U-007-402.4

943

INITIAL SCREENING OF ALTERNATIVES FOR OPERABLE UNIT 5 TASK 12 REPORT DECEMBER 1990

12/28/90

FMPC-0512-6
DOE-ORO
250
REPORT
OU5

[redacted] 943

INITIAL SCREENING OF ALTERNATIVES FOR OPERABLE UNIT 5

TASK 12 REPORT

FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

REMEDIAL INVESTIGATION and FEASIBILITY STUDY

December 1990

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
FMPC-0512-6

FINAL

TABLE OF CONTENTS

	Page
List of Tables	viii
List of Figures	ix
List of Acronyms	x
Distribution List	xii
Executive Summary	ES-1
1.0 Introduction	1-1
1.1 Operable Unit Management Strategy	1-1
1.2 Operable Unit 5: Environmental Media	1-4
1.3 Technical Approach and Organization	1-6
1.4 Site History and Operation	1-8
1.4.1 Operational History	1-8
1.4.2 Waste and Effluent Management	1-9
2.0 Characterization of the Study Area	2-1
2.1 Surface Water Hydrology	2-1
2.1.1 Great Miami River	2-1
2.1.2 Paddys Run	2-3
2.1.3 Storm Sewer Outfall Ditch	2-3
2.2 Groundwater Hydrology	2-3
2.3 Soils	2-8
2.4 Vegetation and Wildlife	2-9
2.5 Land Use and Population	2-10
2.6 Ambient Air	2-11
2.6.1 Regional Air Quality	2-11
2.6.2 Meteorological Factors	2-12
3.0 Nature and Extent of Contamination	3-1
3.1 Contaminant Distribution	3-3
3.1.1 Groundwater	3-3
3.1.1.1 Regional Aquifer	3-3
3.1.2 Soil	3-7
3.1.3 Surface Water	3-12
3.1.4 Sediments	3-15
3.1.5 Air	3-17
3.1.6 Biota	3-17

TABLE OF CONTENTS
(Continued)

		Page
3.2	Contaminant Transport and Fate	3-19
3.2.1	Contaminant Migration Pathways and Receptors	3-19
3.2.1.1	Groundwater	3-19
3.2.1.2	Surface Water and Sediment	3-21
3.2.1.3	Soils	3-21
3.2.1.4	Ambient Air	3-22
3.2.1.5	Biota	3-22
3.2.2	Contaminant Fate	3-22
4.0	Identification and Screening of Technologies	4-1
4.1	Introduction	4-1
4.2	Remedial Action Objectives	4-1
4.3	Identification of General Response Actions	4-4
4.4	Identification and Screening of Technologies and Process Options	4-4
4.4.1	Initial Screening: Groundwater Medium	4-6
4.4.1.1	No Action	4-6
4.4.1.2	Institutional Actions	4-6
4.4.1.3	Control/Containment	4-6
4.4.1.4	Removal	4-12
4.4.1.5	Treatment	4-12
4.4.1.6	Discharge	4-13
4.4.1.7	Summary of Technology Screening for Groundwater	4-13
4.4.2	Initial Screening: Soils and Sediments	4-15
4.4.2.1	No Action	4-15
4.4.2.2	Institutional Actions	4-15
4.4.2.3	Control/Containment	4-15
4.4.2.4	Removal	4-21
4.4.2.5	Treatment	4-21
4.4.2.6	On-Site Disposal	4-23
4.4.2.7	Off-Site Disposal	4-23
4.4.2.8	Summary of Technology Screening for Soils and Sediments	4-24

TABLE OF CONTENTS
(Continued)

				Page
5.0	Evaluation of Technology Process Options			5-1
5.1	Screening Criteria			5-1
	5.1.1	Effectiveness		5-1
	5.1.2	Implementability		5-1
	5.1.3	Cost		5-2
5.2	Evaluation of Process Options for Groundwater			5-2
	5.2.1	No Action		5-2
	5.2.2	Institutional Actions		5-2
		5.2.2.1	Groundwater Monitoring	5-4
		5.2.2.2	Land Acquisition	5-4
		5.2.2.3	Deed Restrictions	5-5
	5.2.3	Control/Containment Actions		5-5
		5.2.3.1	Extraction/Injection Wells (Uncontaminated Water)	5-6
		5.2.3.2	Alter Natural Drainage System	5-6
	5.2.4	Extraction Wells (Contaminated Water)		5-8
	5.2.5	Treatment Actions		5-9
		5.2.5.1	Biological/Biosorbant	5-9
		5.2.5.2	Physicochemical/Precipitation	5-9
		5.2.5.3	Physicochemical/Coagulation/Polymerization	5-10
		5.2.5.4	Physicochemical/Adsorption	5-11
		5.2.5.5	Physicochemical/Reverse Osmosis	5-12
		5.2.5.6	Physicochemical/Advanced Membrane Filtration/ Ultrafiltration	5-13
		5.2.5.7	Chemical/Ion Exchange	5-13
	5.2.6	Discharge Actions		5-15
		5.2.6.1	Discharge Treated Groundwater to Great Miami River via New Pipeline	5-15
		5.2.6.2	Discharge Treated Groundwater to Great Miami River via Existing Pipeline	5-16
		5.2.6.3	Discharge Untreated Groundwater to Great Miami River via New Pipeline	5-16
		5.2.6.4	Discharge Untreated Groundwater to Great Miami River via Existing Pipeline	5-17

5

TABLE OF CONTENTS
(Continued)

		Page
	5.2.6.5 Injection Wells	5-18
5.3	Evaluation of Technology Process Options for Soils and Sediments	5-18
	5.3.1 No Action	5-18
	5.3.2 Institutional Actions	5-20
	5.3.2.1 Fence Site Areas	5-20
	5.3.2.2 Deed Restrictions	5-21
	5.3.3 Control/Containment Actions	5-21
	5.3.4 Removal Actions	5-22
	5.3.5 Treatment Actions	5-23
	5.3.5.1 Gravimetric Separation	5-23
	5.3.5.2 Soil Washing	5-24
	5.3.5.3 Cement-Based Solidification	5-25
	5.3.5.4 Thermoplastic Solidification	5-25
	5.3.5.5 Vitrification	5-26
	5.3.6 On-Site Disposal	5-26
	5.3.7 Off-Site Disposal	5-27
5.4	Summary of Selected Process Options	5-28
	5.4.1 Selection of Process Options for Groundwater	5-28
	5.4.2 Selection of Process Options for Soil/Sediment	5-29
6.0	Development and Description of Remedial Action Alternatives	6-1
6.1	Alternative 1 - Groundwater: No Action; Sediments/Soils; No Action	6-4
6.2	Alternative 2 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, On-Site Disposal	6-7
	6.2.1 Groundwater	6-7
	6.2.2 Sediments/Soils	6-8

TABLE OF CONTENTS
(Continued)

		Page
6.3	Alternative 3 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Disposal	6-10
	6.3.1 Groundwater	6-10
	6.3.2 Sediments/Soils	6-10
6.4	Alternative 4 - Groundwater: Extract, Discharge; Sediments/ Soils: Excavate, Off-Site Disposal	6-11
	6.4.1 Groundwater	6-11
	6.4.2 Sediments/Soils	6-11
6.5	Alternative 5 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Off-Site Disposal	6-11
	6.5.1 Groundwater	6-11
	6.5.2 Sediments/Soils	6-11
6.6	Alternative 6 - Groundwater: Extract, Discharge; Sediments/ Soils: Excavate, On-Site Treatment, On-Site Disposal of Treatment Residuals	6-12
	6.6.1 Groundwater	6-12
	6.6.2 Sediments/Soils	6-12
6.7	Alternative 7 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Treatment, On-Site Disposal of Treatment Residuals	6-12
	6.7.1 Groundwater	6-12
	6.7.2 Sediments/Soils	6-13
6.8	Alternative 8 - Groundwater: Extract, Discharge; Sediment/ Soils: Single-Layer Cap	6-13
	6.8.1 Groundwater	6-13
	6.8.2 Sediments/Soils	6-13
6.9	Alternative 9 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Single-Layer Cap	6-14
	6.9.1 Groundwater	6-14
	6.9.2 Sediments/Soils	6-14
6.10	Alternative 10 - Groundwater: Extract and Reinject for Plume Control; Sediments/Soils: Excavate, On-Site Disposal	6-14
	6.10.1 Groundwater	6-14
	6.10.2 Sediments/Soils	6-15

TABLE OF CONTENTS
(Continued)

				Page
6.11	Alternative 11 - Groundwater: Recharge Area Modification; Sediments/Soils: Excavate, On-Site Disposal			6-15
	6.11.1	Groundwater		6-15
	6.11.2	Sediments/Soils		6-15
7.0	Initial Screening of Alternatives			7-1
7.1	Effectiveness and Implementability Evaluations			7-1
	7.1.1	Alternative 1 - No Action		7-2
	7.1.2	Alternative 2 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, On-Site Disposal		7-2
		7.1.2.1	Groundwater	7-2
		7.1.2.2	Sediments/Soils	7-4
	7.1.3	Alternative 3 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Disposal		7-5
		7.1.3.1	Groundwater	7-5
		7.1.3.2	Sediments/Soils	7-5
	7.1.4	Alternative 4 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, Off-Site Disposal		7-5
		7.1.4.1	Groundwater	7-5
		7.1.4.2	Sediments/Soils	7-5
	7.1.5	Alternative 5 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Off-Site Disposal		7-6
		7.1.5.1	Groundwater	7-6
		7.1.5.2	Sediments/Soils	7-6
	7.1.6	Alternative 6 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, Treatment, Off-Site Disposal		7-6
		7.1.6.1	Groundwater	7-6
		7.1.6.2	Sediments/Soils	7-6
	7.1.7	Alternative 7 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Disposal		7-7
		7.1.7.1	Groundwater	7-7
		7.1.7.2	Sediments/Soils	7-7

TABLE OF CONTENTS
(Continued)

		Page
7.1.8	Alternative 8 - Groundwater: Extract, Discharge; Sediment/Soils: Single-Layer Cap	7-7
7.1.8.1	Groundwater	7-7
7.1.8.2	Sediments/Soils	7-7
7.1.9	Alternative 9 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Single-Layer Cap	7-8
7.1.9.1	Groundwater	7-8
7.1.9.2	Sediments/Soils	7-8
7.1.10	Alternative 10 - Groundwater: Extract and Reinject for Plume Control; Sediments/Soils: Excavate, On-Site Disposal	7-8
7.1.10.1	Groundwater	7-8
7.1.10.2	Sediments/Soils	7-8
7.1.11	Alternative 11 - Groundwater: Recharge Area Modification; Soils: Excavate, On-Site Disposal	7-9
7.1.11.1	Groundwater	7-9
7.1.11.2	Sediments/Soils	7-9
7.2	Cost Evaluation	7-9
7.3	Alternatives Retained for Detailed Analysis	7-10
8.0	Compliance with Applicable or Relevant and Appropriate Requirements (ARARS)	8-1
References		
Appendix A - Data Summaries		
Appendix B - Applicable or Relevant and Appropriate Requirements (ARARs)		

LIST OF TABLES

Table No.	Title	Page
4-1	Initial Screening of Technologies and Process Options for Groundwater	4-14
4-2	Technologies and Process Options Retained for Further Evaluation - Groundwater	4-14
4-3	Initial Screening of Technologies and Process Options for Soils and Sediments	4-16
4-4	Technologies and Process Options Retained for Further Evaluation - Soils	4-25
4-5	Technologies and Process Options Retained for Further Evaluation - Sediments	4-26
5-1	Detailed Evaluation of Process Options For Groundwater	5-3
5-2	Detailed Evaluation of Process Options for Soils and Sediments	5-19
6-1	Remedial Action Alternatives - Operable Unit 5	6-2
7-1	Alternative Screening - Operable Unit 5	7-3

LIST OF FIGURES

Figure No.	Title	Page
1-1	Major Site Features and Vicinity	1-2
1-2	Source Operable Units	1-5
1-3	Major Features of the Feed Materials Production Center	1-10
2-1	Operable Unit 5 Study Area	2-2
2-2	Groundwater Elevations, 2000 Series Wells, April 1990	2-6
2-3	Groundwater Elevations, 3000 Series Wells, April 1990	2-7
3-1	Potential Areas of Concern, Groundwater - 2000 Series Wells	3-5
3-2	Potential Areas of Concern, Groundwater - 3000 Series Wells	3-6
3-3	Potential Areas of Concern, Groundwater - 4000 Series Wells	3-8
3-4	Potential Areas of Concern, Soil and Sediment	3-10
3-5	Surface Water Sampling Locations	3-14
6-1	Simulated Uranium Concentrations - Present Conditions	6-5
6-2	South Plume Removal Action	6-6

LIST OF ACRONYMS

AEC	Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
ASI	Advanced Sciences, Inc.
AWQC	Ambient Water Quality Criteria
CAA	Clean Air Act
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
CSF	cancer slope factors
CWA	Clean Water Act
DCG	derived concentration guides
DOE	U.S. Department of Energy
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
IT	International Technology Corporation
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MPRSA	Marine Protection Research and Sanctuaries Act
NAAQS	National Ambient Air Quality Standards
NCP	National Pollutant Discharge Elimination System
NLO	National Lead Company of Ohio
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
O&M	operation and maintenance
ORC	Ohio Revised Code
PCB	polychlorinated biphenyl
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS
(continued)

RfD	reference dose
RI/FS	remedial investigation/feasibility study
RO	reverse osmosis
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SOWC	Southwest Ohio Water Company
SWOAPCA	Southwestern Ohio Air Pollution Control Agency
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
UIC	Underground Injection Control
UMTRA	Uranium Mill Tailings Remedial Action Program
USC	U.S. Code
WMCO	Westinghouse Materials Company of Ohio

DISTRIBUTION LIST

Project Director - John Wood, Fernald
Deputy Director/Technical - John Razor, Fernald
Technical Manager - Bob Galbraith, Fernald
Operable Unit/Task Managers - Linda Dolan, Knoxville
Mike Higgins, Knoxville
Dan Smith, Oak Ridge
Robin Smith, Pittsburgh
Sam Wolinsky, Fernald
John Frazier, Knoxville
Suzanne Gray, Fernald
Sue Wolinsky, Fernald

Project QA Officer - Larry Sexton, Fernald
Technical QA Officer - Don Mack, Knoxville
NEPA Office - Fernald
Site Project Files - Fernald
IT-Monroeville Project Central Files
IT-Knoxville Project Central Files
ASI-Oak Ridge Project Files

DOE COR - Bobby Davis, Fernald
DOE Operable Unit Manager - Carlos J. Fermaintt
WMCO - Pat Hopper, Fernald
WMCO Operable Unit Manager - Dave Brettschneider
Lee Wan & Associates - Thomas Tucker

DOE-HQ - Randi Allen, Washington, D.C.
Oak Ridge Office

EPA, Region 5 - Catherine McCord, Chicago

OEPA - Graham Mitchell, Dayton

EXECUTIVE SUMMARY

The Atomic Energy Commission (AEC), predecessor to the U.S. Department of Energy (DOE), established a production complex in the early 1950s for processing uranium in its compounds from natural uranium ore concentrates. This complex, known as the Feed Materials Production Center (FMPC), is located 1050 acres in a rural area approximately 15 miles northwest of downtown Cincinnati, Ohio. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant.

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the DOE and the U.S. Environmental Protection Agency (EPA) pertaining to environmental impacts associated with the years of operation of the FMPC. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented. In response to the FFCA, a Remedial Investigation and Feasibility Study (RI/FS) is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

The technical strategy adopted for the RI/FS is to issue distinct RI/FS reports for each of five identified operable units at the FMPC. One of the operable units identified for the RI/FS is Operable Unit 5. Operable Unit 5 includes those environmental media that represent pathways and/or environmental receptors presently or potentially affected by FMPC contaminants. In general, the environmental media included in Operable Unit 5 are surface water/sediments (Great Miami River, Paddys Run, and Storm Sewer Outfall Ditch), groundwater (Great Miami Aquifer), soils (all soils not accounted for in other operable units), flora and fauna (within regional area), and ambient air.

The important physical properties and characteristics of Operable Unit 5 are discussed in Chapter 2.0.

Chapter 3.0 discusses the nature and extent of contamination for the various environmental media within Operable Unit 5. Based on the current site data, uranium is a contaminant of concern in the groundwater, soils, surface water and sediments as well as vegetation, benthic macroinvertebrates and fish. Additionally, radium is identified as a contaminant of concern in the sediments of Paddys Run.

Biological samples collected within Operable Unit 5, including grass, fish, and mammal tissues, were analyzed for priority pollutant base, neutral and acid extractable organic compounds as well as pesticides and polychlorinated bephenyls (PCBs). None of these compounds were detected in any sample.

Chapter 4.0 discusses the general response actions developed for Operable Unit 5 and the identification and screening of remedial technologies and process options. Response actions are identified for contaminants of concern with emphasis to satisfy the remedial action objectives and to protect human health and the environment.

The process options remaining from the initial screening are evaluated on the basis of effectiveness, implementability and cost in Chapter 5.0 and assembled into remedial action alternatives in Chapter 6.0.

Eleven potential remedial action alternatives were developed by combining the selected representative process options into alternatives representing possible cleanup remedies for Operable Unit 5. These eleven alternatives are:

- Alternative 1 - Groundwater: Baseline; Sediments/Soils: No Action
- Alternative 2 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, On-Site Disposal
- Alternative 3 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Disposal
- Alternative 4 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, Off-Site Disposal
- Alternative 5 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Off-Site Disposal
- Alternative 6 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, On-Site Treatment, On-Site Disposal
- Alternative 7 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Treatment, On-Site Disposal
- Alternative 8 - Groundwater: Extract, Discharge; Sediments/Soils: Single-Layer Cap
- Alternative 9 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Single-Layer Cap

- Alternative 10 - Groundwater: Extract and Reinject for Plume Control; Sediments/Soils: Excavate, On-Site Disposal

- Alternative 11 - Groundwater: Recharge Area Modification; Soils: Excavate, On-Site Disposal

The remedial action for sediments and soils are combined since the technologies and process options used to formulate the alternatives are applicable to each of these media, and they are best addressed as a unit. The alternatives were formulated by combining the most feasible soil/sediment action (based on the process evaluation) which include excavation/on-site disposal and excavation/off-site disposal with the most feasible groundwater actions. The groundwater actions include extract/discharge and extract/treat/discharge. Other alternatives were formulated to incorporate additional potential actions.

Chapter 7.0 describes the initial screening of the remedial action alternatives and presents those alternatives selected for detailed evaluation in the next phase of the FS process (Task 13). The alternatives were screened against four general criteria: effectiveness, implementability/technical feasibility, implementability/administrative feasibility and cost. The alternatives were evaluated by applying a simple numeric ranking system ranging between one and five for each evaluation factor and each component of the alternative. A ranking of "one" indicates a particular alternative is least favorable for a particular factor (e.g., short-term protection of human health), while "five" represents an alternative that is most favorable for a particular factor relative to other alternatives. This provided a maximum score of 110 points for each alternative. Based on this evaluation, Alternatives 1, 2, 3, 4, 5, 6, 7, and 9 were retained for detailed evaluation.

Chapter 8.0 briefly discusses the development of applicable or relevant and appropriate requirements for proposed actions under this study.

The results of the screening of alternatives that are presented in this document are limited by several factors. Specifically, this document is being prepared prior to the completion of the several RI field activities important to Operable Unit 5 that are being conducted in response to the findings of the baseline RI program. While virtually all of the currently available data have been reviewed and preliminarily evaluated, detailed analysis of the data is still ongoing in conjunction with the RI effort for this operable unit. The baseline risk assessment, the results of which are fundamental to the establishment of cleanup criteria to support the FS, is also still in progress awaiting the collection and analysis of the complete RI data base. Since no standards currently exist for

uranium in soils/sediments and the risk assessment is still in progress, the level of 35 pCi/g is being used in this assessment as adopted from the 1981 NRC Branch Technical Position Paper.

Since the baseline risk assessment may identify different cleanup criteria for soil and sediment than that used for this initial evaluation and since additional areas or contaminants of concern may be identified during the ongoing RI data development task, the remedial alternatives identified in this screening may require modification as the FS process proceeds. It is unlikely, however, that completion of the risk assessment and RI will negate any of the results of technology and process option identification and evaluation contained in this report. It is also unlikely that substantive changes would be required in remedial alternative components identified in this report. As currently envisioned, any modifications would likely be an expansion or contraction of actual areas (volumes) within various media requiring remediation. Any necessary modifications will be addressed and incorporated during the detailed analysis of alternatives in Task 13.

Even with the limitations cited above, the data evaluation completed for this initial screening of alternatives provides an appropriate framework for the development and evaluation of remedial alternatives to address potential contamination problems associated with Operable Unit 5.

1.0 INTRODUCTION

The Feed Materials Production Center (FMPC) is a contractor-operated federal facility for the production of pure uranium metals for the U.S. Department of Energy (DOE). The FMPC site is located on 1,050 acres in a rural area approximately 15 miles northwest of downtown Cincinnati, Ohio. The Production Area is limited to an approximate 136-acre tract near the center of the FMPC site. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant (Figure 1-1).

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the DOE and the U.S. Environmental Protection Agency (EPA) pertaining to environmental impacts associated with the FMPC. The FFCA was entered into pursuant to Executive Order 12088 (43CFR47707) to ensure compliance with existing environmental statutes and implementing regulations such as the Clean Air Act, Resource Conservation and Recovery Act (RCRA), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In particular, the FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented.

In response to the FFCA, and as amended by the Consent Agreement under CERCLA Sections 120 and 106(a) signed in April 1990 and effective June 29, 1990, a Remedial Investigation/Feasibility Study (RI/FS) is in progress. All RI/FS activities are being conducted in conformance with the EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA 1988).

1.1 OPERABLE UNIT MANAGEMENT STRATEGY

Within the CERCLA framework, the purpose of the RI is to determine the nature and extent of any release, or threat thereof, of hazardous or radioactive substances and to gather the necessary data to support the evaluation of remedial action alternatives in the FS. The RI/FS for the FMPC was initially designed to address the entire site and to focus on various environmental media that could be potentially impacted by past and present operations at the FMPC.

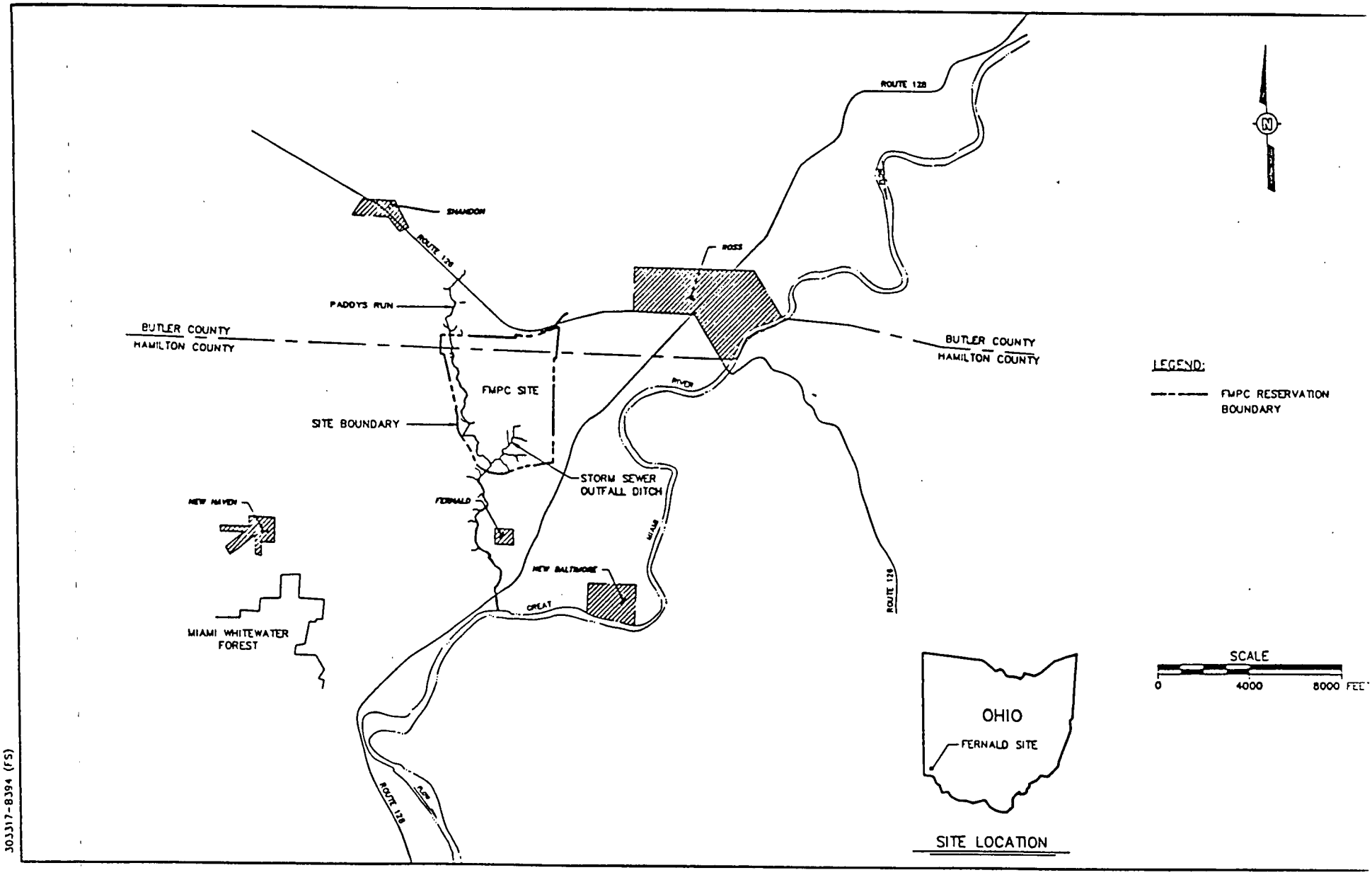


FIGURE 1-1

MAJOR SITE FEATURES AND VICINITY

A Work Plan for the sitewide RI/FS, based on the requirements of the FFCA, was originally submitted to the EPA in December 1986. After a series of technical discussions, the Work Plan was modified and resubmitted in March 1988 and received EPA approval in May 1988.

The Work Plan identified 27 units of the FMPC to be investigated in the RI/FS. Several modifications to the list eventually increased this total to 39 units. Due to the size and complexity of the site, it became apparent that for technical and program management purposes, these 39 units needed to be categorized into groups of candidates for remedial action. The site was divided into six groups called operable units. The concept of operable units was introduced into the program to accommodate separate schedules for each operable unit, thereby allowing the remedial action process to proceed to completion for the most well-defined or problematical units while data collection and analysis continued for other operable units. The operable units were first identified in the August 1988 Work Plan for the FS. The first document prepared to include the six initially identified operable units for the FS was issued in December 1988 (Development of Alternatives for the Feasibility Study, Revision 1), hereafter referred to as the Development of Alternatives Document.

Subsequent to the issuance of this document, Operable Units 5 and 6 were reorganized to allow the introduction of the South Plume groundwater study area as a separate operable unit (Operable Unit 6). The introduction of the South Plume as Operable Unit 6 was triggered by EPA's request for DOE to prioritize a focused remedial action program for a groundwater plume outside the FMPC boundary with elevated uranium concentrations in an area of the aquifer potentially used for drinking water, agriculture, and industrial manufacturing. This plume was identified to be primarily the result of historical releases and included the areas of the Great Miami Aquifer contained within the southerly groundwater flow regime, both within and outside the FMPC property. After this reorganization, Operable Unit 5 became inclusive of all other environmental media: surface water, sediments, groundwater (the regional aquifer, excluding the South Plume), surface and subsurface soils, flora, and fauna.

During the course of the groundwater investigation conducted as part of the RI, a potentially important technical shortcoming became apparent in the separation of the South Plume from the rest of the regional aquifer. Data gathered during this investigation indicated that the groundwater flow divide that provided the initial definitional basis for Operable Unit 6 is a transient phenomenon due

to Paddys Run seasonal recharge. Therefore, the use of the flow divide to differentiate between Operable Units 5 and 6 could lead to significant problems in the FS/ROD process and created a need for integration across operable units. In addition, the analysis of complete source-pathway-receptor relationships within the individual operable units was inhibited by a current lack of data on the southern portion of the plume, the remaining unknowns related to the Southfield near the flow divide, and the contribution of Paddys Run as a source that crosses the groundwater flow divide. For these reasons, the decision was made to deal with the entire regional aquifer within a single operable unit, Operable Unit 5, thus eliminating Operable Unit 6 from the FS process.

In response, the issues of the South Plume concerning the contamination outside the FMPC property were addressed as an accelerated removal action independent of the FS. The Engineering Evaluation/Cost Analysis (EE/CA) document for the South Plume (DOE 1990a) recommends a comprehensive action involving an alternate water supply and a groundwater pumping and discharge system. This proposed action will be considered as the baseline condition during the development and evaluation of alternatives for Operable Unit 5.

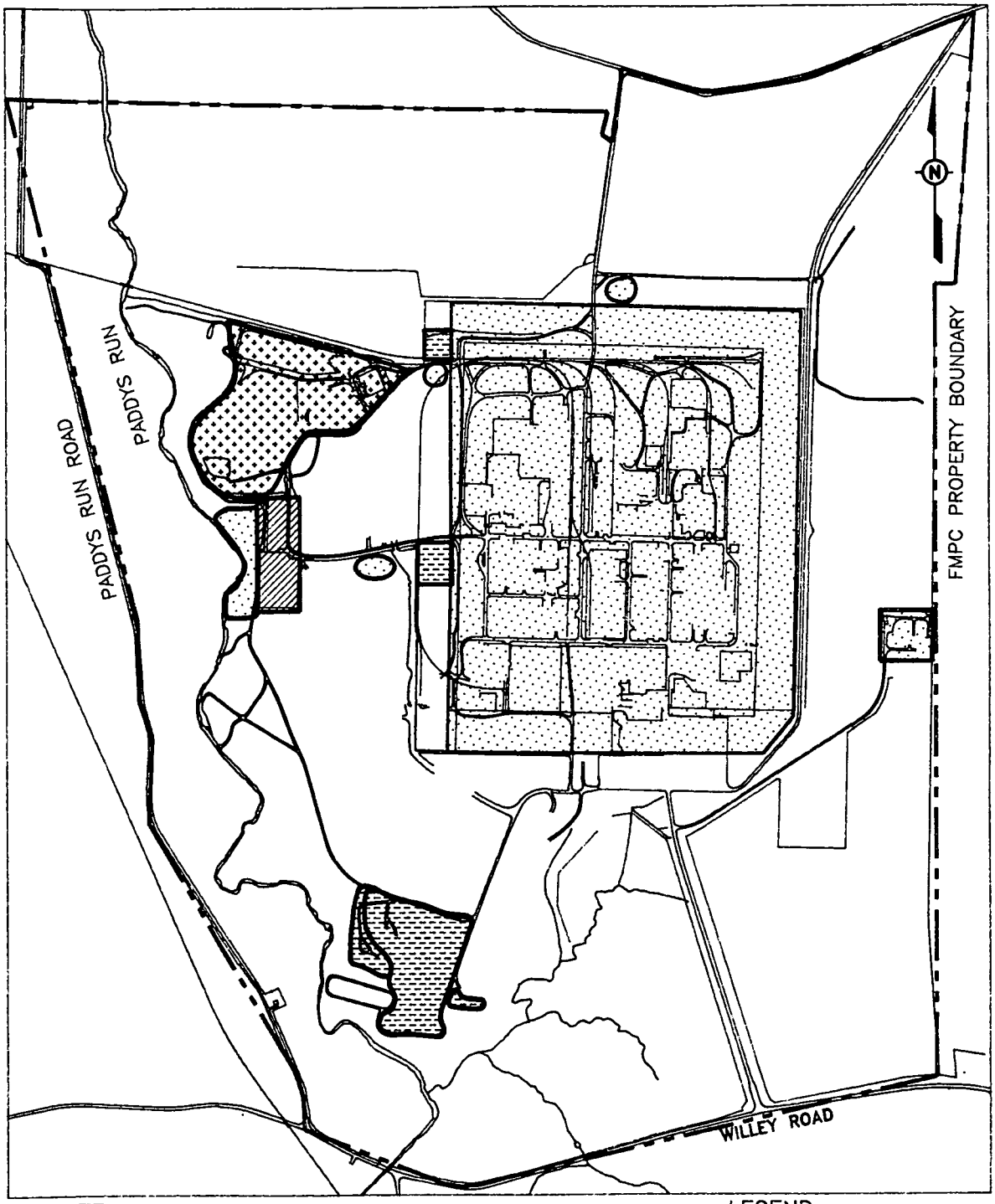
Currently, the FMPC is divided into the following five operable units (refer to Figure 1-2):

- Operable Unit 1 - Waste Pits 1 through 6, Clearwell, and Burn Pit
- Operable Unit 2 - Other Waste Units
- Operable Unit 3 - Production Area and Suspect Areas
- Operable Unit 4 - Silos 1, 2, 3, and 4
- Operable Unit 5 - All Environmental Media

In accordance with the operable unit management strategy, separate RI/FS reports will be generated for each operable unit. Operable Unit 5 is the subject of this report.

1.2 OPERABLE UNIT 5: ENVIRONMENTAL MEDIA

Operable Unit 5 includes those environmental media that represent pathways and/or environmental receptors presently or potentially affected by FMPC contaminants. The Operable Unit 5 media are linked to the four "source control" operable units but in and of themselves represent sources of contaminant release only in terms of serving as a transport pathway from one environmental medium to another. Each of the environmental media included in Operable Unit 5 are defined separately below:



NOTE:

OPERABLE UNIT 5 INCLUDES REGIONAL GROUNDWATER, SURFACE WATER, SOILS, FLORA AND FAUNA.

SCALE

0 600 1200 FEET

LEGEND:

- OPERABLE UNIT 1
- OPERABLE UNIT 2
- OPERABLE UNIT 3
- OPERABLE UNIT 4

602A OPUNITS_BP_FND

FIGURE 1–2. SOURCE OPERABLE UNITS

- Surface Water/Sediments

  - Great Miami River: Addresses the surface waters of the Great Miami River as well as the sediments and their role as a potential source of contaminants to the overlying water column and the aquatic community. Does not include the control of sources to the river, which is the focus of other operable units.

  - Paddys Run: Similar to the Great Miami River, with the additional consideration of the effects of leakage from Paddys Run into the regional aquifer.

  - Storm Sewer Outfall Ditch: Similar to Paddys Run.

- Groundwater: Limited to the Great Miami Aquifer (i.e., the regional aquifer) throughout the study area, with appropriate consideration given to the South Plume Area which is the subject of a separate removal action. Does not include source control, which is the focus of other operable units.

- Soils: Includes all soils not accounted for in other operable units; specifically, soil areas outside of the Production Area, other controlled areas of the site, and suspect areas and areas outside the FMPC boundary.

- Flora and Fauna: Involves the evaluation of the overall flora and fauna in the regional area, including terrestrial vegetation and animals, aquatic communities in the Great Miami River and Paddys Run, locally grown produce and crops, cattle grazing on potentially affected land areas, wetlands, and threatened and endangered species.

- Ambient Air: Involves the evaluation of this media within the RI. For purposes of the FS, ambient air will be evaluated as an environmental pathway but not as a medium requiring direct remediation.

1.3 TECHNICAL APPROACH AND ORGANIZATION

This report on the initial screening of alternatives is prepared in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and current EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988). The initial work effort for the Operable Unit 5 FS, the development and initial screening of alternatives, was accomplished through the completion of the following activities:

- Development of the remedial action objectives to protect human health and the environment

- Development of general response actions to satisfy the remedial action objectives to which the general response actions may apply
- Identification of the volumes and areas of media/contamination
- Identification and screening of technologies and process options for each of the identified general response actions
- Evaluation of process options
- Development and description of remedial action alternatives
- Screening of remedial action alternatives
- Selection of alternatives for detailed evaluation

The first two activities were the subject of the aforementioned Development of Alternatives Document. This Task 12 document presents the results of the remaining six activities and includes both a reiteration and a refinement of the results of the first two activities based on newly acquired information.

The remainder of this chapter provides a brief summary of the FMPC site history. The important physical properties and characteristics of the Operable Unit 5 study area are discussed in Chapter 2.0. Chapter 3.0 includes a summary of the location and extent of contamination for the various environmental media, as well as a discussion of exposure pathways and potential receptors. The remedial action objectives are presented in Chapter 4.0 within the framework of the overall technical approach. Since the governing data such as information on contaminants of concern, the exposure pathways and receptors, and the acceptable contamination levels are still being developed in ongoing studies, the remedial action objectives and technology combinations are being held flexible enough to accommodate potential changes in cleanup levels, receptors, or contaminants of concern at a later date. Chapter 4.0 also includes a discussion of the general response actions developed for Operable Unit 5 and the identification and screening of remedial technologies and process options. The process options remaining from the initial screening are then evaluated on the basis of effectiveness, implementability, and cost in Chapter 5.0 and assembled into remedial action alternatives in Chapter 6.0. Chapter 7.0 describes the initial screening of the remedial action alternatives and presents those alternatives selected for detailed evaluation in the next phase of the FS process (Task 13). Chapter 8.0 briefly discusses the development of applicable or relevant and appropriate requirements for proposed actions under this study.

1.4 SITE HISTORY AND OPERATION

This section briefly discusses the historical development and operational history of the FMPC and historical and current waste and effluent management protection programs.

1.4.1 Operational History

The United States Atomic Energy Commission (AEC), the predecessor to the DOE, established the FMPC for processing uranium and its compounds from natural uranium ore concentrates for U.S. Government needs. This integrated production complex began operations in conformance with AEC orders in the early 1950s. In 1951, NLO, Inc. (formerly National Lead Company of Ohio), entered into a contract with the AEC as Operations and Maintenance (O&M) Contractor. This contractual relationship lasted with the AEC, and eventually the DOE, until January 1, 1986. Westinghouse Materials Company of Ohio (WMCO), a wholly owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities of the site operations and facilities for a minimum five-year period.

A pilot plant was completed in 1951 as the first operational facility at the FMPC. Following completion of the pilot plant, the metals production plant began operations in 1952. The metals fabrication plant, the green salt plant, the recovery plant, the sampling plant, and the refinery began operations in 1953. The hex plant and the special products plant were operational in 1954.

All plants except the sampling plant and refinery were expanded during the period 1954 to 1956. Production peaked in 1960 at approximately 10,000 metric tons of uranium per year. A product decline began in 1964, to a low in 1975 of about 1230 metric tons of uranium. During the 1970s, consideration was given to closing the FMPC; therefore, capital improvements and staffing were minimized. The staffing level, which peaked at 2891 in 1956, slowly declined from 662 in 1972 to 538 in 1979. In 1981, the FMPC began planning to accommodate increased production requirements. Production levels significantly increased and there was a rapid staff buildup in many areas. Implementation of a major facilities restoration program followed.

A variety of chemical and metallurgical processes are utilized at the FMPC for the manufacture of uranium products. During the manufacturing process, high quality uranium compounds are introduced into the FMPC processes at several points. Impure starting materials are dissolved in nitric acid and the uranium is purified through solvent extraction to yield a solution of uranyl nitrate. Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder.

This compound is reduced with hydrogen to uranium dioxide (UO_2) and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot. Various uranium metal working processes also exist.

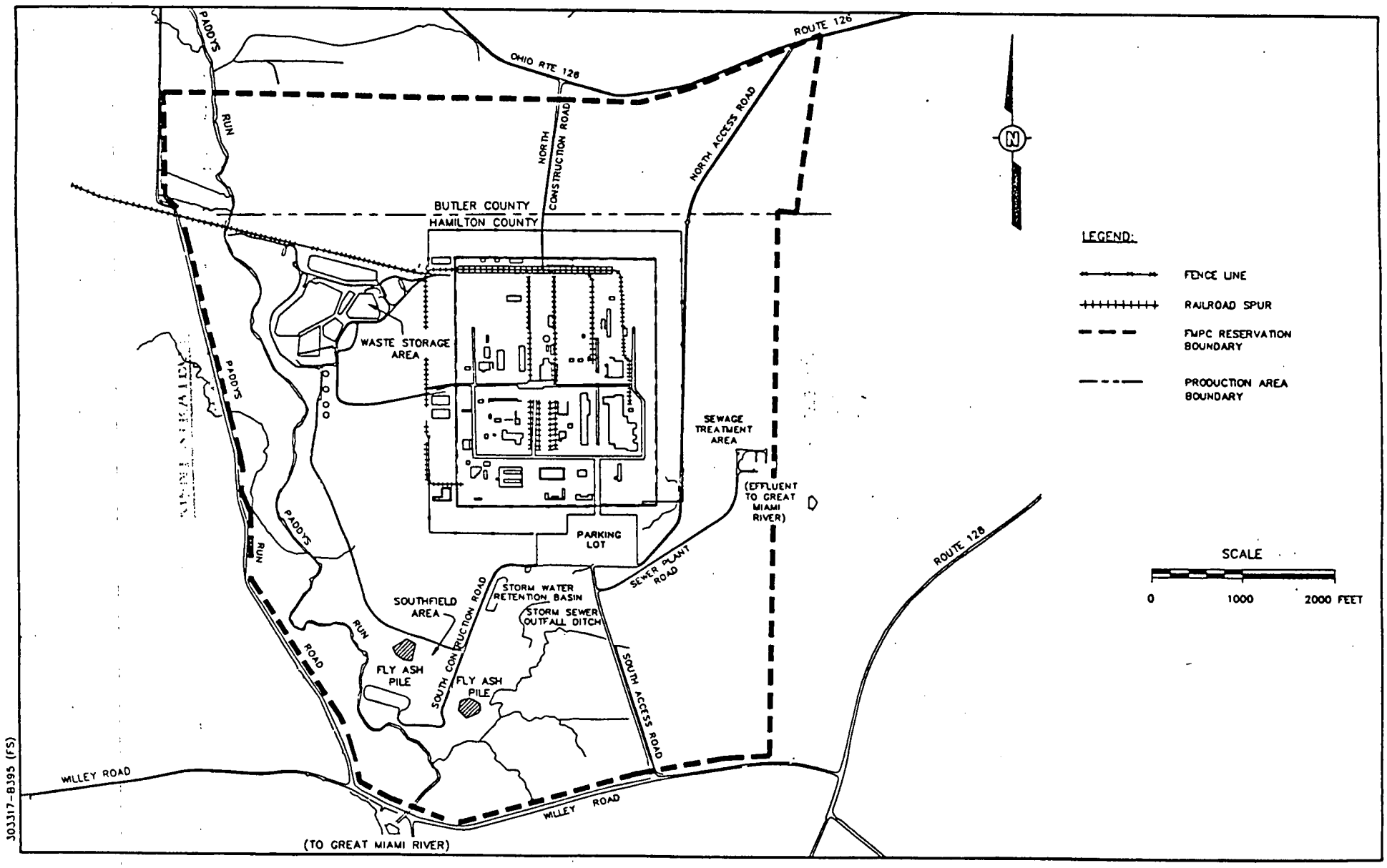
From 1953 to 1955, the FMPC refinery processed pitchblende ore from the Belgian Congo. Pitchblende ore contains all the daughter products of the uranium decay chains and is particularly high in radium content due to high uranium assay. No chemical separation or purification was performed on the ore prior to arrival at the FMPC. Beginning in 1956, the refinery feedstock consisted of uranium concentrates (yellowcake) from Canada and the United States. Canadian concentrates were not processed after 1960. In the production of these concentrates, most of the uranium daughters had been removed. However, radium-226 (Ra-226) remained in the yellowcake in amounts that varied with the process. The Canadian yellowcake contained higher levels of thorium-230 than yellowcake from the U.S. sources.

Small amounts of thorium were produced at the FMPC on several occasions from 1954 through 1975. Thorium operations were performed in the metals fabrication plant, the recovery plant, the special products plant, and the pilot plant. The FMPC currently serves as the thorium repository for the DOE and maintains long-term storage facilities for a variety of thorium materials.

1.4.2 Waste and Effluent Management

This section provides an overview of waste and effluent management practices at the FMPC. These practices played a significant role in determining the nature and extent of contamination at the site and the potential for future contamination events, resulting from the large quantities of liquid and solid wastes generated by the various operations at the FMPC.

Prior to 1984, solid and slurried wastes from FMPC processes were disposed in the on-site Waste Storage Area (Figure 1-3). This area, which is located west of the production facilities, includes six low-level radioactive waste storage pits, two earthen-bermed concrete silos containing K-65 residues which have high specific activity, one silo containing radium-bearing residues resulting from the pitchblende refining process, one silo containing metal oxides, two lime sludge ponds, and a sanitary landfill.



J03317-8395 (FS)

FIGURE 1-3

MAJOR FEATURES OF THE FEED MATERIALS PRODUCTION CENTER

Solid waste materials associated with uranium metals production are presently stored on site in steel drums awaiting further processing or off-site disposal at approved facilities. These wastes include oils, sludges, contaminated combustibles, filter cake, off-spec UF_4 or thorium tetrafluoride (ThF_4), and reject UO_3. The drums sit on various pads and/or warehouses and are inspected on a weekly basis. Contents of deteriorated drums are repackaged. Other waste materials, stored in drums on contained surfaces, include spent degreasing solvents and polychlorinated biphenyl (PCB) contaminated material.

Two fly ash piles are located approximately 3000 feet south-southeast of the Waste Storage Area (Figure 1-3). One pile remains active for the disposal of fly ash from the FMPC coal-fired boiler plant. An area between and adjacent to the fly ash piles, known as the Southfield, is believed to be the disposal site for construction debris and possibly other types of solid wastes from the FMPC operations.

Surface water runoff from the Waste Storage Area, fly ash piles, and other affected areas within the western portion of the FMPC enters Paddys Run, a tributary of the Great Miami River. Paddys Run originates just north of the FMPC and flows south-southwest along the western edge of the site (Figure 1-3). For a large part of the year, it is a dry streambed with occasional rainfall-induced flows. The surface water runoff from this area is currently being addressed as a removal action. The draft EE/CA for the waste pit area storm water runoff (DOE 1990b) recommends the collection and treatment of runoff from this area. Liquid waste generated from FMPC process operations is sent to a general plant sump for sampling and analysis, prior treatment and/or release to the Great Miami River through the main effluent line (Figure 1-3). The main effluent line to the Great Miami River represents a permitted discharge for Figure 1-3 wastewater from the FMPC. The discharge is regulated by a National Pollutant Discharge Elimination System (NPDES) permit and DOE orders, with compliance monitoring performed at Manhole 175 as the effluent leaves the site boundary.

Storm water runoff from the Production Area is collected in storm water retention basins to allow for solids settling prior to being released to the Great Miami River through the same effluent line. During extreme storm events, if the storm water retention basins overflow, storm water is discharged through a storm sewer outfall ditch to Paddys Run. Evaluation of the impacts associated with surface water discharges from the FMPC, including overflows from the storm water retention

basins are being evaluated within the environmental assessment being conducted for incorporation into the Operable Unit 5 RI report.

2.0 CHARACTERIZATION OF THE STUDY AREA

This chapter describes the important physical properties and characteristics of the Operable Unit 5 study area. Operable Unit 5 includes those environmental media that represent pathways and/or environmental receptors presently or potentially affected by FMPC contaminants.

2.1 SURFACE WATER HYDROLOGY

The major surface water features relevant to this study include the Great Miami River, Paddys Run, and the storm sewer outfall ditch.

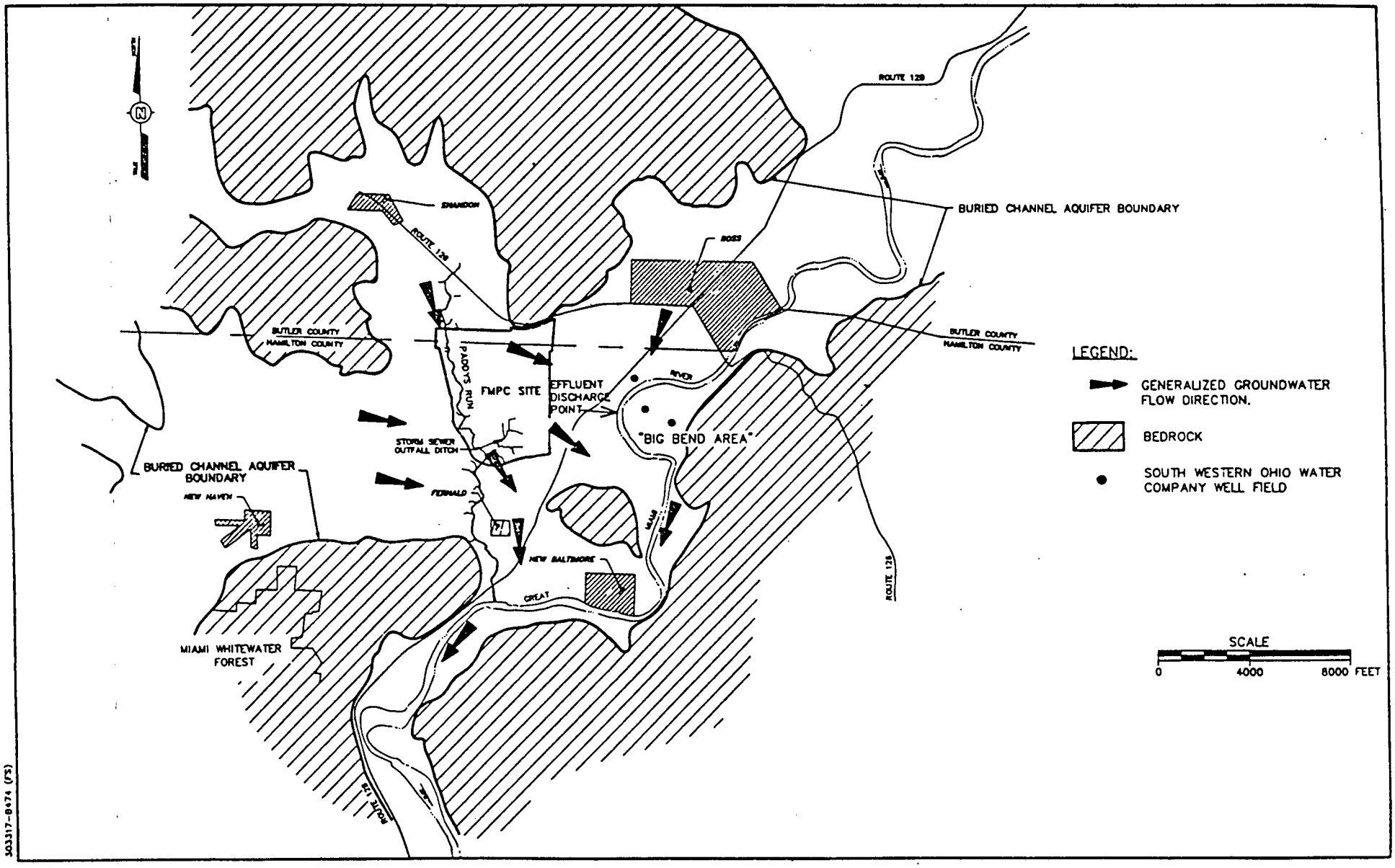
2.1.1 Great Miami River

The FMPC is located within the Great Miami River drainage basin but above the river's present-day floodplain. The Great Miami River (Figure 2-1) is the receiving stream for the FMPC effluent discharge and represents the main surface water feature in the vicinity of the FMPC. The river flows generally to the southwest and has a drainage area of approximately 3360 square miles at the Hamilton gage, which is located about 10 miles upstream from the FMPC discharge outfall.

