic Places. These sites are termed "historic properties." Native American remains and artifacts such as funerary objects and sacred objects are protected under the Native American Graves Protection and Repatriation Act.

Pursuant to implementing regulations for these laws, DOE worked with the Advisory Council on Historic Preservation and the Ohio Historic Preservation Office to develop two programmatic agreements for the FEMP. These agreements specify all activities required to consider and protect cultural resources at the FEMP. As a result, DOE must survey for and recover historic properties prior to any ground-disturbing activities in non-contaminated or previously undisturbed areas. Once construction activities begin, DOE also has contingency plans in place if unexpected cultural resources are uncovered during construction activities. These incidences are called "unexpected discoveries." For 2000 most remediation activities at the FEMP occurred in areas that were already surveyed or otherwise exempt from cultural resource survey requirements (i.e., previously disturbed areas). However, five unexpected discoveries were encountered during remediation activities in 2000 (refer to Table 7-1).

TABLE 7-1
UNEXPECTED CULTURAL RESOURCE DISCOVERIES FOUND IN 2000

Unexpected Discovery[a]	Time Period	Location of Discovery
Remains, Whitetail Deer	Age – Contemporary	Area 1, Phase I
Large animal bone	Historic	Area 2, Phase III
Worked bone artifact	Prehistoric	Area 8, Phase III
Historic pottery	1780 A.D. to 1840 A.D.	Area 8, Phase III
Chert artifact	Prehistoric	Area 8, Phase III

[a]No further excavation is warranted.

During 2000, 12.7 acres (5.14 hectares) were surveyed prior to the initiation of ground-disturbing activities. The surveys resulted in the identification of four previously undocumented prehistoric archaeological sites (33Bu657, 33Bu658, 33Ha759, and 33Ha760). Three of these sites (33Bu657, 33Bu658, and 33Ha760) represent low-density prehistoric lithic scatters. The last site (33Ha759) represents a moderate-density prehistoric site. Figure 7-2 shows the location of on-site archeological sites. In order to prevent disturbances, DOE is not permitted to reveal the location of off-property archeological sites. Therefore, off-property archeological sites are not shown on Figure 7-2.

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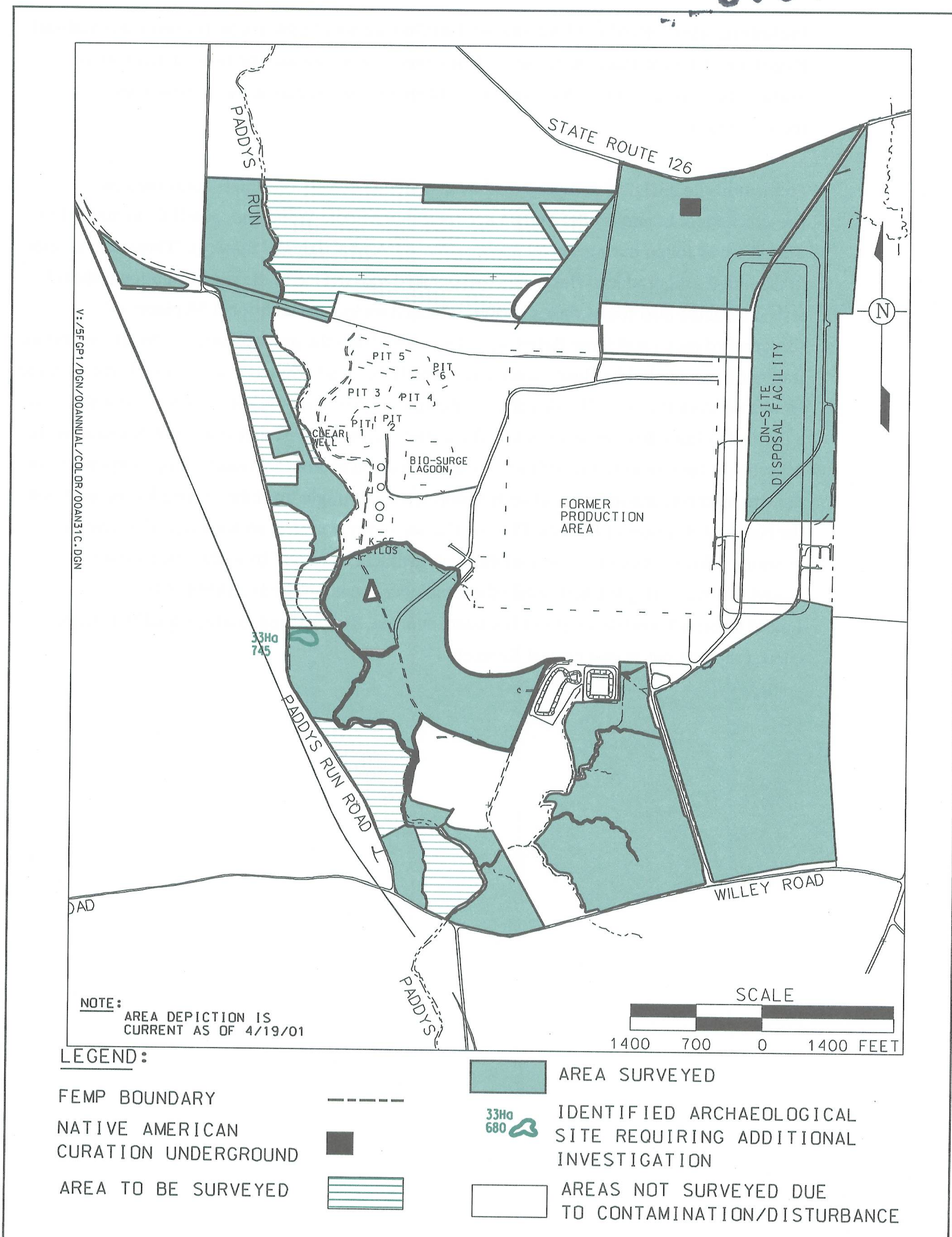

