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REMEDIAL INVESTIGATION REPORT FOR OPERABLE UNIT 2 ***FINAL*** JANUARY 21, 1995 - VOLUME 1 OF 6 - TABLE OF CONTENTS, SECTIONS 1-7 AND REFERENCES

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REPORT

REMEDIAL INVESTIGATION REPORT FOR OPERABLE UNIT 2

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 1 OF 6
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JANUARY 21, 1995

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

FINAL

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LIST OF ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ASI	Advanced Sciences, Inc.
ASL	Analytical Support Level
ASTM	American Society for Testing and Materials
BDN	bio-denitrification
BOB	bottom of boring
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CIS	Characterization Investigation Study
CLP	Contract Laboratory Program (EPA)
cm/s	centimeter/second
COA	Certificate of Analysis
COE	U.S. Army Corps of Engineers
COC	contaminant of concern
COPC	constituent of potential concern
CPC	contaminant of potential concern
CSM	conceptual site model
CT	central tendency
CWA	Clean Water Act
DCR	Document Change Request
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DQO	data quality objective
EIS	environmental impact statement
EM	electromagnetic
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
ERDA	U.S. Energy Research and Development Administration
ERMC	Environmental Restoration Management Contract
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
FEMP	Fernald Environmental Management Project

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

FERMCO	Fernald Environmental Restoration Management Company
FFCA	Federal Facility Compliance Agreement
FID	flame ionization detector
FIDLER	field instrument for detecting low-energy radiation
FMPC	Feed Materials Production Center
FR	Federal Register
FS	feasibility study
ft/yr	feet/year
GC/MS	gas chromatograph/mass spectrometry
GFAA	Graphite Furnace Atomic Absorption
GIS	Geographic Information System
GPR	ground penetrating radar
HI	hazard index
HQ	hazard quotient
HSL	Hazardous Substance List
HWMU	hazardous waste management unit (RCRA)
ICAP	Inductively Coupled Atomic Plasma
ILCR	incremental lifetime cancer risk
IT	IT Corporation
μg/g	microgram/gram
μg/L	microgram/liter
μg/kg	microgram/kilogram
μm	micrometer
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MEK	2-butanone (synonym: methyl ethyl ketone)
mg/kg	milligram/kilogram
mg/L	milligram/liter
MSL	mean sea level
MUSLE	Modified Universal Soil Loss Equation
NAD	North American Datum
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEPA	National Environmental Policy Act
NLO	National Lead (Company) of Ohio
NOAA	National Oceanic and Atmospheric Administration

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
O&M	operations and maintenance
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
OEPA	Ohio Environmental Protection Agency
ORAU	Oak Ridge Associated Universities
PAH	polynuclear aromatic hydrocarbon
PC	personal computer
PCB	polychlorinated biphenyls
pCi/g	picoCuries/gram
pCi/L	picoCuries/liter
PIC	products of incomplete combustion
PID	photoionization detector
PP	proposed plan
PPE	personal protective equipment
ppm	parts per million
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RA	risk assessment
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RFA/CC	request for analysis/chain of custody
RfD	reference dose
RFI	RCRA Facility Investigation
RI	remedial investigation
RI/FS	Remedial Investigation/Feasibility Study
RM	river mile
RME	reasonable maximum exposure
RMI	Reactive Metals, Inc.
ROD	record of decision
RSE	Removal Site Evaluation
SAP	Sampling and Analysis Plan