The river exhibits meandering patterns that result in sharp directional changes over distances of less than 3000 feet. Directly east of the FMPC and within the RI/FS study area, the river passes through a 180-degree curve known as the "Big Bend" (Figure 2-1). A 90-degree bend in the river also occurs near New Baltimore, approximately two miles downstream from the FMPC point of discharge.

The average flow of the Great Miami River at Hamilton, based on 55 years of records, is 3305 cubic feet per second (cfs). Using drainage area scaling, the corresponding average flow at the FMPC point of discharge has been estimated to be 3460 cfs.

The Great Miami River has minimum and maximum flow rates equal to 155 cfs and 108,000 cfs, respectively. In addition, the 7-day 10-year low flow equals 410 cfs.



503317-8674 (FS)

FIGURE 2-1
OPERABLE UNIT 5 STUDY AREA

2.1.2 Paddys Run

Natural surface drainage from the FMPC is primarily to Paddys Run. Paddys Run originates north of the site, drains southward along the west side of the FMPC, and eventually enters the Great Miami River approximately 1.5 miles south of the FMPC (Figure 2-1). This stream loses flow to the underlying aquifer along much of its course due to its highly permeable channel bottom which is carved through the till and into the sands and gravels of the Great Miami Aquifer. Paddys Run is an ungaged, intermittent stream that flows primarily between January and May, with an estimated discharge for this period ranging between 0.2 and 4.0 cfs. Peak flows have not been measured.

2.1.3 Storm Sewer Outfall Ditch

A principal drainage feature of the FMPC is a tributary to Paddys Run known as the storm sewer outfall ditch. This drainage course originates east of the Production Area, flows southwest across the southern portion of the site, and enters Paddys Run near the southwest corner of the property (Figure 2-1). Much of the stream bottom of this drainage course is composed of sand and gravel; therefore, vertical seepage rates through the stream bottom are similar to Paddys Run. This drainage course is generally dry throughout most of the year, with flows occurring during and immediately after precipitation events.

The storm sewer outfall ditch historically conveyed surface water runoff from the Production Area directly to Paddys Run when the capacity of the storm sewer lift station, which diverted low flow storm water to Manhole 175, was exceeded. A storm water retention basin was recently constructed at the head of the storm sewer outfall ditch. The first chamber of the storm water retention basin began operation in October 1986. The second chamber became operational in December 1988. Storm water runoff from the Production Area is now conveyed to this retention basin. After at least a 24-hour retention period to allow for settling of suspended solids, the water is pumped out of the basin to the Great Miami River via the FMPC's main effluent line. The basin is designed to retain the runoff from a 10-year, 24-hour rainfall event; only in the event of an overflow would storm water from the Production Area enter the outfall ditch. Overflows have occurred seven times since 1986.

2.2 GROUNDWATER HYDROLOGY

The FMPC is located within a two- to three-mile wide subterranean valley known as the New Haven Trough. This valley formed as a result of Pleistocene glaciation and subsequently filled with

glacial outwash materials and till. The bedrock in the vicinity of the FMPC consists of predominantly flat-lying, olive-gray Ordovician shales with thin, interbedded layers of limestone. This shale forms the floor and valley walls of the New Haven Trough. The buried channel is generally carved into this shale between 60 and more than 200 feet below the pre-erosional land surface in the vicinity of the FMPC (Figure 2-1).

Unconformably overlying the shales in the bedrock channel are approximately 150 feet of regionally extensive Pleistocene glacial valley fill deposits. The buried valley is about one-half to over two miles wide and is U-shaped, having a broad, relatively flat bottom and steep valley walls. Interbedded glacial till deposits occur within the outwash deposits but in most cases are of limited lateral extent. The till deposits are composed primarily of poorly sorted pebbles, cobbles, and boulders in a predominantly clay matrix.

Within some areas, till deposits overlie the bedrock uplands and portions of the outwash materials where they form the thick, unconsolidated sediment layers beneath the soil zone. This glacial till is composed of dense, silty clay that varies in composition vertically and laterally. The silty clay till contains lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt with layers of silty clay.

Regional hydrogeologic environments of the buried channel aquifer have been investigated and reported by the U.S. Geological Survey (USGS) in a paper entitled "Groundwater, Hydrology, and Geology of the Lower Great Miami River Valley, Ohio" (Spieker 1968). A hydrogeologic environment describes a portion of an aquifer possessing hydrologic and geologic properties that differ from the properties of the aquifer in adjacent areas. Five major hydrogeologic environments have been identified and mapped in the Great Miami River Valley. Types I, III, and V environments generally describe the hydrogeologic conditions in the vicinity of the FMPC and are summarized in the following paragraphs.

The Type I hydrogeological environment is found along the floodplain of the Great Miami River to the south and east of the FMPC facility. The aquifer is principally composed of sand and gravel. Scattered lenses of clay and other fine-grained material may exist anywhere in the environment. These lenses are not of sufficient thickness or areal extent to affect groundwater movement. The potential for infiltration from streams exists in these areas. Transmissivity values, or the amount of

water than can be transmitted horizontally by the aquifer, generally range from 40,000 to 67,000 square feet per day (ft^2/day). The Type I aquifer may be classified with a storage coefficient of about 0.2. Individual wells can yield as much as 3000 gallons per minute (gpm). The Type III hydrogeologic environment is characterized by 50 or more feet of clayey till overlying the main buried channel aquifer. In the region of the FMPC, the buried channel aquifer is further divided into an upper and lower part by a semipervious clay layer approximately 10 to 20 feet thick, occurring approximately 120 feet below land surface. Hence, the lower aquifer is classed as a semiconfined or leaky confined aquifer. A coefficient of storage of 0.001 was estimated for the lower sand and gravel aquifer. Estimated transmissivities range from 4700 to 40,000 ft^2/day. The Type V hydrogeologic environment includes all of the area outside of the buried channel. These areas are uplands and consist of shale with interbedded limestone overlain by 50 or less feet of clay-rich till. Large quantities of groundwater are not generally transported through this material. Well yields vary widely, typically ranging from near 0 to 10 gpm. However, because sand and gravel lenses are erratically distributed throughout the overlying till, wells completed in these units may yield up to 50 gpm.

Large groundwater supplies occur in the outwash deposits of the buried channel aquifer and are recharged by three principal sources: recharge from bedrock, precipitation recharge, and recharge by stream infiltration. Although the shales and limestones have a low permeability, small amounts of water occur in erratically distributed joints and cracks and produce seepage into the glacial deposits. The permeability of the bedrock has been estimated to be five gallons per day (gpd) per square foot of contact with the glacial deposits. Recharge by precipitation amounts to approximately 570,000 gpd per square mile of catchment area and represents the dominant source of recharge on a regional basis. Under natural conditions, the gradient of groundwater flow is from the aquifer to the Great Miami River, except during dry periods when the gradient is reversed. Intermittent recharge to the aquifer also occurs along Paddys Run.

The groundwater in the regional aquifer enters the FMPC study area from the buried valleys on the west, north, and east. Natural gradients cause the groundwater to exit the FMPC study area by either flowing to the southeast to the Great Miami River upstream from New Baltimore or by flowing south-southwest through the branch of the bedrock channel west of New Baltimore (refer to Figures 2-2 and 2-3 for groundwater elevations of the 2000-series and 3000-series Wells,

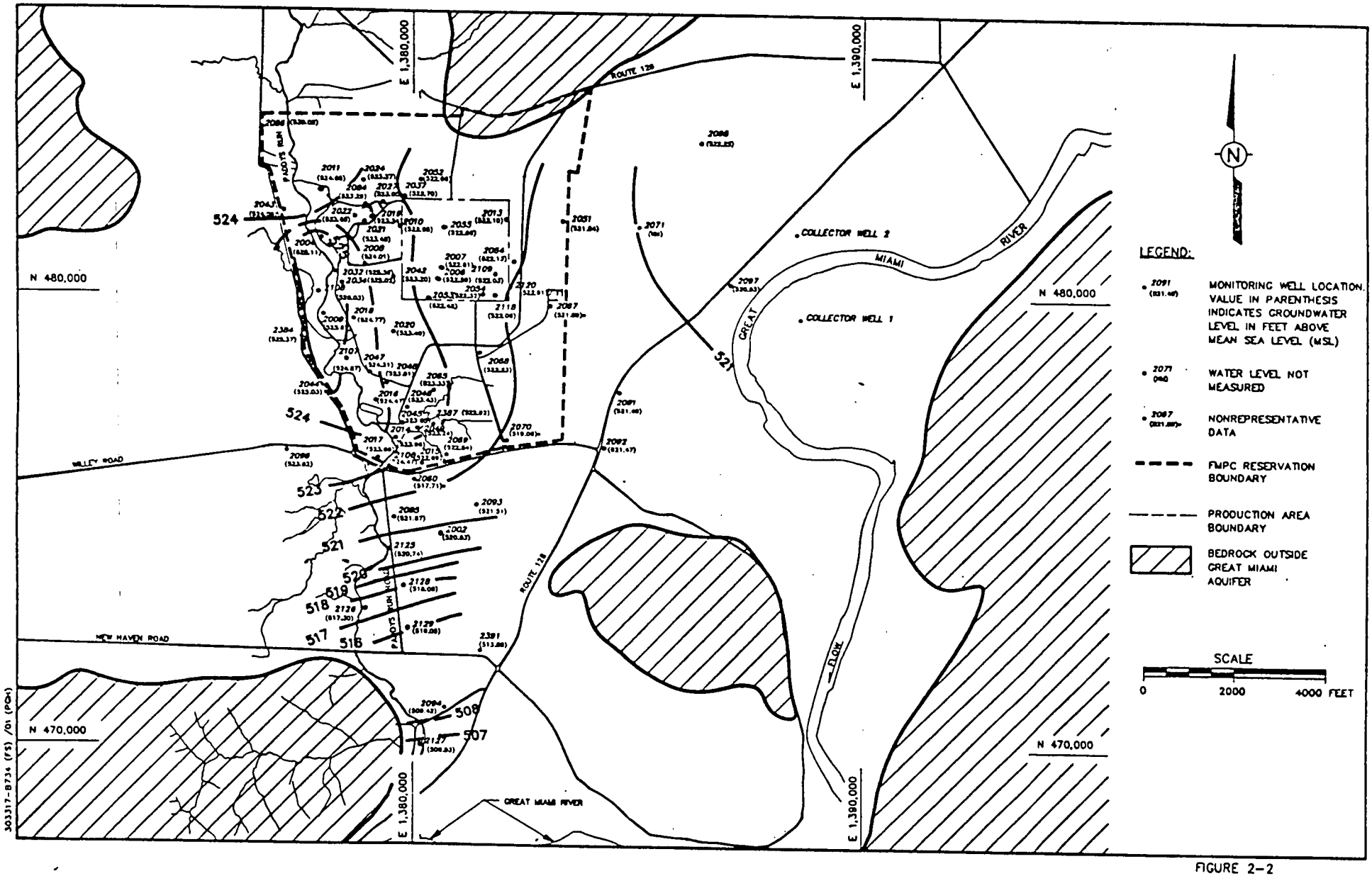


FIGURE 2-2
GROUNDWATER ELEVATIONS
2000 SERIES WELLS
APRIL 1990

303317-B734 (FS) /01 (PDH)

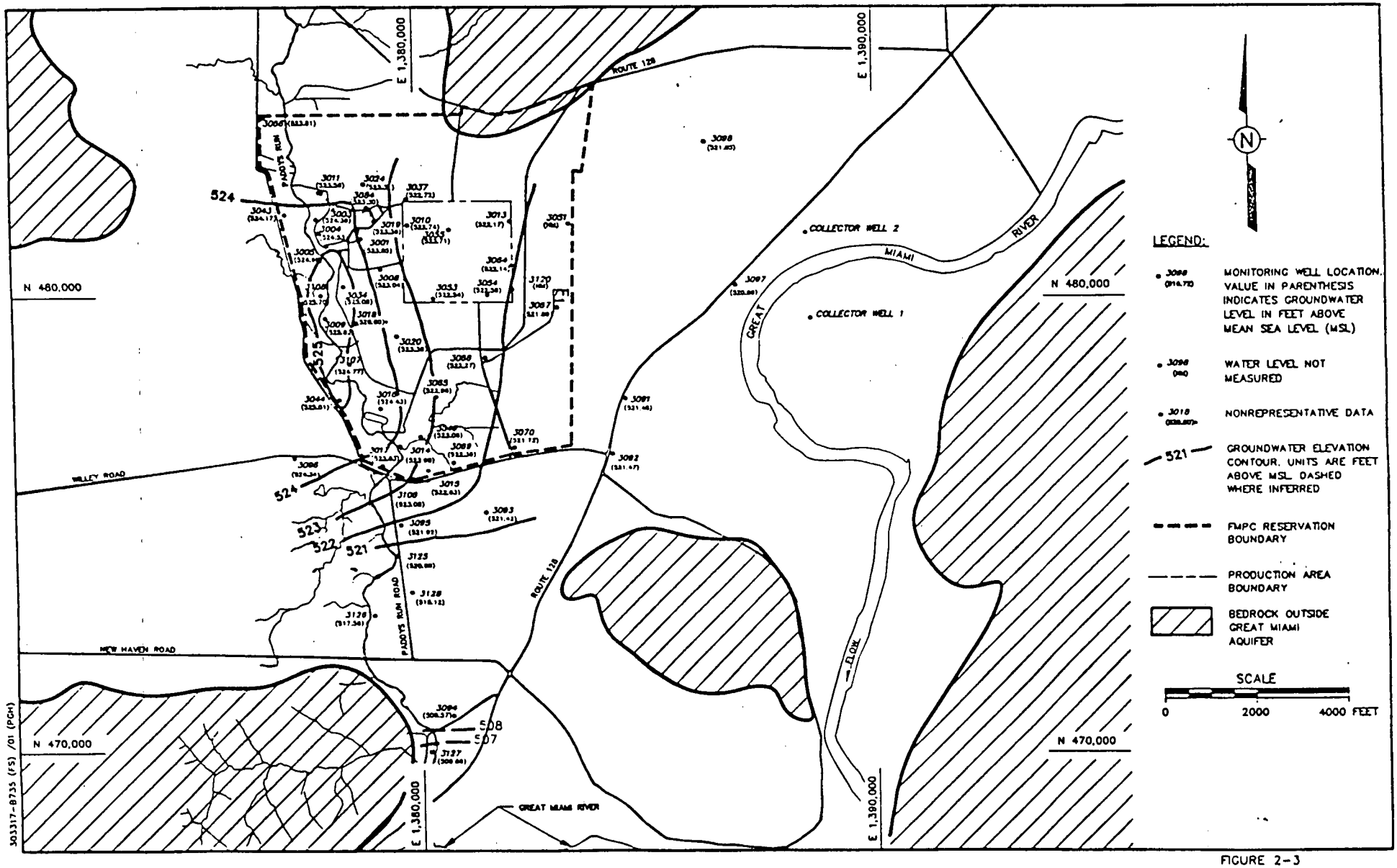


FIGURE 2-3
GROUNDWATER ELEVATIONS
3000 SERIES WELLS
APRIL 1990

303317-8735 (FS) /01 (PGH)

37

943

respectively. In either case, the Great Miami River is the ultimate receptor of groundwater in the study area.

The large pumping wells of the Southwest Ohio Water Company (SOWC), located in the "Big Bend" meander of the Great Miami River east of the FMPC (Figure 2-1), produce a pronounced and persistent cone of depression in the potentiometric surface centered on the pumping wells. Groundwater elevation maps indicate that the resultant cone of depression from the SOWC wells influences groundwater flow patterns beneath the FMPC. In particular, a groundwater flow divide is created such that groundwater underlying the northern portion of the FMPC, including those areas underlying the Waste Storage Area and the Production Area, flows to the east toward the SOWC wells and the Great Miami River. Groundwater from the southern and southwestern portion of the FMPC continues to flow along the natural gradient to the south-southwest through the buried valley. Near the southwest corner of the FMPC, a groundwater component from the west is also present due to the western leg of the buried channel. This causes the recharge from certain reaches of Paddys Run to flow east-southeast until the regional southern component is encountered.

2.3 SOILS

Soils at the FMPC site are primarily categorized as Fincastle-Xenia silt loams. These soils are light colored, medium acid, and moderately high in productivity when properly managed. Moisture-supplying capacity is moderate, as is fertility and organic content. The soils have formed as 18 to 40 inches of wind-blown material (loess) over the limy loam till of the Wisconsin Age. Fincastle soils are developed on glacial till of the upland till plain where the FMPC Production Area and waste pits are located. These soils are poorly drained, due in part to the nearly flat slopes on which they lie and the presence of clay-rich subsoil beneath the topsoil. The soils are drained by open ditches, drain tile, or natural gullies. If artificial drainage is not used, the water content remains high for extended periods in winter and spring.

Soils along Paddys Run are categorized as Fox-Genessee loams. These soils are light colored, high in productivity, and moderate in fertility and organic matter. Fox soils are slightly to medium acid, moderate in moisture-supplying capacity, and well drained. They have formed as 24 to 40 inches of silty materials over sand and gravel on level areas of the first terrace above the stream's normal floodplain. They are well drained, high in moisture-supplying capacity, and subject to flooding.

2.4 VEGETATION AND WILDLIFE

The following ecological data have been summarized from the report, "Biological & Ecological Site Characterization of the Feed Materials Production Center," (Facemire, et al. 1990). Additional source documents are appropriately cited in the text.

The FMPC lies in the Oak-Hickory Forest Section of the Eastern Deciduous Forest as described by Bailey (1978). Habitat types sampled, and the percentage of the total FMPC area represented by each, were ungrazed pastures (30 percent), grazed pastures (25 percent), deciduous woodlands (20 percent), riparian woodlands (12 percent), two pine plantations (11 percent), and a reclaimed fly ash pile area (2 percent). Each of these habitats supports a distinct ecological community. A total of 47 species of trees and shrubs, 190 species of herbaceous plants, 20 mammal species, 98 bird species, 10 species of amphibians and reptiles, 21 species of fish, 47 families of benthic macroinvertebrates, and 132 families of terrestrial invertebrates has been recorded from these habitats.

Typical grasses found on the FMPC are red fescue, Kentucky bluegrass, timothy, and red top. Herbs include teasel, red and white clovers, and goldenrod. The dominant tree species in the pine plantations is white pine, with Norway spruce occurring occasionally. Common trees in the deciduous woodlands are white ash, American elm, shellbark hickory, and slippery elm. Dominant tree species in the riparian woodlands are eastern cottonwood, hackberry, American elm, and box elder. The reclaimed fly ash pile area is dominated by American elm, eastern cottonwood, and black locust.

Mammal species observed on the FMPC include white-tailed deer, coyote, red fox, opossum, raccoon, groundhog, eastern cottontail, fox squirrel, and several species of bats. Common small mammals are the white-footed mouse, short-tailed shrew, meadow vole, meadow jumping mouse, and eastern chipmunk.

The most common birds breeding on site include the mourning dove, American robin, blue jay, American crow, American goldfinch, northern bobwhite, and common grackle. Species occurring in the greatest density are the goldfinch, song sparrow, and robin. Raptor species observed on site are the northern harrier, red-shouldered hawk, Cooper's hawk, red-tailed hawk, and American kestrel. The eastern screech owl and great horned owl are also common.

Amphibians and reptiles that occur on the FMPC include the American toad, spring peeper, eastern box turtle, and snapping turtle. Several species of snakes also occur on site, including the eastern garter snake, Butler's garter snake, black rat snake, northern water snake, and the queen snake.

Approximately 130 insect families from 15 orders are represented in FMPC habitats. Leaf hoppers are abundant in all habitats while less abundant groups include short-horned grasshoppers, leaf beetles, springtails, fruit flies, dark-winged fungus gnats, ants, bees, and wasps.

Jurisdictional wetlands occupy areas along the railroad on the north side of the FMPC, along Paddys Run, and in several drainageways. These wetlands are defined as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. These habitats harbor small fish, amphibians, and a variety of benthic macroinvertebrates. The most common fish in Paddys Run are the bluntnose minnow, creek chub, and stoneroller minnow. The most common benthic macroinvertebrates are nonbiting midges, riffle beetles, mayflies, and stoneflies.

No federally listed threatened or endangered species have been observed on the FMPC or in its immediate vicinity. Suitable habitat for one species of mammal listed as federally endangered, the Indiana bat, occurs along Paddys Run. The Indiana bat was not found on site, however. Two species listed as threatened in Ohio, Cooper's hawks (Accipiter cooperii) and the Cincinnati crayfish (Orconectes sloanii), were seen frequently in the pine plantations and Paddys Run, respectively.

2.5 LAND USE AND POPULATION

The land use surrounding the FMPC is mainly agricultural, with dairy, beef, corn, and soy bean production. Several industries, including Delta Steel, Albright & Wilson Americas, Inc., Ruetgers-Nease Chemical Company, two commercial gravel operations, and a cement plant are located south of the site. The Miami Whitewater Forest, a Hamilton County park, is located five miles to the southwest of the FMPC.

Scattered residences and several villages, including Fernald, New Baltimore, Ross, New Haven, and Shandon, are located near the FMPC. The city of Cincinnati and its suburbs are 10 to 15 miles

southeast of the FMPC and the city of Hamilton and Fairfield are 6 to 8 miles to the northeast. There is an estimated population of over 24,000 within a five-mile radius of the site.

The area surrounding the FMPC contains several sites of historical interest. The National Register of Historic Places lists five prehistoric Indian sites within a three-mile radius. These include the Adena Circle, the Hogen-Borger Mound, the Demoret Mound, the Colerain Work, and the Dunlap Work. The closest site, the Colerain Work, is situated approximately one mile east of the FMPC. The State Historical Preservation Officer reports that there are no known sites of archaeological significance on the FMPC site.

2.6 AMBIENT AIR

2.6.1 Regional Air Quality

The FMPC is located in a four-county area under the air quality responsibility of the Southwestern Ohio Air Pollution Control Agency (SWOAPCA). The state of Ohio, as represented by SWOAPCA, has adopted verbatim the National Ambient Air Quality Standards (NAAQS). There are no additional state or local ambient air quality standards. The NAAQS contain standards for the following six criterion pollutants: total suspended particulates (TSP), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O^3), and lead (Pb). The region is in compliance for all pollutants except ozone for which it is in nonattainment status. Occasional air pollution episodes in Southwestern Ohio are usually the result of stable, stagnant air associated with a stationary high-pressure system. Low surface wind speeds and a temperature inversion (air temperature increasing with height in the atmosphere) combine to produce a "lid" over the area which dramatically reduces the dispersion of pollutants. Most air pollution episodes occur during late summer and early autumn.

Nonradiological air emissions which have been measured at the FMPC are as follows: TSP, nitrogen dioxide, and sulfur dioxide (WMCO 1987). The annual concentrations measured by SWOAPCA (1986) do not exceed the applicable federal and state standards for particulates, nitrogen dioxide, and sulfur dioxide.

2.6.2 Meteorological Factors

Ambient air is affected by such meteorological factors as wind speed and direction (wind rose). Windflow data from the Greater Cincinnati International Airport and the Dayton Airport, for the period 1948 through 1978 indicates that the prevailing winds were from the south-southwest. During this period, average monthly wind speed recorded at the Greater Cincinnati Airport ranged from 6.7 miles per hour (mph) in August to 11.1 mph in March (NOAA 1985). Highest wind speeds occurred in winter and spring while the lowest wind speeds occurred in summer and early fall. Maximum sustained wind speeds (one minute or more) ranged from 32 mph in September 1975 to 46 mph in January and again in April 1985 (NOAA 1985). The strongest winds tend to come from the west-northwest to south-southwest.

The FMPC installed an on-site meteorological monitoring system in August 1986. The system includes a meteorological tower, monitoring instruments, a data logger, and a computer. The tower instruments measure wind speed and direction, ambient air temperature, lapse rate (a measure of atmospheric stability), dewpoint temperature, relative humidity, barometric pressure, sigma theta (the standard deviation of horizontal wind direction over time and also a measure of atmospheric stability), and precipitation.

Before the tower was installed, and at times when the on-site meteorological system was not operating, the FMPC obtained its meteorological data from the Greater Cincinnati International Airport. The on-site system enables the FMPC, and in particular the Emergency Operations Center, to use site-specific meteorological data, thus improving the accuracy of computer models used to estimate the doses from routine releases as well as doses from an accidental release at the FMPC.

3.0 NATURE AND EXTENT OF CONTAMINATION

Operable Unit 5 focuses on environmental media on and near the FMPC, and contaminants associated with these media. The nature and extent of contamination in environmental media have been documented as part of several investigative efforts including the following:

- An RI/FS sampling and laboratory analytical program designed specifically to assess contamination of environmental media at and near the FMPC. This program includes radiological and nonradiological constituents and is designed to provide a basis for the formulation of scenarios for remediation as necessary. Summaries of the findings of this program with respect to soil, surface water, and groundwater are included in this report.

- A sampling and laboratory analytical program for compliance with RCRA provisions. This program includes radiological, organic, and inorganic constituents. Pertinent information on groundwater quality characteristics at or near the FMPC collected as part of this program is included in this report.

- Annual monitoring completed by the facility operator on and near the FMPC, which is summarized in annual Environmental Monitoring Reports. This monitoring includes all media for both radiological and nonradiological parameters. Pertinent information from these reports regarding surface water, groundwater, and soil on or near the FMPC is included in this chapter.

- Data developed during litigation regarding site contamination and produced as a document entitled "Interim Report - Air, Soil, Water, and Health Risk Assessment in the Vicinity of the FMPC, Fernald, Ohio" (IT 1986).

- Special or focused studies such as a human dose assessment study (IT 1989), investigation of the impact of contamination at the FMPC on groundwater and surface water (IT 1988), and groundwater characterization study (Dames and Moore 1985).

This summary of the nature and extent of contamination for Operable Unit 5 is based largely on the results of the RCRA, RI/FS, the most recent Environmental Monitoring Reports, and data developed during the litigation support effort. Supplemental data from other studies are used as appropriate.

The results of the screening of alternatives that are presented in this document are limited by several factors. Specifically, this document is being prepared prior to the completion of the several RI field activities important to Operable Unit 5 that are being conducted in response to the findings of the baseline RI program. While virtually all of the currently available data have been reviewed and preliminarily evaluated, detailed analysis of the data is still ongoing in conjunction with the RI effort for this operable unit. The baseline risk assessment, the results of which are fundamental to the establishment of cleanup criteria to support the FS, is also still in progress awaiting the collection and analysis of the complete RI data base. Since no standards currently exist for uranium in soils/sediment and the risk assessment is currently underway, the level of 35 pCi/g is being used in this assessment as adopted from the 1981 NRC Branch Technical Position Paper.

Since the baseline risk assessment may identify different cleanup criteria for soil and sediment than that used for this initial evaluation, and since additional areas or contaminants of concern may be identified during the ongoing RI data development task, the remedial alternatives identified in this screening may require modification as the FS process proceeds. It is unlikely, however, that completion of the risk assessment and RI will negate any of the results of technology and process option identification and evaluation contained in this report. It is also unlikely that substantive changes would be required in remedial alternative components identified in this report. As currently envisioned, any modifications would likely be an expansion or contraction of actual areas (volumes) within various media requiring remediation. Any necessary modifications will be addressed and incorporated during the detailed analysis of alternatives.

Even with the limitations cited above, the data evaluation completed for this initial screening of alternatives provides an appropriate framework for the development and evaluation of remedial alternatives to address potential contamination problems associated with Operable Unit 5. The remainder of this section provides a discussion of contaminant distribution in various media and the associated contaminant fate, migration pathways, and potential receptors.

3.1 CONTAMINANT DISTRIBUTION

3.1.1 Groundwater

Groundwater in the unconsolidated sediments at the FMPC has been extensively characterized at and near the site. The perched water zone, as monitored by a network of wells designated as the 1000-series wells, is contained within sand lenses in the till and not currently being used as a source of drinking water for human consumption near the FMPC. The regional aquifer is the primary source of water for domestic, industrial, and commercial use in the vicinity of the FMPC. A well monitoring network has been established to monitor the portion of the regional aquifer impacted or potentially impacted by the FMPC operations. These wells are designated as the 2000-, 3000-, and 4000-series wells. The 2000-series wells are screened approximately five feet above to ten feet below the water table. The 3000-series wells have ten feet of screen approximately near the middle of the aquifer. The 4000-series wells have ten feet of screen near the bottom of the aquifer.

Analytical results indicate that the groundwater contains radionuclides and, to a lesser extent, metals and organics at levels above natural background. Of primary concern is uranium, which is present at levels that would lead to an exceedance of the 50-year committed effective dose equivalent (CEDE) limit of four millirem (mrem) from an annual intake of radioactive materials in drinking water. This limit is specified in DOE Order 5400.5 for areas where water could be used as a drinking water source (DOE 1990). The concentration of uranium in drinking water which corresponds to the 4 mrem radiation dose is derived to be 30 ug/L or 20 pCi/L, assuming a natural distribution for the various uranium isotopes and the general absence of other radionuclides above natural background. Currently, no wells located within portions of the aquifer containing elevated levels of uranium are being used for drinking water supplies. Potential areas of concern for metals have been identified based on the presence of concentrations of constituents higher than those in nearby groundwater, and potential areas of concern for organics have been identified based on the sporadic detection of organic substances in a few wells.

3.1.1.1 Regional Aquifer

A summary of the groundwater data is presented in Appendix A, Table Numbers A-1 through A-7. These tables contain radionuclide, metal, and general chemistry data for the 2000- 3000-, and 4000-series monitoring wells. The groundwater data indicates that uranium is the only constituent of

concern in the regional aquifer. While data also indicate above-background detections of constituents other than uranium, the evaluation of these detections are being considered in the risk assessment as the contaminants of concern are being identified for the RI.

Tables A-8 through A-11 (Appendix A) show all of the organic compounds detected in the 2000-, 3000-, and 4000-series groundwater wells. This list of organic constituents was compared to the Interim Primary Drinking Water Standards (Maximum Contaminant Levels - MCLs) established by the EPA.[1] No organic compounds detected in the groundwater exceed any of the MCL standards.

As mentioned previously, the 2000-, 3000-, and 4000-series wells monitor the portion of the regional aquifer potentially impacted by the FMPC. Figure 3-1 indicates the areas of concern with respect to the 2000-series wells including the location of all wells sampled for volatile organic compounds. As shown in this figure, there are two areas with uranium concentrations exceeding the DOE DCG of 30 ug/L. One is located in the vicinity of the waste pits and a larger area of concern is situated in the southern portion of the FMPC. The larger area extends outside the FMPC boundary to the south towards the town of Fernald and the Great Miami River. The extent of the areas of concern for uranium in the regional aquifer have been established based on a review of groundwater data and the results of groundwater modeling of uranium distribution. The groundwater model used in support of the RI/FS is a finite-difference computer model of groundwater flow and solute transport. The computer program is SWIFT III, Version 2.2.5. A detailed presentation of the model, its development, and the baseline input data will be issued as part of the overall modeling report being prepared under the RI/FS.

Figure 3-2 indicates areas of groundwater with concentrations exceeding 30 ug/L in the 3000-series wells and the location of all wells sampled for volatile organic compounds. Within the monitoring network of the 3000-series wells, there is an area of concern for uranium beneath the waste pits, another smaller area is south of the waste pits (Monitoring Well 3103), and another area of concern is situated just south of the FMPC boundary. No verified samples from 4000-series wells exhibited uranium concentrations greater than 30 ug/L. However, the results of the modeling study indicate the potential presence of an area of concern south of the FMPC boundary at approximately the

[1]The U.S. Environmental Protection Agency (EPA) Safe Drinking Water Act (SDWA), Interim Primary Drinking Water Standards MCLs, 40 CFR Part 141.

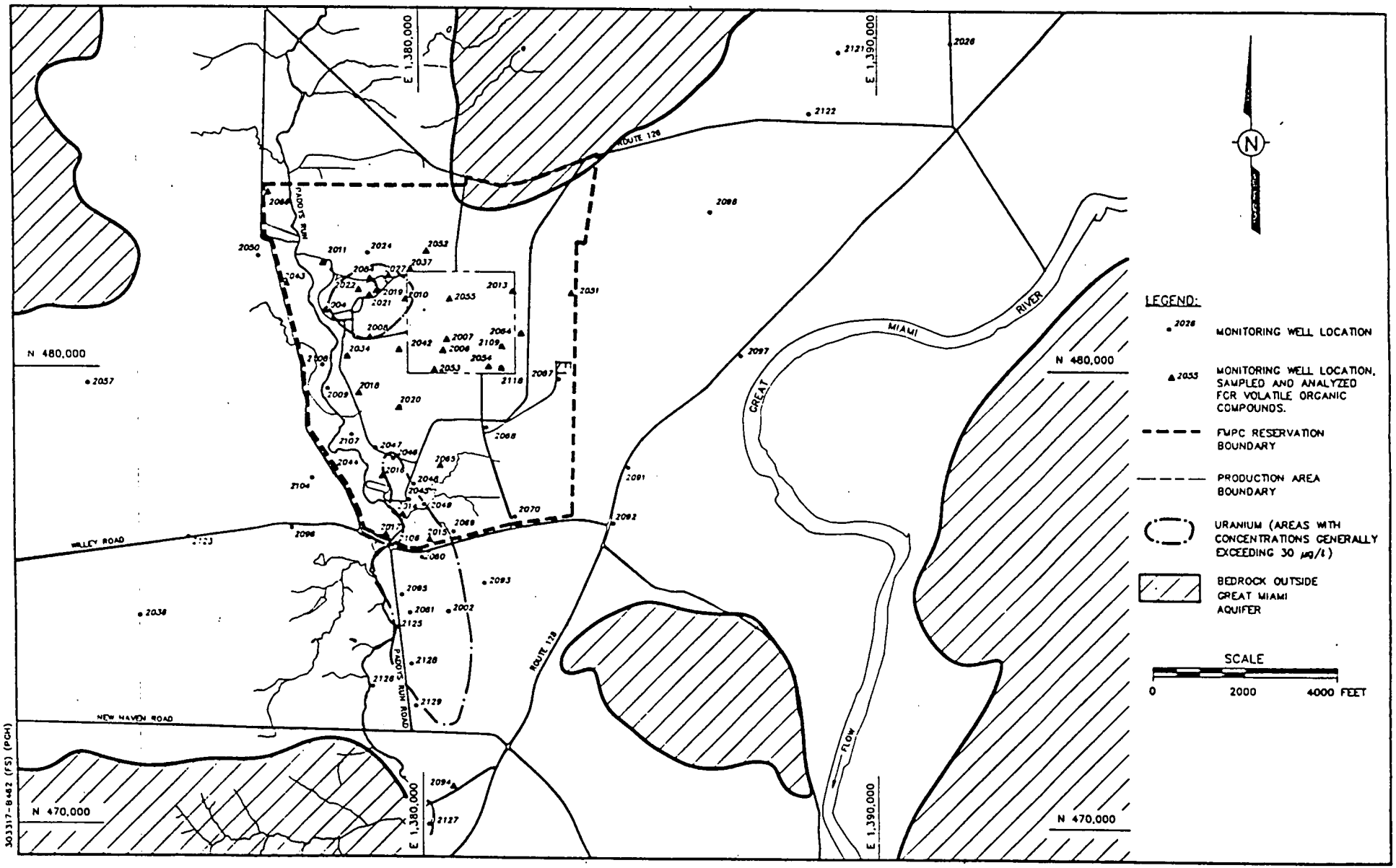


FIGURE 3-1
POTENTIAL AREAS OF CONCERN
GROUNDWATER – 2000 SERIES WELLS

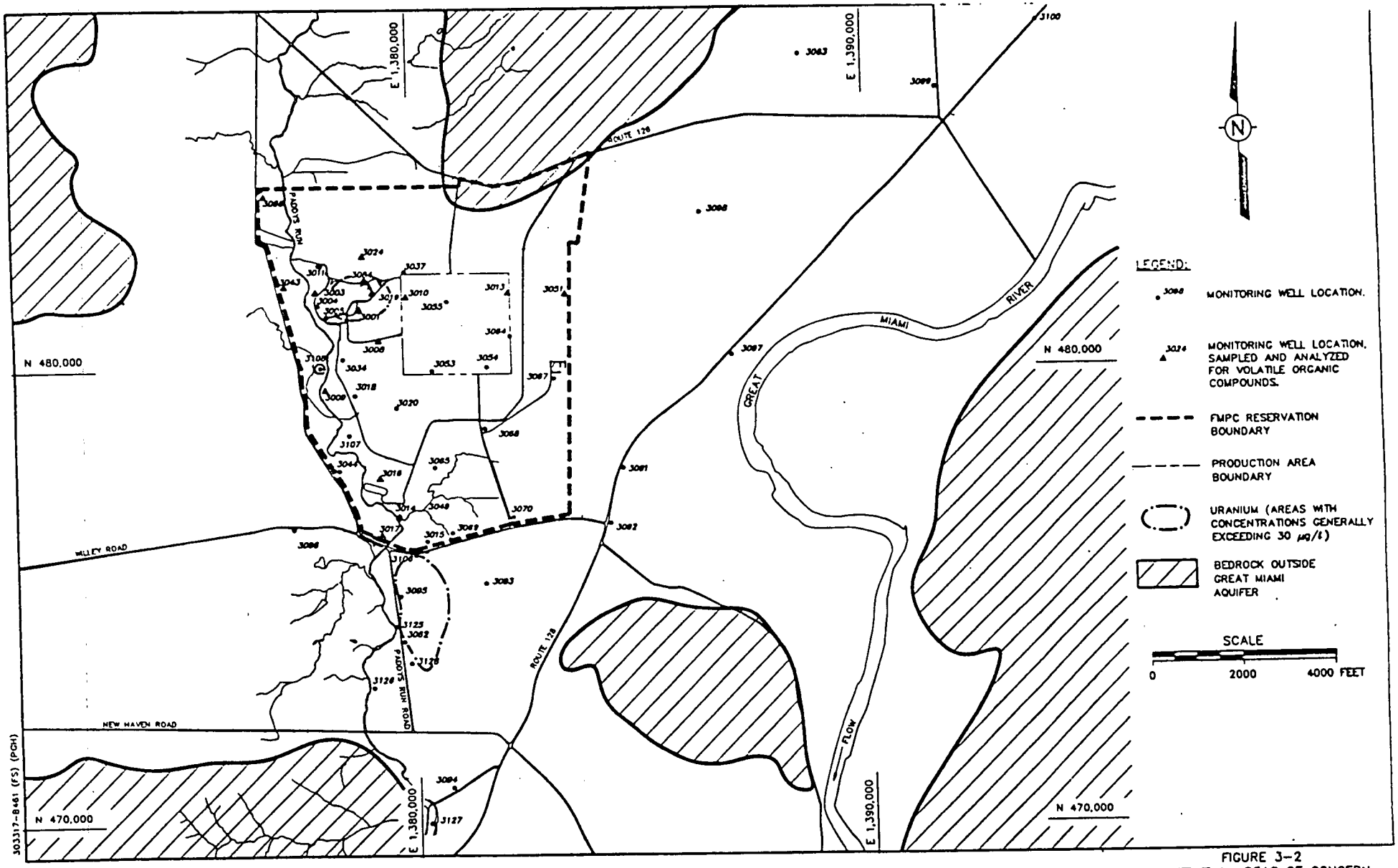


FIGURE 3-2
POTENTIAL AREAS OF CONCERN
GROUNDWATER - 3000 SERIES WELLS

same location as the area outside of the southern boundary of the FMPC shown in the 3000-series wells (Figure 3-3). Figure 3-3 also shows the location of all wells sampled for volatile organic compounds for the 4000-series wells.

One value of uranium (greater than 30 ug/L) has been detected in each of the following monitoring wells: 2013, 3013, and 4013. In each case, the uranium value is suspected of being an outlier result. The data indicates that the uranium trend in Monitoring Wells 2013, 3013, and 4013 is level and low, except for one, high uranium concentration detected in each well. The concentrations of total uranium found in these wells range from less than 1 ug/L to 12 ug/L. In Wells 2013, and 3013, peak values of 36 ug/L and 490 ug/L have been detected and are considered outliers because duplicate sampling results (less than 1 ug/L and 4 ug/L, respectively) shows 36 ug/L and 490 ug/L to be outside of the main group of data for these monitoring wells. In Well 4013, 89 ug/L of uranium has been detected and is suspected of being an outlier value because it does not follow the historical trend of data for total-U detected at this well.

3.1.2 Soils

Soils at and in the vicinity of the FMPC have been assessed primarily with respect to radiological constituents. A review of the available data indicates that, with the exception of uranium, radionuclides are not generally present in soils at levels above background. Naturally occurring uranium-238 in Ohio soils range in concentration from approximately 1 to 2 pCi/g. Total natural uranium is approximately twice this concentration since the two major isotopes of uranium, U-238 and U-234, occur together naturally in about the same activity in the soil. Summaries of soil data from the FMPC Environmental Monitoring Annual Reports, the RI sampling program, and the Fernald Litigation sampling program are presented in Tables A-12, A-13, and A-14 (Appendix A).

There are widespread areas, both inside and outside the FMPC boundary, where uranium levels exceed background. However, concentrations in excess of background do not necessarily indicate areas which are of concern or where remedial action is necessary. No DOE or EPA standards have been established for uranium in soil. This action level will be established in conjunction with the risk assessment. However, the NRC has established a concentration of 35 pCi/g of uranium activity in soils, which is the level generally used as a guideline for allowing the public to use the land. This level is adopted from the 1981 NRC Branch Technical Position Paper and will be used to identify soil areas of concern. A removal action was completed in the summer of 1989 to remove

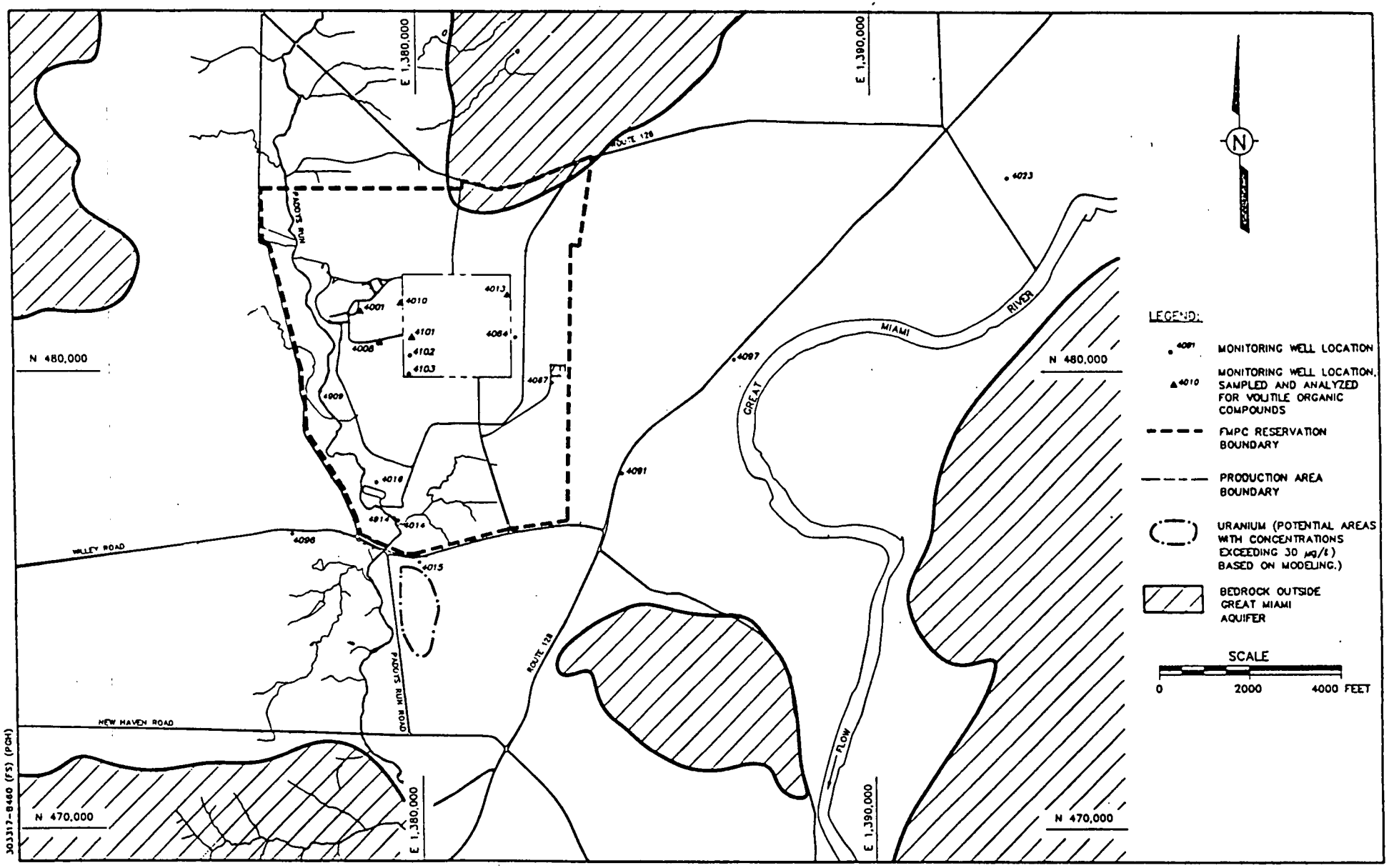


FIGURE 3-3
POTENTIAL AREAS OF CONCERN
GROUNDWATER - 4000 SERIES WELLS

uranium-contaminated soils from the area around Manhole 180. The cleanup level used was 35 pCi/g.

Soils which were evaluated as part of Operable Unit 5 include all soils on the FMPC property which are not specifically included within another operable unit (Figure 3-4). Additionally, soils outside the FMPC boundary are also, for the most part, within the framework of Operable Unit 5. Exceptions include those soils found both in the vicinity and north of the out-of-service incinerator, located near the sewage treatment area which are being considered as part of Operable Unit 3.

Soil samples were collected both inside and outside of the FMPC boundary as part of the FMPC Environmental Monitoring Program. Five locations were sampled inside the boundary, around the periphery of the site, from 1976 to 1981. An additional location was sampled from 1982 to 1989. Soil samples were collected outside the FMPC boundary at seven locations from 1983 to 1986, six locations in 1987, and 18 and 17 locations in 1988 and 1989, respectively. As in all of the sampling programs, data collected from soil sampling locations in Operable Unit 3 are not included in this evaluation.

The RI sampling program (1987 and 1988) also included the collection of soils both inside and outside the FMPC boundary. Soils were collected in the zero-to-six inch zone for most on-property samples, and in the zero-to-two inch zone for most off-property samples. In general, RI sampling was concentrated north and east of the site.

The Fernald Litigation sampling program involved the collection of soil samples at more than 400 locations in 1984 and 1986. In 1984, sampling was concentrated on the perimeter of the FMPC, both on- and off-property, with sampling outside the boundary concentrated east of the site. Sampling in 1986 was conducted at more than 300 locations within a five-mile radius of the FMPC. Again, soils east of the FMPC were more heavily sampled.