Figure 7-2. Cultural Resource Survey Areas

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Prehistoric sites 33Bu657, 33Bu658, and 33Ha760 are not eligible for inclusion on the National Register of Historic Places because of their ephemeral nature and the limited diversity of artifacts recovered from each of the sites. Therefore, no further work at these sites is recommended.

Prehistoric site 33Ha759 is represented by a moderate density of lithics, dominated by fire-cracked rocks and is of unknown age (possibly Middle Woodland, 500 B.C. to 500 A.D.). This site was found during shovel testing (Phase I Archaeological Survey). Three shovel tests in the initial grid produced flakes and fire-cracked rocks. One of the seven additional shovel tests conducted also found flakes and fire-cracked rocks. An additional 36 pieces of fire-cracked rocks and three flakes were recovered from the ground surface. In all, one biface fragment, one blade-like flake, seven late-stage flakes, and 45 pieces of fire-cracked rock were recovered from the site. The densities of the fire-cracked rocks suggest the high probability of a thermal cultural feature on the site. These discoveries suggest that stone tool manufacturing activities at the site were limited to late-stage reduction and/or tool refurbishing. Depending on the size, number, and integrity of such features, the site might meet the criteria for inclusion on the National Register of Historic Places. Consequently, Phase II archaeological testing is recommended for this site. Some of the chert artifacts identified from this site include Laurel Chert and Bogle Chert, while the remainder is unidentified or Pebble Cherts. Laurel Chert is known to crop-out in eastern Indiana. Bogle Chert is a high quality foreign chert, cropping out in east central Kentucky.