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

SARA	Superfund Amendment and Reauthorization Act of 1986
SAR/CR	site-wide analysis request/custody record
SC/DM	Site Characterization/Data Management
SCQ	Site-Wide CERCLA Quality Assurance Project Plan
SDWA	Safe Drinking Water Act
SED	Site-wide Environmental Database
SHPO	State Historic Preservation Officer
SPA	scintillation detector
SR	State Route
SVOC	semivolatile organic compound
SWIFT III	Sandia Waste Isolation Flow and Transport (computer model)
SWMU	solid waste management unit (RCRA)
TAL	target analyte list
TBC	to be considered
TCA	trichloroethane
TCLP	toxicity characteristic leaching procedure
TLD	thermoluminescence dosimeters
TOC	total organic carbon
UCL	upper confidence limit
USCS	Unified Soils Classification System
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
VOA	volatile organic analysis
VOC	volatile organic compound
WEMCO	Westinghouse Environmental Management Company of Ohio
WMCO	Westinghouse Materials Company of Ohio

OPERABLE UNIT 2
RI/FS GLOSSARY

This fact sheet has been prepared as part of the effort to familiarize the reader with the specific vocabulary used in discussions about environmental restoration and waste management at Fernald.

1000-series wells - Wells extending into the perched groundwater within the till.

2000-series wells - Wells extending into the Upper Great Miami Aquifer.

3000-series wells - Wells extending into the middle of the Great Miami Aquifer.

4000-series wells - Wells extending into the Lower Great Miami Aquifer.

Analytical Support Level - The level of accuracy and documentation used to support analytical analyses. There are five general levels and these levels are distinguished by the types of technology and documentation used.

Billet - A billet is an ingot with the top section of each ingot is cropped to remove shrinkage cavities and impurities, machined, and heat treated.

Blowdown - Water from the boiler in the boiler plant.

Baseline Risk Assessment - The study undertaken to characterize the current and potential threats to human health and the environment that may be posed by contaminants within an area. The Baseline Risk Assessment provides a framework for developing risk information necessary to assist in developing remedial alternatives, and considers the risks that currently exist at the site, if no further response actions or institutional controls are applied. There are four steps in the Baseline Risk Assessment process: identification of constituents of potential concern; exposure assessment; toxicity assessment; and risk characterization and analysis. The Baseline Risk Assessment contributes to site characterization and subsequent development, evaluation, and selection of appropriate response alternatives.

Clay Lens - A body of clay with the general form of a lens, thick in the central part and thinning toward the edges.

Data Quality Objectives (DQO) - Defines 1) the decisions, 2) the level of data quality needed for those decisions, and 3) the specific procedures required to produce this level of data

quality. Also, ensures that the resources expended to collect and analyze each sample are justified.

Deciduous (Woodlots) - Trees with leaves that fall off or shed seasonally or at a certain stage of development in the tree's life cycle.

Derby - UF_4 is blended with magnesium granules and placed in a closed reduction pot; the reduction pot is heated in a furnace until the contents react to produce a uranium metal ingot shaped in the form of a man's derby.

Dose - Quantity of radiation absorbed in living tissue.

DQOs - See **Data Quality Objectives**.

Enrichment - The percent of U_{235} isotopes in the amount of total uranium above that which is naturally occurring (greater than 0.71%).

Exposure Pathway - An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site, such as air transport of dust. Each pathway includes a source or release from a source, an exposure point, and an exposure route.

Feasibility Study - The study that evaluates and develops remedial action alternatives to prevent or mitigate the migration or release of hazardous substances, pollutants, contaminants, or hazardous constituents at and from the site. The FS is generally performed in conjunction with the RI and uses data gathered during the RI to develop remedial action alternatives and undertake an initial screening and detailed analysis of the alternatives. The FS includes a report that describes remedial action alternatives and documents the selection process.

Fluvial - Deposits produced by streams or river action.

FS - See **Feasibility Study**.

Gamma Spectroscopy - An analytical method of measuring radiation of a sample.

Glaciofluvial - Pertaining to streams flowing from glaciers or to the deposits made by such streams.

Gross Alpha - The measurement of total alpha activity for a sample. Total alpha activity is the sum of the activities of all isotopes within a sample that decay by releasing an alpha particle.

Ingot - An ingot is formed by melting a derby until the metal reaches the proper temperature to be poured into a graphite mold to form an ingot. Ingots vary in weight, size, and shape depending on how they will be used.