In general, data collected as part of the FMPC Environmental Monitoring Program indicates that Operable Unit 5 soils sampled within the FMPC boundary had uranium concentrations ranging from 0.42 to 16 pCi/g from 1976 to 1989 (Table A-12). Soils sampled outside the FMPC boundary had uranium concentrations which ranged from 0.35 to 13.2 pCi/g from 1984 to 1989 (Tables A-12 and A-13). Technetium-99, thorium-228, thorium-230, and thorium-232 were also present at detectable

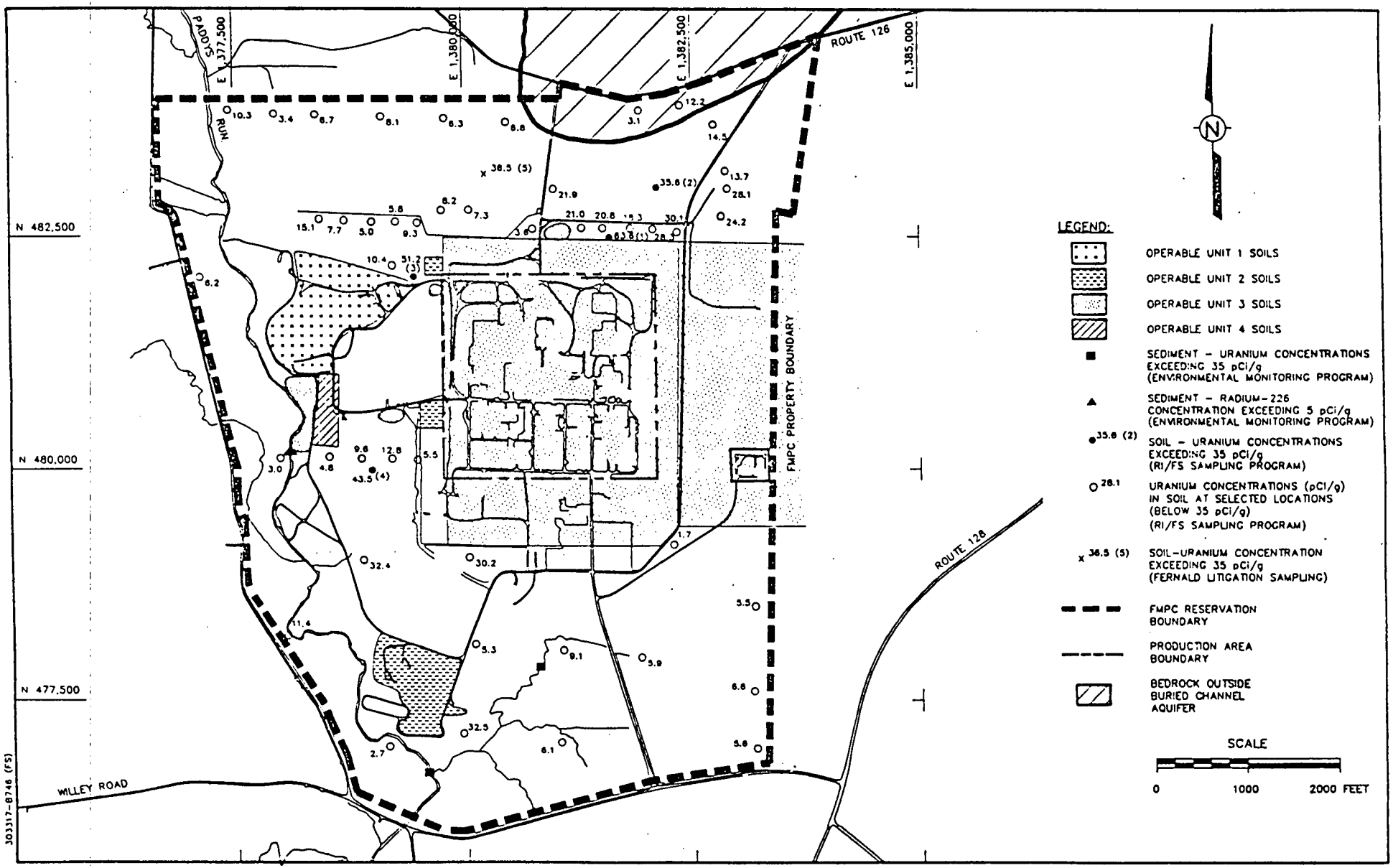


FIGURE 3-4
POTENTIAL AREAS OF CONCERN
SOIL AND SEDIMENT

concentrations in 1984 (Table A-13).

Data from the 1984 and 1986 off-site surveys and the 1988 RI soil data indicate that the potential areas of concern for uranium based on the 35 pCi/g criterion are largely limited to locations within the framework of the Production Area, which deals with controlled access areas and other suspect areas. Figure 3-4 identifies those areas of concern for surface soils within Operable Unit 5. As shown in the figure, there are no areas of concern outside the FMPC boundary and only five areas of concern within the property boundary. Each of the five areas of concern are indicated by a single point since each represents the results of only one sample analysis. Concentrations at these locations were 51.2, 35.6, 63.6, 43.5, and 36.5 pCi/g of uranium. In some cases, nearby sample locations had concentrations below the level of concern. This provides evidence that the observed exceedances are localized and do not represent a significant area of concern. Even though nearby samples are not available for direct comparison at other locations, the results of the radiation survey conducted across the entire site provide direct evidence of the lack of any widespread problem.

Soil samples were also collected along with parallel vegetation samples as part of the FMPC Environmental Monitoring Program (Table A-15). In 1985, uranium levels ranged from 1.08 to 64.32 pCi/g, with the highest detection along the western boundary. Samples collected in 1987 ranged from 1.2 to 23.8 pCi/g with the highest detection along the southern boundary. In 1988, the routine soil sampling program was combined with the parallel soil and vegetation sampling program. However, soil samples were still collected at four sampling locations which were previously part of the parallel soil and vegetation sampling program in 1988 and 1989. These samples were collected at locations outside the FMPC boundary, northeast of the site. The total uranium concentrations measured at these locations, in addition to the locations sampled outside the FMPC boundary in 1988 and 1989 were relatively low, ranging from 1.4 to 9.1 pCi/g.

Even though only a small area of soils containing concentrations of uranium exceeding the criteria have been identified, remedial alternatives have been formulated for soils under Operable Unit 5. This is necessary to provide for the evaluation of alternative strategies to remediate even small areas of concern. In addition, since a lowering of the concentration of concern may occur as a result of the risk assessment, the area and volume of soil requiring remediation may substantially increase.

3.1.3 Surface Water

The storm sewer outfall ditch, Paddys Run, and the Great Miami River are the principal surface water bodies potentially impacted by operations at the FMPC. Surface water at and in the vicinity of the FMPC has been sampled and analyzed to determine the presence and concentration of a variety of radionuclides. Summaries of this data obtained from the FMPC Environmental Monitoring Reports and the RI sampling program are provided in Tables A-16, A-17, A-18, and A-20. It should be noted, however, that surface water concentrations are not directly comparable due to different states of dilution as a result of high and low flow rates, as well as differing rates of evaporation.

Uranium has been identified as a potential constituent of concern at the FMPC because it has routinely been detected at both low (above the detection limit) and elevated (greater than 35 pCi/L) concentrations (Tables A-16, A-17, and A-18). Other radionuclides, including technetium-99 and radium-228, were also detected at elevated concentrations. Technetium-99 was found below detection limits, at low concentrations, and at elevated concentrations in the Great Miami River. Radium-228 was occasionally detected at low concentrations (less than 1.0 pCi/L) in both Paddys Run and Great Miami River samples. One unfiltered Great Miami River sample, however, had a detected concentration of 5.0 pCi/L, which is equal to the maximum contaminant level (MCL) for drinking water. Other radionuclides which were also detected, but only at low concentrations, include radium-226, strontium-90, thorium-228, and thorium-230 (Tables A-16 and A-17).

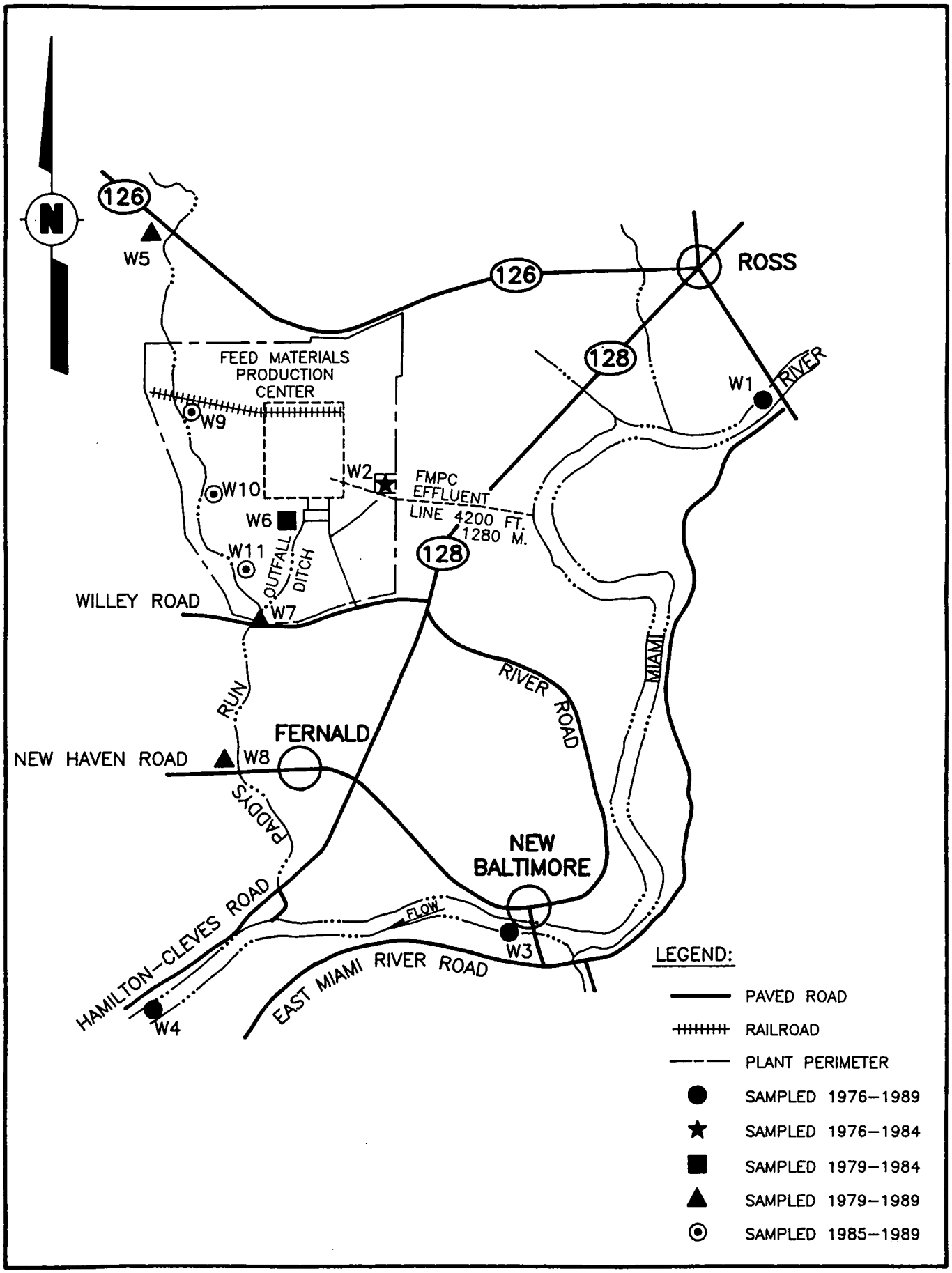
The storm sewer outfall ditch has historically conveyed runoff from the Production Area and other areas within the FMPC to Paddys Run and ultimately to the Great Miami River. During the period of 1952 to 1986, surface water runoff containing high concentrations of uranium was discharged to the storm sewer outfall ditch. Since 1986, a retention basin has greatly reduced the discharge of uranium-containing water to the storm sewer outfall ditch. Water is pumped from the basins to the FMPC permitted effluent line. The basin system has the capacity to contain the 10-year, 24-hour rainfall event. Thus, at the present time, little uranium is entering the storm sewer outfall ditch. An evaluation of the impacts on environmental pathways associated with surface water discharged from the FMPC, including overflows from the storm water retention basin, is being included in the RI report. During the 1989 RI sampling, surface water samples were collected from the storm sewer outfall ditch and analyzed for uranium. The range of concentrations observed in unfiltered

samples was from 2 to 24 ug/L (1.3 to 16 pCi/L) and 2 to 44 ug/L (1.3 to 29 pCi/L) in filtered samples (Table A-17).

Concentrations of uranium in Paddys Run have been monitored at selected locations since 1975. Sampling locations have been situated upstream of the FMPC, upstream of the confluence with the storm sewer outfall ditch, near the confluence, and downstream of the confluence (see Figure 3-5). All sampling locations show evidence of the presence of uranium, either historically or at the present time. Historically, samples collected from Paddys Run within the FMPC boundary both above and at the confluence with the storm sewer outfall ditch had (greater than 35 pCi/L) measured total uranium concentrations. These elevated concentrations were not measured consistently at these locations, however. Average annual uranium concentrations at four sampling locations on Paddys Run have ranged between 1.2 to 351.5 ug/L (0.8 to 236 pCi/L) during the period 1975 through 1989. Concentrations over the last three years (1987, 1988, and 1989) have averaged from 1.2 to 12 ug/L (0.8 to 8 pCi/L), with the exception of one location sampled and analyzed in 1988 (Table A-18). This sampling location had an average of 58.2 ug/L (39 pCi/L) due to a single high reading which was included in the average.

Surface waters in the Great Miami River have been sampled and analyzed for uranium for many years. The three sampling locations are situated upstream of the FMPC discharge point, between the effluent discharge and Paddys Run, and downstream of Paddys Run (see Figure 3-5). Concentrations of uranium at these locations, as reported in the annual Environmental Monitoring Reports 1984 to 1988 (Tables A-16 and A-20), have ranged from a low of 0.9 ug/L (0.61 pCi/L) to a high of 38.4 ug/L (25.7 pCi/L). The average annual concentration has not exceeded 2.8 ug/L (1.9 pCi/L); the high value of 38.4 ug/L (25.7 pCi/L) was reported as the maximum in 1984 at one location. Data collected in 1987 from 11 locations on the Great Miami River between Ross Bridge and one mile downstream of the FMPC outfall indicated uranium concentrations ranging from less than detection limits to 5.0 ug/L (3.35 pCi/L) (IT 1988). FMPC RI samples collected at seven locations in 1988 and 1989 indicate concentrations ranging from below detection limits to 4.1 pCi/L (6.1 ug/L.)

At the present time, a concentration of concern for uranium in surface water has not yet been established. However, if the current surface water concentrations are evaluated with respect to the designated level of concern for potable groundwater (30 ug/L), the surface waters would not



303317-A175 (FS)

FIGURE 3-5 SURFACE WATER SAMPLING LOCATIONS

generally represent a threat to human health or the environment. Historically, the principal source of uranium contamination in Paddys Run has been runoff from the storm sewer outfall ditch, with storm water runoff from the Waste Storage Area also representing a nontrivial source term. As previously indicated, the establishment of the retention basin has dramatically reduced uranium levels in both Paddys Run and the storm sewer outfall ditch. Remedial actions taken as part of other operable units regarding the production facilities, suspect areas, and the Waste Storage Area should further reduce the level of uranium in surface water at the site. In particular, a planned removal action to eliminate the discharge of contaminated storm water runoff from the Waste Storage Area to Paddys Run will control a major contaminant pathway to surface waters.

Tables A-19 and A-21 (Appendix A) contain the chemicals (organic compounds and heavy metals) identified in the surface waters of Paddys Run and the Great Miami River, respectively. The results indicate that neither the three organic constituents detected at Paddys Run nor any of the identified metals exceed the MCL drinking water standards.

3.1.4 Sediments

Sediments in the storm sewer outfall ditch, Paddys Run, and the Great Miami River have been assessed primarily with respect to radiological constituents, but chemical data (organics and metals) have also been analyzed. Two constituents of potential concern, uranium and radium-226, have been identified. A review of the available data indicates that concentrations of radionuclides are present in the sediments at levels above background. Elevated levels in the sediments could represent a continuing source of contamination to surface waters and have potential adverse impacts on aquatic life. No action level has yet been established for radiological constituents in sediments. This will be completed in conjunction with the risk assessment. Therefore, the 35 pCi/g uranium limit used for delineation of soils of concern will also be applied to the sediments. An activity level of 5 pCi/g was selected for radium-226 since this has been established as an action level for soils at sites where radiological contamination was remediated under other federal programs. During the 1987 and 1988 Environmental Monitoring Program samplings (Table A-24 and A-27), sediments were collected in the storm sewer outfall ditch at approximately 10 locations and in Paddys Run at approximately 40 locations. The samples were analyzed for 12 radionuclides. Based on this sampling and the above levels of concern, three areas above the criteria have been identified. Two of these are in Paddys Run and one in the storm sewer outfall ditch. Figure 3-4 indicates the approximate location of these areas. The constituent of concern at two of the

locations is uranium while radium-226 is of concern at the third location. It is noted that the area of concern in all cases has been identified on the basis of a high concentration at only one of three sampling locations across the width of the channel (Table A-22). It is also noted that concentrations were below the levels of concern at sampling locations immediately upstream and downstream of the locations shown in Figure 3-4.

The sum of uranium isotope concentrations of 14 RI sediment samples collected at seven locations along the Great Miami River in 1988 and 1989 ranged from less than detection limits <0.6 pCi/g to 2.5 pCi/g, with U-234 and U-238 contributing approximately 51 and 49 percent respectively (Table A-23.) These concentrations, which are much lower than the specified action level (35 pCi/g), are consistent with those measured during the Environmental Monitoring Program from 1984 to 1988 (Tables A-24, A-27, and A-29). Concentrations from the latter program ranged up to 2.96 pCi/g during this period.

The organic compounds and metals identified in the sediments of Paddys Run (above and below the confluence of the storm sewer outfall ditch with Paddys Run) and at the storm sewer outfall ditch are presented in Tables A-25, A-26, and A-28, respectively. One constituent of potential concern, aluminum, has been identified.

Tables A-30 and A-31 provide a comparison for surface water and sediment data from the same sampling locations. The lab results for the surface water samples consist of 199 water samples that were taken in 1988 and 1989 at eight main sampling regions (refer to Figure 3-5). The Great Miami River (above the effluent discharge) had the lowest total uranium concentrations. It ranged from 0.00 pCi/L to 1.1 pCi/L. Some of the highest concentrations were found in Manhole 175 and miscellaneous ditches that lead to Paddys Run. Manhole 175 had a range of 337.5 pCi/L to 751.0 pCi/L, but the highest total concentration of uranium was 3544.5 pCi/L, which was found in a ditch southwest of Pit 5.

The lab results for sediment samples consist of 142 samples that were taken in 1988 and 1989. The total uranium concentration was lowest in the Great Miami River (below the effluent discharge, see Figure 3-5). It ranged from 0.00 pCi/L to 1.50 pCi/L (dry weight). The highest concentration of total uranium was found in Manhole 175. It ranged from 315.6 pCi/L to 430.1 pCi/L (dry weight).

3.1.5 Air

Measurable concentrations of radionuclides have at times been present in air at and in the vicinity of the FMPC. These occurrences have been primarily associated with site stack emissions and fugitive emissions from waste areas and have been shown not to result in unacceptable doses to off-site populations (Center for Disease Control 1989). Source control represents the only valid action for addressing this environmental condition. While fugitive dust emissions will be addressed during implementation of remedial actions, site stacks are not included within the scope of Operable Unit 5. Available air data will be documented as part of the Operable Unit 5 RI and will be considered as a pathway within the risk assessment.

3.1.6 Biota

Terrestrial and aquatic biota have been sampled to determine whether any radiological or hazardous substances released to the FMPC environs were transferred to wildlife habitats, including wetlands, or to agricultural produce and milk to determine if any such transfers represent a significant hazard to human beings or to threatened or endangered wildlife species.

Local produce, including green peppers, okra, tomatoes, cucumbers, squash, potatoes, alfalfa, and corn, had uranium concentrations no higher than those in produce from an upwind control area in Brookville, Indiana (Table A-32). This indicates that local produce is probably not a significant pathway for human exposure to uranium derived from FMPC operations. Exposure to other FMPC-derived radionuclides through agricultural products does not appear to be significant. Neither cesium-137 nor strontium-90 was detected in any of the produce sampled.

Milk samples were collected from cows grazing both in the vicinity of the FMPC and from dairy farms approximately 30 km away from 1983 to 1988 as part of the FMPC Environmental Monitoring Program. In all, only 3 of 62 samples collected at the FMPC and control locations had detectable levels of uranium (Table A-33).

Vegetation sampling at the FMPC included the collection and radiological analysis of the roots and shoots of both grasses and forbs, in addition to accompanying soil samples. All samples were collected inside the FMPC boundary, but outside the production area. Total uranium concentrations in vegetation ranged from nondetectable (<0.6 pCi/g) to 35.5 pCi/g and occurred at detectable levels in about 62 percent of the samples. Uranium concentrations in soil and vegetation exhibited high

spatial variability. Cesium-137 and strontium-90 concentrations were consistently low, occurring at detectable levels in only 27 and 7 percent of the samples, respectively (Table A-34).

No detectable radionuclides were found in mammal samples, except for uranium in a composite sample of small mammal organs (including liver, kidney, and gonads) collected adjacent to Waste Pit 5 (Table A-35). This could indicate a potential exposure pathway to receptors feeding on the FMPC. However, their wide feeding ranges should limit their exposure to radionuclides from the FMPC. The composite carcass sample from which the organs were taken had no detectable radionuclides.

Aquatic organisms could be exposed to FMPC-derived radionuclides in wetlands, Paddys Run, and the Great Miami River. The radiological analysis of aquatic vegetation (cattail, sedge, and grass leaf and root samples) revealed total uranium concentrations which ranged from nondetectable (<0.6 pCi/g) to 31.3 pCi/g and occurred at detectable levels in 44 percent of the samples. Strontium-90 was detected in only one algae sample (0.9 pCi/g), and technetium-99 was detected in one leaf sample (1.9 pCi/g). All other concentrations were below detection limits. Cesium-137 was below detection limits in all samples (Table A-36).

Benthic macroinvertebrate samples collected from both Paddys Run and the Great Miami River had detectable uranium-234 and uranium-238 concentrations. Detected total uranium concentrations ranged from 1.5 to 6.5 pCi/g. Cesium-137, strontium-90, and technetium-99 were below detection limits in all samples (Table A-37). These detected concentrations indicate that uranium may be entering the aquatic food chain. Fish collected from Paddys Run had detected levels of uranium (0.6 to 3.7 pCi/g) in 30 percent of the samples analyzed (Table A-37). Cesium-137, strontium-90, and technetium-99 were not detected in any of the samples. No detectable radionuclides were found in fish samples from any site on the Great Miami River. Because whole-body fish samples did not have radionuclide concentrations higher than macroinvertebrates, there is no evidence of biomagnification of radionuclides by fish in Paddys Run or the Great Miami River.

Biological samples, including grass, fish, and mammal tissues, were also analyzed for priority pollutant base, neutral, and acid extractable organic compounds as well as pesticides and PCBs. None of these compounds were detected in any sample.

There is no evidence that threatened or endangered species are currently at risk from radionuclides or hazardous substances released by the FMPC.

3.2 CONTAMINANT TRANSPORT AND FATE

As indicated in Section 3.1, radiological contaminants which may adversely affect human health and the environment are present in various environmental media at the FMPC. The transport pathways, potential receptors, and risk to receptors will be thoroughly evaluated as part of the risk assessment which will be included in the RI. Section 3.2.1 provides an overview of the role of environmental media in the transport of contaminants and the associated potential exposure of receptors. The environmental fate of contaminants is discussed in Section 3.2.2.

3.2.1 Contaminant Migration Pathways and Receptors

3.2.1.1 Groundwater

The existing radiological contamination in the regional aquifer south of the FMPC is believed to be largely the result of historical releases of radioactive materials from the FMPC that entered Paddys Run by way of the storm sewer outfall ditch and other overland pathways and subsequently infiltrated into the aquifer through the streambed. The addition of the retention basin and the implementation of other surface water management practices have minimized the loading of contaminants associated with this pathway to the aquifer. The observed contamination of the regional aquifer immediately beneath the Waste Storage Area is likely the result of vertical migration of uranium originating in the waste pits through the till.

There are currently a large number of users of groundwater in the regional aquifer in the vicinity of the FMPC. However, there are no known users of groundwater as a potable water source from those areas with uranium concentrations above the level of concern. The only known users of potentially contaminated groundwater are industrial users. No one is currently known to be at risk due to usage of water from the regional aquifer.

If not controlled, the flow of the southern uranium plume in the regional aquifer will continue southward along the natural groundwater flow path and will eventually be discharged into the Great Miami River. The movement of the plume out of the regional aquifer into the Great Miami River,

which would result in uranium concentrations in the aquifer typically below 30 ug/L, would take approximately 120 to 150 years assuming remediation of surface sources.

The long-term migration of the plume underlying the Waste Storage Area is dependent on the continued pumping of the SOWC or other wells. Continued pumping will cause an eastward plume migration. In the absence of pumping, the plume would migrate southward along the natural gradient. In either case, the extent of plume dilution prior to reaching the FMPC boundary may be sufficient to reduce uranium concentrations to below the 30 ug/L criterion. This long-term migration scenario will be further evaluated as part of the ongoing modeling study and risk assessment.

3.2.1.2 Surface Water and Sediment

As previously indicated in Section 3.1.3, Surface Water (paragraphs 2 and 3), concentrations of uranium in surface waters of the storm sewer outfall ditch and Paddys Run are relatively low and have significantly decreased with time. The major sources of contamination to these surface water bodies have been surface runoff from the Production Area and other areas within the FMPC. Projects to control these sources have been completed; others are planned. The potential for human exposure to surface water is primarily associated with contact with the water. Neither the outfall ditch nor Paddys Run is used as a water supply, and the concentration of uranium in these surface waters is typically well below the level of concern established for consumption use of groundwater.

Uranium concentrations in the Great Miami River are only slightly elevated above background levels and are well below DOE DCGs for drinking water. Specifically, the average uranium concentration in the Great Miami River for samples collected at locations W3 (downstream from the effluent discharge, see Figure 3-5) and W4 (located approximately 7.6 km downstream from the confluence of Paddys Run with the Great Miami River) is approximately 1.6 pCi/L; the average background concentration is 1.2 pCi/L (collected upstream from the main effluent line at sampling location W1). Uranium is added to the river by the FMPC in conjunction with operations under the authority of a discharge permit. Earlier studies as presented in the "Hydrogeologic Study of the FMPC Discharge to the Great Miami River" (IT 1988) have demonstrated that any contribution of uranium from the regional aquifer does not result in measurable effects on uranium concentrations in the river. Surface water runoff from the site via the storm sewer outfall ditch and Paddys Run

does not significantly contribute to uranium concentrations in the river due to the extreme differences in the associated flow rates.

Environmental exposure pathways in surface waters include the direct ingestion of water by organisms and the transfer of contaminants up the food chain through ingestion at various trophic levels. Ultimately, this pathway can affect human health. However, neither the outfall ditch nor Paddys Run support a viable commercial or recreational fishery; therefore, any associated exposure and risk to humans is not an issue.

Sediments in the outfall ditch, Paddys Run, and the Great Miami River generally have concentrations of contaminants at levels below that of concern. The sources of contaminants in these sediments are the same as those for surface water. The primary potential exposure pathway for humans is direct ingestion of the sediments. Environmental exposure pathways include both the consumption of sediments by bottom feeding organisms and subsequent transfer into the food chain. The release of contaminants from the sediments to the water column is also a potential exposure pathway, but the lack of observed surface water concentrations exceeding the level of concern would negate the need to consider this pathway.

3.2.1.3 Soils

As discussed in Section 3.1.2, there are areas within the FMPC where concentrations of uranium exceed the level of concern (Figure 3-4). There are also widespread areas within and outside the FMPC boundary where concentrations are above background but below the level of concern. The overall pattern of above-background levels of uranium is due primarily to the deposition of uranium-contaminated particulates released from numerous stacks. Localized areas with uranium concentrations exceeding 35 pCi/g are typically linked to specific operations (e.g., the historic use of the incinerator) or previous spill events. Human exposure pathways to contaminated surface soils include direct ingestion, inhalation, and ingestion of agricultural crops grown in soil.

3.2.1.4 Ambient Air

Transport of radionuclides and chemicals via the air can occur as a consequence of mechanical disturbances of the soil or sediment or by resuspension by local winds. Subsequent transport and dispersion to receptor locations will be calculated as part of the risk assessment.

3.2.1.5 Biota

Biota can be receptors of radionuclides and chemicals dispersed through air, surface water, sediments, or groundwater pathways. As intermediate receptors for final exposure by humans, biota will be evaluated as part of the risk assessment.

3.2.2 Contaminant Fate

While uranium is radioactive and will decay to become other radioisotopes and ultimately stable lead, the half-lives of uranium-238, -237, and-234 are 4.9×10^9, 7.04×10^8, and 2.47×10^5 years, respectively. Relative to these half-lives, the uranium has been present at and near the site for a very short time and will remain in its present forms with little change over the period of interest. Uranium in the groundwater will migrate from the area to ultimately be discharged in the regional surface water system associated with the Great Miami River. Once in the Great Miami River, the uranium will be transported downstream at concentrations below levels of concern. Some uranium could be lost to the sediments, but surface water runoff data collected in the spring of 1989 as part of the RI indicate that the uranium is in a nonfilterable form. The data show that the total uranium concentrations in both filtered and unfiltered samples collected from within drainageways in the waste pit area are essentially the same and that little, if any, uranium is bound up in suspended solids in the storm water runoff. Uranium in surface water and sediments will either remain in place and be slowly transformed through the decay process, undergo erosion or leaching and enter the hydrologic system, or be physically transported to other areas by wind or rain in the case of soil and washout in the case of sediments.

4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

4.1 INTRODUCTION

The identification and screening of technologies consist of the following general steps:

- Develop remedial action objectives specifying the contaminants and media of interest, exposure pathways, and preliminary remediation goals that permit a range of treatment and containment alternatives to be developed. The preliminary remediation goals are developed on the basis of chemical-specific ARARs, when available; other available information (e.g., reference doses [Rfds]); and site-specific, risk-related factors.

- Develop general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the remedial action objectives for the site.

- Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements as identified in the remedial action objectives and the chemical and physical characterization of the site.

- Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site.

These tasks were initially completed as part of the Development of Alternatives Report for the overall site. The refinement of these initial tasks for Operable Unit 5 are presented in the following sections.

4.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives consist of medium-specific or operable unit-specific goals for protecting human health and the environment. In general, remedial action objectives aimed at protecting human health and the environment must consider:

- The contaminant(s) of concern

- Exposure route(s) and receptor(s)

- An acceptable contaminant level or range of levels for each exposure route (i.e., a preliminary remediation goal)

EPA guidance requires that remedial action objectives be developed in the initial phase of the FS and used as the framework for developing the detailed remedial alternatives. The specificity of these objectives may vary depending on the availability and quality of site information, conditions, and complexity. As discussed in Chapter 3.0, the development of these remedial action objectives, and ultimately the remedial action alternatives, is dependent upon the completion of the Operable Unit 5 RI and risk assessment. Therefore, the objectives developed for Operable Unit 5 may require modification if additional areas of concern or different levels for cleanup are identified in these tasks.

Based on the current understanding of site data, uranium is the major contaminant of concern in the groundwater, soil, and sediment media. Additionally, radium-226 is identified as a contaminant of concern in the sediments of Paddys Run.

The transport media, transport mechanisms, and corresponding exposure pathways applicable to Operable Unit 5 are summarized below:

TRANSPORT MEDIUM	TRANSPORT MECHANISM	EXPOSURE PATHWAY
Groundwater	Discharge to surface water course; extraction by pumping	Direct ingestion; indirect ingestion via watering of plants and livestock
Air	Mechanical disturbance or resuspension; transport and dispersion by local winds	Inhalation; indirect ingestion via deposition on soil or vegetation and subsequent uptake by plants and livestock
Soils	Release into surface water course (erosion); resuspension into air; uptake by vegetation; and bioaccumulation in food chain	Direct ingestion; inhalation; indirect ingestion via uptake by plants and livestock
Sediment/Surface Water	Sediment release into surface water; ingestion by aquatic organisms; release of surface water to other surface water courses; release to underlying aquifer	Direct ingestion; indirect ingestion via uptake by plants or fish; indirect ingestion via watering of plants and livestock

Based on the above information, the following remedial action objectives for the protection of human health and the environment have been established for Operable Unit 5:

Human Health

- Prevent ingestion (direct or indirect) of groundwater exceeding the derived concentration guideline of 30 ug/L for uranium and other standards for hazardous chemicals, or other risk-based criteria that may be developed
- Prevent the migration of groundwater exceeding the derived concentration guideline of 30 ug/L to potential additional receptors
- Prevent the release of uranium and other carcinogens, noncarcinogens, and/or radionuclides from soils and sediments that would result in the exceedance of acceptable risk levels through exposure modes involving those media
- Prevent the ingestion of surface water in exceedance of acceptable risk levels for radionuclides and standards for hazardous chemicals
- Prevent the potential for ingestion of contaminated soils and sediments in exceedance of acceptable risk levels

Environmental

- Protect the groundwater for current and potential future uses
- Prevent excessive uptake of uranium contamination in soils and sediments by terrestrial and aquatic flora and fauna
- Prevent degradation of surface water bodies

These objectives established for the Operable Unit 5 FS focus on pathways and receptors. Continuing and/or existing sources of contamination to these pathways are the subject of other operable units. Based on the existing data, the media addressed in this report that potentially require direct remediation include groundwater, soils, and sediments. Direct remediation of the air, surface water, and flora and fauna receptors/pathways is not considered a viable solution. These media will be addressed by remediating the source(s) of contamination. These actions are evaluated in the four source operable units.

4.3 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

General response actions are identified for contaminants of concern to satisfy the remedial action objectives. Response actions represent classes or groups of technologies which have characteristics in common. Response actions for Operable Unit 5 are considered and defined as follows:

- No Action: Represents no further remedial action at the site in addition to what is currently proposed as part of other operational or regulatory compliance programs
- Institutional Actions: Represents minimum activity and includes additional monitoring or use/access restrictions
- Control/Containment: Includes primarily in situ physical measures to restrict contaminant migration or waste movement
- Removal: Involves the removal of waste material from its in situ state to a treatment or disposal facility
- Treatment (on and off site): Includes physical, chemical, and biological measures which will reduce the volume, toxicity, or mobility of a contaminant or waste by altering the physical or chemical properties
- Disposal (on and off site): Includes the removal of the treated or untreated waste and placement in a temporary or permanent preengineered environment which will restrict contaminant migration and thus eliminate exposure routes
- Discharge: Includes the release of treated or untreated groundwater to the environment

Each of these response actions is applicable to groundwater with the exception of disposal. Disposal is, however, an ancillary operation associated with groundwater treatment. Treatment residuals may require disposal. Also, with the exception of the discharge action, each is considered applicable to the soil and sediment media.

4.4 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

For each media (i.e., groundwater, soils, and sediments), potentially feasible remedial technologies and process options have been identified for each of the relevant response actions. These technologies were compiled by utilizing technologies described in various EPA documents as well as other applicable references. Each of these technologies and process options has undergone a refinement of the previously completed screening of technologies and process options in the

Development of Alternatives Document. The goal of the screening process is to reduce the original number of possible technologies to a smaller and more workable number of individual technologies which are considered applicable or appropriate for the various media. In this step, both process options and entire technology types could be eliminated based on technical implementability. Information regarding site characterization, contaminant types, and contaminant concentrations was used to eliminate technologies and process options that are either not applicable or cannot be effectively implemented at the site.

As mentioned in Section 1.0 of this report, the removal action proposed as the preferred alternative within the South Plume EE/CA (DOE 1990) is considered as the baseline condition for this FS. This removal action includes the provision of an alternate water supply to the two currently affected industrial users in the area and application of institutional measures regarding the use of contaminated groundwater by potential receptors. Additionally, two to five wells will be located at the leading edge of the plume to extract and discharge the groundwater to the Great Miami River. Compliance monitoring and monitoring for the effectiveness of the extraction system are also part of this removal action.

For purposes of the initial screening of technologies and process options for the groundwater medium, the alternate water supply and associated institutional measures are considered permanent actions once implemented as part of the removal action and will not be reevaluated. On the other hand, since the continuation, discontinuation, or expansion of the extraction and monitoring system components of the removal action are considered to be candidate options for the final remedial action alternatives for the groundwater medium, these technologies are reevaluated in this screening document.

The following sections provide a discussion of the screening process. The technologies and process options for groundwater are first identified and screened. The soils and sediments are discussed together since most of the technologies and process options are common to both media. The surface water overlying the sediments is addressed either in other operable units (i.e., those that address contamination sources) or implicitly by addressing the sediments in this operable unit.

4.4.1 Initial Screening: Groundwater Medium

The general response actions that are applicable for groundwater include no action, institutional actions, control/containment, removal, treatment, and discharge. A summary of the screening process for the groundwater medium is presented in Table 4-1. The following sections provide a discussion of this screening process. Technologies and process options that are considered to be implementable at the site are further evaluated in Chapter 5.0 of this document.

4.4.1.1 No Action

The no-action response was retained for consideration during the development and analysis of alternatives as required by the NCP. The no-action response does not provide additional remediation, monitoring, or security activities at the site to further minimize risk to public health or the environment. This no-action response will be further evaluated as a baseline for comparison with other remedial action alternatives developed for the environmental media operable unit.

4.4.1.2 Institutional Actions

The institutional actions screened for the groundwater medium include monitoring and use or access restrictions. Both of these actions are applicable for groundwater. Monitoring includes the use of existing wells or the installation of new wells. These well networks can be used to monitor the performance of collection/treatment systems for groundwater, for detecting changes in contaminant releases from the site, and/or for compliance monitoring. Use/access restrictions over and above the institutional controls considered under the south plume removal action include the purchase of property over the contaminated aquifer area and deed restrictions. Each of these actions is retained for further evaluation.

4.4.1.3 Control/Containment

The pathway control/containment measures screened for the groundwater medium include primarily physical measures that restrict contaminant migration and minimize potential impacts on receptors. The control and containment technologies evaluated include subsurface drains, pumping wells, capping, alteration of the natural drainage system, and vertical and horizontal barriers. The primary area of concern of the contaminated aquifer underlies greater than 600 acres of land surface, with the majority being outside the FMPC boundary. For this reason, as well as the aquifer thickness and high aquifer transmissivity (25,000 to 50,000 ft^2/day), a large number of the control/containment

TABLE 4-1

FMPC FEASIBILITY STUDY
OPERABLE UNIT 5 - ENVIRONMENTAL MEDIA
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	No Action	No Action	No action is taken	NCP requires no action to be carried through detailed analysis
Institutional Actions	Monitoring	Groundwater Monitoring	Ongoing monitoring of existing wells or installation and monitoring of new wells	Potentially applicable
	Use/Access Restrictions	Land Acquisition	Purchase of property over the contaminated portion of the aquifer	Potentially applicable
		Deed Restrictions	Deeds for property and water rights within contaminated areas include restrictions on groundwater use	Potentially applicable
Control/Containment	Subsurface Drains	Interceptor Trenches	Perforated pipe in trenches backfilled with porous media to collect groundwater	Potential support technology
	Pumping Wells	Extraction Wells (uncontaminated water)	Series of wells to extract uncontaminated groundwater for injection or to modify flow paths	Potentially applicable
		Injection Wells (uncontaminated water)	Inject uncontaminated water via pumping wells to direct flow away from receptor wells	Potentially applicable

TABLE 4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Control/Containment (Continued)	Capping	Clay or Multimedia Cap over Recharge Area	Prevent infiltration/re-charge to aquifer	Not applicable due to large surface area involved over the aquifer and its off-site location (under privately held land)
	Alter Natural Drainage System	Pave Channels Which Contribute Recharge to Aquifer	Prevent infiltration/re-charge to aquifer by paving Paddys Run	Potentially applicable
	Vertical Barriers	Cement-Bentonite/ Soil Bentonite Slurry Wall	Barrier of cement-bentonite or soil-bentonite mix to prevent horizontal migration of contaminated groundwater	Not applicable due to unsuitable aquifer geology
	Horizontal Barriers	Grout Injection	Barrier to prevent vertical migration of contaminated groundwater	Not applicable due to unsuitable aquifer geology
Removal	Pumping Wells	Extraction Wells (contaminated water)	Series of wells to extract contaminated groundwater	Potentially applicable
Treatment	Biological	Aerobic/Anaerobic	Degradation of organics using microorganisms	Not applicable for uranium (inorganic contaminant) removal
		Biosorbant	Use of a biological exchange resin to remove heavy metals from water	Potentially applicable
	Physical	Belt Filter Press	Dewater sludges by forced flow through media	Potentially applicable for ancillary treatment process (sludge dewatering only)
		Sedimentation/ Clarification	Settle out suspended solids in water	Potentially applicable for ancillary treatment process (pretreatment or sludge dewatering) only
		Dual Media Filtration	Use of media to separate solid from a liquid	Potentially applicable for ancillary treatment process (pretreatment or sludge dewatering) only

72

943

TABLE 4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (Continued)	Physicochemical	Precipitation	Use chemical additives to change water chemistry and reduce solubility of contaminants	Potentially applicable
		Coagulation/ Polymerization	Aggregate contaminants by use of additives	Potentially applicable
		Adsorption (various media)	Adsorption of contaminants onto media	Potentially applicable
		Reverse Osmosis	Use of high pressure to force water through a membrane leaving contaminants behind	Potentially applicable
		Advanced Membrane Filtration or Ultra-filtration	Use of fine mesh media and physicochemical reactions to filter out contaminants	Potentially applicable
		Solvent Extraction (air stripping)	Use of differential pressure to separate contaminants	Not applicable to uranium removal
		Freeze Crystallization	Separation of water from contaminants (solvents) with different freeze points	Not applicable to uranium removal
		Distillation	Separation of water from contaminants with different boiling points	Not applicable due to volume of water required for treatment

TABLE 4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (Continued)	Physicochemical (Continued)	Electrodialysis	Use of high pressure to force water through an electrically charged membrane leaving contaminants behind	Not applicable to uranium removal
	Chemical	Neutralization/pH Adjustment	Addition of chemicals to adjust water pH	Potentially applicable as pretreatment process only
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water	Potentially applicable
	In Situ	Oxidation/Degradation	Various methods to oxidize or degrade organic or chemical contaminants	Not applicable to uranium contamination
	Use Existing Treatment Plant	Albright & Wilson Plant	Treat extracted groundwater at Albright & Wilson Plant where uranium removal from groundwater is currently performed	Not applicable due to private ownership
Discharge	Discharge to Surface Water	Discharge to River via Existing Pipeline (treated groundwater)	Discharge treated water to the Great Miami River via existing pipeline at FMPC	Potentially applicable

74

643

TABLE 4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Discharge (Continued)	Discharge to Surface Water (Continued)	Discharge to River via Existing Pipeline (untreated groundwater)	Discharge untreated groundwater to Great Miami River via existing pipe at FMPC	Potentially applicable
		Discharge to River via New Pipeline (treated groundwater)	Discharge treated water to the Great Miami River via new pipeline	Potentially applicable
		Discharge to River via New Pipeline (untreated groundwater)	Discharge untreated water to the Great Miami River via new pipeline	Potentially applicable
	Pumping Wells	Reinjection	Reinject water to aquifer after treatment	Potentially applicable

technologies are not applicable to the groundwater medium. Technologies and their accompanying process options eliminated for these reasons include subsurface drains, capping, vertical barriers, and horizontal barriers.

Pumping wells are retained for consideration for use in extracting uncontaminated groundwater from the aquifer for purposes of modifying groundwater flow patterns or to provide water for injection to direct flow away from receptors.

Another control/containment technology considered potentially applicable for groundwater is paving Paddys Run and the storm sewer outfall ditch to prevent the infiltration or recharge of contaminated surface water to the underlying aquifer.

4.4.1.4 Removal

The technology screened for groundwater removal is pumping wells. Pumping wells are retained for use in extracting contaminated groundwater from the aquifer to subsequent treatment or discharge.

4.4.1.5 Treatment

The treatment response action includes biological, physical, physicochemical, and chemical processes which reduce the volume, toxicity, or mobility of a contaminant by altering its physical or chemical properties.

A majority of the technologies and process options considered in the initial screening are ineffective in removing uranium from the groundwater. While they may be effective for treatment of organics, uranium is most prevalent in the aquifer and only technologies applicable for uranium removal will be used in the initial development and screening of alternatives. Aerobic and anaerobic biological treatment processes are ineffective for removing inorganic compounds, particularly chemical elements such as uranium. The processes of oxidation, and chemical reduction, are also ineffective for treating uranium. Other treatment processes that are ineffective for the removal of uranium contamination include solvent extraction, freeze crystallization, and electrodialysis. All of these technologies and process options have been eliminated at this phase of the study. The process of distillation was also eliminated due to the large volume of water requiring treatment (approximately 4000 gpm) and the corresponding energy usage requirements. Additionally, the option of using

Albright & Wilson's treatment plant was eliminated because of legal aspects of private industry ownership of the plant and the volumes of water requiring treatment.

The potentially applicable process options retained for uranium removal include biosorbant, adsorption, precipitation, coagulation/polymerization, reverse osmosis, advanced membrane filtration, and ion exchange. Additionally, several treatment processes were found to be potentially applicable as ancillary pre- or post-treatment processes. These include dual media filtration, belt filter press, sedimentation, and neutralization. These ancillary process options are not carried through the evaluation of process options and the assembly of alternatives but may be included during the detailed analysis of alternatives as necessary for the complete conceptualization, costing, and evaluation of a groundwater treatment system.

4.4.1.6 Discharge

Discharge refers to the release of treated or untreated groundwater to either a surface water body via a permitted outfall or to the subsurface environment via deep well injection. The options of discharge to the Great Miami River via an existing or new pipeline have been retained for consideration, as well as the use of pumping wells for reinjection of treated groundwater back into the aquifer. Each is considered potentially applicable for groundwater discharge. The discharge of treated groundwater to Paddys Run represents a variation of the discharge technology and will not be independently evaluated.

4.4.1.7 Summary of Technology Screening For Groundwater

The previous sections provided a discussion of the rationale for elimination of numerous technologies and process options inapplicable for remediation of the site groundwater. The technologies and related process options that have been retained for further evaluation and subsequent development of remedial action alternatives are presented in Table 4-2. The general technologies retained for the groundwater medium include monitoring, use/access restrictions, pumping wells, prevention of recharge from local streams, biological, physicochemical and chemical treatment processes, and discharge to surface water. The no-action response has also been retained and will be considered throughout the FS process.

TABLE 4-2

FMPC FEASIBILITY STUDY
OPERABLE UNIT 5 - ENVIRONMENTAL MEDIA

TECHNOLOGIES AND PROCESS OPTIONS RETAINED
FOR FURTHER EVALUATION - GROUNDWATER

General Response Action	Remedial Technology	Process Option
No Action	No Action	No Action
Institutional Controls	Monitoring	Groundwater Monitoring
	Access/Use Restrictions	Land Acquisition Deed Restrictions
Control/Containment	Pumping Wells	Extraction Wells Injection Wells
	Alter Natural Drainage System	Pave Channels which Contribute contaminants via Recharge to Aquifer
Removal	Pumping Wells	Extraction Wells
Treatment	Biological	Biosorbant
	Physicochemical	Precipitation Coagulation Adsorption Reverse Osmosis Ultrafiltration
	Chemical	Ion Exchange
Discharge	Discharge to Surface Water	Existing Pipeline to River (treated and untreated)
		New Pipeline to River (treated and untreated)
	Pumping Wells	Reinjection Wells

4.4.2 Initial Screening: Soils and Sediments

This section includes a discussion of the initial screening of technologies and process options considered potentially applicable for remediation of site soils and sediments. Summaries of each process for both soil and sediment are presented in Table 4-3, and are jointly discussed in the following sections. Most options were considered appropriate for both media. However, several options are noted in Table 4-3 as being applicable to only soil or sediment.

4.4.2.1 No Action

The no-action response is applicable to the soils and sediments as required by the NCP. The no-action response does not provide additional remediation, monitoring, or security activities at the site to further minimize risk to public health or the environment. The NCP requires that the no-action response be carried through the detailed analysis of alternatives, and therefore, it will not be eliminated at this stage. The no-action response will be further evaluated as a baseline for comparison with other remedial action alternatives developed for the soils and sediments.

4.4.2.2 Institutional Actions

This general response action includes access/use restrictions for soils and sediments. The access/use restriction response includes fencing, deed restrictions, and/or land acquisition and will minimize access to and use of the areas of concern. The implementation of this response will result in no changes to the existing site environment. Fencing may be applicable in localized areas of soil contamination and as a support technology for sediments. Deed restrictions and land acquisitions are considered for soils only. Deed restrictions will be retained for further evaluation, however, land acquisition is eliminated because data has shown soils contaminated above the preliminary levels of concern within the FMPC boundary only.

4.4.2.3 Control/Containment

The control/containment response is applicable for both soils and sediments. Major control and containment remedial technologies evaluated for these media include vertical barriers, capping, and surface water control systems.