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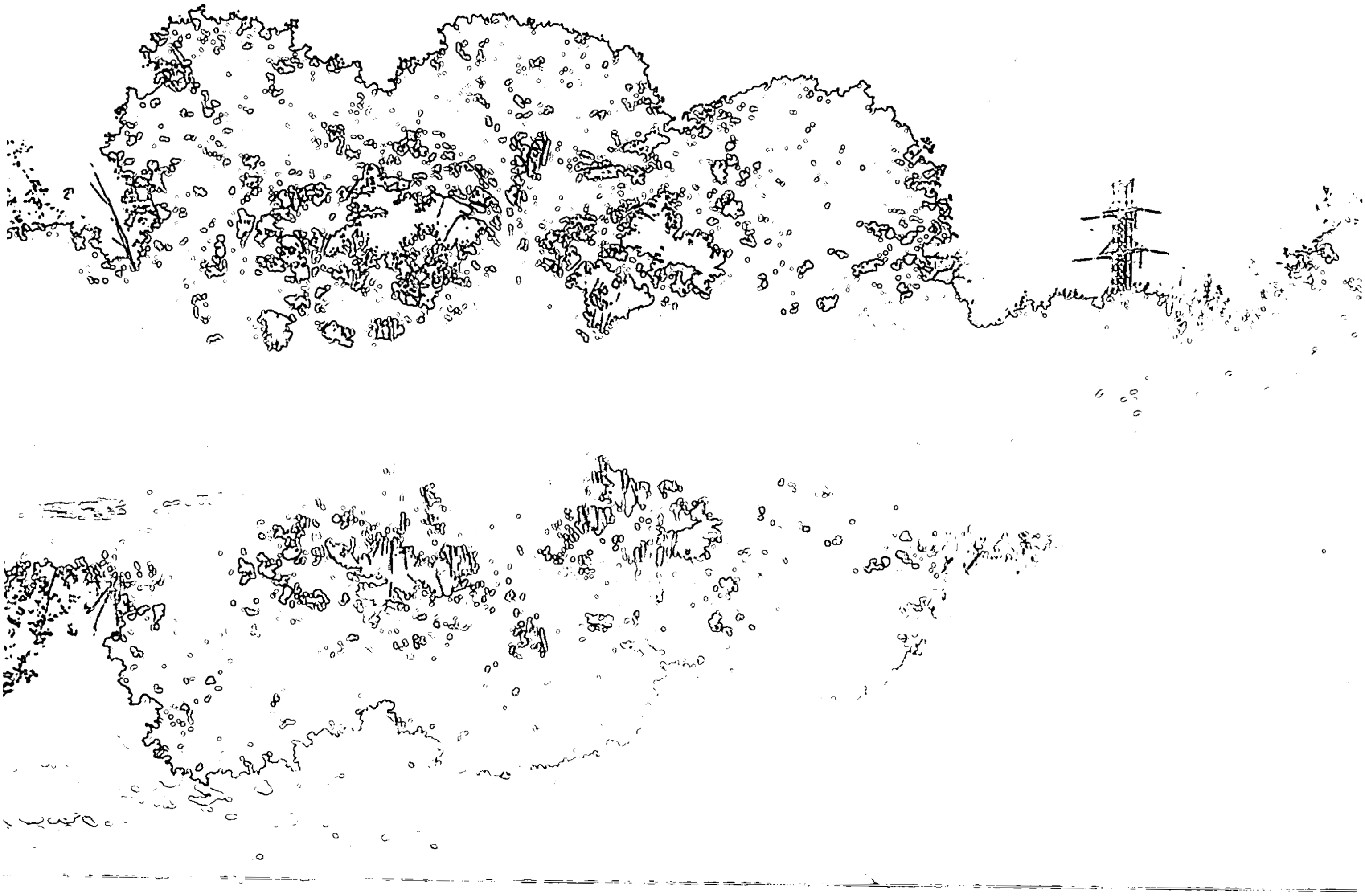

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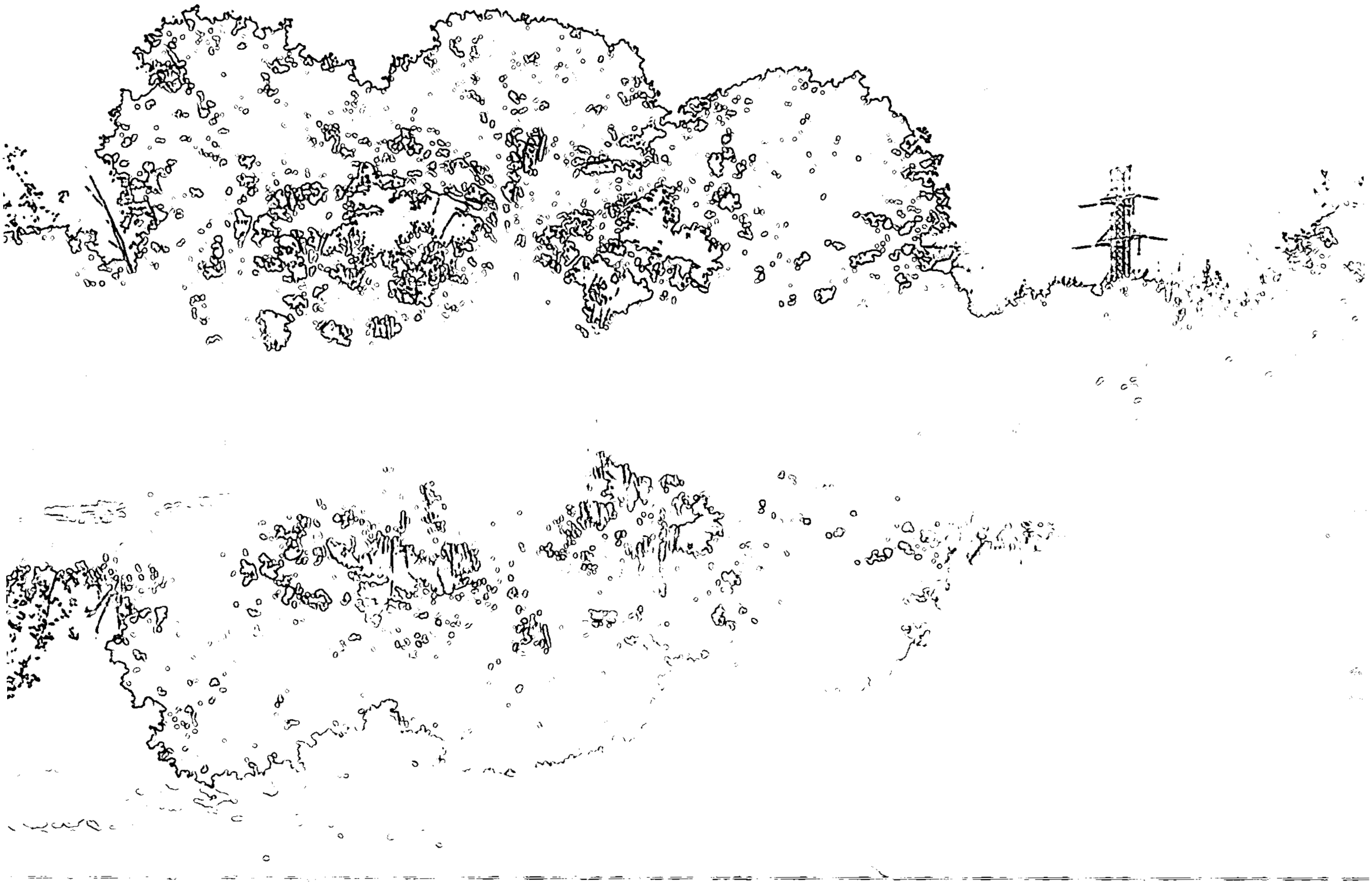
Glossary