Isotope - The species of a chemical element having the same atomic number but different atomic mass.

Isotopic Uranium - The listing of uranium mass or concentration in a sample by its isotope.

Isotopic Thorium - The listing of thorium mass or concentration in a sample by its isotopes.

Joint - Fracture in rocks or soils generally more or less vertical or horizontal to bedding, along which no appreciable movement has occurred.

Kriging - The mathematical process of interpreting data by a weighted-moving-average interpolation method.

Lacustrine - Pertaining to, produced by, or formed in a lake or lakes.

Leach - To dissolve out by the action of a percolating liquid.

Loess - A consistent, nonstratified, fine-grained silt which lacks any bedding but often has vertical joints. Loess is transported by wind from deserts, from dried-up flood plains, from river courses, or from glacial deposits.

millirem (mrem) - A unit of radiation dosage equal to one-thousandth of a rem. A member of the public can safely receive up to 500 millirems per year, according to federal standards, but the U.S. EPA ordinarily limits public exposure to 25 to 200 mrem per year.

Moraine - Deposits of glacial till formed either as curved or bowed mounds at the front of the glacier (terminal moraine) or as sheets of till over considerable areas (boulder clay). Successive terminal moraines often mark retreat stages of glaciers (recessional moraine). Moraines are made up of a variety of unsorted rock fragments in unbedded clay matrix.

mrem - (See **millirem**).

Nuclide - A species of atom characterized by the constitution of its nucleus and hence by the number of protons, the number of neutrons, and the energy content.

Outcrops - The exposure of bedrock or strata projecting through the overlying cover of soil.

Overburden - Material of any nature, consolidated or unconsolidated, that overlies a deposit of useful material, ores, or coal, especially those deposits that are mined from the surface by open cuts. At the FEMP, glacial till is the overburden that overlies the sands and gravels of the Great Miami Aquifer formation.

Perched Groundwater - Groundwater separated from an underlying body of groundwater by unsaturated rock or soil.

Permeability - The permeability of a rock or soil is its capacity for transmitting or yielding fluids. The degree of permeability depends upon the size and shape of pores (porosity) within the rock or soil, the size and shape of pore interconnections, and the extent of interconnections between pores.

Photogrammetric Surveys - A shadow like photograph made by placing objects between light sensitive paper and a light source. To examine as to condition, situation, or valve.

Radionuclide - A radioactive nuclide.

Receptor Populations - The human, animal, or plant populations that may be exposed to radioactive or hazardous materials.

rem - Roentgen equivalent man, a unit used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation. Incorporates the health risks from radiation.

Remedial Investigation - An investigation conducted to determine the nature and extent of a release or threat of release of hazardous substances, pollutants, contaminants, or hazardous constituents. The RI emphasizes data collection and site characterization. The RI includes sampling and monitoring, as necessary, as well as the gathering of sufficient information to determine the necessity for remedial action and support the evaluation of remedial alternatives.

RI - (See **Remedial Investigation**).

Silt - Broken rock fragments grading down into particles of which are between 1/16 and 1/256 mm in diameter.

State Planar Coordinates - A coordinate system based on a survey of the State of Ohio.

Till - Nonsorted, nonstratified sediment carried or deposited by a glacier.

Transuranics - Manmade, radioactive elements above atomic number 92.

Treatability Study - A laboratory or field test designed to provide critical data needed to evaluate and ultimately implement one or more treatment technologies. Treatability studies generally involve characterizing untreated waste and evaluating the performance of the technology under different operating conditions. Treatability studies conducted during the RI/FS to support remedy selection are generally used to

determine whether the technology can achieve the ROD goals.

Well Logs (also called boring logs) - The written or recorded facts relating to the drilling of a well (e.g., depth, soil consistency, texture, color, etc.).

Vadose Zone - The portion of a geologic formation that is not saturated with water.