Vertical barriers will be considered for the sediments and can be used to divert groundwater flow away from a contaminated sediment area and/or to isolate the sediment. Vertical barriers are

TABLE 4-3
FMPC FEASIBILITY STUDY
OPERABLE UNIT 5 - ENVIRONMENTAL MEDIA
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOILS AND SEDIMENTS

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	No Action	No Action	May include environmental monitoring, but excludes actions that would reduce the potential for exposure	NCP requires no action to be carried through detailed analysis of alternatives
Institutional Actions	Access/Use Restrictions	Fence Site	Fencing of the site to restrict access areas	Potentially applicable in localized areas of contamination
		Deed Restrictions[a]	All deeds for property within potentially contaminated areas should include restrictions on use of property	Potentially viable
		Land Acquisition[a]	Purchase of property with elevated uranium concentration in soils	Not applicable
Control/Containment	Vertical Barriers	Sheet Piling	Driven steel sheet piling	Potentially applicable as a support technology
	Capping	Single-layer Cap	Cap constructed of low permeability materials, either concrete, asphalt, clay, or soil	Potentially viable
		Multi-layer Cap	Compacted clay covered with a synthetic membrane followed by a drainage/ filter layer and top soil to provide erosion and moisture control	Not applicable to localized, discrete "hot" spots; may be used in conjunction with on-site landfilling
	Surface Water Control	Diversion/Collection[a]	Dikes and berms, channels, terrace and benches, chutes, seepage basins, and ditches	Potentially viable as a support technology

80

943

TABLE 4-3
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Control/Containment (Continued)	Surface Water Control (Continued)	Grading[a]	Techniques to reshape the land surface to manage surface water infiltration and run off, and to control erosion	Potentially viable as a support technology
		Site Revegetation[a]	Establishing a vegetative cover to stabilize site soils	Potentially viable as a support technology
	Surface Water Control	Channel Relocation[b]	Relocating surface water course to expose clean sediments and allow the covering of contaminated sediments	Not applicable due to site specific conditions
		Channel Modification[b]	Modifying channel alignment or cross-section to control sediment deposition or resuspension	Not applicable due to site specific conditions
Removal	Extraction of Source	Mechanical Excavation	Removing soils and or sediments by excavation using such construction equipment as bulldozers and loaders	Potentially viable
		Dredging[b]	Suction of sediment from their in situ state for treatment or disposal	Potentially applicable
Treatment	Biological	In Situ Bioremediation	Soil and groundwater introduced with oxygen and nutrients to enhance biological degradation of chemicals	Not applicable for uranium
		Soil Aeration	Aeration of soils via injection wells used to promote microbial biodegradation and to strip volatile chemicals from soil/sediments	Not applicable for uranium

TABLE 4-3
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
		Land Farming	Soil spread over land for biological degradation with microorganisms in aerated and nutrient rich soil	Not applicable for uranium
Treatment (Continued)	Chemical	In Situ Vitrification	High current of electricity passed through soil/sediments in situ to melt material into glassy, solid matrix resistant to leaching	Potentially applicable
	Physical	Vapor Extraction	Removal of organic contaminants from soil/sediment matrix via negative pressure	Not applicable for uranium
		Volatilization	In situ radio frequency heating to volatilize VOC's from contaminated soil/sediment	Not applicable for uranium
		Gravimetric Separation	Separation of soils/sediments by denisty; thereby concentrating uranium in density-specific fractions	Potentially applicable
	Physicochemical	Soil/Sediment Washing	Extracts contaminants from excavated soil/sediments using a liquid medium such as water, acids, solvents, or chelating agents	Potentially applicable
	Solidification/ Stabilization	Cement-Based	Slurry of excavated soil/wastes and water mixed with Portland cement to form a stable solid	Potentially applicable
		Thermoplastic	Dried excavated soil/waste heated and disposed through a heated plastic matrix of asphalt, bitumen, parrafin, or polyethylene to form a solid	Potentially applicable

TABLE 4-3
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
		Vitrification	Treatment of excavated soil/ sediment to immobilize contaminants in a vitrous mass	Potentially applicable
Treatment (Continued)	Thermal Treatment	Thermal Desorption	A process used to thermally desorb volatile compounds from soil by increasing temperature	Not applicable for uranium
		Mobile Incinerator (rotary kiln)	Transportable rotary kiln incinerator to destroy wastes by on-site combustion	Not applicable for uranium
On-Site Disposal	Landfill	Landfill	Disposal of soils/sediments in an approved onsite disposal area	Potentially applicable
Off-Site Disposal	Landfill	Landfill	Disposal of soils/sediments in an approved offsite landfill	Potentially applicable

[a]Considered for soil media only.

[b]Considered for sediment media only.

considered for temporary use only, i.e., to be used as a support technology during actions taken on the sediments. The only type of vertical barrier considered appropriate is steel sheet piling. Although sheet piling is susceptible to leakage at the joints, it would provide an effective temporary barrier at the FMPC site during remedial activities. This action, as stated, is considered as a support technology and will not be carried forward for further evaluation.

Capping involves the installation of a barrier over the surface of the contaminated area. Capping is designed to control erosion, prevent the generation of leachate due to surface water infiltration, and alleviate or eliminate possible direct and indirect exposures to the contaminants via inhalation, ingestion, or dermal contact. Capping techniques considered for evaluation for soils and sediments include single-layer and multilayer caps. The single-layer cap is potentially applicable for types of contaminants and areas of concern for both soils and sediments. Single-layer caps may include the use of concrete, asphalt, clay, or soil with the latter two being applicable only to soils. The multilayer cap is not considered viable as an option for localized areas of soil contamination due to complex installation requirements and because the objectives of capping for soil and sediment within Operable Unit 5 can be met by the single-layer cap. A multilayer cap for a subaqueous sediment environment is also not considered applicable. For these reasons, the multilayer cap is eliminated as an individual remediation option. It may, however, be considered as an integral part of the design of an on-site disposal facility.

Surface water control can be used to minimize contamination of surface waters by reducing the erosion and off-site transport of soils which have been contaminated. This technology includes the use of diversion and collection systems, grading, and site revegetation. Since these are considered support actions, they will not be carried further in the evaluation of process options but will be included, as necessary, during the detailed evaluation of alternatives.

Two other surface water control measures are potentially applicable to sediments. These include channel relocation for the purpose of covering the contaminated sediments and exposing clean materials within the new channel bottom and channel modifications to control sediment deposition/resuspension patterns as a result of changes in channel alignment or cross section. Neither technology is considered applicable to a major river system such as the Great Miami River. For different reasons, each is also determined not to be applicable for the specific conditions associated with Paddys Run and the storm sewer outfall ditch. Channel relocation is not a viable

alternative when the sediments can be easily accessed for removal or treatment during the prolonged dry periods experienced at the two surface water courses. As far as channel modification in Paddys Run or the storm sewer outfall ditch, the effectiveness of any changes would be minimal and short-term due to the high variability in flow conditions and the potential for the periodic flush-out of sediments by intense storm conditions. Even the construction of physical structures such as sediment traps would not be effective in the long-term due to the potential for high flow rates in the narrow channels.

4.4.2.4 Removal

Complete or partial removal of contaminated material will prevent migration of contaminants toward potential receptors. This may be accomplished using either mechanical excavation equipment or, in the case of contaminated sediments, dredging equipment.

Mechanical excavation involves the use of common construction equipment, such as a backhoe or bulldozer to remove the soil or sediments. These methods are potentially viable for soils and for sediments not in contact with surface waters (i.e., Paddys Run and the storm sewer outfall ditch during the dry season).

Dredging of material from streambeds is a common technique for sediments in contact with surface waters, i.e., Paddys Run and the storm sewer outfall ditch during the wet season. Dredging and mechanical excavation will be retained for further consideration.

4.4.2.5 Treatment

The treatment options include biological, chemical, physical, physicochemical, solidification/stabilization, and thermal measures which reduce the volume, toxicity, or mobility of a contaminant by altering its physical or chemical properties. Applicable technologies for soils and sediments are discussed below.

The following biological treatment processes were screened for the surface soils and sediments:

- In situ bioremediation
- Soil aeration
- Land farming

All three of these techniques are suitable for remediation of organics; however, they do not address the uranium contamination found at the site. All of the biological treatment methods will therefore be deleted from further consideration.

In situ vitrification was evaluated as a technology for the chemical treatment of soils and sediments. In this process, a high current of electricity is passed through the contaminated media in situ. The heat generated will drive off any volatile organic compounds and solidify the soils into a glassy, solid matrix resistant to deterioration from weathering or leaching. This technology may be feasible for soils or sediments and is retained for further evaluation.

Physical treatment technologies are applicable when the properties of the contaminant compounds make them amenable to separation, replacement, or volatilization. The following physical treatment technologies were screened for soils and sediments:

- Vapor extraction
- Volatilization
- Gravimetric separation

Vapor extraction and volatilization are applicable for volatile organics only and will not remove uranium; therefore, these options were deleted from further consideration. The process of gravimetric separation uses a pulsating sieve to separate materials by density through stratification in a fluid media. Since uranium compounds tend to fall out in the most dense fraction, this may be a viable option for minimizing the waste requiring subsequent disposal and is retained for further evaluation.

The physicochemical treatment process of soil washing was also evaluated for the treatment of soils/sediments. Soil washing involves the extraction of organic and inorganic compounds from soils or sediments by leaching. Soil washing may be viable for the removal of soluble uranium compounds and is retained for further evaluation for both the surface soils and sediments.

Solidification/stabilization involves techniques to seal the contaminated soils and sediments in a solid, stable mass that reduces the mobility of the contaminants in the environment. Some of these techniques physically surround the contaminant particles with a solidifying agent. Others chemically

fix the contaminants by reaction with a solidifier. The following solidification/stabilization techniques were reviewed for treatment of the surface soils and sediments after they are excavated:

- Cement-based
- Thermoplastic
- Vitrification

These technologies are suitable for solidifying or fixing either inorganic wastes or radioactive materials. All will be retained for further analysis. Should any organics be found at the site, these technologies may have limited application because the presence of organics may interfere with the solidification or fixation process.

Thermal treatment is a process in which molecular bonding of organic or inorganic compounds is altered through thermal decomposition and oxidation. The end products of this process typically include carbon dioxide, elemental carbon, ionized halogen, phosphorus, sulfur, and other inorganics, depending upon the original composition of the waste material. The following process options were evaluated for on-site thermal treatment of surface soils and sediments:

- Thermal desorption
- Mobile incinerator (rotary kiln)

These thermal treatment methods are not applicable to soils and sediments contaminated by elemental metals such as uranium and, therefore, will be deleted from further evaluation.

4.4.2.6 On-Site Disposal

Disposal technologies include physical measures (other than in situ) which will provide a permanent preengineered environment to restrict contaminant movement or migration and thus minimize potential impacts on a receptor. For this screening process, an on-site landfill has been defined as an engineered disposal facility designed to meet established federal and state regulations. On-site disposal of contaminated soils and sediments is considered applicable and has been retained for further consideration.

4.4.2.7 Off-Site Disposal

Off-site disposal technologies are considered to be practiced at existing facilities which are approved by the appropriate federal and state regulatory agencies, such as the EPA. For this screening

process, an off-site landfill has been defined as a preengineered disposal area which meets the applicable regulations. Off-site disposal of contaminated soils and sediments will be retained for further consideration.

4.4.2.8 Summary Of Technology Screening For Surface Soils And Sediments

Based on the rationale presented in the previous sections, numerous technologies and process options were judged not to be applicable to uranium or other site-specific conditions and have been deleted from further consideration. Tables 4-4 and 4-5 present the technologies and related process options that have been retained for further evaluation and for subsequent development of remedial action alternatives for soils and sediments, respectively. The retained technologies for both soils and sediments include access/use restrictions, capping, extraction, physical and physicochemical treatment, solidification/stabilization techniques, and landfilling. The no-action response has also been retained for both media and will be considered as a remedial action alternative in the next phase of the FS.

TABLE 4-4

FMPC FEASIBILITY STUDY
OPERABLE UNIT 5 - ENVIRONMENTAL MEDIA

TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR FURTHER EVALUATION - SOILS

General Response Action	Remedial Technology	Process Option
No Action	No Action	No Action
Institutional Controls	Access/Use Restrictions	Fence Site Deed Restrictions
Control/Containment	Capping	Single-Layer Cap
Removal	Extraction of Source	Mechanical Excavation
Treatment	Physical Physicochemical Solidification/Stabilization	Gravimetric Separation Soil Washing Cement-Based Thermoplastic Vitrification In Situ Vitrification
On-site Disposal	Landfill	Engineered Disposal Facility
Off-site Disposal	Landfill	Engineered Disposal Facility

TABLE 4-5
FMPC FEASIBILITY STUDY
OPERABLE UNIT 5 - ENVIRONMENTAL MEDIA

TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR FURTHER EVALUATION - SEDIMENTS

General Response Action	Remedial Technology	Process Option
No Action	No Action	No Action
Institutional Controls	Access/Use Restrictions	Fence Site
Control/Containment	Capping	Single-Layer Cap
Removal	Extraction	Mechanical Excavation Dredging
Treatment	Physical Physicochemical Solidification/Stabilization	Gravimetric Separation Soil Washing Cement-Based Thermoplastic Vitrification In Situ Vitrification
On-site Disposal	Landfill	Engineered Disposal Facility
Off-site Disposal	Landfill	Engineered Disposal Facility

5.0 EVALUATION OF TECHNOLOGY PROCESS OPTIONS

The next step of alternative development and screening involves a detailed evaluation of the technologies and process options remaining from the initial technology screening. In particular, the initial list of screened technologies and process options is further evaluated against three criteria: effectiveness, implementability, and cost. The technology process options that have been identified are evaluated based on these criteria relative to other processes within the same technology types. The major focus of this evaluation is the effectiveness of each option, with less emphasis on implementability and cost. These three criteria and the results of the evaluation process for the groundwater, soils, and sediment media are described in the remainder of the section.

5.1 SCREENING CRITERIA

5.1.1 Effectiveness

The effectiveness evaluation focuses on the following elements:

- The potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the remedial action objectives
- The potential impacts to human health and the environment during the construction and implementation phase
- The reliability and proven effectiveness of the process with respect to the contaminants and conditions at the site

5.1.2 Implementability

The implementability evaluation includes both the technical and institutional feasibility of implementing each process at the FMPC. The initial technology screening eliminated technology types or process options that were clearly ineffective or unworkable at the site; therefore, this subsequent, more detailed evaluation places greater emphasis on the institutional aspects of implementability. These institutional aspects include:

- Ability to obtain necessary permits and rights-of-way for off-site actions
- The availability of necessary equipment and skilled workers to implement the technology
- The availability of treatment, storage, and disposal services

5.1.3 Cost

Cost plays a limited role in the screening of techniques. Relative capital and operating costs are considered rather than detailed estimates. For this evaluation, the cost analysis is made on the basis of engineering judgment, and each technique is evaluated as to whether costs are low, moderate, or high relative to other techniques in the same technology type. A technology process option can be eliminated on the basis of cost only if other process options within the same technology type are comparably effective and implementable but have a much lower cost.

5.2 EVALUATION OF PROCESS OPTIONS FOR GROUNDWATER

The technologies and process options remaining after the initial screening for the groundwater medium were evaluated based on effectiveness, implementability, and cost. The preferred or representative process option for each technology type was retained for incorporation into the remedial action alternatives. The results of this evaluation are summarized in Table 5-1 and are discussed below.

5.2.1 No Action

The no-action response does not provide additional remediation, monitoring, or security activities at the site to further minimize risk to the environment or public health, and will not achieve the remedial action objectives. The NCP, however, requires the no-action response to be carried through the detailed analysis of alternatives; therefore, it will not be eliminated at this stage. The no-action response will be further evaluated as a baseline for comparison with other remedial action alternatives developed for the groundwater medium.

5.2.2 Institutional Actions

The remedial technologies retained for this response action include monitoring and use/access restrictions. The process options pertaining to these technology groups are groundwater monitoring, land acquisition, and deed restrictions.

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	
					CAPITAL	O & M
* NO ACTION	———	———	WILL NOT ACHIEVE REMEDIAL ACTION OBJECTIVES	MAY BE UNACCEPTABLE TO PUBLIC AND LOCAL GOVERNMENT	NONE	NONE
INSTITUTIONAL ACTIONS	MONITORING	* GROUNDWATER MONITORING	WILL NOT ACHIEVE REMEDIAL ACTION OBJECTIVES BY ITSELF	TO IMPLEMENT ALONE MAY BE UNACCEPTABLE TO PUBLIC AND AGENCIES; TECHNICALLY STRAIGHTFORWARD	LOW	LOW
	ACCESS/USE RESTRICTIONS	LAND ACQUISITION	SHOULD BE SOMEWHAT EFFECTIVE IN ACHIEVING HUMAN HEALTH OBJECTIVE; INEFFECTIVE IN ACHIEVING ENVIRONMENTAL OBJECTIVE SINCE IT DOES NOT REDUCE CONTAMINATION IN GROUNDWATER	DIFFICULT TO IMPLEMENT DUE TO POTENTIAL LAND OWNER RESISTANCE AND LEGAL COMPLICATIONS	HIGH	LOW
		DEED RESTRICTIONS	ACHIEVING THE PUBLIC HEALTH OBJECTIVES IS DEPENDENT UPON ADHERENCE AND IMPLEMENTATION INTO THE FUTURE; DOES NOT ACHIEVE ENVIRONMENTAL OBJECTIVES	STRAIGHTFORWARD; CONFINED TO DOE PROPERTY	MODERATE	NONE
CONTROL/ CONTAINMENT		* EXTRACTION WELLS (UNCONTAMINATED WATER)	EFFECTIVE IN ACHIEVING PUBLIC HEALTH OBJECTIVES; INEFFECTIVE IN ACHIEVING ENVIRONMENTAL PROTECTION OBJECTIVES – DOES NOT REDUCE VOLUME/CONCENTRATION OF URANIUM IN AQUIFER	DUE TO HYDROGEOLOGIC CONDITIONS (HIGH AQUIFER TRANSMISSIVITIES AND RELATIVELY STEEP GROUNDWATER GRADIENTS), A LARGE VOLUME OF WATER WOULD BE REQUIRED TO BE EXTRACTED AND TRANSMITTED TO THE INJECTION WELLS; THEREFORE, THIS WOULD BE DIFFICULT TO IMPLEMENT	MODERATE	MODERATE
		* INJECTION WELLS (UNCONTAMINATED WATER)	EFFECTIVE IN ACHIEVING PUBLIC HEALTH OBJECTIVE; INEFFECTIVE IN ACHIEVING ENVIRONMENTAL PROTECTION OBJECTIVES – DOES NOT REDUCE VOLUME/CONCENTRATION OF URANIUM IN AQUIFER	DIFFICULT TO IMPLEMENT FOR SAME REASONS AS EXTRACTION WELLS (UNCONTAMINATED) ABOVE	MODERATE	MODERATE
	ALTER NATURAL DRAINAGE SYSTEM	* PAVE PADDYS RUN	MAY BE INEFFECTIVE IN ACHIEVING PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION OBJECTIVES SINCE FLOWS FROM PADDYS RUN AND STORM SEWER OUTFALL DITCH ARE SMALL RELATIVE TO THE TOTAL FLOW IN THE AQUIFER; DOES NOT ADDRESS EXISTING PLUME; LIMITED FUTURE VALUE SINCE URANIUM LOADING HAS BEEN SIGNIFICANTLY REDUCED	DIFFICULT TO IMPLEMENT DUE TO LAND ACCESS PROBLEMS; DESTRUCTION OF AQUATIC ECOSYSTEM PROBLEM FOR AGENCY ACCEPTANCE	MODERATE	LOW/ MODERATE
REMOVAL	PUMPING WELLS	* EXTRACTION WELLS (CONTAMINATED WATER)	EFFECTIVE REMOVAL TECHNIQUE FOR ACHIEVING PUBLIC HEALTH AND ENVIRONMENTAL PROTECTION OBJECTIVES	DUE TO LAND ACCESS PROBLEMS, MAY BE SOMEWHAT DIFFICULT TO IMPLEMENT	MODERATE	MODERATE
	BIOLOGICAL	BIOSORBANT	HAS ACHIEVED SOME DEGREE OF SEPARATION OF HEAVY METALS IN PILOT-PLANT TESTING, NEW TECHNOLOGY	EMERGING TECHNOLOGY; TREATABILITY STUDIES REQUIRED	MODERATE	HIGH
	PHYSICOCHEMICAL	PRECIPITATION	EFFECTIVE IN TREATMENT OF URANIUM COMPLEXES	COMMONLY UTILIZED TECHNOLOGY; IMPLEMENTABILITY CONCERNS REGARDING RESIDUALS GENERATED NEED TO BE ADDRESSED	LOW	HIGH
		COAGULATION/POLYMERIZATION	MAY BE EFFECTIVE IN TREATMENT OF URANIUM COMPLEXES; REQUIRES FURTHER STUDY	COMMONLY UTILIZED TECHNOLOGY; IMPLEMENTABILITY CONCERNS REGARDING RESIDUALS GENERATED NEED TO BE ADDRESSED	HIGH	HIGH
		ADSORPTION	LIMITED EFFECTIVENESS IN TREATMENT OF URANIUM COMPLEXES	COMMONLY UTILIZED TECHNOLOGY; GENERATION OF RESIDUALS	HIGH	HIGH
		REVERSE OSMOSIS	FOUND TO BE EFFECTIVE IN EXPERIMENTAL APPLICATIONS; FURTHER STUDY REQUIRED	COMMONLY UTILIZED TECHNOLOGY; IMPLEMENTABILITY CONCERNS REGARDING RESIDUALS AND HIGH CONCENTRATION WASTE STREAM	HIGH	HIGH
		ADVANCED MEMBRANE FILTRATION OR ULTRAFILTRATION	NOT EFFECTIVE FOR DISSOLVED URANIUM REMOVAL	COMMONLY UTILIZED TECHNOLOGY; IMPLEMENTABILITY CONCERNS REGARDING RESIDUALS GENERATED NEED TO BE ADDRESSED	HIGH	HIGH
	CHEMICAL	* ION EXCHANGE	EFFECTIVE IN REDUCTION OF URANIUM IN AQUEOUS WASTE STREAMS	COMMONLY UTILIZED TECHNOLOGY FOR URANIUM REMOVAL; IMPLEMENTABILITY CONCERNS REGARDING RESIDUALS GENERATED NEED TO BE ADDRESSED	HIGH	LOW
DISCHARGE	DISCHARGE TO SURFACE WATER	* DISCHARGE OF TREATED GROUNDWATER TO RIVER VIA EXISTING PIPELINE	EFFECTIVE IN ACHIEVING PUBLIC HEALTH AND ENVIRONMENTAL OBJECTIVES	EASY TO IMPLEMENT; NPDES PERMIT MODIFICATION REQUIRED	LOW	LOW
		* DISCHARGE OF UNTREATED GROUNDWATER TO RIVER VIA EXISTING PIPELINE	POTENTIALLY EFFECTIVE IN ACHIEVING PUBLIC HEALTH AND ENVIRONMENTAL OBJECTIVES	EASY TO IMPLEMENT; NPDES PERMIT MODIFICATION REQUIRED; MAY BE UNACCEPTABLE TO PUBLIC AND AGENCIES	LOW	LOW
		DISCHARGE OF TREATED GROUNDWATER TO RIVER VIA NEW PIPELINE	EFFECTIVE IN ACHIEVING PUBLIC HEALTH AND ENVIRONMENTAL OBJECTIVES	EASY TO IMPLEMENT; NEW NPDES PERMIT REQUIRED	MODERATE	LOW
		DISCHARGE OF UNTREATED GROUNDWATER TO RIVER VIA NEW PIPELINE	POTENTIALLY EFFECTIVE IN ACHIEVING PUBLIC HEALTH AND ENVIRONMENTAL OBJECTIVES	EASY TO IMPLEMENT; NEW NPDES PERMIT REQUIRED; MAY BE UNACCEPTABLE TO PUBLIC AND AGENCIES	MODERATE	LOW
	PUMPING WELLS	INJECTION WELL (TREATED WATER)	EFFECTIVE IN ACHIEVING PUBLIC HEALTH AND ENVIRONMENTAL OBJECTIVES	MAY BE DIFFICULT TO OBTAIN PERMIT TO INJECT WATER INTO SOLE SOURCE AQUIFER	HIGH	MODERATE

303317-8471 (FS) (PCH)

* SELECTED AS REPRESENTATIVE OPTIONS FOR INCORPORATION INTO ALTERNATIVE DEVELOPMENT.

TABLE 5-1
OPERABLE UNIT 5 – ENVIRONMENTAL MEDIA
DETAILED EVALUATION OF PROCESS
OPTIONS FOR GROUNDWATER

5.2.2.1 Groundwater Monitoring

Groundwater monitoring, sampling, and analysis of selected existing wells is used to assess the concentration levels and movement of the contaminants of concern. The evaluation of groundwater monitoring is summarized below:

- Effectiveness (low): Groundwater monitoring will not meet any of the remedial action objectives by itself. The potential impact on human health and the environment during the construction and implementation phase of this option is negligible. The only additional exposure to the contaminated groundwater is by sampling and analytical personnel.

- Implementability (high): A large number of monitoring wells currently exist at and near the FMPC site. Also, additional wells can be installed quickly and equipment and services are readily available. This process option may not, however, be acceptable to the agencies without additional remedial response.

- Capital Cost (low): This item includes only additional monitoring wells and public notice.

- O&M Cost (low): Major cost items include well maintenance, sampling and analysis, and payments to landowners.

Groundwater monitoring will be retained for incorporation into the remedial action alternatives. Monitoring may be appropriate as either compliance monitoring or corrective action monitoring.

5.2.2.2 Land Acquisition

This process option involves the purchasing of land to prevent receptor access to groundwater containing elevated levels of uranium. It would require the purchase of the off-site land above the contaminated aquifer. Eminent domain rights of the federal government could potentially be implemented if necessary. This process option evaluation follows:

- Effectiveness (moderate): Use of this process option should be effective in achieving the human health objectives but does not achieve the environmental objective of reducing the contaminant volume or concentration.

- Implementability (low): Landowner resistance to the purchase of their property is expected. Potential lawsuits may contribute to the difficulty of implementing this process option.

- Capital Costs (high): Cost items include purchase of homes, industries, and productive farmland. Also, the potential for legal action stemming

from the implementation of eminent domain rights will contribute significantly to the final cost for this option.

- O&M Costs (low): Cost items will include maintenance of property, fencing, security, and warning signs.

This option does not meet environmental protection objectives. In addition, the potential for community resistance to this option is high and legal issues can be complex and difficult. For these reasons, land acquisition is not a preferred option and will not be carried forward.

5.2.2.3 Deed Restrictions

This option involves restricting the use of water rights via property deeds. The effectiveness, implementability, and cost of this option is discussed below:

- Effectiveness (moderate): Use of this option should be effective in achieving human health objectives but would not reduce contaminant concentrations in the environment.
- Implementability (moderate): Acquisition of water rights and deed restrictions on groundwater use may be hindered by legal issues, but is expected to be more viable than land acquisition.
- Capital Costs (moderate): Costs include fees for legal counsel.
- O&M Costs (none): No O&M costs are associated with this action.

This option is potentially viable in support of other engineering actions.

5.2.3 Control/Containment Actions

The technologies retained from the initial screening for this response action include pumping wells and alteration of the natural drainage system. The specific process options retained for these technology groups are extraction and injection wells and the pavement of channels which contribute contaminated recharge to the aquifer. Each of these options are evaluated in the following sections.

5.2.3.1 Extraction/Injection Wells (Uncontaminated Water)

This option is the combination of two process options, extraction and injection of uncontaminated groundwater. It includes extraction of uncontaminated groundwater by pumping and the injection of this groundwater into wells to divert the plume and alter the direction of groundwater movement.

Using techniques of actively modifying and managing the groundwater system, the contaminated plume can be directed away from residential and industrial wells. The effectiveness, implementability, and cost of this option are discussed below:

- Effectiveness (moderate): The use of this process option is effective in achieving public health objectives by diverting the plume away from receptor wells but is ineffective in achieving the environmental objectives. The uranium content/concentration in the plume is not reduced. The process of controlling a groundwater gradient with pumping and injection is proven and has been effectively used for hydraulic isolation.

- Implementability (low): The high transmissivities and relatively steep groundwater gradients of the Great Miami Aquifer will make the implementation of this technology difficult. In addition, obtaining land access for well installation may cause delays and difficulties. Permits may be required for the well installations.

- Capital Costs (moderate): The high well yields from the Great Miami Aquifer require large volumes of uncontaminated water to be extracted and injected in order to impact the plume movement. The large number of wells required, high capacity pumps, and large diameter transfer piping add to the capital cost.

- O&M Costs (moderate): The primary O&M cost items include electric usage for the pumps and maintenance of the wells, valves, and instrumentation.

Technical considerations such as the steep groundwater gradients and high transmissivities make the implementation of this option difficult. However, it will still be considered a viable technology and is therefore retained for incorporation into remedial alternatives.

5.2.3.2 Alter Natural Drainage System

This technology provides for paved channels which would reduce infiltration to the aquifer from the waterway. This action reduces the recharge to the aquifer and slows the movement of the plume. The lining may consist of traditional materials emplaced by standard construction methods, including:

- Concrete
- Gunite (sprayed-on cement mortar)
- Asphalt

Each of these materials, within specific design limitations, provides a durable, low or nonerodible surface. In this case, concrete was chosen as the representative process option for paving the major recharge channel within the aquifer, Paddys Run.

This technology is commonly applied to all aspects of erosion control and sediment stabilization. The paving is specifically useful for limiting the effects of recharge from periodic high-velocity water discharges and has been used to isolate contaminated bottom sediments in large stream channels. The construction techniques of this technology are simple and environmentally safe, but installation costs can be high. The application of a concrete channel may not be acceptable since it destroys all vegetation and wildlife habitats in the stream. Also, its effectiveness for reducing the plume movement has not yet been established. The evaluation of this process option is discussed in the following paragraphs:

- Effectiveness (low): Due to the historic nature of the effect of Paddys Run recharge on the uranium contribution into the aquifer, the ability of this technology to meet the remedial action objectives is not certain. Existing and planned storm water runoff control projects will compromise the need for channel lining. The lining will have no observable effect on regional groundwater flow patterns. Implementation of this process option will not remove or decrease the concentration in the existing off-site plume. In addition, removal of the actual source of contaminants flowing into Paddys Run would be more effective than paving the bottom of the stream. Channel paving, however, is a proven technology.

- Implementability (moderate): Substantive requirements of permitting required by the U.S. Army Corps of Engineers are required to be met for this option. Additionally, interactions with other agencies are required due to possible destruction of existing wetlands, habitat, and vegetation along Paddys Run. The long-term integrity of a concrete liner is a concern.

- Capital Costs (moderate): Concrete is moderately priced and easy to install. Major capital costs include materials, clearing, grubbing, and preparation of the creek bottom.

- O&M Costs (low/moderate): Concrete channels crack easily, are subject to scouring damage from flood flows, and will need regular inspection and repair.

This process option may be viable as a pathway control method for selected channel reaches and will be retained for further consideration and incorporation into remedial action alternatives.

5.2.4 Removal Actions

Extraction Wells (Contaminated Water)

The remedial technology considered under this general response action is pumping wells. These wells will be used for the extraction of contaminated groundwater from the aquifer. This process option involves the pumping of water from the aquifer to capture a plume and alter the direction of the plume towards the extraction wells. Using techniques of actively modifying and managing the groundwater system, a contaminated plume can be contained and removed. Pumping has been found to be effective where underlying aquifers have high permeability/hydraulic conductivity. For plume removal in deep aquifers, extraction wells are used. Extraction wells can be useful where contaminants are miscible and move readily with water, hydraulic conductivity is high, and quick removal is not a requirement. The evaluation of this process option is discussed in the following paragraphs:

- Effectiveness (high): This option has the potential to meet both the human health and environmental objectives by removal/reduction of the plume. Potential exposure to humans and the environment exists during implementation of this option.

- Implementability (moderate): The installation, construction, and operation of a groundwater extraction system will utilize commonly practiced engineering techniques and pose no unusual technical difficulties. The necessary materials, equipment, and labor services are readily available. Minimal access and easements across other properties will be required. Removal of contaminated groundwater by pumping is currently widely accepted practice for remediation. In the case of the FMPC, however, the transmissivities and steep gradients will require the use of multiple wells pumping at high rates.

- Capital Costs (moderate): Pumping wells and transfer piping are standard construction items and therefore relatively inexpensive to install.

- O&M Costs (moderate): The major cost item is the electrical usage of the pumps.

Groundwater extraction is a viable technology and is therefore retained for further consideration and incorporation into the various remedial alternatives.

5.2.5 Treatment Actions

The treatment technologies retained from the initial screening for this response action include biological, physicochemical and chemical treatments. Specific process options retained from these technology groups include precipitation, coagulation, reverse osmosis, ultrafiltration, and ion exchange. Each of these options is evaluated in the following sections.

5.2.5.1 Biological/Biosorbant

This sorption process for removing toxic metal ions from water is based upon the natural strong affinity of biological materials, such as the cell walls of plants and microorganisms, for heavy metal ions. Biological materials, primarily algae, are immobilized in a polymer to produce a "biological" ion exchange resin. The material has a remarkable affinity for heavy metal ions. The bound metals can be stripped and recovered from the algal material in a manner similar to conventional resins (Darnall et al. 1989). An evaluation of this option is discussed below:

- Effectiveness (moderate): The biological exchange resin has achieved some degree of separation of heavy metals in pilot plant testing; it is a relatively new commercial process. Feasibility assessments would be required. This process would be effective in meeting long-term public health and environmental objectives.

- Implementability (moderate): This process uses a proprietary sorption technique and is being newly marketed; therefore, the availability of equipment or workers may be limited.

- Capital Cost (moderate): Components of capital cost include plant construction, design, equipment, instrumentation, and treatability studies.

- O&M Cost (high): Major O&M costs include residual disposal, electric usage, operator/maintenance costs, and costs associated with meeting the intent of permitting requirements.

Information obtained from Biorecovery Systems Inc. of Las Cruces, New Mexico, indicate that this process is viable for the removal of uranium from groundwater. Site-specific treatability testing would be required.

5.2.5.2 Physicochemical/Precipitation

Precipitation is a physicochemical process whereby some or all of a substance in solution is transformed into a solid phase, thereby promoting separation. It is based on the alteration of chemical equilibrium relationships affecting the solubility of inorganic species.

The most commonly used precipitation technique is pH adjustment with alkaline materials (e.g., caustic soda, soda ash, or lime) or sulfides. The insoluble compounds that precipitate can be removed from the wastewater by flocculation, clarification, and filtration. Coagulants such as alum, ferrous sulfate, or ferric chloride are also used to facilitate metals removal, including uranium. An evaluation of this option is discussed below:

- Effectiveness (high): Precipitation is a proven technology for metals removal, including uranium removal from wastewater. Additionally, this process option is effective in meeting long-term public health and environmental objectives. However, there is a potential for workers to be exposed to concentrated uranium in the precipitate from the process.

- Implementability (moderate): The chemicals and equipment required to implement this technology are readily available. Precipitation requires close manual control and the operation is difficult to operate. All precipitation processes generate a solid sludge, which requires subsequent disposal as a hazardous/radiological waste. Adherance to substantive requirements for NPDES permits for discharge of treated water and for sludge treatment and disposal will be required.

- Capital Cost (low): Capital costs include equipment and design.

- O&M Costs (high): Major costs include the required chemicals, electric power usage, sludge treatment and effluent disposal.

Precipitation may be an option for uranium removal from the site groundwater. The results of laboratory treatability testing indicate that precipitation was successful in reducing uranium concentrations in site groundwater from 270 to 20 ug/L. Bench-scale tests would be necessary to optimize this process.

5.2.5.3 Physicochemical/Coagulation/Polymerization

Coagulation is the process by which fine particulate material is removed from water by the addition of inorganic or organic chemicals, called coagulants, which accelerate the aggregation of particles into larger aggregates. Polymerization is a type of coagulation which uses organic polymers as the coagulant.

Coagulation is one of the most frequently used process options for water treatment. The process involves reducing the repelling charges between colloidal particles in order to destabilize the particulates and assist in their aggregation. To improve the performance of a coagulant, it is

necessary to include a slow mixing step. Various chemicals have been used as coagulants, including polyelectrolytes and polymers. Coagulants can be cationic, anionic, or nonionic. The evaluation of this process option is provided below:

- Effectiveness (moderate): Coagulation is an efficient way of removing submicron particles, therefore reducing their toxicity and volume in water. Residual and contaminated water handling will result in a potential increased risk of exposure to plant employees, the public, and the environment. This technology has not been widely used for uranium removal.

- Implementability (moderate): This technology requires ancillary treatment processes, such as precipitation and pH adjustment. The technical literature indicates optimum uranium removal occurs at an acidic or basic pH, depending upon the coagulant used. Use of high or low pH raises the possibility of generating mixed waste sludge which will create disposal problems.

- Capital Costs (high): The cost of design and construction of a treatment facility will be high due to the requirement for both pre- and posttreatment.

- O&M Costs (high): Chemical additions and the disposal of sludges from multiple treatment processes will be a high cost factor. Other costs include operators, electrical usage, and analytical costs associated with permit compliance.

Coagulation may be a viable treatment process for uranium removal. However, difficulties with this technology for uranium removal include double treatment handling and possible generation of mixed waste. This technology is not retained for incorporation into the remedial action alternatives.

5.2.5.4 Physicochemical Adsorption

Adsorption is a physicochemical process that involves the removal of dissolved solids from liquid waste by adsorption onto a treatment medium (e.g., activated carbon or activated alumina). An evaluation of the effectiveness, implementability, and cost for this process option is discussed in the following paragraphs:

- Effectiveness (low): The use of adsorption has been shown to be effective in removal of uranium from water, but efficiencies are not as great as other treatment processes. Most commonly, however, this technology has been used for the removal of organics.

- Implementability (moderate): The phenomenon of adsorption is extremely complex and not mathematically predictable. Pilot studies are necessary to predict performance, longevity, and operating economics.

- Capital Cost (high): Capital costs for this process are high compared to other processes. These costs include housing, foundations, and pipes, valves, nozzles for operating the unit plus the initial resins.

- O&M Costs (high): Operating costs include the electricity and resin replacement.

Due to the low effectiveness and high costs, adsorption has not been retained for incorporation into alternatives.

5.2.5.5 Physicochemical/Reverse Osmosis

Reverse osmosis (RO) involves diffusion of water through a semipermeable membrane with applied pressure. RO is used to reduce the concentrations of solids, both organic and inorganic. RO has been used only on an experimental basis for uranium removal. An evaluation of the effectiveness, implementability, and cost for this process option is discussed in the following paragraphs:

- Effectiveness (moderate): Further studies will be required to confirm the effectiveness of this technology for uranium removal. There is an increased potential exposure risk to plant employees, the environment, and the public from handling the contaminated groundwater and from residual disposal.

- Implementability (moderate): RO is a commercial process that can be reliably implemented. Pretreatment may be required to use RO. Also, a sizeable concentrated waste stream needs to be handled for treatment and disposal. Multiple permits will be required for operation as well as for residual and effluent disposal.

- Capital Cost (high): RO is similar in cost to ion exchange and the other treatment systems.

- O&M Costs (high): Module replacement, chemical additions, residual disposal, electric, and operator costs are the primary O&M cost items.

Using pretreatment, RO may be a viable technology for removing uranium from the groundwater but is not considered as effective as other treatments.

5.2.5.6 Physicochemical/Advanced Membrane Filtration/Ultrafiltration

Advanced membrane filtration uses a specific pore-sized membrane usually in a special configuration to perform filtration. Ultrafiltration is the use of micro-pore membranes, which may be enhanced chemically or structurally to attract particles to the surface of the media for more effective filtering. Advanced membrane filtration has been used in the treatment of plating wastewater, printed circuit board wastewater, laundry recycling, and contaminated groundwater. Advanced membrane filtration consists of the following three essential elements:

- Pretreatment
- Membrane design
- System cleaning

The evaluation of this process option is discussed below:

- Effectiveness (low): To use advanced membrane filtration for uranium removal from the groundwater, suitable pretreatment would be required. The use of this technology is not applicable to the removal of dissolved species. Since the uranium present in the groundwater is assumed to be primarily in the dissolved form, advanced membrane filtration would not be effective.

- Implementability (moderate): This technology is undergoing rapid improvement and adaptation to numerous industrial wastewater problems but has not yet been accepted as a uranium removal process. Residual production and disposal presents additional technical difficulties. Multiple permits for operation as well as for residual and effluent disposal will be required.

- Capital Cost (high): Complex design, construction, and bench and pilot-plant studies of multiple membrane types would be required to develop the application of this technology to uranium removal.

- O&M Costs (high): Residual disposal, membrane replacement, chemical additions, electric usage, and operators are all major cost factors.

Due to the various complexities and unproven nature of this technology, advanced membrane filtration is not a preferred technology for removal of uranium from the site groundwater and will not be considered in the subsequent development and screening of alternatives.

5.2.5.7 Chemical/Ion Exchange

Ion exchange is a process in which certain dissolved ions are removed from water by exchanging them with other (counter) ions held by electrostatic forces to charged groups on the surface of an

insoluble solid (resin) with which the solution is contacted. Ion exchange resins are typically polymer beads that have been modified by the addition of chemical groups which attract various ionic species. The resins can be regenerated for reuse with a strong solution of the exchangeable counter ion. Resin types range from general purpose demineralization resins that remove nearly all salts to selective chelating resins that have high affinities for specific ions. The effectiveness, implementability, and cost of this treatment option are discussed in the following paragraphs:

- Effectiveness (high): Ion exchange is a suitable process option for removing uranium from groundwater based upon information available on the effectiveness and reliability of this technology for dissolved uranium removal. Use of this technology will assist in meeting the remedial action objectives by reducing the uranium concentration in the treated water to acceptable levels. Potential exposure to humans and the environment exists during the implementation of this process.

- Implementability (high): Ion exchange is an easily implemented, reliable, commercial technology. The resins may be used once and disposed or they may be regenerated, which will produce a concentrated waste stream for treatment and disposal; the concentrated regenerate can be treated with the sludge. Pretreatment and sludge disposal will be required. Adherance to substantive permit requirements will be for the treatment facilities and for disposal of residuals and the treated water. The ion exchange process is a proven technology for which several equipment suppliers are available, but it could require a specific design for this application.

- Capital Cost (high): Plant construction requires extensive studies, design, complex equipment, and instrumentation. The capital cost will be high due to the need to treat a high flow rate, low concentration waste stream.

- O&M Costs (low): Major O&M cost items include chemicals, residual disposal, electric usage, operator/maintenance costs, and costs associated with meeting the intent of permitting requirements. Treatment cost is dependent on the type of resin employed, the quantity of the various ionic species removed from the wastewater, and the amount of waste generated.

A laboratory treatability study conducted as part of the Operable Unit 5 FS (DOE 1989) indicates that ion exchange can be successful in reducing uranium concentrations in groundwater from an initial concentration of 270 ug/L to less than 20 ug/L. Ion exchange is considered a suitable technology for removing uranium from water. This treatment process is selected as the

representative treatment process for groundwater and will be used in the formulation of remedial action alternatives.

5.2.6 Discharge Actions

The technologies retained from the initial screening for this response action include discharge to surface water or discharge via wells. The specific process options relating to these technologies are discharge of treated and/or untreated groundwater to the Great Miami River via the existing FMPC pipeline or a new outfall constructed for this purpose. The other process option is discharge into the aquifer via an injection well. Each of these options is evaluated in the following sections.

5.2.6.1 Discharge Treated Groundwater to Great Miami River via New Pipeline

This process option consists of the construction of a new outfall for discharge of treated groundwater effluent to the Great Miami River from a treatment facility. This discharge will require an NPDES permit. However, the uranium content of the discharge is not regulated by the NPDES permit but by internal DOE standards. The evaluation of this option is discussed below:

- Effectiveness (high): Discharge of treated groundwater to the Great Miami River should meet the remedial action objectives. Discharge to surface water is the most commonly used technology for disposal of treated industrial effluent. The FMPC already operates under a permit to discharge treated water containing radionuclides to the Great Miami River at concentrations greater than would be expected under the groundwater treatment scenario.

- Implementability (moderate): The installation of a discharge pipeline is common engineering/construction practice. This option will require access for pipeline right-of-way and an NPDES permit. Construction permits may also be required if the line crosses wetlands or state/county roads.

- Capital Cost (moderate): Capital costs include standard construction materials and labor.

- O&M Costs (low): A buried gravity flow sewer line requires minimal maintenance. However, sampling and analysis at the outfall will be required.

Discharge of treated groundwater to the Great Miami River via a new pipeline is a viable process option.

5.2.6.2 Discharge Treated Groundwater to Great Miami River via Existing Pipeline

This process option consists of discharging treated site groundwater via a force main to the existing main effluent line for release to the Great Miami River. The effectiveness, implementability, and cost of this option are discussed below:

- Effectiveness (high): Discharge of treated effluent to the Great Miami River meets the remedial action objectives. The FMPC currently operates a permit to discharge treated water containing radionuclides to the Great Miami River.

- Implementability (moderate): Recent studies have shown that the existing effluent line is not used to capacity and can accommodate additional flows. However, testing has also shown that modifications, repairs or replacement of sections of the existing pipe may be necessary. The use of the FMPC facilities introduces a greater level of administrative controls and security. However, this option will require modification of the existing NPDES permit. Discharge of treated effluent is likely to be acceptable to the public and other agencies.

- Capital Cost (low): Construction costs to tie the proposed system into the existing pipeline include standard construction materials and labor.

- O&M Costs (low): Maintenance, sampling, and analysis are currently performed by the FMPC.

Discharge of treated effluent to the Great Miami River via the existing main effluent line is a viable process option.

5.2.6.3 Discharge Untreated Groundwater to Great Miami River via New Pipeline

This process option consists of the discharge of untreated groundwater to the Great Miami River via a new pipeline/outfall constructed for this purpose. The evaluation of this option is discussed in the following paragraphs:

- Effectiveness (moderate): Discharge of untreated site groundwater to the Great Miami River will be evaluated in the FS risk assessment. Direct discharge via the existing FMPC pipeline/outfall is currently proposed as the preferred removal action alternative in the South Plume EE/CA. However, this discharge will not include the portion of the groundwater with the highest uranium concentrations.

- Implementability (moderate): The installation of a discharge pipeline is common engineering/construction practice. This option will require access for pipeline right-of-way and an NPDES permit. Construction permits may also be required if the

line crosses wetlands or state/county roads. Public and agency opposition to the discharge of untreated groundwater is expected.

- Capital Cost (moderate): Capital costs include standard construction materials and labor.

- O&M Costs (low): A buried gravity flow sewer line requires minimal maintenance. However, sampling and analyses at the outfall will be required.

Discharge of untreated effluent to the Great Miami River via a new pipeline is a viable process option.

5.2.6.4 Discharge Untreated Groundwater to Great Miami River via Existing Pipeline

This process option consists of discharging untreated groundwater via a force main to Manhole 175 at the FMPC and release to the Great Miami River through the existing FMPC pipeline. The evaluation of this option is discussed in the following paragraphs:

- Effectiveness (moderate): Discharge of untreated site groundwater to the Great Miami River will be evaluated in the FS risk assessment. This option is currently proposed as the preferred removal action alternative in the South Plume EE/CA. However, the higher ranges of uranium are not addressed in the EE/CA. The effectiveness of discharging untreated groundwater into the Great Miami River is reduced due to the increased loading of uranium into the river.

- Implementability (moderate): The existing effluent line can accommodate the additional flows that would result from groundwater pumping. The use of FMPC facilities introduces a greater level of administrative controls and security. However, this option may require modification of the NPDES permit. Minimal access to and easement across other properties will be required. Public and agency opposition to the discharge of untreated groundwater is expected.

- Capital Cost (low): Capital costs to tie the proposed system into the existing pipeline will include standard construction materials and labor.

- O&M Costs (low): The FMPC is currently maintaining the line and performing daily sampling and analysis for radionuclides.

Discharge of untreated effluent to the Great Miami River through the existing effluent line is a viable process option.

5.2.6.5 Injection Wells

This process option consists of using injection wells to reinject extracted groundwater back into the aquifer after treatment. The evaluation of this option is discussed below:

- Effectiveness (high): Use of this process option should be effective in achieving both the human health and environmental objectives. The current understanding of the regional hydrogeology is considered adequate to evaluate the impact of injection well stresses on the groundwater flow regime.

- Implementability (low): Deep well injection is a common and proven technology. The materials necessary for this option are readily available; however, the substantive permitting requirements to inject treated effluent into sole-source aquifers used for drinking water may not be met.

- Capital Costs (high): Installation of an injection well system is expensive compared to discharge outfall construction costs.

- O&M Costs (moderate): Injection wells require regular borehole and pump maintenance. Electric, sampling, and analytical costs are also a factor.

Reinjection of treated effluent into the aquifer may be difficult to implement due to administrative requirements and subsequently is not retained for incorporation into remedial action alternatives.

5.3 EVALUATION OF TECHNOLOGY PROCESS OPTIONS FOR SOILS AND SEDIMENTS

The technologies and process options remaining after the initial screening for the soils and sediments were evaluated based on the criteria defined in Section 5.1. The process options within each technology were compared and the preferred or representative options were retained for incorporation into the remedial action alternatives. The results of this evaluation are summarized in Table 5-2 for soil and sediment and are discussed below.