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Glossary

10-year, Uranium-based Restoration Footprint
The 10-year, uranium-based restoration footprint shows the anticipated areal extent of the effects of aquifer restoration activities on the Great Miami Aquifer over the 10-year duration of the remediation as presented in aquifer restoration remedial design documents. The boundary of impact was developed using groundwater modeling results which shows the composite groundwater capture zone derived from the capture zones for each extraction well.

ALARA
A phrase and acronym (As Low As Reasonably Achievable) used to describe an approach to radiation exposure and emissions control or management whereby exposures and resulting doses to workers and the public are maintained as far below the specified limits as economic, technical, and practical considerations will permit.

Alpha Particle
Type of particulate radiation emitted from the nucleus of an atom. It consists of two protons and two neutrons. It does not travel long distances and loses its energy quickly.

Applicable or Relevant and Appropriate Requirements (ARARs)
Requirements set forth in regulations that implement environmental and public health laws and must be attained or exceeded by a selected remedy unless a waiver is invoked. ARARs are divided into three categories: chemical-specific, location-specific, and action-specific, based on whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action.

Aquifer
A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

Background Radiation
Particle or wave energy spontaneously released from atomic nuclei in the natural environment, including cosmic rays and such releases from naturally radioactive elements both outside and inside the bodies of humans and animals, and fallout from nuclear weapons tests.

Beta Particle
Type of particulate radiation emitted from the nucleus of an atom that has a mass and charge equal in magnitude to that of the electron.

Bypass Events
A bypass event occurs when storm water is bypassed around treatment and is directly discharged to the Great Miami River via the FEMP effluent line. Bypass events can occur during "significant precipitation" or when water treatment facilities are down for maintenance. Bypassing treatment is only implemented when the FEMP's storm water retention capacity is in danger of being exceeded.

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Capture Zone	Estimated area that is being "captured" by pumping of groundwater extraction wells. Definition of capture zone is important in ensuring that the uranium plumes targeted for clean up are being remediated.
Certification	The process by which a soil remediation area is certified as clean. Samples from the area are collected, analyzed, and the contaminant levels compared to the final remedial levels established in the Operable Unit 5 Record of Decision. Not all soil remediation areas on site require excavation before certification is done.
Contaminant	A substance that when present in air, surface water, sediment, soil, or groundwater above naturally occurring (background) levels causes degradation of the media.
Controlled Runoff	Contaminated storm water requiring treatment that is collected, treated, and eventually discharged to the Great Miami River as treated effluent.
Curie (Ci)	Unit of radioactivity that measures the rate of spontaneous, energy-emitting transformations in the nuclei of atoms.
Dose	Quantity of radiation absorbed in tissue.
Ecological Receptor	A biological organism selected by ecological risk assessors to represent a target species most likely to be affected by site-related chemicals, especially through bioaccumulation. Such organisms may include terrestrial and aquatic species.
Effective Dose Equivalent	The sum of the products of the dose equivalent received by specified tissues of the body and tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health-effects risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent due to penetrating radiation from sources external to the body. Effective dose equivalent is expressed in units of rem (or sievert).
Exposure Pathway	A route by which materials could travel between the point of release and the point of delivery of a radiation or chemical dose to a receptor organism.
Flyash	The ash remaining after the burning of coal in a boiler plant.