EXECUTIVE SUMMARY

This report documents the Remedial Investigation (RI) phase of the Fernald Environmental Management Project (FEMP) Operable Unit 2 Remedial Investigation/Feasibility Study (RI/FS). The FEMP is a U.S. Department of Energy (DOE) facility located near Fernald, Ohio, which operated from 1952 to 1989 providing high purity uranium metal products to support United States defense programs. In 1989, the mission of the facility was changed to environmental restoration. Also in 1989, the facility was placed on the National Priorities List ("Superfund List"). The RI/FS for the FEMP is executed according to an Amended Consent Agreement between DOE and the U.S. Environmental Protection Agency (EPA), under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Ohio Environmental Protection Agency (OEPA) also is participating in the FEMP RI/FS process through direct involvement in review meetings, public meetings, and technical review of project documentation.

The RI/FS is part of a process through which decisions are made to determine the specific environmental cleanup methods that will be used at a site. The Operable Unit 2 Feasibility Study (FS) will develop and compare a range of possible remedial alternatives to identify the most effective approach for meeting specific cleanup goals. Consistent with the Amended Consent Agreement, selection of the preferred cleanup alternative will be documented in a Record of Decision (ROD), which is issued by EPA after consideration of comments received from the public and other interested parties. The Operable Unit 2 RI Report provides a detailed understanding of the nature and extent of the waste materials, their present and future impacts on the surrounding environment, and the present and future risks to human health if the Operable Unit 2 wastes were not remediated. Therefore, this RI Report meets the need for the evaluation of risks due to the Operable Unit 2 wastes and provides the basis to develop and evaluate a wide range of remedial alternatives.

EPA approved the FEMP RI/FS Work Plan in May 1988. The work plan provided the overall technical approach, identified areas to be investigated, and presented the objectives and data evaluation criteria for the planned investigations. The work plan identified 27 specific areas, or units, within the FEMP for investigation. Subsequent evaluations increased the number of units to 39. It soon became apparent that for purposes of effective management, the 39 units should be categorized and grouped. The resultant groupings formed the five operable units of the FEMP. The operable units are:

- Operable Unit 1 - Waste Pit Area
- Operable Unit 2 - Other Waste Areas
- Operable Unit 3 - Former Production Area
- Operable Unit 4 - Silos 1 through 4
- Operable Unit 5 - Environmental Media

Operable Unit 2 is comprised of five subunits: Solid Waste Landfill, Lime Sludge Ponds, Active Flyash Pile, Inactive Flyash Pile, and South Field. Large volumes of conventional industrial wastes, assumed to have small amounts of hazardous chemicals and radionuclides, were placed in these subunits during the period of production operations.

NEPA Integration

Consistent with DOE policy, the FEMP is integrating the requirements of the National Environmental Policy Act (NEPA) into the RI/FS process. On May 15, 1990, a Notice of Intent was published in the Federal Register to announce that DOE intended to prepare an Environmental Impact Statement (EIS) to evaluate the environmental impacts associated with the planned cleanup activities at the FEMP. As identified in the Notice of Intent, the FS and Proposed Plan (PP) for the earliest scheduled operable unit, (Operable Unit 4) will be issued as a FS/PP-EIS. The FS/PP-EIS will examine the environmental impacts associated with Operable Unit 4 remedial activities as well as the cumulative impacts associated with the implementation of remedial actions for all five operable units at the FEMP. An additional element of NEPA compliance is the FEMP Site-Wide Characterization Report, which supplements the Operable Unit 4 FS/PP-EIS by providing an assessment of cumulative environmental impacts associated with the existing conditions at the FEMP on a site-wide basis.

The Operable Unit 2 FS and PP will be coordinated with the Operable Unit 4 FS/PP-EIS for purposes of NEPA integration, and if necessary, the cumulative impact analysis presented in the Operable Unit 4 impact statement will be updated and attached to the Operable Unit 2 NEPA evaluation. The Operable Unit 2 RI Report will be incorporated by reference into the Operable Unit 2 FS and PP NEPA evaluation. This RI Report includes the characterization of Operable Unit 2 and hence, will support the necessary description of the affected environment in the Operable Unit 2 NEPA evaluation. This report also provides the baseline risk assessment that will support the evaluation of the no action alternative for Operable Unit 2.