5.3.1 No Action

The no-action response is applicable to the soils and sediments as required by the NCP. The no-action response will be further evaluated as a baseline for comparison with other remedial action alternatives developed for the soils and sediments.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	
					CAPITAL	O & M
• NO ACTION	———	———	WILL NOT ACHIEVE REMEDIAL ACTION OBJECTIVES IF AREAS EXCEEDING THE CLEAN-UP LEVELS EXIST	MAY BE UNACCEPTABLE TO PUBLIC AND AGENCIES	NONE	NONE
INSTITUTIONAL ACTIONS	ACCESS/USE RESTRICTIONS	• FENCE SITE	ACHIEVES PUBLIC HEALTH OBJECTIVES BY PREVENTING ACCESS; DEPENDENT ON MAINTENANCE; DOES NOT ACHIEVE ENVIRONMENTAL OBJECTIVES SINCE CONTAMINANTS ARE LEFT IN PLACE	COMMONLY AVAILABLE TECHNOLOGY; NO PERMITS REQUIRED	LOW-MODERATE	LOW
		DEED RESTRICTIONS	ACHIEVING THE PUBLIC HEALTH OBJECTIVES IS DEPENDENT UPON ADHERENCE AND IMPLEMENTATION INTO THE FUTURE; DOES NOT ACHIEVE ENVIRONMENTAL OBJECTIVES	OWNER RESISTANCE AND LEGAL ISSUES COMPLICATE IMPLEMENTATION	MODERATE	NONE
CONTROL/ CONTAINMENT	CAPPING	• SINGLE-LAYER CAP	EFFECTIVE IN ACHIEVING HUMAN HEALTH AND ENVIRONMENTAL OBJECTIVES SUBJECT TO MAINTENANCE	EASILY CONSTRUCTED AND IMPLEMENTED; RESTRICTIONS ON FUTURE LAND USE	MODERATE	MODERATE
REMOVAL	EXTRACTION OF SOURCE	• MECHANICAL EXCAVATION	EFFECTIVE IN ACHIEVING REMEDIAL ACTION OBJECTIVES	REQUIRES COMMONLY AVAILABLE AND RELIABLE TECHNOLOGY; MAY REQUIRE CONSTRUCTION PERMIT	MODERATE	LOW
TREATMENT	PHYSICAL	GRAVIMETRIC SEPARATION	MINIMIZES WASTE QUANTITIES BY CONCENTRATING URANIUM IN SOIL FRACTION; REQUIRES SUBSEQUENT DISPOSAL OF RESIDUALS TO ACHIEVE REMEDIAL OBJECTIVES	COMMONLY USED PROCESS IN MINERALS AND COAL PROCESSING INDUSTRIES; DOES NOT WORK WELL ON CLAYEY OR CHEMICALLY BONDED MATERIALS	MODERATE	MODERATE
	PHYSICOCHEMICAL	• SOIL WASHING	HAS ACHIEVED SOME DEGREE OF SEPARATION WITH CLAY SOIL IN PILOT-PLANT TESTING, EMERGING TECHNOLOGY.	TREATABILITY STUDIES REQUIRED; NO PERMITS REQUIRED	LOW	LOW
	SOLIDIFICATION/ STABILIZATION	CEMENT-BASED	EFFECTIVE AT IMMOBILIZING RADIOACTIVE WASTES, THUS ELIMINATING EXPOSURE PATHWAYS; SUBJECT TO LEACHING	USES COMMONLY AVAILABLE TECHNOLOGY; NO PERMITS REQUIRED	MODERATE	LOW
		THERMOPLASTIC	LIMITED APPLICABILITY TO RADIOACTIVE WASTES; LESS POTENTIAL FOR LEACHING	REQUIRES SPECIAL EQUIPMENT AND HIGHLY TRAINED OPERATORS; NO PERMITS REQUIRED	HIGH	HIGH
		VITRIFICATION	HAS BEEN USED TO SOLIDIFY LOW-LEVEL RADIOACTIVE WASTE; STILL EXPERIMENTAL	REQUIRES SPECIAL EQUIPMENT AND HIGHLY TRAINED OPERATORS; AIR PERMIT REQUIRED FOR OFF-GASES	HIGH	HIGH
ON-SITE DISPOSAL	LANDFILL	• ENGINEERED DISPOSAL FACILITY	EFFECTIVE AND RELIABLE	USES CONVENTIONAL TECHNOLOGY; MUST MEET INTENT OF PERMIT REQUIREMENTS	LOW/ MODERATE	MODERATE
OFF-SITE DISPOSAL	LANDFILL	• ENGINEERED DISPOSAL FACILITY	EFFECTIVE AND RELIABLE	USES CONVENTIONAL TECHNOLOGY; MUST MEET PERMIT REQUIREMENTS; TRANSPORTATION REQUIRED	HIGH/ MODERATE	NONE

303317-8487 (FS) (PGH)

• SELECTED AS REPRESENTATIVE OPTIONS FOR INCORPORATION INTO DEVELOPMENT OF ALTERNATIVES

TABLE 5-2
FERNALD FEASIBILITY STUDY
OPERABLE UNIT 5 - ENVIRONMENTAL MEDIA
DETAILED EVALUATION OF PROCESS OPTIONS FOR SOILS AND SEDIMENTS

5.3.2 Institutional Actions

The remedial technology retained under this general response action is access/use restrictions. Under this technology type, three process options are considered applicable for soils including fencing of contaminated areas of the site and deed restrictions. The only access restriction process option considered potentially viable for sediments is fencing.

5.3.2.1 Fence Site Areas

This option includes fencing localized areas of soil contamination to prevent access. As applied to sediments, fencing may be used as a temporary measure to restrict access during implementation of the selected remedial action. The following paragraphs summarize the evaluation of this process option:

- Effectiveness (low): This option achieves the public health objectives by preventing access of potential human receptors to these areas. Continued restrictions to these areas, however, require maintenance of the fence into the future. Fencing does not meet environmental objectives since the contaminated material is left in place. The potential exists for migration of contaminants through the soils to the groundwater. Fencing also does not restrict the resuspension of materials to the air or in runoff to surface waters. Also, the potential for uptake of contaminants via roots/plants still exists.

- Implementability (high): Fencing is a readily available technical solution. The extent of contaminated soils and sediments is not widespread and, therefore, fencing of these areas can be easily implemented.

- Cost/Capital (low to moderate): The capital costs necessary for fencing include materials and labor and are dependent on the extent of the areas to be enclosed.

- Cost/O&M (low): Once installed, maintenance requirements are minimal. A requirement to prevent breeching of the fence by unauthorized individuals may necessitate the provision of security guards.

Providing a fence does not adequately achieve the remedial objectives by itself. However, it may be considered as an ancillary option in conjunction with a more proactive remedial solution and will be retained as an institutional measure.

5.3.2.2 Deed Restrictions

Deed restrictions may be potentially viable for areas of contaminated soil. This would include possible restrictions on the use of land for agricultural purposes. A summary of the effectiveness, implementability, and cost of this process option is discussed in the following paragraphs:

- Effectiveness (moderate): Achieving the public health objectives is dependent upon adherence to the restrictions by landowners. The environmental objectives are not met by this option since the contamination is not reduced and/or eliminated. As with the fencing options, the contaminated soil areas remain as a potential pathway to other environmental media.

- Implementability (high): Currently, data show elevated soil contamination within the FMPC boundary only.

- Cost/Capital (moderate): The capital costs associated with this option include fees for legal counsel.

- Cost/O&M (none): No O&M costs are associated with this option.

Although this action alone does not achieve the environmental objectives, it is applicable if used in conjunction with active engineering options and will be retained as an institutional measure.

5.3.3 Control/Containment Actions

The remedial technology retained under this general response action is capping. Single-layer capping is the specific process option retained in this technology group. Single-layer capping may be applicable to both soils and sediments although not all capping materials would be applicable to sediments in subaqueous conditions. Capping involves the installation of a barrier over the surface of the contaminated area and can alleviate possible direct and/or indirect exposures.

Single-layer caps are constructed of any low permeability materials such as concrete, asphalt, or clay. Natural soil and admixes are not recommended because they are susceptible to freeze/thaw cycles and because exposure to drying can cause shrinkage and cracking. The most effective single-layered caps are composed of concrete and/or bituminous asphalt, particularly for sediments. The discussion of the effectiveness, implementability, and cost of this option is presented in the following paragraphs:

- Effectiveness (moderate): This option provides protection of human health by eliminating the potential for direct contact with or ingestion of

soils or sediments. Additionally, it reduces the potential of the surface soils and sediments to act as a pathway of contaminants to air, groundwater, water, and plant and/or aquatic uptake. However, the overall effectiveness is dependent upon the type of material used and how well it is maintained.

- Implementability (high): Materials and equipment necessary for the installation of a cap are readily available. The equipment utilized is mostly standard construction equipment. No significant technical difficulties are expected during implementation.

- Cost/Capital (moderate): The capital costs include materials and installation costs. These costs are dependent on the type of material selected and the extent of the area to be covered.

- Cost/O&M (moderate): O&M costs are limited to inspections on a regular basis and any necessary subsequent repairs.

Single-layer caps are considered applicable for soils and sediments and are retained for incorporation into remedial action alternatives.

5.3.4 Removal Actions

The removal response is applicable for both soils and sediment. The only process option remaining from the initial screening for the surface soil is mechanical excavation. Removal options considered for sediments include mechanical excavation and dredging. Because Paddys Run and the storm sewer outfall ditch are dry during most of the year, removal activities will most likely occur during the dry periods; therefore, standard excavation techniques may be preferred for the sediments.

Removal by excavation can be accomplished with conventional heavy construction equipment and is applicable to almost all site conditions. Dozers and loaders are most appropriate for the removal of surface soils and dry stream sediments. An evaluation of this process option is presented in the following paragraphs:

- Effectiveness (high): Mechanical excavation is effective for removal of contaminated soils and sediments and in achieving the objectives for protection of public health and the environment. However, there is a potential for increased exposure to workers during the removal process.

- Implementability (high): The equipment necessary for the removal of site soils and sediments is conventional and readily available. The site conditions are also conducive for easy implementation. This action must be followed by treatment and/or disposal. The removal of soils or

sediments from off-site properties will require access approval and adherance to substantive requirements of USACOE dredging permits.

- Capital Costs (moderate): The capital costs for soil and sediment excavation would include equipment rental and labor. The cost per unit basis is moderate.

- O&M Costs (low): The O&M costs are negligible to low and would include fuel and maintenance for equipment.

Excavation of soils and sediments is effective and is retained for incorporation into the site remedial alternatives.

5.3.5 Treatment Actions

The technologies remaining from the initial screening for the response action of treatment include physical separation, physicochemical treatment, and solidification/stabilization techniques. The specific process options considered for these technology groups are gravimetric separation, soil washing, cement-based solidification, thermoplastic solidification, and vitrification. Each of these processes are considered for soils and sediments after they are excavated. A discussion of each is provided in the following sections.

5.3.5.1 Gravimetric Separation

Gravimetric separation is a physical treatment process which involves the separation of materials by density through stratification in a fluid media. This is accomplished by placing the soils/sediments into a pulsating bed of stainless steel shot that is acted upon by a flow of water that dilates and then contracts the bed. The material settles over the bed and stratifies by particle density and grain size. The higher density particles that are small enough in size tend to make their way through the interstitial spaces and are deposited in the bottom sedimentation trap. In most cases, the uranium will become concentrated with the most dense fraction and what is left behind is generally "clean" material. The evaluation of this process option is discussed in the following paragraphs:

- Effectiveness (low): This technology has been widely used in the mineral/mining industry but is of questionable value for nonhomogeneous materials with high clay or organic content. It is not effective in removal of material chemically bonded in the soil/sediment matrix.

- Implementability (low): The process is available commercially and has been tested on soils from the Fernald site with little success. Process requires substantial disposal of residual fraction as contaminated.

- Cost/Capital (moderate): The capital costs include equipment rental and excavation costs.

- Cost/O&M (moderate): The residuals will require disposal, in addition to the cost of operators and electric usage.

Gravimetric separation has not proven successful in treating the type of materials expected from the FMPC site in Operable Unit 5 and, therefore, is not retained for further incorporation as a part of a remedial action alternative.

5.3.5.2 Soil Washing

Soil washing is a physicochemical treatment process which involves the extraction of organic and inorganic compounds from soils or sediments by leaching. This is accomplished by passing leaching solution (ammonium carabonate) through the soils using an injection/recirculation process. This process is used on excavated soils or sediments that are fed into a washing unit. The evaluation of this process option is discussed in the following paragraphs:

- Effectiveness (moderate): Soil washing is a simple operation and should require no major process development. This technology has achieved some degree of separation with clay soils in pilot-plant testing. The process is based on commonly available mineral treatment processes and has been proven effective during batch treatability testing. In this process, waste is minimized and both environmental and health objectives can be met.

- Implementability (moderate): Only a few mobile units necessary for this process are commercially available.

- Cost/Capital (low): The capital costs include equipment rental, material, and excavation costs. The costs are usually competitive or lower than other treatment technologies.

- Cost/O&M (low): The washing solution and disposal of residuals are part of the O&M costs, in addition to the cost of operators and electric usage.

Soil washing is a potentially viable option and is retained for incorporation into remedial action alternatives.

5.3.5.3 Cement-Based Solidification

This process technology reduces the mobility of contaminants by binding them into a solid mass that resists leaching. This particular process achieves this result by combining the contaminated soils/sediments with a cement-based mixture. The evaluation of this process option is presented in the following paragraphs:

- Effectiveness (moderate): On a commercial basis, pozzolanic-based methods, either lime or cement-based, have been effective in immobilizing radioactive wastes. This solidification process would be effective in eliminating direct exposures to receptors and also in eliminating the soil/sediments as a pathway to other environmental media.

- Implementability (high): The equipment necessary for this process is similar to that used for cement mixing and handling. It includes a feed system, mixing vessels, and a curing area. Bench-scale treatability testing may be necessary to determine the selection of proper additives.

- Cost/Capital (moderate): Capital costs include equipment, reagents, and labor expenses.

- Cost/O&M (low): O&M costs include equipment rental and electrical usage.

Cement-based solidification is a potentially applicable process for treatment of soils/sediments.

5.3.5.4 Thermoplastic Solidification

This process option involves the mixing of heated, dried material with either an asphalt-bitumen, paraffin, or polyethylene matrix, resulting in a stable, solid mass. The evaluation of this process is discussed below:

- Effectiveness (low): This method is most applicable and effective for heavy metals. Relative to cement solidification, the increase in volume and rate of leaching is significantly less. However, this technique has not been applied to radioactive materials.

- Implementability (moderate): Specialized equipment and operators are required for this process.

- Cost/Capital (high): High equipment costs are associated with this process option. Also, the treated materials generally require containers for transportation and disposal due to the plasticity of the solidified matrix. This significantly increases costs.

- Cost O&M (high): Energy requirements for operation of this process are high.

Based on the overall evaluation, this option is not retained for incorporation into the remedial alternatives.

5.3.5.5 Vitrification

Vitrification is used to transform chemical and physical characteristics of wastes such that the treated residues contain contaminated material immobilized in a vitreous glassified mass. Within a reaction chamber, high temperatures reduce organics to elemental gas and carbon while inorganic contaminants become entrained in the glass and siliceous melts. The evaluation of this process option is presented below:

- Effectiveness (moderate): This process is largely in the experimental stage in this country. It has, however, been shown to be generally applicable to radiologically contaminated soils and has been used for the solidification of low-level radioactive wastes in Great Britain. The volume of soil is usually reduced after vitrification treatment. The collection and treatment of off-gases is an important technical consideration. In the event of system failure, the superheated gases would be released to the environment.

- Implementability (moderate): Most techniques for this process are not commercially available but can be made available for DOE sites since much of the supporting research and development were conducted in support of DOE programs.

- Cost/Capital (high): High equipment costs are expected for implementation of this option.

- Cost/O&M (high): This process requires high electrical usage.

This process is potentially viable for treatment of soils/sediments.

5.3.6 On-Site Disposal

The general technology retained for this response action is landfilling. As a process option, on-site landfilling is applicable for both soils and sediments. Landfill is defined to mean an engineered facility for disposal of excavated soils and sediments that would be transported to an on-site facility. This facility may be a tumulus or other concrete structure if such a facility is constructed for other types of wastes, (i.e., in other operable units). Another option may be to create a separate

disposal facility, such as an engineered disposal cell, since the design criteria for soils and sediments may be less stringent than for other types of site waste. The effectiveness, implementability, and cost of this option are discussed below:

- Effectiveness (moderate): This option is effective in isolating contaminated soils and sediments, thereby meeting the public health and environmental objectives. However, the effectiveness is dependent on continuing maintenance of the facility. The potential exposure of workers to the contaminants is increased during excavation and transport of material. These activities also create a potential for resuspension of these materials into the air.

- Implementability (high): The design and construction of landfills is a widely practiced technology. Equipment and skilled workers are readily available. No permits are required for this on-site action. However, siting of a permanent disposal facility within the property boundaries will likely be highly resisted by the public and agencies.

- Cost/Capital (low to moderate): This cost is dependent on whether this material is disposed in a tumulus designed and built for other operable units or if a separate disposal cell is used; this decision could be dependent on the volume of material involved.

- Cost/O&M (moderate): On-site disposal will require monitoring, maintenance, and security measures for the life of the facility.

This option has been retained for incorporation into the remedial action alternatives.

5.3.7 Off-Site Disposal

Off-site disposal in an approved landfill was retained as the applicable process option for both soils and sediments for this general response action. The contaminated soils and sediments can be transported to the DOE Nevada Test Site (NTS) for permanent disposal. As a condition of NTS disposal, no untreated wet, raw waste, or free liquids will be accepted. An additional NTS requirement is that the waste can be characterized as either mixed or low-level radioactive waste. If identified as mixed waste, it will only be accepted in a solidified form. Waste transport may be provided by truck or railroad. Radioactive waste from the FMPC is currently shipped to NTS; however, depending on the level of uranium in the material and whether any organics are present, the soil could qualify for disposal at other low-level disposal facilities in closer proximity to the FMPC. The evaluation of this process option follows:

- Effectiveness (high): Most effective at meeting public health and long-term environmental objectives at the FMPC. Exposure scenarios possible during removal and transport.

- Implementability (medium): Removal is straightforward; however, packaging and transport in a form acceptable to disposal site may need further study; potential mixed waste issues are complex; safety issues are important. Resistance from communities along transport route may lead to logistical problems. Vulnerable to dictates from host states.

- Cost/Capital (medium to high): Transport (via truck or rail) to Nevada is expensive and disposal costs are high.

- Cost/O&M: No O&M costs are associated with this option.

This option has been retained for incorporation into the remedial action alternatives.

5.4 SUMMARY OF SELECTION OF PROCESS OPTIONS

Based on the evaluations presented in Sections 5.2 and 5.3, representative process options were selected to simplify the subsequent development and evaluation of alternatives without limiting flexibility during design. This summary indicates which actions are viable and which were selected for inclusion into the development of alternatives in Section 6.0 of this report. The representative process options selected provide a basis for preliminary or conceptual design; however, the specific process actually used to implement the design may not be selected until the remedial design phase.

5.4.1 Selection of Process Options for Groundwater

- No action has been retained for incorporation into remedial action alternatives as required by the NCP.

- Groundwater monitoring and deed restrictions are both viable as institutional actions for groundwater. Monitoring may be appropriate as either compliance monitoring or corrective action monitoring. Since monitoring will be required under each alternative, it is included in the alternative development at this stage. Deed restrictions, however, will be included as appropriate in the detailed description of alternatives.

- Two options were retained as representative of control/containment actions since each of these processes provide a potential remedial solution in a unique way. The extraction and injection of uncontaminated water for purposes of plume control is retained for incorporation into remedial alternatives. Additionally, the pavement of

channels that contribute potential contaminant via recharge to the aquifer was also retained for alternative development.

- The removal of groundwater via extraction wells is also retained for incorporation into the development of alternatives.

- Four groundwater treatment options were found to be potentially applicable for uranium removal as a result of the process option evaluations. These include biosorbants, precipitation, reverse osmosis, and ion exchange. However, the treatment option selected as representative for uranium removal from groundwater is on-site treatment using ion exchange. Treatability studies have shown this process to be successful.

- The representative discharge action selected for incorporation into remedial alternatives is the use of the existing FMPC pipeline with discharge to the Great Miami River. The use of the FMPC facilities introduces a greater level of administrative control and security, and recent studies have shown that the existing effluent line can accommodate additional flows.

5.4.2 Selection of Process Options for Soil/Sediment

The options selected as representative processes for soils and sediments include the following:

- The no-action response has been retained for the soils and sediments as required by the NCP.

- Fencing is considered viable as an institutional action for soils and sediments. Deed restriction is also a viable institutional action for soils if used in conjunction with engineering controls. However, these are considered as ancillary options and are not specifically defined in the development of initial alternatives. They will be included where appropriate in the detailed analysis.

- Single-layer capping was the selected control/containment action for incorporation into the remedial alternatives.

- Mechanical excavation was selected as the representative removal option for the soils. Since Paddys Run and the storm sewer outfall ditch are dry during most of the year, standard excavation techniques are preferred for the removal of sediments also.

- Several soil/sediment treatment options remain viable as a result of the process evaluation. These include soil washing, cement-based solidification, and vitrification. For the development and initial screening of alternatives, however, soil washing is selected as the representative treatment option since the volume of residuals is

reduced. Each option will however, be further evaluated during detailed analysis.

- Both on-site and off-site engineered disposal facilities have been retained for incorporation into remedial alternatives.

Each of the selected options for the groundwater, surface soils, and sediment media are used in the development of potential remedial action alternatives for Operable Unit 5 as presented in Sections 6.0 and 7.0.

6.0 DEVELOPMENT AND DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

Remedial action alternatives have been assembled by combining the selected representative process options into alternatives representing possible cleanup remedies for Operable Unit 5. The alternatives were developed to address identified problems in Operable Unit 5 with respect to the specified remedial objectives. Guidance for the development of these alternatives was obtained from the following sources:

- Code of Federal Regulations (CFR), Title 40, Part 300 (NCP)
- Section 121 of the Superfund Amendments and Reauthorization Act of 1986 (SARA)
- EPA, October 1988, Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA

As recommended by the EPA Guidance Document and the NCP, acceptable engineering practices, as related to site-specific conditions, were considered during remedial action alternative development.

The selected process options discussed in Section 5.0 have been assembled into 11 remedial action alternatives for initial screening as shown in matrix form in Table 6-1. The remedial actions for sediments and surface soils are combined since the technologies and process options used to formulate the alternatives are applicable to each of these media, and they are best addressed as a unit. The process options used for each alternative are indicated in the matrix. The alternatives were formulated by combining the most feasible soil/sediment actions (based on the process evaluations) which include excavation/on-site disposal and excavation/off-site disposal with the most feasible groundwater actions. The groundwater actions include extract/discharge and extract/treat/discharge. Other alternatives were formulated to incorporate additional potential actions. This method was used in an effort to limit the number of alternatives requiring evaluation. The process remains flexible for any necessary additions or refinements to these alternatives. The 11 alternatives developed for the initial screening process for the Operable Unit 5 remedial action are as follows:

- Alternative 1 - Groundwater: Baseline; Sediments/Soils: No Action

MEDIUM	PROCESS OPTION	APPLICATION	1 GW: BASELINE SED/SS: NO ACTION	2 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL	3 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL	4 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL	5 GW: EXTRACT, ON-SITE TREATMENT DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL	6 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, TREATMENT, ON-SITE DISPOSAL	7 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, TREATMENT, ON-SITE DISPOSAL	8 GW: EXTRACT, DISCHARGE SED/SS: SINGLE-LAYER CAP	9 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: SINGLE-LAYER CAP	10 GW: PLUME CONTROL SED/SS: EXCAVATE, ON-SITE DISPOSAL	11 GW: RECHARGE AREA MODIFICATION SED/SS: EXCAVATE, ON-SITE DISPOSAL
GROUNDWATER (GW)	MONITORING	TRACK PLUME MOVEMENT	●	●	●	●	●	●	●	●	●	●	●
	EXTRACTION	REMOVE CONTAMINATED GROUNDWATER		●	●	●	●	●	●	●	●	●	
	EXTRACTION/INJECTION	REMOVE AND INJECT UNCONTAMINATED WATER TO CONTROL PLUME										●	
	PAVE CHANNELS THAT CONTRIBUTE TO AQUIFER RECHARGE	PAVE PADDYS RUN AND OUTFALL DITCH											●
	ION EXCHANGE	NEW ON-SITE TREATMENT PLANT			●		●		●		●		
	DISCHARGE TREATED GW TO SW	USE EXISTING FMPC PIPELINE/OUTFALL			●		●		●		●		
	DISCHARGE UNTREATED GW TO SW	USE EXISTING FMPC PIPELINE/OUTFALL		●		●		●		●			
SEDIMENT/SURFACE SOIL (SED/SS)	NO ACTION		●										
	EXCAVATION	REMOVE CONTAMINATED SOIL/SEDIMENTS		●	●	●	●	●	●			●	●
	SINGLE-LAYER CAP	PAVE CONTAMINATED PORTIONS OF PADDYS RUN AND THE STORM SEWER OUTFALL DITCH								●	●		
	SOIL WASHING	WASH SOIL/SEDIMENTS TO REMOVE CONTAMINANTS						●	●				
	ON-SITE DISPOSAL	DISPOSAL OF MATERIAL IN NEW TUMULUS OR RCRA-TYPE CELL		●	●			●	●			●	●
	OFF-SITE DISPOSAL	DISPOSAL IN APPROVED OFF-SITE FACILITY				●	●						

TABLE 6-1

REMEDIAL ACTION ALTERNATIVES
OPERABLE UNIT 5

303317-8468 (FS) (PCH)

- Alternative 2 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, On-Site Disposal
- Alternative 3 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Disposal
- Alternative 4 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, Off-Site Disposal
- Alternative 5 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Off-Site Disposal
- Alternative 6 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, On-Site Treatment, On-Site Disposal
- Alternative 7 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Treatment, On-Site Disposal
- Alternative 8 - Groundwater: Extract, Discharge; Sediments/Soils: Single-Layer Cap
- Alternative 9 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Single-Layer Cap
- Alternative 10 - Groundwater: Extract and Reinject for Plume Control; Sediments/Soils: Excavate, On-Site Disposal
- Alternative 11 - Groundwater: Recharge Area Modification; Sediments/Soils: Excavate, On-Site Disposal

As shown in Table 6-1, all alternatives provide for groundwater monitoring. The monitoring process option consists of the continued or additional monitoring of selected on- and off-site wells in the affected area. At present, no residential wells containing concentrations of uranium in excess of the derived concentration limit of 30 ug/L for uranium in drinking water are being used. The monitoring program associated with these alternatives will be designed to detect increases in uranium content which may indicate movement of the plume into or toward industrial, commercial, or residential wells. Quarterly monitoring for uranium will take place in selected wells until a modified monitoring program is implemented as part of the final remedial action. If increasing uranium concentrations are detected in any wells during the monitoring program, the potential for exceeding the derived concentration limit for uranium in drinking water will be evaluated and, if necessary, an appropriate additional response action will be taken.

As previously indicated, certain baseline condition assumptions and strategic planning considerations for cleanup of the FMPC have been incorporated into the remedial alternative development process for Operable Unit 5. The acceptance and implementation of the removal action for the uranium-contaminated groundwater south of the FMPC (South Plume) represents a major baseline condition assumption. The preferred alternative for the South Plume removal action as detailed in the South Plume EE/CA (DOE 1990a) includes the following components:

- Installation and operation of capture wells at the southern (leading) edge of the uranium plume with subsequent pumping to the FMPC site and discharge (untreated) through the existing FMPC effluent line to the Great Miami River
- Provision of an alternate water supply for the two industrial receptors known to be using groundwater with concentrations exceeding 30 ug/L
- Groundwater monitoring
- Institutional controls in the form of tracking and controlling any new groundwater extraction points (wells) in the area

Figure 6-1 shows the projected extent of the groundwater contamination under present conditions and the components of the recommended removal action are shown in Figure 6-2.

Of the above actions, two are considered to be permanent and have not been included in the alternatives for Operable Unit 5. These are the provision of an alternate water supply for currently affected users and the establishment of the institutional controls specifically identified in the preferred alternative for the removal action. The specifications for other activities of the removal action (e.g., number and placement of wells for removal of contaminated groundwater and placement of monitoring wells) have been used as the baseline condition and have not been duplicated for Operable Unit 5. However, they have been expanded and/or supplemented to fulfill the needs for remediation of media in Operable Unit 5.

6.1 ALTERNATIVE 1 - GROUNDWATER: BASELINE; SEDIMENTS/SOILS: NO ACTION

Under the no-action alternative, no additional remediation, monitoring, or security activities are provided to minimize risk to public health or the environment. Routine monitoring and security activities will continue at the FMPC in accordance with DOE operational requirements. The no-action alternative provides no remediation for soils and sediments and will result in no changes to

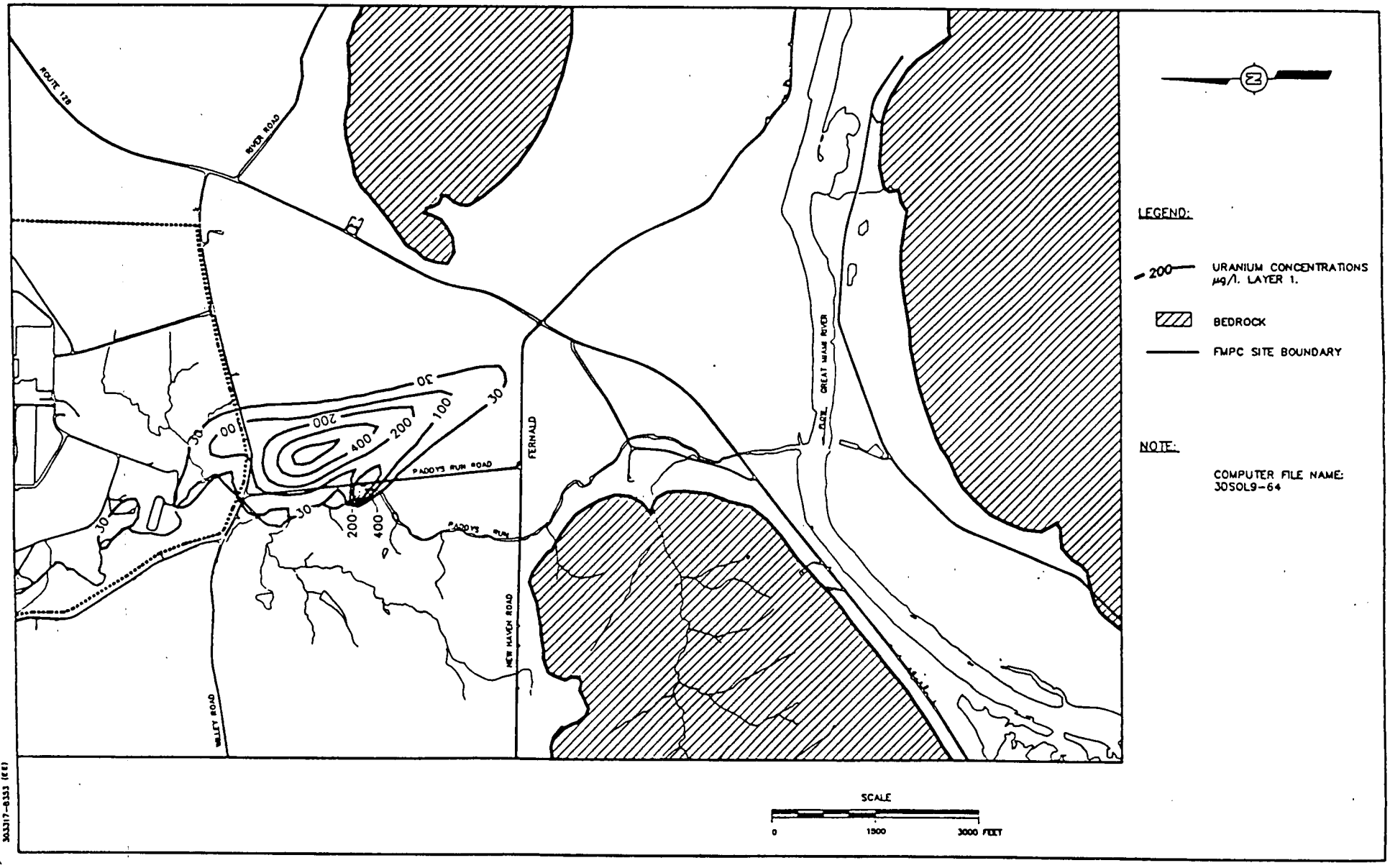


FIGURE 6-1
SIMULATED URANIUM CONCENTRATIONS
PRESENT CONDITIONS

303317-0333 (KE)

125

943

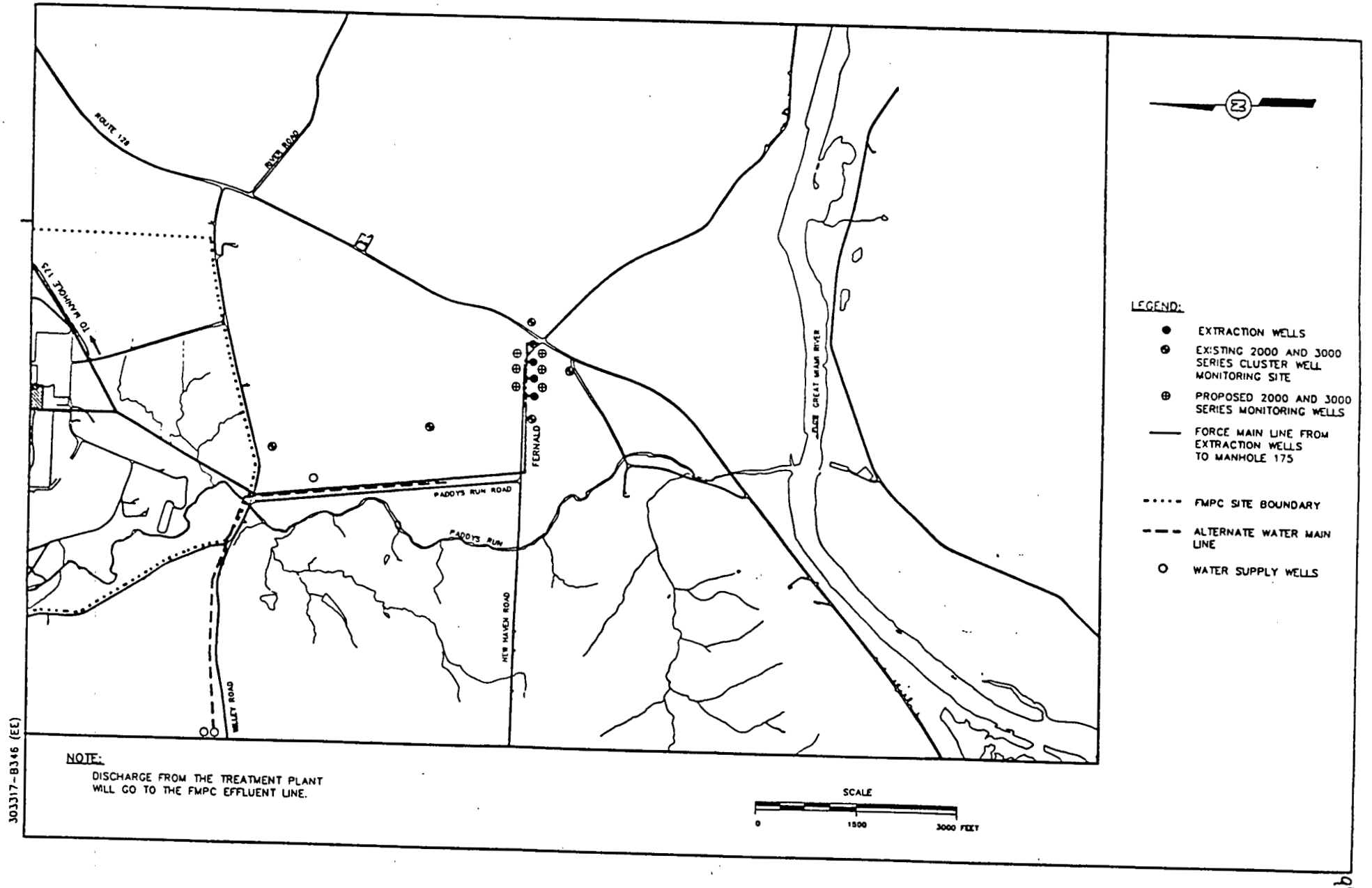


FIGURE 6-2
SOUTH PLUME REMOVAL ACTION

the existing site environment. No additional remediation is provided for the groundwater component. This assumes that the alternate water supply and institutional actions performed for the South Plume removal action are permanent changes. It does not however, provide for the permanent continuation of pumping from the four extraction wells placed at the leading edge of the plume.

6.2 ALTERNATIVE 2 - GROUNDWATER: EXTRACT, DISCHARGE; SEDIMENTS/SOILS: EXCAVATE, ON-SITE DISPOSAL

6.2.1 Groundwater

This alternative includes the extraction of groundwater from the regional aquifer containing elevated levels of uranium. The untreated water will be conveyed directly to the existing FMPC effluent discharge line and subsequently discharged to the Great Miami River. This action will be supplemented with groundwater monitoring.

The extraction wells installed as part of the removal action will become an integral part of this alternative. Depending on the time frame for cleanup, as determined in the detailed analysis, additional wells may be added in other portions of the plume to accelerate removal. For example, two to four wells may be placed in the middle of the portion of the South Plume outside the FMPC boundary. If there is concern for future southward migration of uranium from the production facility, an additional two to four wells may be placed further north along the southern boundary of the FMPC. Within the FMPC, localized areas with elevated contamination levels may be candidates for additional well locations. For example, the Southfield could require from one to two wells and the waste pit area two to four wells. The additional well coverage for the site would range from 7 to 14 wells to achieve the target level of 30 ug/L. For purposes of scoping and costing this alternative and others requiring groundwater extraction, a total of eight wells, in addition to the four wells proposed for the South Plume removal action, will be used.

For purposes of this analysis, each well is estimated to be able to produce 500 gpm maximum. This value is consistent with the existing analysis of plume capture modeling performed as part of the South Plume EE/CA. This is considered a maximum flow rate. A reduction of these rates may be realized depending on localized aquifer conditions. Further refinements of these rates will

be accomplished during the detailed analyses of alternatives using the regional groundwater flow and solute transport model.

For purposes of scoping and costing this alternative, system requirements are assumed to include the following:

- Public notice
- Associated substantive permitting requirements for construction and surface water discharge
- Eight pumping wells to handle up to 500 gpm each
- Centralized water collection and flow equalization facility with booster pumps
- Piping system from each well (assumed 6-inch PVC) to water collection facility and to existing FMPC effluent discharge line (assumed 12-inch PVC)
- Electric power/instrumentation

Discharge into the pipeline/outfall to the Great Miami River would require confirmation of available capacity as well as modifications to the existing NPDES permit.

6.2.2 Sediments/Soils

This alternative proposes the excavation or dredging of sediments from contaminated portions of the FMPC storm sewer outfall ditch and Paddys Run, excavation from five localized soil locations, and disposal in an approved on-site facility. The locations of sediment and soil samples exceeding the criterion are provided in Figure 3-4.

For purposes of obtaining an estimation of the quantities of sediments/soils to be removed from the site, the extent of contamination is assumed to extend upstream and downstream from the identified "hot" spot to the next sample location. The sampling grid provided three sample locations across the width of the stream. Since, in each case, only one of the sample locations is above the criteria for uranium or radium, the effective width of the stream subject to removal is assumed to be a third of the total width. A total volume of approximately 140 yd^3 of sediments would be removed as part of this alternative as derived from the following calculations:

- FMPC Storm Water Outfall - 10 ft. wide x 300 ft. long x 6 in. deep x 1/3 effective width (total of 500 ft^3 or approximately 20 yd^3)
- Paddys Run - 15 ft. wide x 600 ft. long x 6 in. deep x 1/3 effective width (total of 1,500 ft^3 or approximately 60 yd^3)
- Paddys Run near FMPC Storm Water Outfall Confluence - 15 ft. wide x 600 ft. long x 6 in. deep x 1/3 effective width (total of approx. 1,500 ft^3 or 60 yd^3)

The estimated volumes may change in the field since excavation would continue until the acceptable target level is reached.

Since these water courses are dry much of the year, standard construction equipment (backhoe, bulldozer, or front-end loader) can be used to remove the material if the work is timed to coincide with the dry season. As excavation progresses, the contaminated material will be loaded into covered dump trucks, transported, and disposed on site. If the material is dry (i.e., passes a paint filter test), it can be loaded directly onto trucks for transport to the designated on-site disposal facility. If necessary, a stabilizing agent such as concrete or kiln dust can be added to solidify the material sufficiently for transport and disposal.

The sample locations for soils exceeding the criteria for uranium are indicated in Figure 3-4, with a number keyed to the following calculation for effective areas/volumes subject to removal. A depth of 6 inches was selected for these preliminary volume calculations based on the existing soils analytical results. Elevated soil concentrations were seen within the first six inches of the soil samples. A total of 80 yd^3 of contaminated soil requiring removal is based on the following calculation:

Area 1: 20-ft. radius around sample location x 6 in. deep (total of 628 ft^3 or approximately 25 yd^3)

Area 2: 5-ft. radius around sample location x 6 in. deep (total of 40 ft^3 or approximately 2 yd^3)

Area 3: 20 x 20 ft. square around sample location x 6 in. deep (total of 200 ft^3 or approximately 8 yd^3)

Area 4: 20-ft. radius around sample location x 6 in. deep (total of 628 ft^3 or approximately 25 yd^3)

Area 5: 20-ft. radius around sample location x 6 in. deep
(total of 628 ft^3 or approximately 25 yd^3

The soils can be excavated with standard construction equipment, loaded into covered trucks, and transported to the on-site disposal site.

The excavated sediments and soils can be disposed in an engineered disposal facility if such a facility is constructed for other types of wastes (from other operable units) and capacity is available.

6.3 ALTERNATIVE 3 - GROUNDWATER: EXTRACT, ON-SITE TREATMENT, DISCHARGE; SEDIMENTS/SOILS: EXCAVATE, ON-SITE DISPOSAL

6.3.1 Groundwater

This alternative proposes the extraction of groundwater containing elevated levels of uranium, treatment of the water by ion exchange at an on-site facility to reduce the uranium concentration to below the derived concentration guideline of 30 ug/L, and discharge of the treated water to the Great Miami River. As in the other alternatives, it also provides for groundwater monitoring. Water will be removed via extraction wells as described in Alternative 2 and pumped to the on-site treatment plant. Treated water will then be conveyed to the Great Miami River through the existing FMPC discharge line.

Conceptually, the treatment plant will consist of an up-front equalization tank, a pretreatment process, ion exchange for uranium removal, sludge dewatering, and a treated water storage tank. The system will be able to process a nominal 4000 gpm from the aquifer pumping system and will be designed to remove uranium to an effluent concentration of less than 30 ug/L.

A highly concentrated uranium sludge will be generated as a result of the treatment system. This sludge will contain the same radionuclides processed, produced, or otherwise used at the FMPC. The disposal of this sludge will be accomplished in accordance with all regulatory requirements as part of FMPC's ongoing waste management activities and could be incorporated into the disposal strategy for higher concentration wastes being removed from other operable units.

6.3.2 Sediments/Soils

The sediment/soil portion of this alternative is the same as in Alternative 2.

6.4 ALTERNATIVE 4 - GROUNDWATER; EXTRACT, DISCHARGE; SEDIMENTS/SOILS: EXCAVATE, OFF-SITE DISPOSAL

6.4.1 Groundwater

The groundwater portion of this alternative is the same as in Alternative 2.

6.4.2 Sediments/Soils

This alternative proposes the excavation and removal of the sediments and surface soils as described in Alternative 2. For this alternative, the material will be transported and disposed at an approved off-site facility.

The contaminated soils and sediments may be transported to the DOE Nevada Test Site (NTS) for permanent disposal. As a condition of NTS disposal, no untreated wet, raw waste, or free liquids will be accepted. An additional NTS requirement is that the waste can be characterized as either mixed or low-level radioactive waste. If identified as mixed waste, it will only be accepted in a solidified form. Waste transport may be provided by truck or railroad and packaged in low specific activity (LSA) boxes. Radioactive waste from the FMPC is currently shipped to NTS; however, depending on the level of uranium in the material and whether any organics are present, the soil could qualify for disposal at other low-level disposal facilities in closer proximity to the FMPC.

6.5 ALTERNATIVE 5 - GROUNDWATER: EXTRACT, ON-SITE TREATMENT, DISCHARGE; SEDIMENTS/SOILS: EXCAVATE, OFF-SITE DISPOSAL

6.5.1 Groundwater

The groundwater portion of this alternative is the same as in Alternative 3.

6.5.2 Sediments/Soils

The sediment/soil portion of this alternative is the same as in Alternative 4.

6.6 ALTERNATIVE 6 - GROUNDWATER: EXTRACT, DISCHARGE; SEDIMENTS/SOILS: EXCAVATE, ON-SITE TREATMENT, ON-SITE DISPOSAL OF TREATMENT RESIDUALS

6.6.1 Groundwater

The groundwater portion of this alternative is the same as in Alternative 2.

6.6.2 Sediments/Soils

This alternative proposes the excavation and removal of the sediments and soils as described in Alternative 2. For this alternative, the material will be stockpiled in a suitable area prior to being treated. The chosen treatment option for this material is soil washing. The nature of the stream sediments (i.e., sandy till) should be amenable to the soil washing procedure. The higher organic content of the soils may present problems for this method. A treatability study will be conducted to determine its effectiveness.

The soil washing process will extract uranium from the sediment/soil matrix using a liquid medium as the washing solution. Initially the excavated soil is processed to remove large rocks and debris. The soil is then processed in a rotating drum or vibrating screen device to sort and prewash the material. Large and probably uncontaminated pieces of soil are washed with a leach solution, rinsed with water and returned to the site.

The remaining soil enters a countercurrent chemical extractor, where additional washing fluid is passed countercurrent to the soil/sediment flow, removing the contaminants. The treated solids are then dewatered. The remainder of the process is a multistep treatment for removal of contaminants from the washing fluid prior to its recycling. The treatment sludges will have concentrated uranium and will require approved disposal on or off site. Once the sediments have been treated, they can be safely disposed of in a suitable on-site area.

6.7 ALTERNATIVE 7 - GROUNDWATER: EXTRACT, ON-SITE TREATMENT, DISCHARGE; SEDIMENTS/SOILS: EXCAVATE, ON-SITE TREATMENT, ON-SITE DISPOSAL OF TREATMENT RESIDUALS

6.7.1 Groundwater

The groundwater portion of this alternative is the same as in Alternative 3.

6.7.2 Sediments/Soils

The sediment/soil portion of this alternative is the same as in Alternative 6.

6.8 ALTERNATIVE 8 - GROUNDWATER: EXTRACT, DISCHARGE; SEDIMENTS/SOILS: SINGLE-LAYER CAP

6.8.1 Groundwater

The groundwater portion of this alternative is the same as in Alternative 2.

6.8.2 Sediments/Soils

This alternative proposes paving contaminated portions of the storm water outfall ditch and Paddys Run as well as contaminated areas of soil as designated in Figure 3-4 and discussed in Alternative 2. An impermeable cap of concrete or bituminous asphalt would be used. The streambeds would be prepared for capping by grading and removal of large boulders. This work will be undertaken during the summer dry season in order to avoid diverting or dewatering the site. Paving of portions of streams will provide an impermeable layer, thus preventing infiltration of uranium contaminates into the underlying aquifer or transport of contaminated sediment by surface waters. This alternative will require ongoing maintenance and monitoring into the future.

The total area requiring coverage in the streambeds is derived from the dimensions established in Section 6.2.2, except that in this case, the coverage will include the full width of the streambed. A total area of 21,000 ft^2 of required capping is derived from the following calculations:

- FMPC Storm Water Outfall - 10 ft wide x 300 ft long = 3000 ft^2
- Paddys Run - 15 ft wide x 600 ft long = 9000 ft^2
- Paddys Run near Storm Water Outfall Confluence - 15 ft wide x 600 ft long = 9000 ft^2

The total of the soil areas requiring coverage (approximately 3000 $ft.^2$) is derived from the dimensions established in Section 6.2.2 as follows:

Area 1: 20-ft radius or approximately 1250 ft^2
Area 2: 5-ft radius or approximately 80 ft^2
Area 3: 20 x 20 ft square = 400 ft^2

Area 4: 20-ft radius or approximately 1250 ft^2

6.9 ALTERNATIVE 9 - GROUNDWATER: EXTRACT, ON-SITE TREATMENT, DISCHARGE; SEDIMENTS/SOILS: SINGLE-LAYER CAP

6.9.1 Groundwater

The groundwater portion of this alternative is the same as in Alternative 3.

6.9.2 Sediments/Soils

The sediment/soil portion of this alternative is the same as in Alternative 8.

6.10 ALTERNATIVE 10 - GROUNDWATER: EXTRACT AND REINJECT FOR PLUME CONTROL; SEDIMENTS/SOILS: EXCAVATE, ON-SITE DISPOSAL

6.10.1 Groundwater

This alternative proposes the use of a series of pumping and injection wells to create cones of depression and mounds in the groundwater table. The intention is to manipulate the hydraulic gradient to control the direction and rate of migration of contaminated portions of the aquifer. This could potentially be used to direct the contaminated plume away from potential human receptors. As with the other alternatives, groundwater monitoring is required.

Pumping wells will be used to remove groundwater in specific locations to change the hydraulic gradient and consequently alter groundwater velocity and direction. In particular, an inward hydraulic gradient is created within the zone of influence of the well, creating a hydraulic barrier and trapping contaminants from outward migration. Injection wells would inject uncontaminated groundwater obtained from pumping wells located in areas or screened at depths not affected by uranium contamination. This injection will change the hydraulic gradient and consequently alter and control groundwater velocity and direction.

For purposes of scoping and costing this alternative, system requirements are assumed to include the following:

- Public notice
- Construction and injection permits
- 18 wells to extract and inject groundwater

- Pumps
- PVC piping
- Electric power/instrumentation

6.10.2 Sediments/Soils

The sediment/soil portion of this alternative is the same as in Alternative 2.

6.11 ALTERNATIVE 11 - GROUNDWATER: RECHARGE AREA MODIFICATION FOR PLUME CONTROL; SEDIMENTS/SOILS: EXCAVATE, ON-SITE DISPOSAL

6.11.1 Groundwater

This alternative proposes recharge area modification by paving Paddys Run and the FMPC storm sewer outfall ditch with a concrete or bituminous asphalt liner. This action would prevent surface water infiltration to the underlying aquifer and reduce the potential for contaminant migration. Changes in groundwater flow patterns could result (e.g., a reduction of groundwater beneath Paddys Run), but these would be of a local nature and would not affect regional gradients. As in the other alternatives, it also requires groundwater monitoring.