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Gamma Ray Type of electromagnetic radiation of discrete energy emitted during radioactive decay of many radioactive elements.

Glacial Overburden/Glacial Till Silt, sand, gravel, and clay deposited by glacial action on top of the Great Miami Aquifer and surrounding bedrock highs.

Great Miami Aquifer Sand and gravel deposited by the meltwaters of Pleistocene glaciers within the entrenched ancestral Ohio and Miami rivers. This is also called a buried channel or sand and gravel aquifer.

Groundwater Water in a saturated zone or stratum beneath the surface of land.

Head Works Includes the various flow equalization basins and/or preliminary treatment units which serve as the central collection and distribution points to the wastewater treatment operations in the main facility.

Mixed Waste Hazardous waste that has been contaminated with low-level radioactive materials.

Opacity How much light is blocked by particulates present in stack emissions.

Overpacking The act of placing a deteriorating drum inside a new, larger drum to prevent further deterioration or the possible release of contaminants during storage.

Point Source The single defined point (origin) of a release such as a stack, vent, or other discernable conveyance.

Radiation The energy released as particles or waves when an atom's nucleus spontaneously loses or gains neutrons and/or protons. The three main types are alpha particles, beta particles, and gamma rays.

Radioactive Material Refers to any material or combination of materials that spontaneously emits ionizing radiation.

Radionuclide Refers to a radioactive nuclide. There are several hundred known radionuclides, both artificially produced and naturally occurring. Radionuclides are characterized by the number of neutrons and protons in an atom's nucleus and their characteristic decay processes.

Receptors Individuals or organisms that are or could potentially be impacted by contamination.

Remedial Action The actual construction and implementation phase of a Superfund site cleanup that follows the remedy selection process and remedial design.

Remedial Investigation/ Feasibility Study
The first major event in the remedial action process which serves to assess site conditions and evaluate alternatives to the extent necessary to select a remedy.

Remedial Response
A long-term action potentially involving site characterization, risk assessment, a technology treatability study, a feasibility study, a remedial design, and remedial implementation.

Removal Action
A short-term cleanup or removal of released hazardous substances from the environment. This occurs in the event of a release or the imminent threat of release of hazardous substances into the environment.

Roentgen Equivalent Man (Rem)
A special unit of dose equivalent that expresses the effective dose calculated for all radiation on a common scale; the absorbed dose in rads multiplied by certain modifying factors (e.g., quality factor); 100 rem = 1 sievert.

Sediment
The unconsolidated inorganic and organic material that is suspended in surface water and is either transported by the water or has settled out and become deposited in beds.

Source
A controlled source of radioactive material used to calibrate radiation detection equipment. Can also be used to refer to any source of contamination (e.g., a point source such as the stack on the waste pits stack, a source of radon such as the silos headspace, etc.).

Surface Water
Water that is flowing within natural drainage features.

Treated Effluent
Water from numerous sources at the site which is treated through one of the FEMP's wastewater treatment facilities and discharged to the Great Miami River.

Thermoluminescent Dosimeter
A device used to monitor the amount of radiation to which it has been exposed.

Uncontrolled Runoff
Storm water that is not collected by the site for treatment, but enters the site's natural drainages.

Volatile Organic Compound
A hydrocarbon compound, except methane and ethane, with a vapor pressure equal to or greater than 0.1 millimeter of mercury.

Waste Acceptance Criteria
Disposal facilities specify the types and sizes of materials, acceptable levels of constituents, and other criteria for all material that will be disposed in that facility. These are known as waste acceptance criteria. Off-site disposal facilities that will dispose of FEMP waste (such as the Nevada Test Site) have specific waste acceptance criteria. In addition, the FEMP on-site disposal facility has waste acceptance criteria that have been approved by the regulatory agencies. The FEMP Waste Acceptance Organization is responsible for ensuring that all waste to be placed in the on-site disposal facility meet all these criteria before waste placement.