The total extent of this paving system would be approximately 16,000 lineal feet of streambed from 20 to 40 feet wide for a total of approximately 500,000 sq. ft. Assuming a six-inch pavement thickness, approximately 10,000 cubic yards of materials would be required. The stream modification will require a permit from the U.S. Army Corps of Engineers.

6.11.2 Sediments/Soils

The sediment/soil portion of this alternative is the same as in Alternative 2.

7.0 INITIAL SCREENING OF ALTERNATIVES

An initial screening of each of the assembled remedial action alternatives presented in Chapter 6.0 was conducted based on the following factors:

- Effectiveness
  - Short-term protection of human health
  - Short-term protection of the environment
  - Long-term protection of human health
  - Long-term protection of the environment
  - Reduction of mobility, toxicity, or volume of waste
- Implementability/Technical Feasibility
  - Constructability
  - Operational reliability
  - Maintenance
- Implementability/Administrative Feasibility
  - Agency approvals
  - Availability of services
  - Specialized equipment and personnel
- Cost
  - Capital
  - Operation and Maintenance (O&M)
  - Present worth analysis

7.1 EFFECTIVENESS AND IMPLEMENTABILITY EVALUATIONS

The assembled remedial action alternatives have been screened on the basis of short - and long-term effectiveness and technical and administrative implementability. The alternatives were evaluated by applying a simple numeric ranking system ranging between one and five for each evaluation factor and each component of the alternative. The groundwater and soil/sediment component of each alternative is scored separately and then added together to obtain a total score for the alternative. The total score is used to rank the alternatives in order of preference and to eliminate the least preferred alternatives from further consideration in the detailed analysis of alternatives (Task 13).

The rating value assignments, although quantitative in nature, remain subjective and are based on both experience and the overall characteristics of the components. If a specific evaluation factor was considered unfavorable for a given component of a remedial action alternative, a rating value

of one was assigned for that factor. Likewise, if a particular evaluation factor was considered highly favorable, a rating value of five was assigned to that factor for that specific alternative component. Rating scores of two through four were given to distinguish between varying degrees of unfavorable and favorable criteria. The total scores for each alternative are determined by summing the screening criteria values assigned to each component. The highest possible score is 50 points for effectiveness and 60 points for implementability, for a total of 110 points (combining groundwater and soil/sediments).

The results of these evaluations and specific assumptions made in the evaluations are given in Table 7-1. This section provides a brief description by alternative of the rationale behind the numerical score allotted for each evaluation factor and alternative component.

7.1.1 Alternative 1 - No Action

Effectiveness: Based on the assumed baseline conditions of the no-action alternative, i.e., the implementation of the South Plume removal action, adequate protection of the public health is provided for the short-term, and thus the short-term protection factor was given a rating of 5. However, no protection of the environment is provided. Additionally, future protection of the public health is not provided, and no treatment is used to reduce the mobility, toxicity, or volume of wastes. Therefore, all other effectiveness factors were given ratings of 1.

Implementability: The no-action alternative involves no technical implementation or requirements for services or equipment. Therefore, these factors were given a 5 rating. However, the no-action alternative is unlikely to receive agency approvals so this factor was given a rating of 1.

7.1.2 Alternative 2 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate On-Site Disposal

7.1.2.1 Groundwater

Effectiveness: During the implementation of this alternative, a low potential exists for human exposure. Additionally, actions taken under this alternative during implementation should not cause major impacts to the environment (factors scored a 4). However, since no treatment of the groundwater is provided, full protection of human health may not be provided in the long-term (factor scored a 3). This condition will be assessed in the FS risk assessment. Also, since no

GENERAL EVALUATION CRITERIA	EVALUATION FACTORS	1 GW: NO ACTION SED/SS: NO ACTION		2 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL		3 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL		4 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL		5 GW: EXTRACT, ON-SITE TREATMENT DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL		6 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, TREATMENT ON-SITE DISPOSAL		7 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, TREATMENT ON-SITE DISPOSAL		8 GW: EXTRACT, DISCHARGE SED/SS: SINGLE-LAYER CAP		9 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: SINGLE-LAYER CAP		10 GW: PLUME CONTROL SED/SS: EXCAVATE, ON-SITE DISPOSAL		11 GW: RECHARGE AREA MODIFICATION SED/SS: EXCAVATE, ON-SITE DISPOSAL	
		GW[1]	SED SS[2]	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS
EFFECTIVENESS	SHORT-TERM PROTECTION OF HUMAN HEALTH	5	1	4	4	4	4	4	3	4	3	4	4	4	4	4	3	4	3	3	4	1	4
	SHORT-TERM PROTECTION OF THE ENVIRONMENT	1	1	4	5	4	5	4	5	4	5	4	5	4	5	4	3	4	3	1	5	1	5
	LONG-TERM PROTECTION OF HUMAN HEALTH	1	1	3	5	5	5	3	5	5	5	3	5	5	5	3	3	5	3	4	5	1	5
	LONG-TERM PROTECTION OF THE ENVIRONMENT	1	1	2	5	5	5	2	5	5	5	2	5	5	5	2	3	5	3	1	5	1	5
	REDUCTION OF MOBILITY, TOXICITY OR VOLUME OF WASTE	1	1	1	2	5	2	1	2	5	2	1	5	5	5	1	2	5	2	1	2	1	2
IMPLEMENTABILITY TECHNICAL FEASIBILTY	CONSTRUCTABILITY	5	5	5	0	4	4	5	5	4	5	5	3	4	3	5	4	4	4	3	4	2	4
	OPERATIONAL RELIABILITY	5	5	5	5	4	5	5	5	4	5	5	3	4	3	5	2	4	2	3	5	4	5
	MAINTENANCE	5	5	5	3	2	3	5	5	2	5	5	4	2	4	5	3	2	3	4	4	4	3
IMPLEMENTABILITY ADMINISTRATIVE FEASIBILITY	AGENCY APPROVALS	1	1	2	3	5	3	2	3	5	3	2	5	5	5	2	3	5	3	1	3	3	3
	AVAILABILITY OF SERVICES	5	5	5	4	5	4	5	3	5	3	5	4	5	4	5	5	5	5	5	4	5	4
	SPECIALIZED EQUIPMENT AND PERSONNEL	5	5	5	4	4	4	5	3	4	3	5	4	4	4	5	5	4	5	5	4	5	4
	SUBTOTAL	35	31	41	44	47	44	41	44	47	44	41	47	47	47	41	36	47	36	31	45	28	44
	TOTAL	66		85		91		85		91		88		94		77		83		76		72	
COST		NONE		M[3]		H[4]		M		H		M		H		M		H		M		L[5]	

NOTES:

1. GW = GROUNDWATER COMPONENT
2. SED/SS = SEDIMENT AND SOIL COMPONENTS
3. M = MODERATE PRESENT WORTH COST
4. H = HIGH PRESENT WORTH COST
5. L = LOW PRESENT WORTH COST

TABLE 7-1

ALTERNATIVE SCREENING
OPERABLE UNIT 5

groundwater treatment is provided, long-term protection of the environment may not be adequately addressed since uranium loadings to the Great Miami River will increase; therefore, this factor scored a 2. Although a reduction of toxicity is accomplished within this alternative, treatment is not utilized; therefore, the reduction of mobility, toxicity, or volume criterion received a rating of 1.

Implementability: This alternative would require the installation of a number of extraction wells with connecting pipeline to a discharge line. This is proven technology, is easily constructed, and requires minimal maintenance (factors scored a 5). However, agency approvals are not expected since this alternative proposes discharge of untreated groundwater a surface water body (factor scored a 2). No specialized services, equipment, or personnel are required for the implementation of the alternative (factor scored a 5).

7.1.2.2 Sediments/Soils

Effectiveness: A low potential exists for human exposure in the short term during remediation (factor scored a 4). Removal and secure disposal provides short- and long-term protection of the environment and long-term protection of human health (factors scored a 5). This solution provides only a reduction in mobility of the materials via containment and does not address toxicity or volume (factor scored a 2).

Implementability: This alternative would require the construction of an on-site disposal facility to prevent contact and leaching of material. Although techniques required for construction of this facility are widely practiced, various complexities may be associated with staging and operation of the facility; therefore, constructability was given a rating of 4. Based on proper design procedures and adequate monitoring, the on-site engineered disposal facility should provide a highly reliable system and has therefore rated a 5. Since no treatment is provided for the soils, agency acceptance is questionable (factor scored a 3). The use of specialized equipment and personnel are required for the construction (i.e., synthetic liners and skilled labor), but should be readily available in the marketplace (factors scored a 4).

7.1.3 Alternative 3 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Disposal

7.1.3.1 Groundwater

Effectiveness: During implementation, a low potential exists for human exposure and continuing release to the environment in the short term (factors scored a 4). Through removal and treatment of groundwater, long-term protection of human health and the environment should be fully effective (factors scored a 5). On-site treatment of the groundwater reduces the primary threat and achieves reduction of mobility, toxicity, or volume of waste (factor scored a 5).

Implementability: This alternative will require the construction of a treatment plant in addition to the installation of extraction wells and pipelines. The treatment process is relatively complex and subject to operational problems (factors scored a 4). The facility will require constant maintenance and management of residuals (factors scored a 2). Agency approval for this alternative is expected (factors scored a 5). The services required for this alternative are readily available (factor scored a 5). The operation of the treatment facility will require specialized equipment and personnel (factors scored a 4).

7.1.3.2 Sediments/Soils

This is the same as Alternative 2, and all comments apply.

7.1.4 Alternative 4 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, Off-Site Disposal

7.1.4.1 Groundwater

This is the same as Alternative 2, and all comments apply.

7.1.4.2 Sediments/Soils

Effectiveness: Since soils/sediments are being taken off-site, the potential exists for exposure of additional populations (factor scored a 3). Short- and long-term protection of the environment, and long-term protection of human health should be fully effective (factors scored a 5). This solution provides a reduction in the mobility of the material through containment, however, no treatment is utilized. Therefore, this criterion was given a rating of 2.

Implementability: The constructability, reliability of the operations, and maintenance are not a problem. This assumes proper management of the permitted off-site facility (factors scored a 5). Agency approvals may be a problem particularly as they relate to transport of waste to the disposal site and acceptance by the host state (factor scored a 3). Additionally, there is a limited number of disposal sites permitted for acceptance of this material (factors scored a 3).

7.1.5 Alternative 5 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Off-Site Disposal

7.1.5.1 Groundwater

This is the same as Alternative 3, and all comments apply.

7.1.5.2 Sediments/Soils

This is the same as Alternative 4, and all comments apply.

7.1.6 Alternative 6 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, Treatment, On-Site Disposal

7.1.6.1 Groundwater

This is the same as Alternative 2, and all comments apply.

7.1.6.2 Sediments/Soils

Effectiveness: A low potential exists for human exposure in the short term during remediation (factor scored a 4). Removal and secure disposal provides short- and long-term protection of the environment and long-term protection of human health (factors scored a 5). Reduction of the volume immobility or toxicity of waste is addressed through treatment of the sediment/soil (factor scored a five).

Implementability: This solution will require the construction of a treatment unit and the establishment of a secure on-site disposal area for residuals (factor scored a 3). Assuming amenability of the material, operation should be fully reliable (factor scored a 5). The maintenance of the treatment unit and on-site disposal facility is required (factor scored a 4). Agency approval for a treatment option is expected (factor scored a 5). The availability of this type of treatment system and people skilled in the operation may be limited (factors scored a 4).

7.1.7 Alternative 7 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Treatment, On-Site Disposal

7.1.7.1 Groundwater

This is the same as Alternative 3, and all comments apply.

7.1.7.2 Sediments/Soils

This is the same as Alternative 6, and all comments apply.

7.1.8 Alternative 8 - Groundwater: Extract, Discharge; Sediments/Soils: Single-Layer Cap

7.1.8.1 Groundwater

This is the same as Alternative 2, and all comments apply.

7.1.8.2 Sediments/Soils

Effectiveness: This alternative would leave the contaminated sediments in place and thus is subject to groundwater infiltration and leaching of contaminants. Additionally, streambed preparation may result in the disturbance and movement of the contaminated sediments thus jeopardizing the effectiveness of the containment. These factors reduce the short- and long-term protection of human health and the environment provided by this alternative (factors scored a 3). This solution reduces mobility via containment but does not address toxicity or volume of material (factor scored a 2).

Implementability: Constructing a single-layer cap over portions of the streambeds to immobilize sediments would be impacted by the possibility of rain-induced flows and the irregular nature of the surface (i.e., large boulders, etc.) but should not cause major technical difficulties (factor scored a 4). The reliability of this alternative will be jeopardized by possible damage from flood flows and turbulent scouring of the streambed (factor scored a 2). Periodic removal of sediment and debris will be necessary for maintenance (factor scored a 3). Agency approval is subject to concerns on stream integrity (factor scored a 3). The services and equipment required to perform this work should be widely available and nonspecialized (factors scored a 5).

7.1.9 Alternative 9 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Single-Layer Cap

7.1.9.1 Groundwater

This is the same as Alternative 3, and all comments apply.

7.1.9.2 Sediments/Soils

This is the same as Alternative 8, and all comments apply.

7.1.10 Alternative 10 - Groundwater: Extract and Reinject for Plume Control; Sediments/Soils: Excavate, On-Site Disposal

7.1.10.1 Groundwater

Effectiveness: Short-term protection of human health is jeopardized during extended periods of implementation of this alternative (factor scored a 3). Since this action does not remove the uranium from the environment, short- and long-term protection of the environment is minimal (factors scored a 1). Assuming the uranium in the aquifer is from historical releases and there are no significant continuing releases, the long-term protection of human health is relatively effective (factor scored a 4). This option does not reduce mobility, toxicity, or volume of material (factor scored a 1).

Implementability: A large number of wells are required to successfully implement this option due to high aquifer transmissivities and relatively steep piezometric gradients. The constructability is relatively low (factor scored a 3). Due to the large number of wells, interconnecting pipeline, and potential for clogging of the injection wells, the operational reliability is relatively low (factor scored a 3). This system would require 24-hour-per-day maintenance, and breakdown would have to be corrected quickly (factor scored a 4). The ability to obtain agency approval for injection of water into a sole-source aquifer and obtain access for wells and pipeline placement would likely be severely limited (factor scored a 1). The availability of services, equipment, and personnel to perform this type of work is not a problem (factors scored a 5).

7.1.10.2 Sediments/Soils

This is the same as Alternative 2, and all comments apply.

7.1.11 Alternative 11 - Groundwater: Recharge Area Modification; Sediments/Soils: Excavate, On-Site Disposal

7.1.11.1 Groundwater

Effectiveness: Recharge area modification (i.e., paving Paddys Run and the storm sewer outfall ditch) would be ineffective in changing the regional flow and contamination pattern of the aquifer because of the small volume of water affected relative to the total recharge to the aquifer. The reduction in uranium loadings from Paddys Run and the outfall ditch is also limited by the completed and planned projects to eliminate contaminant loadings to these surface water courses. All effectiveness factors are scored as 1.

Implementability: The limitation on effectively diverting the stream during high flows adversely impacts constructability (factor scored a 2). Possible damage from settling or flood flows exceeding design specifications would impact operational reliability (factor scored a 4). Maintenance would consist of periodic removal of sediment and debris and inspection of the integrity of the liner (factor scored a 4). Agency approval of the modification of an entire stream must consider the destruction of a small contaminated community and accepting a stable, uncontaminated, but lower quality, intermittent stream community (factor scored a 3). The implementability of this option does not require specialized services, equipment, or personnel (factors scored a 5).

7.1.11.2 Sediments/Soils

This is the same as Alternative 2, and all comments apply.

7.2 COST EVALUATION

Cost evaluations were prepared for each alternative to provide a general comparison of alternatives. Because of uncertainties associated with several of the alternatives at this phase of the study, it was not practical to define the cost of each alternative. For purposes of this report, High (H), Medium (M), and Low (L) relative costs are provided and are shown in Table 7-1. Detailed capital and operation and maintenance costs will be prepared within the detailed analysis.

7.3 ALTERNATIVES RETAINED FOR DETAILED ANALYSIS

In selecting the alternatives for consideration during detailed analysis, the composite evaluation was considered. In addition, consideration was given to preserving a range of treatment and containment alternatives, where practicable.

As shown in Table 7-1, the range of the rating values is narrow with the majority of alternatives receiving relative costs of high or medium. However, two of the alternatives (Alternatives 10 and 11) receiving the lowest scores (excluding No Action) are shown to provide unsatisfactory protection of human health and the environment in the long term. For these reasons, Alternative 10 - Groundwater: Plume Control; Sediment/Soil: Single-Layer Cap and Alternative 11 - Groundwater: Recharge Area Modification; Sediment/Soil: Excavate, On-Site Disposal will not be carried forward for detailed evaluation. Additionally, Alternative 8 - Groundwater: Extract, Discharge; Sediment/Soil: Single-Layer Cap has not been retained for evaluation since Alternatives 2, 4, and 6 are similar by providing the same action on groundwater, but more viable options for the handling of soils and sediments.

The remaining alternatives will be retained, along with the No Action Alternative for evaluation within the detailed analysis and include:

Alternative 1 - Groundwater: No Action; Sediments/Soils: No Action

Alternative 2 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate; On-Site Disposal

Alternative 3 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Disposal

Alternative 4 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, Off-Site Disposal

Alternative 5 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, Off-Site Disposal

Alternative 6 - Groundwater: Extract, Discharge; Sediments/Soils: Excavate, On-Site Treatment, On-Site Disposal of Residuals

Alternative 7 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils: Excavate, On-Site Treatment

Alternative 9 - Groundwater: Extract, On-Site Treatment, Discharge; Sediments/Soils; Single Layer Cap

8.0 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

To ensure a smooth transition from the screening of alternatives to the detailed analysis, it becomes necessary to begin verifying ARARs. CERCLA requires that remedial actions achieve a level of cleanup or standard of control of hazardous substances, pollutants, or contaminants that, as a minimum, assures the protection of human health and the environment. With respect to those hazardous substances, pollutants, and contaminants that will remain on site, CERCLA further defines this level as that remedial action which at least attains legally applicable or relevant and appropriate standards, requirements, criteria, or limitations.

ARARs are classified as: 1) chemical-specific, 2) location-specific, and 3) action-specific. Chemical-specific ARARs address the acceptable amount or concentration of a specific pollutant that may be found in or discharged to soil, water, and air. Location-specific ARARs are based on the specific setting and nature of the site, and action-specific ARARs relate to technology or activity-based requirements or limitations on the specific response actions taken with respect to the type of wastes. Thus, the determination of the potential ARARs for proposed actions at a site is based on factors specific to that site and the individual action, that is, on the nature of the contamination, the location of the site, and the general scope of the identified remedial action alternatives.

The potential ARARs identified for Operable Unit 5 are discussed in Appendix B.

REFERENCES

Aas, E.A., D.L. Jones, and R.W. Keys, 1986, "Feed Materials Production Center Environmental Monitoring Report for 1985," FMPC Special UC-41, Westinghouse Materials Company of Ohio, Cincinnati, Ohio.

Bailey, R. 1978, "Ecoregions of the United States," U.S. Forest Service, Ogden, Utah.

Dames and Moore, 1985, Department of Energy Feed Materials Production Center, Groundwater Study, Task A Report, prepared for National Lead of Ohio, Inc., Cincinnati, Ohio.

Darnall, D.W., Gabel, A.M., Gardea-Torresdey, J., 1989, "AlgaSORB: A New Biotechnology for Removing and Recovering Heavy Metal Ions From Groundwater And Industrial Wastewater," Biorecovery Systems, Inc., Las Cruces, NM.

Facemire, C.F., S.I. Guttman, D.R. Osborne and R.H. Sperger, 1990, "Biological and Ecological Site Characterization of the Feed Materials Production Center," FMPC-SUB-018, prepared for Westinghouse Materials Company of Ohio, Cincinnati, OH.

IT Corporation, 1986 "Final Interim Report - Air, Soil, Water, and Health Risk Assessment in the Vicinity of the FMPC, Fernald, Ohio", Report and Data Package Prepared for U.S. Dept. of Energy in support of the Fernald Litigation, Oak Ridge Operations Office, Oak Ridge, TN.

IT Corporation, 1988, "Hydrogeologic Study of the FMPC Discharge to the Great Miami River," (Zone of Influence Report) prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

IT Corporation, 1989, "Assessment of Radiation Dose and Cancer Risk for Emissions from 1951 through 1989, Feed Materials Production Center, Fernald, Ohio," IT Corp., prepared for the U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Spieker, A.M., 1968, "Groundwater Hydrology and Geology of the Lower Great Miami River Valley, Ohio," U.S. Geological Survey Professional Paper 605-A, available from the U.S. Government Printing Office, Washington, DC.

U.S. Department of Energy, 1988, "Development of Alternatives (Task 12) for the Feasibility Study, Revision 1," Oak Ridge Operations Office, Oak Ridge, TN.

U.S. Department of Energy, 1989, "Groundwater Treatability Testing Results - Operable Unit 5, Remedial Investigation and Feasibility Study," Oak Ridge Operations Office, Oak Ridge, TN.

U.S. Department of Energy, 1990a, "Engineering Evaluation/Cost Analysis - South Plume," DOE, Oak Ridge Operations Office, Oak Ridge, TN.

U.S. Department of Energy, 1990b, "Draft Engineering Evaluation/Cost Analysis - Waste Pit Area Storm Water Run-off Control," DOE, Oak Ridge Operations Office, Oak Ridge, TN.

REFERENCES
(Continued)

U.S. Department of Energy, 1990c, "DOE Order of Radiation Protection of the Public and the Environment (5400.5)," DOE, Washington, DC.

U.S. Environmental Protection Agency, 1988, "Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA," EPA/540/G-89/004 (OSWER Directive 9355.3-01), Office of Emergency and Remedial Response, Washington, DC.

APPENDIX A
DATA SUMMARIES

APPENDIX A
LIST OF TABLES

Table	Title	Page
A-1	Radionuclides and Chemicals Detected, North and West Monitoring Wells, 2000-Series	A-1
A-2	Radionuclides and Chemicals Detected, Western Monitoring Wells, 2000-Series	A-3
A-3	Radionuclides and Chemicals Detected, Central Monitoring Wells, 2000-Series	A-5
A-4	Radionuclides and Chemicals Detected, North and West Monitoring Wells, 3000-Series	A-7
A-5	Radionuclides and Chemicals Detected, Western Monitoring Wells, 3000-Series	A-9
A-6	Radionuclides and Chemicals Detected, Central Monitoring Wells, 3000-Series	A-11
A-7	Radionuclides and Chemicals Detected, 4000-Series	A-13
A-8	Detected Organic Compounds (ug/L) In Groundwater from 2000-Series Wells	A-15
A-9	Detected Organic Compounds (ug/L) In Groundwater from 3000-Series Wells	A-20
A-10	Detected Organic Compounds (ug/L) In Groundwater from 4000-Series Wells	A-23
A-11	Organic Chemicals in Groundwater During FMPC Litigation Support Sampling	A-24
A-12	Surface Soil Data, Uranium, Routing Soil Sampling Locations	A-25
A-13	Radionuclides in Soil Outside FMPC Boundary	A-26
A-14	Summary, Total Uranium Concentrations In Soil	A-27
A-15	Total Uranium Concentration in Soil, Parallel Vegetation and Soil Sampling	A-28
A-16	Radionuclides in Surface Water	A-29
A-17	Radionuclides in Surface, Water RI/FS Sampling	A-31

APPENDIX A
LIST OF TABLES
(Continued)

Table	Title	Page
A-18	Average Total Uranium Concentration in Paddys Run Surface Water, 1975-1989	A-33
A-19	Chemicals Identified in Surface Water of Paddys Run	A-34
A-20	Uranium Concentrations in Surface Water of the Great Miami River (Reported in FMPC Environmental Monitoring Reports)	A-36
A-21	Chemicals Identified in Surface Water of the Great Miami River	A-37
A-22	Radionuclides of Concern in Sediments 1987-1988 FMPC Environmental Monitoring Program	A-39
A-23	Uranium Concentrations in Great Miami River Sediments, 1988-1989	A-40
A-24	Radionuclides in Sediments of Paddys Run, (Reported in FMPC Environmental Monitoring Reports)	A-41
A-25	Chemicals Identified in Sediment of Paddys Run, Above the Confluence	A-45
A-26	Chemicals Identified in Sediment of Paddys Run, Below the Confluence	A-47
A-27	Radionuclides in Sediments of the Storm Sewer Outfall Ditch, (Reported in FMPC Environmental Monitoring Reports)	A-49
A-28	Chemicals Identified in Sediment at the Storm Sewer Outfall Ditch	A-52
A-29	Radionuclides in Sediments of the Great Miami River (Reported in FMPC Environmental Monitoring Reports)	A-54
A-30	Surface Water Summary Data, Radionuclides Detected, RI/FS Sampling	A-57
A-31	Sediment Summary Data, Radionuclides Detected, RI/FS Sampling	A-58

APPENDIX A
LIST OF TABLES
(Continued)

Table	Title	Page
A-32	Radionuclide Concentrations in Garden Produce and Agricultural Crops (RI/FS Sampling)	A-59
A-33	Uranium in Milk	A-60
A-34	Radionuclide Concentrations in Vegetation and Soil on the FMPC, (RI/FS) Sampling	A-61
A-35	Radionuclides in Mammal Tissue from the FMPC, (RI/FS Sampling)	A-62
A-36	Radionuclide Concentrations in Wetland Plants on the FMPC, (RI/FS) Sampling	A-63
A-37	Radionuclides in Aquatic Fauna, (RI/FS) Sampling	A-64

TABLE A-1

RADIONUCLIDES AND CHEMICALS DETECTED NORTH AND WEST MONITORING WELLS 2000-SERIES

Constituent	N. and W. Compliance Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]	N. Background Avg. Conc.[2]	NW Background Avg. Conc.[2]
Radionuclides:						
Cs-137, (pCi/l)	38	0	< 20.0	< 20.0	< 20.0	< 20.0
Np-237, (pCi/l)	38	0	< 1.0	< 1.0	< 1.0	< 1.0
Pu-238, (pCi/l)	38	0	< 1.0	< 1.0	< 1.0	< 1.0
Pu-239/240, (pCi/l)	38	0	< 1.0	< 1.0	< 1.0	< 1.0
Ra-226, (pCi/l)	38	0	< 1.0	< 1.0	1.1	1.1
Ra-228, (pCi/l)	36	1	3.0	< 3.0	< 3.0	< 3.0
Ru-106, (pCi/l)	38	0	< 150.0	< 150.0	< 150.0	< 150.0
Sr-90, (pCi/l)	38	0	< 5.0	< 5.0	< 5.0	< 5.0
Tc-99, (pCi/l)	38	0	< 30.0	< 30.0	< 30.0	< 30.0
Th-228, (pCi/l)	39	3	1.0	< 1.0	1.1	1.0
Th-230, (pCi/l)	39	5	1.0	1.1	< 1.0	1.0
Th-232, (pCi/l)	37	1	1.0	< 1.0	< 1.0	< 1.0
Th-TOTAL, (ug/l)	37	1	< 13.0	< 13.0	< 13.0	< 13.0
U-234, (pCi/l)	40	23	13.1	< 1.0	< 1.0	< 1.0
U-235/236, (pCi/l)	40	3	1.4	< 1.0	< 1.0	< 1.0
U-238, (pCi/l)	40	23	13.8	< 1.0	< 1.0	< 1.0
U-TOTAL, (ug/l)	39	27	43.9	< 1.0	1.2	1.1
Organics:						
Total Organic Halides, (mg/l)	26	0	< 0.05	< 0.05	< 0.05	< 0.05
Metals:						
Aluminum, (mg/l)	10	5	0.11	< 0.10	0.11	0.11
Arsenic, (mg/l)	27	0	< 0.002	0.002	0.021	0.014
Barium, (mg/l)	32	32	0.049	0.038	0.638	0.047
Cadmium, (mg/l)	37	9	0.005	< 0.005	0.005	0.005

TABLE A-1
(Continued)

Constituent	N. and W. Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]	N. Background Avg. Conc.[2]	NW Background Avg. Conc.[2]
Metals (Cont.):						
Calcium, (mg/l)	37	37	104.42	89.10	74.55	80.27
Chromium, (mg/l)	38	15	0.024	0.021	0.021	0.021
Copper, (mg/l)	33	17	0.013	0.016	< 0.010	0.012
Iron, (mg/l)	31	30	0.331	0.015	2.272	1.520
Lead, (mg/l)	28	15	0.004	0.002	0.005	0.004
Magnesium, (mg/l)	37	37	28.33	23.20	26.06	24.88
Manganese, (mg/l)	33	33	0.097	0.201	0.047	0.102
Mercury, (ug/l)	34	8	0.33	< 0.20	0.26	0.23
Molybdenum, (mg/l)	32	1	0.02	< 0.02	0.02	0.02
Nickel, (mg/l)	31	5	0.021	< 0.02	< 0.02	< 0.02
Potassium, (mg/l)	32	31	2.56	1.28	1.49	1.39
Selenium, (mg/l)	29	5	0.002	< 0.002	< 0.002	< 0.002
Silver, (mg/l)	35	5	0.011	0.012	0.01	0.011
Sodium, (mg/l)	38	38	15.20	3.23	41.09	22.92
Vanadium, (mg/l)	11	7	0.014	< 0.010	0.014	0.013
Zinc, (mg/l)	2	1	0.03	0.17	0.03	0.05
General Chemistry:						
Alkalinity, (mg/l)	36	36	338.3	322.2	387.0	359.2
Ammonia, as N, (mg/l)	38	5	0.12	0.11	3.15	1.75
Chloride, (mg/l)	33	33	26.26	9.20	61.01	40.73
Conductance, (umhos/cm)	36	36	548.1	535.0	624.2	589.7
Fluoride, (mg/l)	33	30	0.19	0.25	0.85	0.61
Nitrate, as N, (mg/l)	35	28	1.34	4.64	0.10	1.80
Total Phosphorus, (mg/l)	27	15	0.74	0.08	0.10	0.09
Sulfate, (mg/l)	35	35	78.62	29.59	3.66	14.46
pH, (units)	29	29	7.23	7.17	6.91	6.99

Notes:(1) The north and west monitoring wells include well numbers 2009, 2018, 2020, 2046, 2047, 2048, 2065, 2070, 2093, 2107, and 2108.

(2) When determining average concentrations, non-detected radionuclides and other chemical constituents were assumed to be at the detection limit.

TABLE A-2

RADIONUCLIDES AND CHEMICALS DETECTED
WESTERN MONITORING WELLS
2000-SERIES

Constituent	Western Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Radionuclides:				
Cs-137, (pCi/l)	66	0	< 20.0	< 20.0
Np-237, (pCi/l)	66	0	< 1.0	< 1.0
Pu-238, (pCi/l)	66	0	< 1.0	< 1.0
Pu-239/240, (pCi/l)	66	0	< 1.0	< 1.0
Ra-226, (pCi/l)	66	9	1.2	< 1.0
Ra-228, (pCi/l)	61	7	3.1	< 3.0
Ru-106, (pCi/l)	66	0	< 150.0	< 150.0
Sr-90, (pCi/l)	66	1	5.1	< 5.0
Tc-99, (pCi/l)	65	0	< 30.0	< 30.0
Th-228, (pCi/l)	67	7	1.1	< 1.0
Th-230, (pCi/l)	67	3	1.0	1.1
Th-232, (pCi/l)	66	2	1.0	< 1.0
Th-TOTAL, (ug/l)	66	0	< 13.0	< 13.0
U-234, (pCi/l)	67	51	25.3	< 1.0
U-235/236, (pCi/l)	67	24	1.7	< 1.0
U-238, (pCi/l)	67	49	27.1	< 1.0
U-TOTAL, (ug/l)	66	57	79.3	< 1.0
Organics:				
Total Organic Halides (mg/l)	45	5	0.51	< 0.05
Metals:				
Aluminum, (mg/l)	12	8	0.21	< 0.10
Arsenic, (mg/l)	47	8	0.025	0.002
Barium, (mg/l)	56	56	0.128	0.038
Cadmium, (mg/l)	64	15	0.005	< 0.005

TABLE A-2
(Continued)

Constituent	Western Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Metals (Cont.):				
Calcium, (mg/l)	64	64	97.36	89.10
Chromium, (mg/l)	65	23	0.024	0.021
Copper, (mg/l)	57	27	0.013	0.016
Iron, (mg/l)	55	50	1.739	0.015
Lead, (mg/l)	43	19	0.004	0.002
Magnesium, (mg/l)	64	64	25.85	23.20
Manganese, (mg/l)	51	49	0.113	0.201
Mercury, (ug/l)	61	19	0.33	< 0.20
Molybdenum, (mg/l)	56	4	0.02	< 0.02
Nickel, (mg/l)	56	5	0.022	< 0.02
Potassium, (mg/l)	56	56	13.07	1.28
Selenium, (mg/l)	47	6	0.002	< 0.002
Silver, (mg/l)	62	4	0.010	0.012
Sodium, (mg/l)	60	60	14.22	3.23
Vanadium, (mg/l)	12	7	0.013	0.010
Zinc, (mg/l)	5	5	0.02	0.17
General Chemistry:				
Alkalinity, (mg/l)	64	64	340.4	322.2
Ammonia, as N, (mg/l)	62	10	0.141	0.11
Chloride, (mg/l)	60	60	31.55	9.20
Conductance, (umhos/cm)	57	57	576.0	535.0
Fluoride, (mg/l)	55	52	0.30	0.25
Nitrate, as N, (mg/l)	57	40	1.34	4.64
Total Phosphorus, (mg/l)	54	35	0.60	0.08
Sulfate, (mg/l)	57	57	66.90	29.59
pH, (units)	51	51	6.98	7.17

Notes: (1) The western monitoring wells include well numbers 2002, 2014, 2015, 2016, 2017, 2044, 2045, 2049, 2060, 2061, 2069, 2094, 2095, 2096, 2104, 2106, and 2127.

(2) When determining average concentrations, non-detected radionuclides and other chemical constituents were assumed to be at the detection limit.

TABLE A-3
RADIONUCLIDES AND CHEMICALS DETECTED
CENTRAL MONITORING WELLS
2000-SERIES

Constituent	Central Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Radionuclides:				
Cs-137, (pCi/l)	105	0	< 20.0	< 20.0
Np-237, (pCi/l)	105	0	< 1.0	< 1.0
Pu-238, (pCi/l)	105	0	< 1.0	< 1.0
Pu-239/240, (pCi/l)	105	0	< 1.0	< 1.0
Ra-226, (pCi/l)	105	13	1.1	1.1
Ra-228, (pCi/l)	104	3	3.1	< 3.0
Ru-106, (pCi/l)	105	0	< 150.0	< 150.0
Sr-90, (pCi/l)	105	6	5.9	< 5.0
Tc-99, (pCi/l)	134	15	237.1	< 30.0
Th-228, (pCi/l)	141	8	1.0	1.1
Th-230, (pCi/l)	141	12	1.0	< 1.0
Th-232, (pCi/l)	107	1	1.0	< 1.0
Th-TOTAL, (ug/l)	105	0	< 13.0	< 13.0
U-234, (pCi/l)	139	75	2.7	< 1.0
U-235/236, (pCi/l)	139	1	1.0	< 1.0
U-238, (pCi/l)	140	69	2.7	< 1.0
U-TOTAL, (ug/l)	138	98	6.8	1.2
Organics:				
Total Organic Halides, (mg/l)	87	3	0.05	< 0.05
Metals:				
Aluminum, (mg/l)	46	33	0.16	0.11
Arsenic, (mg/l)	69	6	0.002	0.021
Barium, (mg/l)	106	106	0.092	0.638
Cadmium, (mg/l)	107	25	0.006	0.005
Calcium, (mg/l)	118	118	147.62	74.55
Chromium, (mg/l)	122	53	0.027	0.021
Copper, (mg/l)	111	24	0.012	<0.010
Iron, (mg/l)	108	107	2.017	2.272

TABLE A-3
(Continued)

Constituent	Central Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Lead, (mg/l)	85	35	0.003	0.005
Magnesium, (mg/l)	111	111	35.18	26.06
Manganese, (mg/l)	94	94	0.239	0.047
Mercury, (ug/l)	98	14	0.22	0.26
Molybdenum, (mg/l)	81	13	0.02	0.02
Nickel, (mg/l)	98	27	0.023	< 0.02
Potassium, (mg/l)	89	87	3.92	1.49
Selenium, (mg/l)	74	6	0.002	< 0.002
Silver, (mg/l)	119	29	0.011	0.010
Sodium, (mg/l)	101	101	21.88	41.09
Vanadium, (mg/l)	46	34	0.021	0.014
Zinc, (mg/l)	39	36	0.06	0.03
General Chemistry:				
Alkalinity, (mg/l)	97	97	356.7	387.0
Ammonia, as N, (mg/l)	87	51	0.91	3.15
Chloride, (mg/l)	107	107	44.62	61.01
Conductance, (umhos/cm)	137	137	811.0	624.2
Fluoride, (mg/l)	109	108	0.27	0.85
Nitrate, as N, (mg/l)	107	49	2.70	0.10
Total Phosphorus, (mg/l)	77	44	0.51	0.10
Sulfate, (mg/l)	108	108	161.99	3.66
pH, (units)	125	125	6.78	6.91

Notes: (1) The central monitoring wells include well numbers 2004, 2006, 2007, 2008, 2010, 2011, 2013, 2019, 2021, 2022, 2024, 2027, 2034, 2037, 2042, 2043, 2051, 2052, 2053, 2054, 2055, 2064, 2067, 2068, 2084, 2091, 2092, 2097, 2109, and 2118.

(2) When determining average concentrations, non-detected radionuclides and other chemical constituents were assumed to be at the detection limit.

TABLE A-4

RADIONUCLIDES AND CHEMICALS DETECTED NORTH AND WEST MONITORING WELLS 3000-SERIES

Constituent	N. and W. Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]	N. Background Avg. Conc.[2]	NW Background Avg. Conc.[2]
Radionuclides:						
Cs-137, (pCi/l)	26	0	< 20.0	< 20.0	< 20.0	< 20.0
Np-237, (pCi/l)	25	0	< 1.0	< 1.0	< 1.0	< 1.0
Pu-238, (pCi/l)	26	0	< 1.0	< 1.0	< 1.0	< 1.0
Pu-239/240, (pCi/l)	26	0	< 1.0	< 1.0	< 1.0	< 1.0
Ra-226, (pCi/l)	26	1	1.0	< 1.0	1.1	1.1
Ra-228, (pCi/l)	26	1	3.0	< 3.0	< 3.0	< 3.0
Ru-106, (pCi/l)	26	0	< 150.0	< 150.0	< 150.0	< 150.0
Sr-90, (pCi/l)	26	0	< 5.0	< 5.0	< 5.0	< 5.0
Tc-99, (pCi/l)	25	1	30.6	< 30.0	< 30.0	< 30.0
Th-228, (pCi/l)	25	0	< 1.0	< 1.0	1.1	1.0
Th-230, (pCi/l)	25	1	1.0	1.1	< 1.0	1.0
Th-232, (pCi/l)	25	0	< 1.0	< 1.0	< 1.0	< 1.0
Th-Total, (ug/l)	25	0	< 13.0	< 13.0	< 13.0	< 13.0
U-234, (pCi/l)	26	10	1.9	< 1.0	< 1.0	< 1.0
U-235/236, (pCi/l)	26	0	< 1.0	< 1.0	< 1.0	< 1.0
U-238, (pCi/l)	26	7	1.8	< 1.0	< 1.0	< 1.0
U-Total, (ug/l)	26	14	3.9	< 1.0	1.2	1.1
Organics:						
Total Organic Halides, (mg/l)	16	0	< 0.05	< 0.05	< 0.05	< 0.05
Metals:						
Aluminum, (mg/l)	3	0	< 0.10	< 0.10	0.11	0.11
Arsenic, (mg/l)	16	0	< 0.002	0.002	0.021	0.013
Barium, (mg/l)	22	22	0.053	0.038	0.638	0.407
Cadmium, (mg/l)	26	3	0.005	< 0.005	0.005	0.005
Calcium, (mg/l)	25	25	88.54	89.10	74.55	80.27

TABLE A-4
(Continued)

Background Constituent Conc.[2]	N. and W. Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]	N. Background Avg. Conc.[2]	NW Avg.
Metals (Cont.):						
Chromium, (mg/l)	26	9	0.023	0.021	0.021	0.021
Copper, (mg/l)	22	7	0.014	0.016	< 0.010	0.012
Iron, (mg/l)	24	24	0.904	0.015	2.272	1.520
Lead, (mg/l)	17	5	0.003	0.002	0.005	0.004
Magnesium, (mg/l)	25	25	32.82	23.20	26.06	24.88
Manganese, (mg/l)	22	22	0.162	0.201	0.047	0.102
Mercury, (ug/l)	23	7	0.64	< 0.20	0.26	0.23
Molybdenum, (mg/l)	22	0	< 0.02	< 0.02	0.02	0.02
Nickel, (mg/l)	21	3	0.022	< 0.02	< 0.02	< 0.02
Potassium, (mg/l)	21	19	2.43	1.28	1.49	1.39
Selenium, (mg/l)	16	3	0.002	< 0.002	< 0.002	< 0.002
Silver, (mg/l)	25	2	0.010	0.012	0.010	0.011
Sodium, (mg/l)	25	25	12.99	3.23	41.09	22.92
Vanadium, (mg/l)	2	1	0.014	< 0.010	0.014	0.013
Zinc, (mg/l)	NA[3]	NA	NA	0.17	0.03	0.05
General Chemistry:						
Alkalinity, (mg/l)	24	24	287.1	322.2	387.0	359.2
Ammonia, as N (mg/l)	25	8	0.12	0.11	3.15	1.75
Chloride, (mg/l)	25	25	18.68	9.20	61.01	40.73
Conductance, (umhos/cm)	26	26	479.6	535.0	624.2	589.7
Flouride, (mg/l)	23	21	0.24	0.25	0.85	0.61
Nitrate, as N, (mg/l)	23	6	0.40	4.64	0.10	1.80
Total Phosphorus, (mg/l)	19	7	0.13	0.08	0.10	0.09
Sulfate, (mg/l)	26	26	72.74	29.59	3.66	14.46
pH, (units)	25	25	5.88	7.15	6.91	6.99

Notes: (1) The north and west monitoring wells include well numbers 3009, 3018, 3020, 3065, 3070, 3093, 3107, and 3108.

(2) When determining average concentrations, non-detected radionuclides and other chemical constitutents were assumed to be at the detection limit

(3) NA means not analyzed.

TABLE A-5
RADIONUCLIDES AND CHEMICALS DETECTED
WESTERN MONITORING WELLS
3000-SERIES

Constituent	Western Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Radionuclides:				
Cs-137, (pCi/l)	47	0	< 20.0	< 20.0
Np-237, (pCi/l)	46	0	< 1.0	< 1.0
Pu-238, (pCi/l)	47	0	< 1.0	< 1.0
Pu-239/240, (pCi/l)	47	0	< 1.0	< 1.0
Ra-226, (pCi/l)	47	5	1.2	< 1.0
Ra-228, (pCi/l)	42	3	3.2	< 3.0
Ru-106, (pCi/l)	47	0	< 150.0	< 150.0
Sr-90, (pCi/l)	47	0	< 5.0	< 5.0
Tc-99, (pCi/l)	48	0	< 30.0	< 30.0
Th-228, (pCi/l)	47	4	1.0	< 1.0
Th-230, (pCi/l)	47	4	1.0	1.1
Th-232, (pCi/l)	46	1	1.0	< 1.0
Th-TOTAL, (ug/l)	47	47	13.0	< 13.0
U-234, (pCi/l)	48	21	3.7	< 1.0
U-235/236, (pCi/l)	47	1	1.0	< 1.0
U-238, (pCi/l)	48	20	3.8	< 1.0
U-TOTAL, (ug/l)	48	24	10.4	< 1.0
Organics:				
Total Organic Halides, (mg/l)	31	3	0.13	< 0.05
Metals:				
Aluminum, (mg/l)	2	1	0.16	< 0.10
Arsenic, (mg/l)	32	4	0.002	0.002
Barium, (mg/l)	39	39	0.08	0.038
Cadmium, (mg/l)	46	10	0.005	< 0.005
Calcium, (mg/l)	46	46	88.99	89.10
Chromium, (mg/l)	46	13	0.022	0.021
Copper, (mg/l)	40	17	0.013	0.016
Iron, (mg/l)	40	37	1.035	0.015

TABLE A-5
(Continued)

Constituent	Western Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Metals (Cont.)				
Lead, (mg/l)	32	16	0.011	0.002
Magnesium, (mg/l)	47	47	25.47	23.20
Manganese, (mg/l)	43	41	0.182	0.201
Mercury, (ug/l)	42	12	0.32	< 0.20
Molybdenum, (mg/l)	40	4	0.02	< 0.02
Nickel, (mg/l)	40	7	0.024	< 0.02
Potassium, (mg/l)	38	38	18.55	1.28
Selenium, (mg/l)	34	7	0.002	< 0.002
Silver, (mg/l)	46	1	0.01	0.012
Sodium, (mg/l)	44	44	18.87	3.23
Vanadium, (mg/l)	2	2	0.014	< 0.010
Zinc, (mg/l)	NA[3]	NA	NA	0.17
General Chemistry:				
Alkalinity, (mg/l)	45	45	321.7	322.2
Ammonia, as N, (mg/l)	45	10	0.299	0.11
Chloride, (mg/l)	44	44	32.14	9.20
Conductance, (umhos/cm)	45	45	558.4	535.0
Fluoride, (mg/l)	46	45	0.31	0.25
Nitrate, as N, (mg/l)	44	18	0.69	4.64
Total Phosphorus, (mg/l)	41	25	0.26	0.08
Sulfate, (mg/l)	42	42	73.36	29.59
pH, (units)	43	43	7.12	7.17

Notes: (1) The western monitoring wells include well numbers 3014, 3015, 3016, 3017, 3044, 3049, 3062, 3069, 3094, 3095, 3096, and 3127.

(2) When determining average concentrations, non-detected radionuclides and other chemical constituents were assumed to be at the detection limit.

(3) NA means not analyzed.

TABLE A-6
RADIONUCLIDES AND CHEMICALS DETECTED
CENTRAL MONITORING WELLS
3000-SERIES

Constituent	Central Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Radionuclides:				
Cs-137, (pCi/l)	97	0	< 20.0	< 20.0
Np-237, (pCi/l)	93	0	< 1.0	< 1.0
Pu-238, (pCi/l)	95	0	< 1.0	< 1.0
Pu-239/240, (pCi/l)	95	0	< 1.0	< 1.0
Ra-226, (pCi/l)	97	9	1.1	1.1
Ra-228, (pCi/l)	96	3	3.0	< 3.0
Ru-106, (pCi/l)	97	0	< 150.0	< 150.0
Sr-90, (pCi/l)	97	0	< 5.0	< 5.0
Tc-99, (pCi/l)	121	1	30.1	<30.0
Th-228, (pCi/l)	119	4	1.0	1.1
Th-230, (pCi/l)	120	5	7.0	< 1.0
Th-232, (pCi/l)	93	0	< 1.0	< 1.0
Th-TOTAL, (ug/l)	94	0	< 13.0	< 13.0
U-234, (pCi/l)	120	53	2.9	< 1.0
U-235/236, (pCi/l)	122	4	1.0	<1.0
U-238, (pCi/l)	118	48	2.6	< 1.0
U-TOTAL, (ug/l)	118	61	6.7	1.2
Organics:				
Total Oanic Halides, (mg/l)l)	77	3	0.05	< 0.05
Metals:				
Aluminum, (mg/l)	24	21	0.16	0.11
Arsenic, (mg/l)	50	10	0.004	0.021
Barium, (mg/l)	94	93	0.088	0.638
Cadmium, (mg/l)	96	16	0.006	0.005
Calcium, (mg/l)	113	113	138.17	74.55
Chromium, (mg/l)	113	44	0.025	0.021
Copper, (mg/l)	103	19	0.011	< 0.010
Iron, (mg/l)	103	101	2.853	2.272
Lead, (mg/l)	73	26	0.004	0.002

TABLE A-6
(Continued)

Constituent	Central Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	W. Background Avg. Conc.[2]
Metals (Cont.):				
Magnesium, (mg/l)	113	113	32.83	26.06
Manganese, (mg/l)	90	90	0.691	0.047
Mercury, (ug/l)	90	8	0.24	0.26
Molybdenum, (mg/l)	79	15	0.02	0.02
Nickel, (mg/l)	88	23	0.022	< 0.02
Potassium, (mg/l)	88	86	8.87	1.49
Selenium, (mg/l)	47	8	0.002	< 0.002
Silver, (mg/l)	111	24	0.011	0.010
Sodium, (mg/l)	92	92	26.73	41.09
Vanadium, (mg/l)	24	22	0.025	0.014
Zinc, (mg/l)	23	23	0.06	0.03
General Chemistry:				
Alkalinity, (mg/l)	90	90	342.7	387.0
Ammonia, as N, (mg/l)	88	59	0.91	3.15
Chloride, (mg/l)	107	107	51.78	61.01
Conductance, (umhos/cm)	127	127	760.9	624.2
Fluoride, (mg/l)	109	96	0.23	0.85
Nitrate, as N, (mg/l)	102	37	1.29	0.10
Total Phosphorus, (mg/l)	74	35	0.11	0.10
Sulfate, (mg/l)	112	110	186.01	3.66
pH, (units)	119	119	6.85	6.91

Notes: (1) The central monitoring wells include well numbers 3001, 3003, 3004, 3005, 3008, 3010, 3011, 3013, 3019, 3024, 3034, 3037, 3043, 3051, 3053, 3054, 3055, 3064, 3067, 3068, 3084, 3091, 3092, and 3097.

(2) When determining average concentrations, non-detected radionuclides and other chemical constituents were assumed to be at the detection limits.

TABLE A-7
RADIONUCLIDES AND CHEMICALS DETECTED
4000-SERIES

Constituent	4000-Series Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	Background Wells[3] Avg. Conc.[2]
Radionuclides:				
Cs-137, (pCi/l)	51	0	< 20.0	< 20.0
Np-237, (pCi/l)	51	0	< 1.0	< 1.0
Pu-238, (pCi/l)	51	0	< 1.0	< 1.0
Pu-239/240, (pCi/l)	51	0	< 1.0	< 1.0
Ra-226, (pCi/l)	51	2	1.0	< 1.0
Ra-228, (pCi/l)	49	5	3.0	< 3.0
Ru-106, (pCi/l)	51	0	< 150.0	< 150.0
Sr-90, (pCi/l)	51	0	< 5.0	< 5.0
Tc-99, (pCi/l)	62	0	< 30.0	< 30.0
Th-228, (pCi/l)	63	1	1.0	< 1.0
Th-230, (pCi/l)	63	3	1.0	1.1
Th-232, (pCi/l)	53	0	< 1.0	< 1.0
Th-TOTAL, (ug/l)	44	0	< 13.0	< 13.0
U-234, (pCi/l)	63	7	1.0	< 1.0
U-235/236, (pCi/l)	64	0	< 1.0	< 1.0
U-238, (pCi/l)	63	5	1.0	< 1.0
U-TOTAL, (ug/l)	64	12	1.2	< 1.0
Organics:				
Total Organic Halides, (mg/l)	44	4	0.05	< 0.05
Metals:				
Aluminum, (mg/l)	14	14	0.12	< 0.10
Arsenic, (mg/l)	30	10	0.003	0.002
Barium, (mg/l)	50	37	0.114	0.038
Cadmium, (mg/l)	31	18	0.004	< 0.005
Calcium, (mg/l)	56	56	104.84	89.10
Chromium, (mg/l)	56	24	0.024	0.021
Copper, (mg/l)	50	14	0.013	0.016
Iron, (mg/l)	55	55	3.158	0.015
Lead, (mg/l)	43	21	0.004	0.002
Magnesium, (mg/l)	56	56	29.66	23.20

TABLE A-7
(Continued)

Constituent	4000-Series Monitoring Wells[1] Number of Analyses	Number of Detections	Avg. Group Conc.[2]	Background Wells[3] Avg. Conc.[2]
Metals (Cont.):				
Manganese, (mg/l	46	45	0.381	0.201
Mercury, (ug/l)	44	9	0.46	< 0.20
Molybdenum, (mg/l)	42	12	0.02	< 0.02
Nickel, (mg/l)	45	9	0.021	< 0.02
Potassium, (mg/l)	41	41	2.23	1.28
Selenium, (mg/l)	32	4	0.002	< 0.002
Silver, (mg/l)	54	14	0.012	0.012
Sodium, (mg/l)	48	48	16.56	3.23
Vanadium, (mg/l)	14	12	0.020	< 0.01
Zinc, (mg/l)	9	8	0.03	0.17
General Chemistry:				
Alkalinity, (mg/l)	49	49	351.6	322.1
Ammonia, as N, (mg/l)	50	33	0.77	0.11
Chloride, (mg/l)	56	56	42.78	9.20
Conductance, (umhos/cm)	68	68	611.3	535.0
Fluoride, (mg/l)	56	55	0.26	0.25
Nitrate, as N, (mg/l)	54	19	0.31	4.64
Total Phosphorus, (mg/l)	42	29	0.13	0.08
Sulfate, (mg/l)	51	49	72.40	29.59
pH, (units)	63	63	7.25	7.17

Note: (1) The 4000-Series monitoring wells include well numbers 4001, 4008, 4010, 4013, 4014, 4015, 4016, 4023, 4064, 4067, 4091, 4096, 4097, 4101, 4102, and 4103.

(2) When determining average concentrations, non-detected radionuclides and other chemical constituents were assumed to be at the detection limit.

(3) The background monitoring wells are numbers 2036, 2057, and 2123.

TABLE A-8

DETECTED ORGANIC COMPOUNDS (ug/L) IN GROUNDWATER FROM 2000 SERIES WELLS

Well[a]	2006	2007	2010	2011	2014	2015	2016	
Sampling Quarter	2nd/89	2nd/89	2nd/88	2nd/88	2nd/88	2nd/88	2nd/88	1st/902nd/88
Volatile Organic Compounds								
2-Butanone	4 J	2 J						
Toluene	3 J			5				
Acetone[c]			8 J	37	2 J			
Benzene			1 J					
Carbon disulfide				8				
Methylene chloride				1 J				
1,1,1-Trichloroethane						6		
Chloroform							25	
Semivolatile Organic Compounds								
Phenol		14						
Diethyl phthalate			7 J					
3-Nitroaniline				50				
Isophorone				2 J				
N-nitrosodiphenylamine				10				
bis(2-Ethylhexyl)phthalate					2 J	1 J		4 J

See footnotes at end of table.

943

167

TABLE A-8
(continued)

Well[a]	2019		2021	2022	2027	2034	2037		2042	2106
Sampling Quarter	2nd/88	3rd/89	2nd/88	2nd/88	3rd/89	2nd/88	2nd/88	3rd/89	2nd/88	1st/90
Volatile Organic Compounds										
Acetone[b]	13	2 J							7 J	
Benzene							1 J			
Carbon disulfide					10			11		
Methylene chloride									9	
Ethylbenzene						2 J				
Total xylenes						3 J				
1,1,1-Trichloroethane										10
Trichloroethene										2 J
Semivolatile Organic Compounds										
Diethyl phthalate			1 J							
N-nitrosodiphenylamine					3 J					
bis(2-Ethylhexyl)phthalate		4 J			3 J		7 J	4 J		
4-Nitrophenol			3 J							
Butyl benzyl phthalate						1 J				
Pesticides										
Aldrin				0.11						
Heptachlor				0.07						
alpha-BHC				0.1						

See footnotes at end of table.

943

163

TABLE A-8
(continued)

Well[a]	2051	2052	2053	2054	2060	2065	2066	2094		2095	2109
Sampling Quarter	3rd/89	3rd/88	2nd/89	1st/89	1st/90	2nd/88	3rd/89	3rd/88	4th/88	2nd/90	1st/89
Volatile Organic Compounds											
2-Butanone			2 J								
Toluene							4 J				
Acetone[b]	3 J	4 J				6 J					
Benzene								160			
Ethylbenzene								1 J			
Total xylenes							7	189			
1,1,1-Trichloroethane					6					1 J	
2-Hexanone										1 J	
Semivolatile Organic Compounds											
Diethyl phthalate					20						
Di-n-butyl phthalate				4 J					10		

See footnotes at end of table.

TABLE A-8
(continued)

[a]This table does not include compounds found in method blanks. Second and third quarter 1989 results are from RCRA sampling program. Second quarter 1988 and first quarter 1989 results are from RI/FS sampling.

[b]Also know as 2-Propanone.

Qualifier:

J - Compund detected; below the contract required quantitation limit. The value presented is and estimate.

TABLE A-9

DETECTED ORGANIC COMPOUNDS (ug/L) IN GROUNDWATER FROM 3000 SERIES WELLS

Well[a]	3001	3010	3019	3037		3043		3051		3066	3084
Sampling Quarter	2nd/88	2nd/89	3rd/89	2nd/89	3rd/89	2nd/89	3rd/89	2nd/89	3rd/89	3rd/89	3rd/89
Volatile Organic Compounds											
4-Methyl-2-pentanone	3 J										
Benzene	4 J										
Toluene	10	2 J		3 J		3 J		8			
Trichloroethene		2 J		3 J		2 J		9			
Carbon disulfide							3 J				
Acetone[b]									8 J	4 J	6 J
Semivolatile Organic Compounds											
bis(2-ethylhexyl)phthalate			2J		5 J						
Butyl benzyl phthalate					3 J						
Diethyl phthalate					2 J						
Phenol					17						
Di-n-butyl phthalate											2 J

See footnotes at end of table.

TABLE A-9
(continued)

---

[a]This table does not include compounds found in method blanks. Second and third quarter 1989 results are from RCRA sampling program. Second quarter 1988 results are from RI/FS sampling.

[b]Also known as 2-Propanone.

Qualifier:

J - Compound detected; below the contract required quantitation limit. The value is an estimate.

TABLE A-10

DETECTED ORGANIC COMPOUNDS (ug/L) IN GROUNDWATER FROM 4000 SERIES WELLS

Well[a]	4001		4008		4428	4001
Sampling Quarter	3rd/86	2nd/87	3rd/86	2nd/87	2nd/87	2nd/89
Volatile Organic Compounds						
1,1,1-Trichloroethane	2					
Acetone[b]		15.6		21.3	30.8	
Cyclohexane		20		12		
Carbon disulfide			32.3			
Butanol			180			
Toluene						2

[a]Third quarter 1986, second quarter 1987, and second quarter 1989 results are from RCRA sampling program.

[b]Also known as 2-Propanone.

TABLE A-11
ORGANIC CHEMICALS IN GROUNDWATER
DURING FMPC LITIGATION SUPPORT SAMPLING

Chemical (ug/L)	Frequency of Detection	Highest Blank (a)	Range of Sample Detection Limits	Range of Detected Background Levels (b)	Range of Detected Site-Influenced Concentrations (c)
Acetone	19/20	20	< 0.01	-	3.3 - 97 [19.5]
Benzene	1/20	-	< 0.005	-	2.3
Benzo(a)pyrene	1/20	-	< 0.01	-	14
Bis(2-ethylhexylphthalate)	1/20	-	< 0.01	-	2.2
Bromoform	1/20	-	< 0.005	-	3.9
2-butanone	20/20	11	< 0.005	-	1.3 - 12 [4.3]
Chlorobenzene	2/20	1.5	< 0.005	-	1.1
Chloroform	1/20	1.8	< 0.005	-	1.1
Dibromochloromethane	1/20	-	< 0.005	-	2.5
Di-n-butylphthalate	19/20	42	< 0.01	-	2.2 - 18 [4.9]
2-hexanone	1/20		< 0.01	-	1.4
Methylene chloride	19/20	5.1	< 0.01	-	1.1 -11 [3.4]
N-nitrosodiphenylamine	19/20	57	< 0.01	-	3.8 - 24 [7.6]
Toluene	4/20	-	< 0.005	-	1 - 3.4 [2.1]
1,1,1-trichloroethane	3/20	-	< 0.005	-	2.1 - 3.5 [2.6]
Vinyl acetate	2/20	-	< 0.01	-	1 - 1.1
Total xylenes	2/20	-	< 0.005	-	2.9 - 3.3

(a) IT well samples were collected at a different time than other samples and blanks were taken for both sample collection efforts. Only appropriate blank results are compared to sample results. Acetone, 2-butanone and methylene chloride were found in every blank sample. Toluene, total xylenes, and hexanone were detected in samples during the second sampling effort (IT wells). However, only blanks from the first sampling effort contained these compounds and thus blank concentrations are not recorded here.

(b) Organic constituents are assumed to be zero in background wells.

(c) From FMPC litigation support data.

TABLE A-12

SOIL DATA[a]
URANIUM
ROUTINE SOIL SAMPLING LOCATIONS[b]

	INSIDE FMPC BOUNDARY			OUTSIDE FMPC BOUNDARY		
YEAR	NO. OF SAMPLES	CONCENTRATION RANGE (pCi/g)[c]	AVERAGE (pCi/g)	NO. OF SAMPLES	CONCENTRATION RANGE (pCi/g)	AVERAGE (pCi/g)
1976	5	3.1-7.4	5.4	NS[d]	-[e]	-
1977	5	3.2-7.4	5.8	NS	-	-
1978	5	3.7-7.8	5.5	NS	-	-
1979	5	3.7-5.7	4.4	NS	-	-
1980	5	3.0-7.1	5.3	NS	-	-
1981	5	1.0-8.1	4.9	NS	-	-
1982	6	1.3-3.7	2.7	NS	-	-
1983	6	2.7-13	7.5	7	2.0-3.3	2.5
1984	12	1.56-12.8	7.1	14	1.08-13.2	3.60
1985	6	0.42-4.35	2.3	7	0.35-1.71	0.66
1986	12	2.35-10.2	5.2	14	1.35-3.39	2.09
1987	12	3.0-11.0	6.0	12	1.4-3.2	2.0
1988	12	2.8-10	6.0	38	1.4-6.1	2.7
1989[f]	12	3.1-16	8.6	34	1.9-9.1	4.7

[a]Depth of samples taken from zero to four inches
[b]DOE FMPC Environmental Monitoring Annual Reports
[c]Picocuries per gram
[d]Not sampled
[e]Not applicable
[f]All 1989 data is draft

TABLE A-13

RADIONUCLIDES IN SOIL OUTSIDE FMPC BOUNDARY[a]

RADIONUCLIDE	NUMBER OF SAMPLES	CONCENTRATION (pCi/g) MINIMUM	MAXIMUM
Neptunium-237	24	0.0	0.0
Plutonium-238	24	0.0	0.0
Plutonium-239,240	24	0.0	0.0
Technetium-99	24	0.0	4.0
Thorium-228	24	0.3	1.6
Thorium-230	24	0.4	2.0
Thorium-232	24	0.4	1.7
Uranium	24	1.4	10.8

[a]Environmental Monitoring Report, 1984.

943

TABLE A-14

SUMMARY
URANIUM CONCENTRATIONS IN SOIL

SAMPLING EVENT[a]	AVERAGE CONCENTRATION (pCi/g)	NUMBER OF SAMPLING LOCATIONS	MINIMUM CONCENTRATION (pCi/g)	MAXIMUM CONCENTRATION (pCi/g)
FMPC RI Program[b] (sampling dates 8/28/87-10/26/88), 0- to 6-inch zone	13.7	23	1.5	63.6
FMPC RI Program[b] (sampling dates 8/28/87-10/26/88), 0- to 2-inch zone	11.8	94	2.7	51.2
1984 sampling[c]	5.2	115	1.0	27.6
1986 sampling[b, d]	1.9	303	0.5	36.5

[a]References:

RI, 0- to 6-inch zone: ASI map; soil sampling results; 0 to 6 inches; sum of U-234, U-235/236, and U-238; dated 2/23/89.

RI, 0- to 2-inch zone: ASI map; soil sampling results, 0 to 2 inches; sum of U-234, U-235/236, and U-238; dated 2/23/89.

1984 and 1986 sampling: IT Corporation, undated; Interim Report - Air, Soil, Water, and Health Risk Assessment in the Vicinity of the FMPC, Fernald, Ohio.

[b]See Figure 3-4.

[c]Perimeter of FMPC, both on and off site (off site area generally to the east).

[d]Broad coverage within five-mile radius of FMPC.

943

TABLE A-15

TOTAL URANIUM CONCENTRATION IN SOIL PARALLEL VEGETATION AND SOIL SAMPLING[a]

Year	Number of Samples	Concentration Range (pCi/g)[b]	Average Concentration (pCi/g)
1985	19	1.08 - 64.32	8.31
1986	NS[c]	-[d]	-
1987	36	1.2 - 23.8	5.78
1988	8	1.4 - 5.4	3.1
1989[e]	8	2.2 - 9.1	5.4

[a]FMPC Environmental Monitoring Reports

[b]Picocuries per gram

[c]Not sampled

[d]Not applicable

[e]1989 Data is draft

178

TABLE A-16
RADIONUCLIDES IN SURFACE WATER[a]

RADIONUCLIDE	LOCATION[b]	CONCENTRATION RANGE (pCi/l) 1985	1986	1987	1988
Gross Alpha	GMR[c]	0.81-7.21	1-8	<0.9[d]-8.1	0.9-8.6
	PR[e]	0.45-428.38	0.81-639	<0.9-16	<0.45-824
	SSOD[f]	NS[g]	NS	NS	NS
Gross Beta	GMR	0.81-17.12	0.81-55	2.7-108	3.6-36
	PR	0.90-140.09	0.54-164	1.4-32	1.8-369
	SSOD	NS	NS	NS	NS
Cesium-137	GMR	<2.43-<5.41	<5-<10.0	<2.00-<4.16	<3.9-<7.5
	PR	NS	NS	NS	NS
	SSOD	NS	NS	NS	NS
Radium-226	GMR	<0.45-0.45	<0.5-<0.5	<0.5-<0.5	<0.45-0.45
	PR	<0.45-0.45	<0.5-<0.8	<0.5-<0.5	<0.45-0.90
	SSOD	NS	NS	NS	NS
Radium-228	GMR	<0.45-0.45	<0.5-<1	<0.5-<0.9	<0.45-0.90
	PR	<0.45-0.45	<0.5-<1	<0.5-<0.9	<0.45-0.90
	SSOD	NS	NS	NS	NS
Strontium-90	GMR	0.27-1.89	<1.1-2.4	<0.6-<0.7	0.08-0.33
	PR	NS	NS	NS	NS
	SSOD	NS	NS	NS	NS
Technetium-99	GMR	1.08-4.86	2-7	<11.9-<20.9	<9.1-<10.6
	PR	NS	NS	NS	NS
	SSOD	NS	NS	NS	NS
Uranium-234	GMR	3.40-4.58	0.81-1.1	1.0-1.3	0.78-1.2
	PR	NS	NS	NS	NS
	SSOD	NS	NS	NS	NS
Uranium-235/236	GMR	0.15-0.20/0.04-0.07	0.030/0.0050-0.027	<0.2-0.2	<0.02-<0.02
	PR	NS	NS	NS	NS
	SSOD	NS	NS	NS	NS
Uranium-238	GMR	3.41-4.65	0.81-1.1	0.8-1.2	0.73-1.1
	PR	NS	NS	NS	NS
	SSOD	NS	NS	NS	NS

Footnotes are at the end of the table.

TABLE A-16
(Continued)

RADIONUCLIDE	LOCATION	CONCENTRATION RANGE (pCi/l) 1985	1986	1987	1988
Uranium	GMR	0.88-15.57	0.81-4.6	0.74-3.9	0.61-2.9
	GMR	-	0.40-1.60[h]	<0.67-3.35[i]	-
	PR	0.47-1,827.90	0.54-718	0.47-88	0.27-812
	PR	-	0.95-7.06[h]	-	-
	SSOD	NS	NS	NS	2905

[a]All data from FMPC Environmental Monitoring Reports, except where noted.

[b]See Figure 3-5 for Environmental Monitoring Program sampling locations.

[c]Great Miami River.

[d]Concentration less than reported detection limit.

[e]Paddys Run.

[f]Storm Sewer Outfall Ditch.

[g]Not sampled.

[h]From IT Interim Report: Air, Soil, Water, and Health Risk Assessment in the Vicinity of the FMPC (Exhibit D), 1986.

[i]From IT Hydrogeologic Study of FMPC Discharge to the Great Miami River, August 1988.

943

TABLE A-17

RADIONUCLIDES IN SURFACE WATER
RI/FS SAMPLING

RADIONUCLIDE	LOCATION	CONCENTRATION RANGES (pCi/l) 1988 FILTERED[a]	1988 UNFILTERED	1989 FILTERED	1989 UNFILTERED
Uranium-234	GMR[b]	<1.0-1.9	<1.0-2.2	<1.0	<1.0-1.0
	PR[c]	NS[d]	NS	1.2-4.0	1.3-5.0
	SSOD[e]	NS	NS	<1.0-15.9	<1.0
Uranium-235/236	GMR	<1.0	<1.0	<1.0	<1.0-<1.1
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0
Uranium-238	GMR	<1.0-1.8	<1.0-2.0	<1.0	<1.0-1.2
	PR	NS	NS	2.8-6.2	2.0-6.8
	SSOD	NS	NS	<1.0-15.9	1.3
U-Sum[f]	GMR	<1.0-3.60	<1.0-4.10	<1.0	<1.0-1.20
	PR	NS	NS	5.0-10.10	3.30-11.80
	SSOD	NS	NS	0.00-31.80	1.30
U-Total[g]	GMR	<1.00-5.00	<1.00-5.00	1.00	<1.00-3.00
	PR	NS	NS	9.00-25.00	5.00-19.00
	SSOD	NS	NS	2.00-44.0	2.00-24.00
Radium-226	GMR	<1.0	<1.0	<1.0	<1.0-2.4
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0
Radium-228	GMR	<3.0-<3.4	<3.0-5.0	<3.0	<3.0
	PR	NS	NS	<3.0	<3.0
	SSOD	NS	NS	<3.0	<3.0
Technetium-99	GMR	<30.0-48.4	<30.0-95.9	<30.0-<92.6	<30.0
	PR	NS	NS	<30.0	<30.0
	SSOD	NS	NS	<30.0	<30.0
Plutonium-238	GMR	<1.0	<1.0	<1.0	<1.0
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0
Plutonium-239/240	GMR	<1.0	<1.0	<1.0	<1.0
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0

See footnotes at end of table.

TABLE A-17
(Continued)

RADIONUCLIDE	LOCATION	CONCENTRATION RANGES (pCi/l) 1988 FILTERED[a]	1988 UNFILTERED	1989 FILTERED	1989 UNFILTERED
Thorium-228	GMR	<1.0-2.4	<1.0-2.6	<1.0	<1.0
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0
Thorium-230	GMR	<1.0	<1.0	<1.0	<1.0-1.3
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0
Thorium-232	GMR	<1.0	<1.0	<1.0	<1.0
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0
Strontium-90	GMR	<5.0	<5.0	<5.0	<5.0
	PR	NS	NS	<5.0	<5.0
	SSOD	NS	NS	<5.0	<5.0
Cesium-137	GMR	<20.0	<20.0	<20.0	<20.0-<30.0
	PR	NS	NS	<20.0	<20.0
	SSOD	NS	NS	<20.0	<20.0
Nobelium-237	GMR	<1.0	<1.0	<1.0	<1.0
	PR	NS	NS	<1.0	<1.0
	SSOD	NS	NS	<1.0	<1.0
Ruthenium-106	GMR	<150.0	<150.0	<150.0	<150.0
	PR	NS	NS	<150.0	<150.0
	SSOD	NS	NS	<150.0	<150.0

[a]The data are presented for filtered and unfiltered water samples.

[b]Great Miami River.

[c]Paddys Run.

[d]Not sampled.

[e]Storm sewer outfall ditch.

[f]U-Sum is the additive total of U-234, U-235/236, and U-238 concentrations.

[g]Analyzed for total uranium; units ug/l.

943

TABLE A-18

AVERAGE TOTAL URANIUM CONCENTRATION IN PADDYS RUN SURFACE WATER 1975 THROUGH 1989

CONCENTRATIONS (ug/l)
AT VARIOUS
SAMPLING LOCATIONS[a]

YEAR	W5	W7	W10	W11	SOURCE
1975	6	27	NA[b]	NA	d
1976	4	16	NA	NA	d
1977	8	14	NA	NA	d
1978	8	22	NA	NA	d
1979	3	15	NA	NA	d
1980	4	28	NA	NA	e
1981	4	31	NA	NA	e
1982	<4	17	NA	NA	e
1983	2	112[c]	NA	NA	e
1984	2	23	NA	NA	f
1985	2.4	64.7[c]	351.5[c]	14.7	g
1986	1.6	73.1[c]	16.4	43.3[c]	g
1987	1.5	8.7	10.1	8.7	g
1988	1.2	10.4	58.2[c]	8.5	g
1989	NA	12	8.5	14	h

[a]Sampling locations are as follows: W5, immediately south of Ohio Route 126; W7, confluence of Paddys Run and storm sewer outfall ditch; W10, near K-65 silos; and W11, just upstream of Paddys Run and storm sewer outfall ditch confluence.

[b]Data not available.

[c]Average value is probably too high due to a single high reading which is included in the average.

[d]Dames and Moore Ground Water Study, Task C Report, 1985.

[e]NLO FMPC Environmental Monitoring Report for 1980, 1981, 1982, and 1983.

[f]NLO FMPC Environmental Monitoring Report for 1984. Converted from pCi/l to ug/l by 1 pCi = 1.4925 ug.

[g]WMCO FMPC Environmental Monitoring Report for 1985, 1986, 1987, and 1988. Converted from pCi/l to ug/l by 1 pCi = 1.4925 ug.

[h]FMPC RI/FS, average of two rounds, nonfiltered data used. Data validation is not complete.

TABLE A-19

CHEMICALS IDENTIFIED IN SURFACE WATER OF PADDYS RUN

Chemical	Frequency of Detection	Range of Sample Detection Limits (a)	Range of Detected Site-Influenced Concentrations (b)	Average Site-Influenced Concentration (a,c,d)	Range of Detected Background Levels (e, f)
Organics (ug/L):					
Bis(2-ethylhexyl)phthalate	2/3	<10	2.0 - 4.0	5.3	NA
Diethylphthalate	1/2	<10	2.0	6.0	NA
N-nitrosodiphenylamine	1/2	<10	4.0	7.0	NA
Inorganics (ug/l):					
Aluminum	4/5	<60	76.4-451.0	164.8	NA
Antimony	1/2	<0.5	2.5	(4)	NA
Arsenic	1/7	<2	18.8	(4)	ND (<2 - <5)
Barium	7/7	(2)	26.7 - 65.8	40.7	49.3 - 100 (79.2)
Beryllium	2/2	(2)	1.1 - 1.2	1.2	NA
Cadmium	4/7	<2	1.6 - 3.2	2.4	3.1 - 9.8 (4.7)
Chromium	3/6	<10	13.9 - 24.3	14.3	6.1
Cobalt	0/2	<10	ND	ND	NA
Copper	3/7	<10	8.1 - 14.7	10.4	9.1 - 11.9 (10.2)
Lead	6/7	< 2	2.1 - 9.3	4.9	2.1 - 10 (5.9)
Magnesium	7/7	(2)	9,970 - 21,400	15.524.3	21,400 - 38,951 (28,033)
Manganese	7/7	(2)	9.7 - 46.2	22.5	8.9 - 80 (48.2)
Mercury	4/7	<0.3	0.2 - 0.8	0.3	0.7 - 9.5 (1.8)
Molybdenum	1/2	<3	20.5	(4)	7 - 20 (16.8)
Nickel	1/7	<20	8.0	(4)	10.5 - 13.1 (17.3)
Selenium	1/7	<2	16.9	(4)	ND (<2 - <3)
Silver	0/7	<0.5 - <10.0	ND	ND	10 - 30 (10.2)
Vanadium	2/5	<10	13.6 - 17.7	12.3	NA
Zinc	2/2	(2)	11.1 - 36.8	24.0	NA

See footnotes at end of table.

TABLE A-19
(Continued)

ND = Not Detected NA = Not Analyzed

(a) Calculated from single and double rounds at sampling sites of W-7, W-10, W-11, ASIT-3, and ASIT-9.

(b) Positive hits in all rounds; detection limits could not be determined.

(c) When determining average concentrations, non-detected chemicals were assumed to be at the detection limit.

(d) Averages were not determined with less than two positive hits.

(e) Background values are calculated using data from sampling locations GMR-1 and W-1. When two or more data points are given, arithmetic mean is given in brackets.

(f) Some detection limits for background samples were eliminated from consideration as being too high. This lowered the average background values of background detection limits for arsenic, lead, molybdenum, and selenium.

TABLE A-20

URANIUM CONCENTRATIONS IN SURFACE WATER OF THE GREAT MIAMI RIVER (REPORTED IN FMPC ENVIRONMENTAL MONITORING REPORTS)

SAMPLING POINT	YEAR	NUMBER OF SAMPLES	CONCENTRATION pCi/l[a] MINIMUM	MAXIMUM	AVERAGE
W1	1984	52	0.68	25.7	1.6
W3		52	0.68	16.2	1.6
W4		52	0.68	19.0	1.6
W1	1985	52	0.95	8.8	1.6
W3		52	0.95	2.6	1.6
W4		52	0.88	15.6	1.9
W1	1986	52	0.81	3.0	1.2
W3		52	0.81	2.4	1.4
W4		52	0.81	4.6	1.4
W1	1987	52	0.74	2.2	1.2
W3		52	0.88	3.9	1.6
W4		52	1.0	3.0	1.7
W1	1988	52	0.61	1.6	0.98
W3		52	0.81	2.8	1.5
W4		52	0.81	2.9	1.4

[a]Picocurie per liter.

TABLE A-21

CHEMICALS IDENTIFIED IN SURFACE WATER OF THE GREAT MIAMI RIVER

Chemical	Frequency of Detection	Range of Sample Detection Limits (a)	Range of Detected Site-Influenced Concentrations (b)	Average Site-Influenced Concentration (a,c,d)	Range of Detected Background Levels (e, f)
Organics (ug/L):					
None Detected					
Inorganics (ug/l):					
Aluminum	0/0	NA	NA	NA	NA
Antimony	0/0	NA	NA	NA	NA
Arsenic	2/7	<2 - <5	2.1 - 6.0	3.4	ND (<2 - <5)
Barium	9/9	(2)	37.9 - 106.0	82.8	8.9 - 100 (52.8)
Beryllium	0/0	NA	NA	NA	NA
Cadmium	4/9	<2 - <5	1.8 - 5.0	3.2	3.1 - 9.8 (4.7)
Chromium	2/3	<2	2.0 - 3.7	2.6	6.1
Cobalt	0/0	NA	NA	NA	NA
Copper	3/9	<10	6.9 - 14.2	10.1	9.1 - 11.9 (10.2)
Lead	6/6	(2)	2.2 - 14.0	8.5	2.1 - 10 (5.9)
Magnesium	9/9	(2)	16,500 - 36,900	28,288.9	21,400 -33,900 (28,033)
Manganese	9/9	(2)	7.8 - 100	56.4	8.9 - 80 (48.2)
Mercury	2/9	<0.2	0.6 - 1.0	0.3	0.7 - 9.5 (1.8)
Molybdenum	1/3	<3	20.0	(3)	7 - 20 (16.8)
Nickel	3/9	<20	7.2 - 11.4	16.7	10.5 - 13.1 (17.3)
Selenium	1/6	<2 - <32.0	(3)	ND	(<2 - <3)
Silver	0/9	<0.5 - <10	ND	ND	10 - 30 (10.2)
Vanadium	0/0	NA	NA	NA	NA
Zinc	0/0	NA	NA	NA	NA

Notes are on next page.

TABLE A-21
(Continued)

ND = Not Detected NA = Not Analyzed

(a) Based on data from sampling locations GMR-2, GMR-3, GMR-4.

(b) Positive hits in all rounds; detection limit could not be determined.

(c) When determining average concentrations, non-detected chemicals were assumed to be at the detection limit.

(d) Averages were not determined with less than two positive hits.

(e) Background values are based on data from sampling locations GMR-1 and W-1. In some cases average concentration may be lower than the minimum detected concentration.

(f) Some detection limits for background samples were eliminated from consideration as being too high. This lowered the average background values or range of background detection limits for arsenic, lead, molybdenum, and selenium.

TABLE A-22

RADIONUCLIDES OF CONCERN IN SEDIMENTS
1987 TO 1988 FMPC ENVIRONMENTAL MONITORING PROGRAM

RADIONUCLIDE	YEAR	LOCATION	CONCENTRATION pCi/g[a]			
				BANK LOCATION[b]		
			DISTANCE (m)[c]	NORTH/WEST	MIDDLE	SOUTH/EAST
Total Uranium	1987	Paddys Run (PR)	0	1.21	1.04	1.55
			0	38.50	2.08	7.49
			100U[d]	1.12	1.28	3.32
			100D[e]	2.43	0.84	1.49
		Storm Sewer Outfall Ditch (SSOD)	0	5.67	3.07	7.06
	1988	Storm Sewer Outfall Ditch	600	15.96	4.53	10.99
			700	12.66	8.28	65.41
			750	14.04	6.91	4.76
Radium-226	1988	Paddys Run	1,500U	0.729	0.607	1.390
			1,600U	1.100	0.683	13.700
			1,700U	0.452	0.524	0.508

[a]Picocurie per gram.

[b]See Figure 3-5.

[c]Distance (meters) corresponds to distance along the streambed from the confluence of the SSOD and Paddys Run with zero meters being the location of the confluence.

[d]U - Upstream.

[e]D - Downstream.

TABLE A-23

URANIUM CONCENTRATIONS IN GREAT MIAMI RIVER SEDIMENTS
1988 THROUGH 1989[a]

SAMPLE LOCATION	YEAR	CONCENTRATION (pCi/g)[b]			
		U-234	U-235/236	U-238	U-SUM
W1E	1988	<0.6[c]	<0.6	<0.6	0.00
WIE	1989	0.6	<0.6	<0.6	0.60
W3E	1988	<0.6	<0.6	<0.6	0.00
W3E	1989	<0.6	<0.6	<0.6	0.00
W4E	1988	<0.6	<0.6	<0.6	0.00
W4E	1989	<0.6	<0.6	<0.6	0.00
GMR1E	1988	<0.6	<0.6	0.6	0.60
GMR1E	1989	<0.6	<0.6	<0.6	0.00
GMR2E	1988	0.7	<0.6	0.6	1.30
GMR2E	1989	<0.6	<0.6	<0.6	0.00
GMR3W	1988	1.4	<0.6	1.1	2.50
GMR3W	1989	<0.6	<0.6	<0.6	0.00
GMR4W1/4	1988	0.7	<0.6	0.9	1.60
GMR4W	1989	<0.6	<0.6	<0.6	0.00

[a]RI/FS sampling.

[b]Picocurie per gram.

[c]Not detected at the given detection limit.

TABLE A-24

RADIONUCLIDES IN SEDIMENTS OF PADDYS RUN
(REPORTED IN FMPC ENVIRONMENTAL MONITORING REPORTS)

		NORTH[a]			SOUTH[b]		
RADIONUCLIDE	YEAR	CONCENTRATION RANGE (pCi/g)[c]	NUMBER OF SAMPLES	AVERAGE CONCENTRATION (pCi/g)	CONCENTRATION RANGE (pCi/g)	NUMBER OF SAMPLES	AVERAGE CONCENTRATION (pCi/g)
Uranium-234	1984	NA[d]	-[e]	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.17-3.8	IU[f]	0.44	0.28-21.0	IU	3.4
	1987	0.24-0.69	IU	0.41	0.34-0.59	IU	0.45
	1988	0.04-1.3	IU	0.53	0.06-2.8	IU	0.68
	1989[g]	<1.0[h]-2.2	74	<1.1	<1.0-3.6	53	<1.1
Uranium-235/236	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.0029-0.85[i]/0.0014-1.3[j]	IU	0.0028[i]/0.042[j]	0.0074-1.2[i]/0.30-1.0[j]	IU	0.18[i]/0.53[j]
	1987	<0.02-<0.14	IU	<0.051	0.02-0.08	IU	0.05
	1988	<0.01-0.10	IU	<0.05	<0.05-0.23	IU	0.06
	1989	<1.0-<1.0	74	<1.0	<1.0-<1.0	53	<1.0
Uranium-238	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.0007-5.7	IU	0.75	0.35-37.0	IU	5.2
	1987	0.2-0.82	IU	0.43	0.04-0.59	IU	0.22

TABLE A-24
(Continued)

RADIONUCLIDE	YEAR	NORTH[a] CONCENTRATION RANGE (pCi/g)[c]	NORTH[a] NUMBER OF SAMPLES	NORTH[a] AVERAGE CONCENTRATION (pCi/g)	SOUTH[b] CONCENTRATION RANGE (pCi/g)	SOUTH[b] NUMBER OF SAMPLES	SOUTH[b] AVERAGE CONCENTRATION (pCi/g)
	1988	0.24-1.5	IU	0.62	0.32-3.1	IU	0.77
	1989	<1.0-6.6	74	<1.2	<1.0-3.9	53	<1.1
Uranium-total	1984	0.89-42.31	10	9.12	9.00-296.53	2	152.76
	1985	0.5-46.2	11	7.2	1.1-10.2	4	4.8
	1986	NA	-	NA	NA	-	NA
	1987	NA	-	NA	NA	-	NA
	1988	NA	-	NA	NA	-	NA
	1989	NA	-	NA	NA	-	NA
Radium-223	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.078-0.48	IU	0.22	0.095-0.40	IU	0.23
	1987	NA	-	NA	NA	-	NA
	1988	NA	-	NA	NA	-	NA
	1989	NA	-	NA	NA	-	NA
Radium-224	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.19-1.3	IU	0.51	0.20-1.7	IU	0.54
	1987	<0.0792-<0.511	IU	<0.213	<0.10-<0.403	IU	<0.23
	1988	0.26-0.80	IU	0.45	0.19-0.90	IU	0.44
	1989	0.21-0.82	74	0.44	<0.032-0.92	53	0.41
Radium-226	1984	NA	-	NA	NA	-	NA

TABLE A-24

(Continued)

RADIONUCLIDE	YEAR	NORTH[a] CONCENTRATION RANGE (pCi/g)[c]	NORTH[a] NUMBER OF SAMPLES	NORTH[a] AVERAGE CONCENTRATION (pCi/g)	SOUTH[b] CONCENTRATION RANGE (pCi/g)	SOUTH[b] NUMBER OF SAMPLES	SOUTH[b] AVERAGE CONCENTRATION (pCi/g)
	1985	NA	-	NA	NA	-	NA
	1986	0.4-4.5	IU	0.86	0.49-1.9	IU	0.83
	1987	<0.188-<3.73	78	0.741	<0.25-4.85	48	0.702
	1988	<0.206-13.70	72	0.886	0.42-2.1	54	0.693
	1989	<0.21-1.1	74	0.63	<0.038-1.3	53	0.50
Radium-228	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.2-1.1	IU	0.52	0.23-1.3	IU	0.53
	1987	<0.154-<0.523	IU	<0.322	<0.11-<0.486	IU	<0.28
	1988	0.19-1.1	IU	0.41	0.23-0.85	IU	0.41
	1989	<0.17-0.73	74	0.43	<0.15-1.0	53	0.42
Thorium-228	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.04-2.7	IU	0.48	0.0058-2.3	IU	0.28
	1987	0.18-0.74	IU	0.35	0.13-0.45	IU	0.32
	1988	0.17-0.66	IU	0.36	0.10-0.74	IU	0.34
	1989	<1.0-4.3	74	<1.1	<1.0-6.6	53	<1.2

TABLE A-24
(Continued)

RADIONUCLIDE	YEAR	NORTH[a] CONCENTRATION RANGE (pCi/g)[c]	NORTH[a] NUMBER OF SAMPLES	NORTH[a] AVERAGE CONCENTRATION (pCi/g)	SOUTH[b] CONCENTRATION RANGE (pCi/g)	SOUTH[b] NUMBER OF SAMPLES	SOUTH[b] AVERAGE CONCENTRATION (pCi/g)
Thorium-230	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.22-2.4	IU	0.47	0.22-3.4	IU	0.78
	1987	0.34-1.1	IU	0.63	0.44-0.9	IU	0.64
	1988	0.32-2.5	IU	0.63	0.21-4.8	IU	0.67
	1989	<1.0-2.6	74	<1.1	<1.0-11	53	<1.3
Thorium-232	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.03-0.84	IU	0.22	0.0094-0.58	IU	0.22
	1987	0.17-0.54	IU	0.33	0.16-0.43	IU	0.31
	1988	0.17-0.87	IU	0.35	0.07-1.0	IU	0.32
	1989	<1.0-2.1	74	<1.0	<1.0-1.3	53	<1.0

TABLE A-24

(Continued)

RADIONUCLIDE	YEAR	NORTH[a] CONCENTRATION RANGE (pCi/g)[c]	NORTH[a] NUMBER OF SAMPLES	NORTH[a] AVERAGE CONCENTRATION (pCi/g)	SOUTH[b] CONCENTRATION RANGE (pCi/g)	SOUTH[b] NUMBER OF SAMPLES	SOUTH[b] AVERAGE CONCENTRATION (pCi/g)
Plutonium-238	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.0012-0.043	IU	0.0096	0.0050-0.057	IU	0.016
	1987	<0.02-<0.04	IU	<0.02	<0.02-<0.04	IU	<0.02
	1988	<0.002-<0.003	IU	<0.003	<0.01-<0.05	IU	<0.01
	1989	<0.012-0.46	74	<0.024	<0.012-0.032	53	<0.015
Plutonium-239/240	1984	NA	-	NA	NA	-	NA
	1985	NA	-	NA	NA	-	NA
	1986	0.00099-0.52	IU	0.024	0.0015-0.077	IU	0.015
	1987	<0.02-<0.03	IU	<0.02	<0.02-<0.02	IU	<0.02
	1988	<0.002-<0.003	IU	<0.003	<0.01-<0.05	IU	<0.01
	1989	<0.012-0.056	74	<0.016	<0.012-0.097	53	<0.016
Technetium-99	1984	0.70	1	0.70	30.0	1	30.0
	1985	0.0-5.1	4	1.4	2.3	1	2.3
	1986	-	IU	4.6[k]	0.81-38.0	IU	11.0
	1987	<1.0-<1.3	IU	<1.1	<1.1-<1.3	IU	<1.2
	1988	<1.0-<1.0	IU	<1.0	<0.90-<0.90	IU	<0.90
	1989	<0.90-<0.90	74	<0.90	<0.90-0.96	53	<0.90

943

195

943

TABLE A-24

(Continued)

[a]Paddys Run sampled above confluence with the Storm Sewer Outfall Ditch.
[b]Paddys Run sampled below confluence with the Storm Sewer Outfall Ditch.
[c]Picocuries per gram.
[d]Not analyzed
[e]Not applicable
[f]Information unavailable
[g]All 1989 data is draft.
[h]Concentration less than stated detection limit.
[i]U-235
[j]U-236
[k]All samples less than detectable, except one sample at the confluence of Paddys Run and the Storm Sewer Outfall.

196

TABLE A-25
CHEMICALS IDENTIFIED IN SEDIMENT OF PADDYS RUN ABOVE THE CONFLUENCE

Chemical	Frequency of Detection (a)	Range of Sample Detection Limits (b)	Range of Detected Site-Influenced Concentrations (c)	Average Site-Influenced Concentration (d)	Detected Background Levels (e)
ORGANICS (mg/kg):					
2-Butanone	0/3	<0.012 - <0.015	ND	ND	<0.015
Di-n-butylphthalate	2/3	<0.490	.051 - 0.055	0.199	0.039
bis(2-Ethylhexyl)phthalate	2/3	<0.49	0.490 - 0.590	0.527	0.460
2-Hexanone	0/3	<0.012 - <0.015	ND	ND	<0.012
Methylene chloride	2/3	<0.007	0.015 - 0.019	0.014	0.007
2-Propanone	2/3	0.015	0.008 - 0.094	0.039	0.018
INORGANICS (mg/kg):					
Aluminum	3/3	(2)	2,080.0 - 5,460.0	3,820.0	1,970.0
Antimony	0/3	<0.1	ND	ND	<0.1
Arsenic	3/3	(2)	2.7 - 6.5	4.2	7.0
Barium	3/3	(2)	21.0 - 49.4	33.9	21.0
Beryllium	3/3	(2)	0.2 - 0.5	0.4	0.5
Cadmium	2/3	<0.2	3.9 - 4.5	2.9	3.7
Chromium	3/3	(2)	6.9 - 18.4	14.2	18.3
Cobalt	3/3	(2)	3.8 - 6.5	5.0	4.9
Copper	3/3	(2)	9.2 - 14.5	11.8	10.8
Lead	3/3	(2)	4.6 - 18.4	11.5	9.3
Magnesium	3/3	(2)	8,580.0 - 26,600.0	17,826.7	18,700.0
Manganese	3/3	(2)	362.0 - 500.0	425.7	411.0
Mercury	1/3	<0.1	1.70	(4)	<0.1
Molybdenum	0/3	<2.4 - <5.0	ND	ND	<4.5
Nickel	3/3	(2)	9.4 - 19.5	15.1	13.7
Selenium	0/3	<0.2 - <5.0	ND	ND	<0.4
Silver	0/3	<0.1	ND	ND	<0.1
Vanadium	3/3	(2)	8.4 - 14.0	12.0	12.4
Zinc	3/3	(2)	13.4 - 37.3	25.0	13.5

See footnotes at end of table.

TABLE A-25
(Continued)

ND = Not Detected

(a) Calculated from single rounds of sampling at sites ASIT-10, W-10, and W-11.

(b) Positive hits in all sampling rounds; detection limits were not determined.

(c) When determining average concentrations, non-detects were assumed to be at the detection limit.

(d) Averages were not determined with less than two positive hits.

(e) Background values from site W-5.

TABLE A-26

CHEMICALS IDENTIFIED IN SEDIMENT OF PADDYS RUN BELOW THE CONFLUENCE

Chemical	Frequency of Detection (a)	Sample Detection Limits (a,b)	Detected Site-Influenced Concentrations (a)	Detected Background Levels (c)
ORGANICS (mg/kg):				
2-Butanone	1/1	(2)	0.012	<0.015
Di-n-butylphthlate	0/1	0.390	ND	0.039
bis-(2-Ethylhexyl)phthalate	1/1	(2)	0.400	0.460
2-Hexanone	1/1	(2)	0.011	<0.012
Methylene chloride	1/1	(2)	0.001	0.007
2-Propanone	1/1	(2)	0.014	0.018
INORGANICS (mg/kg):				
Aluminum	1/1	(2)	2,480.0	1,970.0
Antimony	0/1	<0.4	ND	ND
Arsenic	1/1	(2)	2.6	7.0
Barium	1/1	(2)	21.2	21.0
Beryllium	1/1	(2)	0.5	0.5
Cadmium	1/1	(2)	5.5	3.7
Chromium	1/1	(2)	16.9	18.3
Cobalt	1/1	(2)	5.2	4.9
Copper	1/1	(2)	11.5	10.8
Lead	1/1	(2)	4.6	9.3
Magnesium	1/1	(2)	35,900.0	18,700.0
Manganese	1/1	(2)	273.0	411.0
Mercury	0/1	<0.1	ND	ND
Molybdenum	0/1	<4.4	ND	ND
Nickel	1/1	(2)	17.9	13.7
Selenium	0/1	<0.5	ND	ND
Silver	0/1	<0.1	ND	ND
Vanadium	1/1	(2)	15.4	12.4
Zinc	1/1	(2)	15.3	13.5

See footnotes at end of table.

TABLE A-26
(Continued)

ND = Not Detected

(a) Data is from a single round at sampling site W-7. (Refer to Figure 3-5 for sampling location).

(b) Positive hits were detected in the only sampling round: detection limits were not determined.

(c) Background values from sampling location W-5. (Refer to Figure 3-5 for sampling location).

TABLE A-27

RADIONUCLIDES IN SEDIMENTS OF THE STORM SEWER OUTFALL DITCH
(REPORTED IN FMPC ENVIRONMENTAL MONITORING REPORTS)

RADIONUCLIDE	YEAR	CONCENTRATION RANGE (pCi/g)[a]	NUMBER OF SAMPLES	AVERAGE CONCENTRATION (pCi/g)
Uranium-234	1984	NA[b]	-[c]	NA
	1985	NA	-	NA
	1986	1.7-24.0	IU[d]	6.2
	1987	0.34-10.60	IU	2.76
	1988	0.81-25	IU	4.5
	1989[e]	<1.0[f]-19	24	4.3
Uranium-235/236	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.055-1.0[g]/0.024-1.5[h]	IU	0.24[g]/0.35[h]
	1987	0.04-0.59	IU	0.22
	1988	<0.05-2.6	IU	0.38
	1989	<1.0-1.8	24	<1.1
Uranium-238	1984	NA	-	NA
	1985	NA	-	NA
	1986	2.0-31.0	IU	7.8
	1987	0.44-10.3	IU	3.33
	1988	0.92-38	IU	5.6
	1989	<1.0-22	24	5.0
Uranium-total	1984	2.82-214.61	16	77.35
	1985	4.2-33.5	5	17.9
	1986	NA	-	NA
	1987	NA	-	NA
	1988	NA	-	NA
	1989			
Radium-223	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.10-0.64	IU	0.29
	1987	NA	-	NA
	1988	NA	-	NA
	1989	NA	-	NA
Radium-224	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.064-1.3	IU	0.57
	1987	<0.110-<2.96	IU	<0.763
	1988	0.32-1.7	IU	0.77
	1989	0.29-1.9	24	0.70

See footnotes at end of table.

TABLE A-27
(Continued)

RADIONUCLIDE	YEAR	CONCENTRATION RANGE (pCi/g)[a]	NUMBER OF SAMPLES	AVERAGE CONCENTRATION (pCi/g)
Radium-226	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.17-1.3	IU	0.68
	1987	0.549-1.92	IU	0.806
	1988	0.21-0.98	IU	0.72
	1989	0.39-2.4	24	0.76
Radium-228	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.30-1.8	IU	0.74
	1987	0.342-2.860	IU	0.901
	1988	0.35-1.8	IU	0.74
	1989	<0.33-2.0	24	0.68
Thorium-228	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.45-2.6	IU	0.84
	1987	0.29-2.81	IU	0.80
	1988	0.29-1.7	IU	0.64
	1989	<1.0-1.2	24	<1.0
Thorium-230	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.38-4.7	IU	1.3
	1987	0.34-1.1	IU	0.63
	1988	0.49-1.8	IU	0.91
	1989	<1.0-3.4	24	<1.5
Thorium-232	1984	NA	-	NA
	1985	NA	-	NA

See footnotes at end of table.

TABLE A-27
(Continued)

RADIONUCLIDE	YEAR	CONCENTRATION RANGE (pCi/g)[a]	NUMBER OF SAMPLES	AVERAGE CONCENTRATION (pCi/g)
	1986	0.13-3.4	IU	0.63
	1987	0.30-2.19	IU	0.75
	1988	0.30-1.7	IU	0.64
	1989	<1.0-1.1	24	<1.0
Plutonium-238	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.0023-0.17	IU	0.028
	1987	<0.020	IU	<0.020
	1988	<0.001-0.02	IU	<0.004
	1989	<0.012-1.0	24	<0.06
Plutonium-239/240	1984	NA	-	NA
	1985	NA	-	NA
	1986	0.0048-0.11	IU	0.024
	1987	<0.020-<0.030	IU	<0.02
	1988	<0.001-0.05	IU	<0.005
	1989	<0.012-1.0	24	<0.07
Technetium-99	1984	4.3-16.0	2	10.2
	1985	2.5-6.9	2	4.7
	1986	0.11-5.4	IU	1.5
	1987	<1.1-<1.3	IU	<1.2
	1988	<1.0	IU	<1.0
	1989	<0.90	24	<0.90

[a]Picocuries per gram
[b]Not analyzed
[c]Not applicable
[d]Information unavailable
[e]All 1989 data is draft
[f]Concentration less than stated detection limit
[g]U-235
[h]U-236

TABLE A-28

CHEMICALS IDENTIFIED IN SEDIMENT AT THE STORM SEWER OUTFALL DITCH

Chemical	Frequency of Detection	Sample Detection Limits (a)	Detected Site-Influenced Concentrations (b)	Detected Background Levels (c)
ORGANICS (mg/kg):				
2-Butanone	0/1	<0.012	ND	<0.015
Di-n-butylphthalate	0/1	<0.400	ND	0.039
bis(2-Ethylhexyl)phthalate	0/1	<0.400	ND	0.460
2-Hexanone	0/1	<0.012	ND	<0.012
Methylene chloride	1/1	(2)	0.016	0.007
2-Propanone	1/1	(2)	0.055	0.018
INORGANICS (mg/kg):				
Aluminum	1/1	(2)	8,830.0	1,970.0
Antimony	0/1	<0.1	ND	<0.1
Arsenic	1/1	(2)	5.4	7.0
Barium	1/1	(2)	56.7	21.0
Beryllium	1/1	(2)	0.4	0.5
Cadmium	0/1	<0.2	ND	3.7
Chromium	1/1	(2)	12.5	18.3
Cobalt	1/1	(2)	8.1	4.9
Copper	1/1	(2)	16.1	10.8
Lead	1/1	(2)	12.0	9.3
Magnesium	1/1	(2)	21,600.0	18,700.0
Manganese	1/1	(2)	399.0	411.0
Mercury	1/1	(2)	1.3	<0.1
Molybdenum	0/1	<0.1	ND	<4.5
Nickel	1/1	(2)	19.1	13.7
Selenium	0/1	<0.3	ND	<0.4
Silver	0/1	<0.1	ND	<0.1
Vanadium	1/1	(2)	14.4	12.4
Zinc	1/1	(2)	47.6	13.5

See footnotes at end of table.

TABLE A-28
(Continued)

ND = Not Detected

(a) Calculated from a single round of sampling and testing at sampling site ASIT-7.

(b) Chemical detected in the only sampling round; detection limits were not reported.

(c) Background values are from sampling location W-5.

TABLE A-29
RADIONUCLIDES IN SEDIMENTS OF THE GREAT MIAMI RIVER
(REPORTED IN ENVIRONMENTAL MONITORING REPORTS)

		ABOVE FMPC EFFLUENT LINE			BELOW FMPC EFFLUENT LINE, ABOVE PADDY'S RUN			BELOW PADDY'S RUN			FROM ABOVE FMPC EFFLUENT LINE TO BELOW PADDY'S RUN		
RADIONUCLIDE	YEAR	Concentration Range (pCi/g)a	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)
URANIUM-234	1984	NA b	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1985	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1986	–d	–d	–d	–d	–d	–d	–d	–d	–d	0.16 – 0.46	IU e	0.23
	1987	–d	–d	–d	–d	–d	–d	–d	–d	–d	0.38 – 0.75	IU	0.57
	1988	0.40 – 0.60	IU	0.53	0.60 – 0.91	IU	0.69	0.38 – 0.63	IU	0.51	–f	–f	–f
	1989 g	<1.0 h	3	<1.0	<1.0	3	<1.0	<1.0	2	<1.0	–f	–f	–f
URANIUM-235/236	1984	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1985	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1986	–d	–d	–d	–d	–d	–d	–d	–d	–d	0.0028–0.0090i/ 0.0027–0.031j	IU	0.0066i/0.01j
	1987	–d	–d	–d	–d	–d	–d	–d	–d	–d	<0.02 – <0.1	IU	<0.06
	1988	<0.01 – <0.05	IU	<0.04	<0.05	IU	<0.05	<0.05	IU	<0.05	–f	–f	–f
	1989	<1.0	3	<1.0	<1.0	3	<1.0	<1.0	2	<1.0	–f	–f	–f
URANIUM-238	1984	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1985	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1986	–d	–d	–d	–d	–d	–d	–d	–d	–d	0.16 – 0.61	IU	0.25
	1987	–d	–d	–d	–d	–d	–d	–d	–d	–d	<0.31 – <0.84	IU	<0.59
	1988	0.52 – 0.95	IU	0.69	0.63 – 0.85	IU	0.71	0.37 – 0.58	IU	0.48	–f	–f	–f
	1989	<1.0	3	<1.0	<1.0	3	<1.0	<1.0	2	<1.0	–f	–f	–f
URANIUM – TOTAL	1984	0.00 – 2.62	2	1.31	0.00 – 2.96	4	1.86	1.36	1	1.36	–f	–f	–f
	1985	0.8 – 1.5	4	1.1	0.6 – 2.6	4	1.6	0.7	1	0.7	–f	–f	–f
	1986	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1987	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1988	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1989	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
RADIUM-223	1984	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1985	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1986	–d	–d	–d	–d	–d	–d	–d	–d	–d	0.16 – 0.31	IU	0.22
	1987	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1988	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA
	1989	NA	–c	NA	NA	–c	NA	NA	–c	NA	NA	–c	NA

See footnotes at end of table.

943

206

TABLE A-29 (Continued)
RADIONUCLIDES IN SEDIMENTS OF THE GREAT MIAMI RIVER
(REPORTED IN ENVIRONMENTAL MONITORING REPORTS)

RADIONUCLIDE	YEAR	ABOVE FMPC EFFLUENT LINE			BELOW FMPC EFFLUENT LINE, ABOVE PADDY'S RUN			BELOW PADDY'S RUN			FROM ABOVE FMPC EFFLUENT LINE TO BELOW PADDY'S RUN		
		Concentration Range (pCi/g)a	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)
RADIUM-224	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.25 - 0.82	IU	0.48
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	<0.0739 - <0.892	IU	<0.502
	1988	0.37 - 0.81	IU	0.62	0.36 - 1.1	IU	0.69	0.24 - 0.75	IU	0.49	-f	-f	-f
	1989	0.53 - 0.71	3	0.61	0.34 - 0.46	3	0.38	0.46 - 0.56	2	0.51	-f	-f	-f
RADIUM-226	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.39 - 1.1	IU	0.75
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.116 - 1.01	IU	0.688
	1988	0.52 - 0.80	IU	0.71	0.50 - 1.0	IU	0.76	0.42 - 0.77	IU	0.59	-f	-f	-f
	1989	0.57 - 0.81	3	0.65	0.40 - 0.59	3	0.47	0.51 - 0.74	2	0.62	-f	-f	-f
RADIUM-228	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.19 - 0.78	IU	0.49
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	<0.147 - <0.764	IU	<0.515
	1988	0.39 - 0.73	IU	0.60	0.38 - 0.82	IU	0.54	0.21 - 0.77	IU	0.49	-f	-f	-f
	1989	<0.67 - 0.54	3	<0.57	0.28 - 0.43	3	0.34	0.33 - 0.59	2	0.46	-f	-f	-f
THORIUM-228	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.33 - 0.64	IU	0.51
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.41 - 1.07	IU	0.71
	1988	0.14 - 0.62	IU	0.38	0.12 - 0.46	IU	0.28	0.12 - 0.34	IU	0.23	-f	-f	-f
	1989	<1.0	3	<1.0	<1.0	3	<1.0	<1.0	2	<1.0	-f	-f	-f
THORIUM-230	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.15 - 1.3	IU	0.55
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.63 - 1.16	IU	0.92
	1988	0.36 - 0.87	IU	0.66	0.32 - 0.59	IU	0.44	0.33 - 0.54	IU	0.44	-f	-f	-f
	1989	<1.0 - 1.7	3	<1.2	<1.0	3	<1.0	<1.0	2	<1.0	-f	-f	-f

See footnotes at end of table.

TABLE A-29 (Continued)
RADIONUCLIDES IN SEDIMENTS OF THE GREAT MIAMI RIVER
(REPORTED IN ENVIRONMENTAL MONITORING REPORTS)

		ABOVE FMPC EFFLUENT LINE			BELOW FMPC EFFLUENT LINE, ABOVE PADDY'S RUN			BELOW PADDY'S RUN			FROM ABOVE FMPC EFFLUENT LINE TO BELOW PADDY'S RUN		
RADIONUCLIDE	YEAR	Concentration Range (pCi/g)a	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)	Concentration Range (pCi/g)	Number Of Samples	Average Concentration (pCi/g)
THORIUM-232	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.090 - 0.31	IU	0.21
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.33 - 1.08	IU	0.72
	1988	0.13 - 0.44	IU	0.32	0.10 - 0.47	IU	0.25	0.11 - 0.32	IU	0.22	-f	-f	-f
	1989	<1.0 - 1.1	3	<1.0	<1.0	3	<1.0	<1.0	2	<1.0	-f	-f	-f
PLUTONIUM-238	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.0047 - 0.032	IU	0.013
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	<0.01 - <0.05	IU	<0.03
	1988	<0.01	IU	<0.01	<0.01	IU	<0.01	<0.01	IU	<0.01	-f	-f	-f
	1989	<0.012	3	<0.012	<0.012	3	<0.012	<0.012	2	<0.012	-f	-f	-f
PLUTONIUM-239/240	1984	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1985	NA	-c	NA	NA	-c	NA	NA	-c	NA	NA	-c	NA
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.0018 - 0.0062	IU	0.0035
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	0.01 - 0.04	IU	0.03
	1988	<0.01	IU	<0.01	<0.01	IU	<0.01	<0.01	IU	<0.01	-f	-f	-f
	1989	<0.012 - 0.014	3	<0.013	<0.012	3	<0.012	<0.012	2	<0.012	-f	-f	-f
TECHNETIUM-99	1984	0.00	1	0.00	0.80 - 1.30	2	1.55	0.00	1	0.00	-f	-f	-f
	1985	0.00	1	0.00	0.00 - 4.9	3	2.1	NA	NA	NA	-f	-f	-f
	1986	-d	-d	-d	-d	-d	-d	-d	-d	-d	IU	IU	<0.51
	1987	-d	-d	-d	-d	-d	-d	-d	-d	-d	<1.1 - <1.4	IU	<1.3
	1988	<0.90	IU	<0.90	<0.90	IU	<0.90	<0.90	IU	<0.90	-f	-f	-f
	1989	<0.90 - 0.95	3	<0.94	<0.90 - 0.98	3	<0.93	<0.90	2	<0.90	-f	-f	-f

a = Picocuries per gram
b = Not analyzed
c = Not applicable
d = Specific locations on river not sampled
e = Information unavailable
f = Specific locations on river sampled
g = All 1989 data are draft
h = Concentration less than stated detection limit
i = U-235
j = U-236

TABLE A-30

SURFACE WATER SUMMARY DATA[a]
RADIONUCLIDES DETECTED
RI/FS SAMPLING

LOCATION	Stats	U-234[b]	U235/236	U-238	U-SUM	Ra-226	Ra-228	Tc-99	Pu-238	Pu-239/240	Th-228	Th-230	Th-232	U-Tot (ug/L)
GMR[c] ABOVE EFFLUENT	min	<1.0	<1.0	<1.0	0.00	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.00
	max	1.1	<1.0	<1.0	1.10	<1.0	<3.0	<92.6	<1.0	<1.0	<1.0	<1.0	<1.0	1.00
GMR BELOW EFFLUENT	min	<1.0	<1.0	<1.0	0.00	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.00
	max	1.9	<1.0	1.8	3.70	2.4	<3.8	<30.0	<1.0	<1.0	<1.8	<1.0	<1.0	5.00
GMR BELOW CON W/PR[d]	min	<1.0	<1.0	<1.0	0.00	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.00
	max	1.8	<1.0	2.0	3.80	<1.0	<5.0	<30.0	<1.0	<1.0	<2.6	1.3	<1.0	5.00
PR ABOVE SSOD[e]	min	1.2	<1.0	2.0	3.30	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.00
	max	5.0	<1.0	6.8	11.80	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	19.00
SSOD	min	<1.0	<1.0	<1.0	0.00	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.00
	max	15.9	<1.0	15.9	31.80	1.5	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	1829.00
PR BELOW SSOD	min	1.6	<1.0	4.0	5.6	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	9.00
	max	3.2	<1.0	6.1	10.10	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	20.00
MH[f]-175	min	153.0	16.5	168.0	337.5	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	715.00
	max	375.0	37.0	339.0	751.00	<1.0	5.5	21887.0	<1.0	<1.0	<1.0	1.2	4.7	1021.00
MISC. DITCHES	min	<1.0	<1.0	2.9	4.50	<1.0	<3.0	<30.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.00
	max	653.0	51.5	2840.0	3544.50	16.3	127.2	206.0	<1.0	<1.0	<1.0	<1.0	<1.0	9318.00

See footnotes at end of table.

TABLE A-30
(Continued)

---

[a]Surface water and sediment (Table A-31) samples were collected from similar locations. Refer to Figure 3-5 for sampling locations. Summary of the laboratory results consist of 199 surface water samples collected in 1988 and 1989.
[b]The results are presented in pCi/L with the exception of U-total (ug/L).
[c]Great Miami River
[d]Paddys Run
[e]Storm Sewer Outfall Ditch
[f]Manhole 175

TABLE A-31

SEDIMENT SUMMARY DATA[a]
RADIONUCLIDES DETECTED
RI/FS SAMPLING

Location	Stats	U-234[b]	U235/236	U-238	U-SUM	Ra-226	Ra-228	Tc-99	Pu-238	Pu-239/240	Th-228	Th-230	Th-232	U-Tot (ug/g)
GMR ABOVE	min	<.06	<.06	<.06	0.00	0.4	<0.5	<0.9	<0.6	<0.6	<0.6	<0.6	<0.6	<1.0
EFFLUENT	max	1.1	<.06	1.2	2.30	0.6	<0.5	<0.9	<0.6	<0.6	<0.6	1.0	0.8	3.00
GMR BELOW	min	<.06	<.06	<.06	0.00	0.4	<0.5	<0.9	<0.6	<0.6	<0.6	<0.6	<0.6	<1.0
EFFLUENT	max	0.7	<.06	0.8	1.50	0.7	<0.5	<0.9	<0.6	<0.6	<0.6	1.9	<0.6	3.0
GMR BELOW	min	<0.6	<0.6	<0.6	0.00	0.4	<0.5	<0.9	<0.6	<0.6	<0.6	<0.6	<0.6	<1.0
CON W/PR	max	0.7	<0.6	0.9	1.60	0.9	<0.5	<0.9	<0.6	<0.6	<0.6	1.0	<0.6	3.0
PR ABOVE	min	<.06	<.06	<.06	0.00	0.4	<0.5	<0.9	<0.6	<0.6	<0.6	<0.6	<0.6	1.00
SSOD	max	1.4	<.06	1.1	2.50	10.6	21.7	<0.9	<0.6	<0.6	<0.6	2.5	<0.6	4.00
SSOD	min	2.7	<0.6	1.4	2.70	0.4	<0.5	<0.9	<0.6	<0.6	<0.6	1.9	<0.6	4.53
	max	3.8	0.9	4.6	9.30	1.2	2.8	<0.9	<0.6	<0.6	<0.6	2.5	0.8	51.80
PR BELOW	min	<0.6	<0.6	2.8	5.50	0.5	<0.5	<0.9	<0.6	<0.6	<0.6	1.9	<0.6	1.00
SSOD	max	3.8	0.9	4.6	9.30	2.9	2.8	<0.9	<0.6	<0.6	<0.6	2.6	<0.6	9.00
MH-175	min	126.0	9.6	180.0	315.6	5.5	16.8	365.0	<0.6	<0.6	4.4	<0.6	2.2	595.00
	max	174.0	12.2	244.0	430.10	6.8	24.5	692.0	<0.6	<0.6	32.0	28.2	3.4	614.00
MISC.	min	1.3	<0.6	1.4	2.70	0.6	<0.5	<0.9	<0.6	<0.6	<0.6	2.5	0.8	4.00
DITCHES	max	1.3	<0.6	1.4	2.70	10.6	21.7	<0.9	<0.6	<0.6	<0.6	2.5	0.8	230.00

Notes:
[a]Sediment and surface water (Table A-30) samples were collected from similar locations. Refer to Figure 3-5 for sampling locations. Summary of the laboratory results consist of 142 sediment samples collected in 1988 and 1989.
[b]The results are presented in pCi/l with the exception of U-total (ug/g).

TABLE A-32
RADIONUCLIDE CONCENTRATIONS IN GARDEN PRODUCE AND AGRICULTURAL CROPS
(RI/FS SAMPLING)

PRODUCE/ CROP	NUMBER OF SAMPLES	LOCATION	RADIONUCLIDE TYPE AND CONCENTRATION RANGE (pCi/g)[a] CS-137	SR-90	U-234	U-235, -236	U-238	SUM OF U ACTIVITY
Okra	1	Indiana	<0.4[b]	<0.5	<0.6	<0.6	<0.6	-[c]
	3	FMPC Vicinity	<0.3-<0.5	<0.5	<0.6-1.4(1)[d]	<0.6	<0.6-0.8(1)	<0.6-2.2
Tomato	3	Indiana	<0.2-<0.4	<0.5	<0.6-2.5(2)	<0.6	<0.6-0.8(1)	<0.6-3.3
	4	FMPC Vicinity	<0.2-<0.3	<0.5	<0.6-0.8(1)	<0.6	<0.6	<0.6-0.8
Green Pepper	2	Indiana	<0.3	<0.5	<0.6	<0.6	<0.6	-
	3	FMPC Vicinity	<0.2	<0.5	<0.6-1.0(1)	<0.6	<0.6	<0.6-1.0
Potato (Flesh)	2	Indiana	<0.2	<0.5	<0.6	<0.6	<0.6	-
	1	FMPC Vicinity	<0.2	<0.5	<0.6	<0.6	<0.6	-
Potato (Peel)	2	Indiana	<0.2-<0.3	<0.5	<0.6-2.7(1)	<0.6-<1.4	<0.6-<1.4	<0.6-2.7
	1	FMPC Vicinity	<0.2	<0.5	<0.6	<0.6	<0.6	-
Soybean	2	Indiana	<0.2	<0.5	<0.6	<0.6	<0.6	-
	1	FMPC Vicinity	<0.2	<0.5	<0.6	<0.6	<0.6	-
Field Corn	2	Indiana	<0.2-0.3(1)	<0.5	<0.6-1.1(1)	<0.6	<0.6-1.0(1)	<0.6-2.1
	2	FMPC Vicinity	<0.2	<0.5	<0.6	<0.6	<0.6	-
Alfalfa	1	Indiana	<0.5	0.5(1)	2.4(1)	0.6(1)	1.1(1)	4.1
	1	FMPC Vicinity	<0.4	<0.5	1.2(1)	<0.6	<0.6	1.2
Cucumber	1	FMPC Vicinity	<1.1	<0.6	3.0(1)	<0.6	1.8(1)	4.8
Squash	1	FMPC Vicinity	<0.3	<0.5	<0.6	<0.6	<0.6	-
Cabbage	1	FMPC Vicinity	<0.2	<0.5	<0.6	<0.6	<0.6	-
Sweet Potato	1	FMPC Vicinity	<0.2	<0.5	<0.6	<0.6	<0.6	-
Pumpkin	2	FMPC Vicinity	<0.3-<0.4	<0.5	0.9-1.5(2)	<0.6	<0.6-0.8(1)	1.5-1.7

[a]Picocuries per gram.
[b]Concentration less than stated detection limit.
[c]All uranium isotopes below detection limit.
[d]Number of samples with detected concentrations.

TABLE A-33

URANIUM IN MILK[a]

YEAR	FMPC LOCATION[b]			CONTROL LOCATION[c]		
	FREQUENCY OF CONCENTRATION	AVERAGE CONCENTRATION	CONCENTRATION RANGE	FREQUENCY OF OCCURRENCE	AVERAGE CONCENTRATION	CONCENTRATION RANGE
1983	1/4	8.5×10^{-10} uCi/g[d]	<6.8×10^{-10}[e]-1.35×10^{-9} uCi/g	1/4	8.5×10^{-10} uCi/g	<6.8×10^{-10}-1.35×10^{-9} uCi/g
1984	0/5	<0.68 pCi/L	-[f]	0/5	<0.68pCi/L	-
1985	0/3	<0.68 pCi/L	-	0/3	<0.68 pCi/L	-
1986	0/6	<6.8 pCi/L	-	0/6	<6.8 pCi/L	-
1987	NA[g]	<0.7 pCi/L	NA	NA	<0.7 pCi/L	NA
1988	1/12	0.7 pCi/L[d]	<0.7-1.0 pCi/L	0/12	<0.7 pCi/L	-

[a]FMPC Environmental Monitoring Reports 1983-1988.
[b]Dairy farm adjacent to the FMPC.
[c]Dairy farm in Kentucky approximately 30 km southeast of the FMPC in 1983-1986; Dairy farm in Indiana approximately 35 km west of the FMPC in 1987 and 1988.
[d]Average concentration calculated using the detection limit for those samples with uranium concentrations below detectable levels.
[e]Concentration less than stated detection limit.
[f]No detectable quantity of uranium present in samples.
[g]Not available.

TABLE A-34

RADIONUCLIDE CONCENTRATIONS IN VEGETATION AND SOIL ON THE FMPC (RI/FS SAMPLING)

Radionuclide	Parameter	Soil	Grass Leaves	Grass Roots	Forb Leaves	Forb Roots
Total Uranium	Frequency of Detection	28/28	15/30	22/30	12/18	15/18
	Concentration Range (pCi/g)[a]	2.7-35.6	0.7-15.7	0.6-31.9	0.6-6.4	1.5-35.5
	Average Concentration[b]	13.1	3.7	9.9	3.2	11.2
Cesium-137	Frequency of Detection	23/28	1/26	19/27	1/18	3/18
	Concentration Range (pCi/g)	<0.2-1.6	<0.2-0.4	<0.2-1.4	<0.2-0.4	<0.2-0.8
	Average Concentration[c] (pCi/g)	0.7	0.3	0.5	0.3	0.4
Strontium-90	Frequency of Detection	20/26	1/30	1/31	3/18	2/18
	Concentration Range (pCi/g)	<0.5-2.5	<0.5-0.6	<0.2-0.8	<0.5-0.9	<0.5-0.7
	Average Concentration[c] (pCi/g)	0.9	0.7	0.5	0.6	0.6

[a]Picocuries per gram
[b]Mean of detected concentrations calculated
[c]Mean calculated using detected concentrations and the stated detection limit for those samples with undetected concentrations

TABLE A-35

RADIONUCLIDES IN MAMMAL TISSUE FROM THE FMPC (RI/FS SAMPLING)

SAMPLE	TYPE	SITE	RADIONUCLIDE TYPE AND CONCENTRATION RANGE (pCi/g)						
			CS-137	SR-90	TC-99[a]	U-234, -235	U-236	U-238	SUM OF U ACTIVITY
Opossum	Muscle	N. Pine Plantation	<0.2	<0.5	-	<0.2	<0.2	<0.2	-
Opossum	Organs	N. Pine Planation	<0.2	<0.5	-	<0.6	<0.6	<0.6	-
Opossum	Muscle[c]	-	<0.3	<0.5	<1.0	<0.6	<0.6	<0.6	-
Cottontail	Muscle[c]	-	<0.7	<0.5	<0.9	<0.6	<0.6	<0.6	-
Small Mammal[b] (composite)	Carcasses	Waste Pit No. 5	<0.2	<0.1	-	<0.6	<0.6	<0.6	-
Small Mammal[b] (composite)	Organs	Waste Pit No. 5	<1.1	<2.5	-	8.3	1.1	8.6	18.0
Small Mammal[b,c]	Carcasses	-	<0.2	<0.5	ISFA[d]	<0.6	<0.6	<0.6	-
Deer	Kidney[c]	-	<0.2	<0.5	<0.9	<0.6	<0.6	<0.6	-
Deer	Liver[c]	-	<0.2	<0.5	<0.9	<0.6	<0.6	<0.6	-

[a]Technetium-99 analyzed for 1988 samples only.

[b]Composite small mammal samples of white-footed mouse and short-tailed shrew.

[c]1988 samples.

[d]Insufficient sample for analysis.

983

TABLE A-36

RADIONUCLIDE CONCENTRATIONS IN WETLAND PLANTS ON THE FMPC (RI/FS SAMPLING)

SAMPLE	RADIONUCLIDE TYPE AND CONCENTRATION RANGE (pCi/g)						
	CS-137	SR-90	TC-99	U-234	U-235, -236	U-238	SUM OF U ACTIVITY
Algae	<0.2[a]	<0.5-0.9	<0.9	<0.6	<0.6	<0.6	-[b]
Cattail Leaf	<0.2-<0.6	<0.5-<1.0	NA[c]	<0.6-1.4	<0.6	<0.6-1.9	<0.6-3.3
Cattail Root	<0.2-<0.3	<0.5-<0.9	NA	<0.6-2.6	<0.6	<0.6-3.8	<0.6-6.4
Sedge Leaf	<0.2	<0.7-<1.3	NA	<0.6	<0.6	<0.6	-
Grass Leaf	<0.2-<0.3	<0.5-<0.6	1.9	<0.6	<0.6	<0.6	-
Grass Root	<0.2	<0.5	<0.9	0.9-7.7	<0.6-1.3	4.2-22.3	5.1-31.3

[a]Concentration less than stated detection limit.

[b]All uranium isotopes below detection limit.

[c]Not analyzed.

216

TABLE A-37

RADIONUCLIDES IN AQUATIC FAUNA (RI/FS SAMPLING)

SAMPLE	LOCATION	RADIONUCLIDE TYPE AND CONCENTRATION RANGE (pCi/g)						
		CS-137	SR-90	TC-99	U-234	U-235, -236	U-238	SUM OF U ACTIVITY
Benthic Macroinvertebrates[a]	Paddys Run	<0.2[b]-<2.0	<0.5-<3.7	<0.9	<0.6-3.6	<0.6-<1.5	<0.6-2.8	<0.6-6.4
(Crayfish)	Paddys Run	<0.24-<4.00	<1.2-<2.6	NA	1.5-3.6	<0.6-<1.1	<0.6-1.5	1.5-5.1
	Great Miami River	<0.2-<2.1	<1.1-<4.7	<0.9	<0.6-3.4	<0.6-<2.2	<0.6-3.1	<0.6-6.5
Fish								
Minnow	Paddys Run	<0.2-<0.42	<0.5	<0.6-<1.6	<0.6	<0.6	<0.6	-[c]
White Sucker	Paddys Run	<0.20-<0.41	<0.5	NA[d]	<0.6-0.6	<0.6	<0.6	<0.6-0.6
Creek Chub	Paddys Run	<0.17-<1.90	<0.5-<0.7	NA	<0.6-1.0	<0.6	<0.6-0.7	<0.6-1.7
Bluegill	Paddys Run	<0.19-<1.23	<0.5-<3.32	NA	<0.6-2.4	<0.6-<1.1	<0.6-1.3	<0.6-3.7
Gizzard Shad	Great Miami River	<0.2-<0.3	<0.5	NA	<0.6	<0.6	<0.6	-
Channel Catfish	Great Miami River	<0.2	<0.5	NA	<0.6	<0.6	<0.6	-
Minnow	Great Miami River	<0.2	<0.5	NA	<0.6	<0.6	<0.6	-
Catfish (fillets)	Great Miami River	<0.3-<0.7	<0.5	NA	<0.6	<0.6	<0.6	-
Catfish (bones and entrails)	Great Miami River	<0.2	<0.5	NA	<0.6	<0.6	<0.6	-
Freshwater Drum	Great Miami River	<0.2	<0.5	NA	<0.6	<0.6	<0.6	-
Smallmouth Bass	Great Miami River	<0.3	LIA[e]	NA	LIA	LIA	LIA	-
Green Sunfish	Great Miami River	<0.3	<0.5	NA	<0.6	<0.6	<0.6	-
Longear Sunfish	Great Miami River	<0.3	<0.5	NA	<0.6	<0.6	<0.6	-

[a]Benthic macroinvertebrates are aquatic organisms, including insects, insect larvae, annelid worms, and snails.

[b]Concentration less than the stated detection limit.

[c]All uranium isotopes below detection limit.

[d]Not analyzed.

[e]Lost in analysis.

APPENDIX B
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

B.1.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

B.1.1 INTRODUCTION

The U.S. Department of Energy (DOE) must generally comply with all provisions of federal environmental statutes and regulations, as well as all applicable state and local requirements. In performing the Remedial Investigation/Feasibility Study (RI/FS) and subsequent remedial actions for Operable Unit 1 within the Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act of 1986/National Contingency Plan (CERCLA/SARA/NCP) framework, the Feed Materials Production Center (FMPC) is required to comply with all applicable or relevant and appropriate requirements. The purpose of this appendix is to list potential ARARs and/or their sources.

Applicable requirements are those federal and state regulatory requirements that directly and fully address or regulate the hazardous substance, pollutant, contaminant, action being taken, or other circumstance at a CERCLA site. Examples of federal statutes specifically cited in CERCLA from which requirements may apply include the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Marine Protection Research and Sanctuaries Act (MPRSA). Relevant and appropriate requirements are those federal and state human health and environmental regulatory requirements that address problems or situations sufficiently similar to those encountered at CERCLA sites and are appropriate to the circumstances of release or threatened release, so that their uses are well suited to the particular site. In such cases, application of these requirements would be relevant and appropriate although not mandated by law. Relevant and appropriate requirements are intended to carry the same weight as applicable requirements.

B.1.2 POTENTIAL ARARs FOR OPERABLE UNIT 5

In accordance with current EPA guidance, ARARs are to be progressively developed and applied on a site-specific basis as the RI/FS proceeds. The initial step in the process entails the listing of all potential ARARs for the remedial action process at the subject site. A comprehensive listing of potential ARARs for all of the operable units for the FMPC was completed as part of the Feasibility Study Work Plan. The potential ARARs for the FMPC were categorized into the following EPA-recommended classifications:

- Chemical-Specific ARARs - Usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values for each chemical of concern. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the environment.

943

- Location-Specific ARARs - Restrictions placed on the concentration of a chemical or the conduct of activities solely because they occur in special locations.

- Action-Specific ARARs - Usually technology- or activity-based requirements or limitations on actions taken with respect to waste management and site cleanup.

A brief discussion of each of the primary federal and state of Ohio ARARs, along with pertinent agency-issued criteria, advisories, and guidance is given below. A summary listing of potential ARARs is found in Table B-1.

Federal ARARs

Federal ARARs and other criteria, advisories, or guidelines, are drawn from and include the following:

- Safe Drinking Water Act (42USC300f, et. seq. and 40CFR141 to 149) - Establishes Maximum Contaminant Levels (MCLs) which are enforceable standards for chemicals in public drinking water supplies. They not only consider health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. The EPA has recently proposed MCL goals (MCLGs) for several organic and inorganic compounds in drinking water. MCLGs are nonenforceable guidelines that do not consider the technical feasibility of contaminant removal. The SDWA also authorizes the following programs:

  - The Underground Injection Control (UIC) Program
  - The Sole-Source Aquifer Program
  - The Wellhead Protection Program

- Toxic Substances Control Act (15USC2601, et. seq. and 40CFR702 to 799) - Regulates the use and disposal of polychlorinated biphenyls (PCBs) and asbestos.

- Resource Conservation and Recovery Act (42USC6901, et. seq. as amended and 40CFR260 to 279) - Establishes the criteria and standards for identification, management, and disposal of hazardous waste.

- Federal Water Pollution Control Act, As amended by the Clean Water Act (33USC1251, et. seq. and 40CFR104 to 140) - Governs point-source discharges through the National Pollutant Discharge Elimination System (NPDES), dredge and fill activities which may degrade or disturb wetlands or other aquatic habitats, and oil or hazardous substance spills to waters of the United States.

- Ambient Water Quality Criteria - Criteria for 64 chemicals were established in 1980, pursuant to Section 304(a)(1) of the CWA. AWQC are available for the protection of human health from exposure to chemicals in drinking water, from ingestion of aquatic biota, and for the protection of fresh-water and salt-water aquatic life.

943

- Regulation of Activities Affecting Waters of the U.S. (33CFR320 to 329) - U.S. Army Corps of Engineers (COE) regulations that are applicable to wetlands and navigable waters.

- Occupational Safety and Health Act (29USC651, et. seq. and 29CFR1904, 29CFR1910, and 29CFR1926) - Provides occupational safety and health requirements applicable to workers engaged in on-site field and remediation activities.

- Endangered Species Act of 1978 (16USC1531, et. seq.) - Provides for consideration of the impacts of remedial actions on endangered and threatened species.

- Fish and Wildlife Coordination Act (16USC661, et. seq. and 40CFR 6.302) - Provides for consideration of the impacts on wetlands and protected habitats.

- Fish and Wildlife Improvement Act of 1978 (16USC742a) - Provides for consideration of the impacts on wetlands and protected habitats.

- Clean Air Act (42USC4701, et. seq. and 40CFR61, Subparts H and Q) - Through the National Ambient Air Quality Standards (NAAQS) it identifies primary and secondary standards for six "criteria" pollutants, and through the National Emission Standards for Radionuclides Emissions from DOE facilities (40CFR61), it provides annual exposure limits from air emissions from DOE facilities.

- EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192) - Applies to the control of residual radioactive material at designated processing or repository sites under Section 108 of the Uranium Mill Tailings Radiation Control Act of 1978 and to restoration of such sites following any use of subsurface minerals under Section 104(h) of the above-referenced act.

- NRC Regulations for Standards for Protection against Radiation (10CFR20) - Establishes standards for protection against radiation hazards arising out of activities under licenses issued by the U.S. Nuclear Regulatory Commission (NRC) and issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974.

- NRC Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content (10CFR40, Appendix A) - Establishes technical and long-term site surveillance criteria relating to siting, operation, decontamination, decommissioning, and reclamation of mills and tailings or waste systems and sites at which such mills and systems are located.

- The Atomic Energy Act of 1954 (42USC2011, as amended) - Authorizes the conduct of atomic energy activities.

943

- Licensing Requirements for Land Disposal of Radioactive Waste (10CFR61) - Establishes procedures and criteria for the land disposal of radioactive wastes.

- EPA Regulations for National Emission Standards for Radon Emission from DOE Facilities (40CFR61, Subpart Q) - Applies to design and operation of all storage and disposal facilities for radium-containing material that are owned or operated by DOE that emit Radon-222.

State of Ohio ARARs

State of Ohio ARARs and other criteria, advisories, or guidance include the authority of the Ohio Environmental Protection Agency (OEPA) to manage federal environmental programs. OEPA shares several responsibilities with other Ohio agencies including the Department of Health, the Department of Natural Resources (ODNR), and the Public Utilities Commission:

- Ohio Water Pollution Control Act (ORC Chapter 6111) - OEPA has the authority to administer all of the federally mandated water discharge programs, including the National Pollutant Discharge Elimination System (NPDES) programs for all source categories (OAC3745-33-01 through 3745-33-05), and an effective pretreatment program (OAC3745-3). ORC 6111 also prohibits pollution of water of the state.

- Solid and Hazardous Waste Disposal Law (OAC Chapter 3734) - OEPA has been developing extensive solid and hazardous waste regulations (OAC3745 Chapters 27-70). These programs are administered by the Solid and Hazardous Waste Division of OEPA.

- Water Quality Standards (OAC3745-1) - Ohio has developed water quality standards applicable to state surface water (OAC3745-1-04), an antidegradation policy (OAC3745-1-05) and has designated water use criteria for all major surface water bodies (OAC3745-1-07 to 32).

- Drinking Water Rules - The rules for public drinking water are set forth by OAC3745-81-01 to 55, and includes MCLs. OAC3745-82 sets secondary contaminant standards.

- Water Well Installation - For new wells intended for human consumption, well installation is regulated under OAC3745-9 by OEPA and ODNR. The abandonment of testing holes and wells is regulated by OAC 3745-9-0.

- The Underground Injection Well Control Program - Approvals for injection wells are required from the ODNR and OEPA. The requirements for permits to inject fluids via wells are set forth in OAC3745-34.

- Water System - Authority to establish and enforce rules regarding private water systems is granted to the Department of Health under OAC3701. The Department of Health governs plan approvals, procedures, construction, and abandonment for private water systems

222

943

(OAC3701-38). Community and public water supply systems are governed and approved by the OEPA under OAC3745-83 to 95.

- Radiation Standards - Standards for protection and handling of equipment and materials associated with ionizing radiation are governed by rules set by the Department of Health under OAC3701-38.

- Air Pollution Control (ORC3704, OAC3745-15, OAC3745-17) - Establishes the authority of the Ohio EPA to regulate and control air pollution within the state under ORC 3704.03. Requires person responsible for any air contaminant source to install, employ, maintain, and operate such emissions, ambient air quality, meteorological, or other monitoring devices or methods as director prescribes. Requires the sampling of emissions at such locations, intervals and in a manner which the director prescribes. Requires the maintenance of records and filing of periodic reports with the director on the location, size, and height of emissions outlets, as well as the rate, duration, and composition of emissions.

B.1.3 GUIDANCE TO BE CONSIDERED (TBC)

Because ARARs may not exist or may not be sufficient to protect human health and the environment at a CERCLA site, it is necessary to evaluate nonlegally binding or promulgated criteria, advisories, guidance, or policies for protective cleanup levels when determining cleanup requirements or designing a remedy. EPA and support agencies may, as appropriate, identify other advisories, criteria, or guidance to be considered for a particular remediation activity. This to be considered (TBC) category consists of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that are not ARARs.

The application of the ARARs to Operable Unit 5 at the FMPC is complicated by the fact that the DOE and radionuclides (particularly uranium) have been exempt from some environmental regulations. From a radiological standpoint, the DOE has been primarily self-regulating for environmental activities, and has established its own policies for environmental monitoring, waste disposal, and limits of exposure to employees and the public. EPA regulations regarding the handling and disposal of wastes containing radionuclides are under programs set up by the Uranium Mill Tailings Act and the NRC. It should also be noted that DOE orders are not promulgated requirements but fall under the category of TBCs.

A brief discussion of each of the primary Federal TBCs presently being considered is given below.

FEDERAL TBCs

943

- Health Effects Assessments - Presents toxicity data for specific chemicals for use in public health assessments. Also considered applicable are Cancer Slope Factors (CSFs) and referenced doses provided in the Human Health Evaluation Manual (EPA 1989).

- Groundwater Protection Strategy - Documents EPA policy to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater:

  - Class 1 - Special Groundwaters: Waters that are highly vulnerable to contamination and are either irreplaceable or ecologically vital sources of drinking water.

  - Class 2 - Current and Potential Sources of Drinking Water and Waters Having other Beneficial Uses: Waters that are currently used or that are potentially available for use.

  - Class 3 - Groundwater not a Potential Source of Drinking Water and of Limited Beneficial Use: Class 3 groundwater units are further subdivided into the following two subclasses:

    a. Subclass 3A includes groundwater units that are highly to intermediately interconnected to adjacent groundwater units of a higher class and/or surface waters. They may, as a result, be contributing to the degradation of the adjacent waters. They may be managed at a similar level as Class 2 groundwaters, depending upon the potential for producing adverse effects on the quality of adjacent waters.

    b. Subclass 3B is restricted to groundwater units characterized by a low degree of interconnection to adjacent surface waters or other groundwater units of a higher class within the Classification Review Area. These groundwaters are naturally isolated from sources of drinking water in such a way that there is little potential for producing adverse effects on quality. They have low resource value outside of mining or waste disposal.

- DOE Order for CERCLA Program (5400.4) (Draft) - Provides direction for DOE to implement a CERCLA program.

- DOE Order for Radiological Effluent Monitoring and Environmental Surveillance (5400.XY)(Draft) - Establishes requirements and guidance for radiological effluent monitoring and environmental surveillance conducted in support of DOE Operations and Activities.

- DOE Order for Radiation Protection of the Public and the Environment (5400.5) (February 8, 1990) - Establishes standards and requirements with respect to protection of the public and the environment against radiation.

- DOE Order for Hazardous and Radioactive Mixed Waste Management (5480.2) (December 13, 1982) - Establishes hazardous waste

943

management procedures for facilities operated under authority of the Atomic Energy Act of 1954, as amended.

- DOE Order for Environmental Protection, Safety, and Health Protection Information Reporting Requirements (5484.1) (February 24, 1981) - Establishes the requirements and procedures for reporting and investigating matters of environmental protection, safety, and health protection significant to DOE operations.

- DOE Order for Quality Assurance (5700.6B) (September 23, 1986) - Establishes DOE's quality assurance program.

- DOE Order for Radioactive Waste Management (5820.2A) (September 26, 1988) - Establishes policies and guidelines for the management of radioactive waste and contaminated facilities.

- DOE Order for Radiation Protection for Occupational Workers (5480.11) (December 21, 1988) - Establishes standards and requirements with respect to protection of the occupational worker against radiation.

- DOE Plan for Implementing EPA Standard for UMTRA Sites (UMTRA - DOE/AL-163) (January 1984) - Presents guidance for implementing EPA standards on uranium mill tailing remedial action sites.

- DOE Technical Approach Document - Revision II (UMTRA-DOE/AL 050425.0002) (December 1989) - Presents the technical approach for remediation of uranium mill tailings remedial action sites.

- DOE Remedial Action Planning and Disposal Cell Design (UMTRA-DOE/AL 400503) (January 1989) - Presents guidance for complying with the proposal 40CFR192 for planning and disposal cell design for uranium mill tailing remedial action sites.

- DOE Project Surveillance and Maintenance Plan (UMTRA-DOE/AL 350124) - Presents guidance for surveillance and maintenance of uranium mill tailings remedial action sites.

- Executive Order 11988 - Presents requirements for federal agencies to protect floodplains.

- Executive Order 11990 - Presents requirements for federal agencies to protect wetlands.

- NRC Regulatory Guide for Termination of Operating Licenses for Nuclear Reactors (NRC Regulatory Guide 1-86) (June 1974) - Establishes acceptable surface radioactivity contamination levels for releases of equipment and facilities for unrestricted use.

- 40 CFR 141 - Proposed Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) - Nonenforceable levels of protection for contaminants in drinking water.

A summary listing of TBCs is found in Table B-1.

B.4 SUMMARY

The establishment of final federal and state ARARs and TBCs for uranium and other constituents found in the operable unit for the evaluation of remedial action alternatives for Operable Unit 5 at the FMPC will be a progressive, multi-step process involving interactive discussions among DOE, EPA, and OEPA. The critical application of the final ARARs will be performed during the detailed analysis of alternatives. The ARARs, in conjunction with the baseline risk assessment, will assist in the determination of the cleanup levels required to adequately protect public health and the environment at the FMPC.

TABLE B-1.
SUMMARY LIST OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND GUIDANCE TO BE CONSIDERED

Chemical-Specific ARARs

Requirement	Description
Resource Conservation and Recovery Act (RCRA), (40CFR260-272)	Sets standards applicable to hazardous waste treatment, storage, and disposal
RCRA/Solid Waste (40CFR240-257)	Sets standards applicable to solid waste treatment, storage, and disposal
Safe Drinking Water Act (40CFR141-149) a. Maximum contaminant levels (MCLs) b. Maximum contaminant level goals (MCLGs)	Remedial actions may provide cleanup to the MCLs considered pursuant to SARA Section 121(d)(2)(A)(ii)
EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192)	Establishes cleanup limits for uranium and thorium mill tailings in soil and groundwater
Clean Air Act (42USC7401, et. seq.) a. National Ambient Air Quality Standards (NAAQS) for six criteria pollutants (40CFR50)	Identifies primary and secondary standards for six "criteria pollutants" (i.e., lead, particulates)
b. National Emission Standards for Radionuclides Emissions from DOE Facilities (40CFR61 Subpart H)	Provides annual limits of 10 mrem/yr (whole body) for air emissions (except radon) from DOE facilities
NRC Licensing Requirements for Land Disposal of Radioactive Waste (10CFR61)	Provides for protection of the general population from releases of radioactivity (<25 mrem/yr)
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	Establishes dose limits in unrestricted areas (10CFR20.105-106) and for waste disposal (10CFR20.301-302)
NRC Regulations for Standards for Concentrations Protection (10CFR20)	Sets standards applicable to solid waste treatment, storage, and disposal

TABLE B-1.
(Continued)

Chemical-Specific ARARs	
Requirement	Description
Ohio Regulations	
a. Air Pollution	Prevention of air pollution nuisance
OAC3745-15-07	Escape, releases, emissions to open air
OAC3745-17-07	Nondegradation policy
OAC3745-17-05	Particulate emissions to air
OAC3745-17-07	Emissions of organics to air
OAC3745-17-08	Fugitive dust emissions
OAC3745-21-07	Air quality
b. Water Pollution OAC3745-81	Drinking water rules, sets MCLs for gross alpha, beta and radium-226 and radium-228
OAC3745-31	Set requirements for wastewater treatment facilities
OAC3745-1	Water Quality standards, 3745-01-4(D) sets the criterion applicable to all waters, 3745-01-05 sets forth the antidegradation policy for state waters, 3745-01-07 presents specific surface water quality criteria for both acute and chronic effects on aquatic organisms, 3745-01-21 describes use designations for the Great Miami River, 3745-1-32(c)(9) set standards for radioactive materials in receiving waters of the Ohio River
c. Other Regulations OAC3701-38	Ohio Radiation Protection Standards provide concentration limits for discharge of radioactive materials into air or water in unrestricted areas

TABLE B-1.
(Continued)

Location-Specific ARARs	
Requirements	Description
Rivers and Harbors Act of 1899 (33CFR320 to 327)	Remedial alternatives may effect the Great Miami River
Ohio Location Standards (OAC3745-54-18)	Governs the location of hazardous waste treatment, storage, or disposal with respect to floodplains
Regulations of activities affecting waters of the U.S. (33CFR320 to 329)	COE regulations apply to both wetlands and navigable (33CFR320-329), and for Ohio (OAC3745-32) waters
Fish and Wildlife Coordination Act (40CFR6.302)	Provides for coordination of the impacts on wetlands and protected habitats

TABLE B-1.
(Continued)

Action-Specific ARARs	
Requirements	Description
Resource Conservation and Recovery Act (RCRA) (40CFR260-272)	Sets standards applicable to hazardous waste treatment, storage, and disposal
RCRA/Solid Waste (40CFR240-257)	Sets standards applicable to solid waste treatment, storage, and disposal
Clean Water Act Ambient Water Quality Criteria (40CFR104-140)	Alternatives include discharge to surface waters
NRC Licensing Requirements for Land Disposal of Radioactive Waste (10CFR61)	Provides criteria for siting, decontamination, decommissioning, and disposition of uranium tailings and wastes (Appendix A)
NRC Regulations for Licensing of Source Material (10CFR40)	Provides requirements for siting, design, operation, closure, and control after closure for radioactive waste disposal facilities
EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192)	Provides standards for control of residual radioactive materials from inactive uranium processing sites
Ohio General Radiation Protection Standards (OAC3701 to 70)	Applies to all facilities that receive, possess, use, store, transfer, etc., any source of radiation
Ohio Radiation Protection Standards (OAC3701-38)	Applies to all facilities that receive, possess, use, store, transfer, etc., any source of radiation
Hazardous Waste Transport (OAC3745-53-11)	Remedial alternatives may include off-site transport
Air Pollution Nuisances Prohibited (OAC3745-15-07)	Prohibits air emissions which could be constituted as a public nuisance
Nuisance Prevention (ORC 3767)	Prohibits noxious exhalation or smells, obstructions or pollution of water courses, or other nuisances
Water Pollution Prevention (ORC6111)	Prohibits pollution of waters of the state.

943

TABLE B-1.
(Continued)

TBCs	
Requirements	Description
Executive Order 11988 Floodplain Management	Provides considerations for management of floodplain areas
Executive Order 11990 Protection Of the Wetlands	Provides considerations for protection of wetlands
Radioactive Waste Management (DOE Order 5820.2A)	Sets requirements for management of radioactive wastes at DOE facilities
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Sets requirements for protection of the public and the environment from radioactive materials at DOE facilities
CERCLA Program (DOE Order 5400.4) (Draft)	Provides direction for DOE to implement a CERCLA program
Hazardous and Radioactive Mixed Waste Management (DOE Order 5480.2) (December 13, 1982)	Establishes hazardous waste management procedures for facilities operated under authority of the Atomic Energy Act of 1954, as amended
Plan for Implementing EPA Standards for UMTRA Sites (UMTRA-DOE/AL-163)	Presents guidance for implementing EPA standards on uranium mill tailings remedial action sites
Technical Approach Document (UMTRA-DOE/AL 050425)	Presents the technical approach used by DOE for remediation of uranium mill tailings remedial action sites
Remedial Action Planning and Disposal Cell Design (UMTRA-DOE/AL 400503)	Presents guidance for complying with 40CFR192 for planning and disposal cell design for uranium mill tailings remedial action sites
Project Surveillance and Maintenance Plan (UMTRA-DOE/AL 350124)	Presents guidance for surveillance and maintenance of uranium mill tailings remedial action sites
Minimum Technology Guidance for Final Covers on Hazardous Waste Landfills and Surface Impoundments (USEPA)	Presents guidance for final covers of hazardous waste landfills and surfact impoundments