DESCRIPTION OF OPERABLE UNIT 2

The FEMP is a 1050 acre facility located about 17 miles northwest of downtown Cincinnati near Fernald, Ohio, a small farming community. The site lies on the boundary of Hamilton and Butler counties. The primary mission of the FEMP during its 37 years as an operating production facility was to process, refine, and machine high-grade natural uranium ores into high purity uranium metal. The high purity metals were shipped to other DOE or U.S. Department of Defense facilities for use as "feed materials" in the nuclear weapons program. These uranium production activities generated large quantities of waste materials. The storage and disposal of wastes at the site and their potential for impacting human health led to the site being placed on the National Priorities List. Operable Unit 2 is comprised of five areas, or subunits, in which various conventional industrial wastes were disposed.

The FEMP is situated on an area of glacial overburden deposits; the overburden primarily is composed of till, a dense silty clay that may contain lenses of poorly sorted fine to medium grained sand and gravel, silty sand, and silt. Undisturbed glacial till has relatively low permeability. The thickness of the till varies from 0 to 50 feet on site, and the till tends to be thicker in the northern part of the site (the Solid Waste Landfill, for example is sited in thick till) and pinches out completely in the South Field area in the southern part of the site. Areas not covered with till may exhibit higher infiltration rates than those covered with glacial till.

Erratically distributed pockets of sand and gravel within the till contain zones of perched groundwater. Perched groundwater is separated from the underlying aquifer by the surrounding relatively impermeable till materials. Depth to perched groundwater at the FEMP ranges from 1 to 15 feet below ground surface. The depth may fluctuate seasonally by up to 10 feet at a given location, with the highest levels occurring in the early spring and the lowest in the late fall.

The FEMP is sited above a major aquifer system, the Great Miami Aquifer. The Great Miami Aquifer is considered a sole source aquifer and sustains numerous industrial, municipal, and private drinking water wells. The FEMP includes several areas that probably function as recharge zones to the aquifer, including Paddys Run, the Storm Sewer Outfall Ditch, and parts of the South Field.

The subunits comprising Operable Unit 2 are briefly described below.

Solid Waste Landfill

The Solid Waste Landfill is located in the northeast corner of the Waste Storage Area, and is a flat, rectangular area of about one acre. The landfill has been inactive since 1986 and is covered with a layer of soil. The operational history of the landfill is not well documented. A review of historical site aerial photographs indicates that disposal activities may have occurred as early as 1954. Available documentation and interviews indicate that the landfill was intended to be used for "nonburnable wastes"; field investigations have revealed a variety of waste materials including medical wastes, rubbish, wastes from areas other than the Production Area, and on-site construction/demolition wastes.

Lime Sludge Ponds

The North and South Lime Sludge Ponds are two unlined, rectangular ponds, each measuring approximately 125 by 225 feet, located in the southeast corner of the Waste Storage Area. The sludge is confined by earthen dikes of unknown origin. The operational history of the ponds is well understood. Wastes disposed of in the ponds originated from water plant operations, coal pile storm water runoff, and boiler plant blowdown. The South Pond is full and has been inactive since the mid-1960s, and is now overgrown with grasses and shrubs. The North Pond currently remains in use. The west side of the North Pond usually is covered with one to two feet of water, mainly depending on precipitation. The remainder of the pond is dry and sparsely covered with vegetation.

The waste from water plant operations is generated from a water softening process. About one cubic yard of waste sludge is generated each day and is pumped to Tanks 6 and 7 of the General Sump. Coal pile runoff is treated in a retention basin to settle out the solids, then pumped to Tanks 6 and 7 of the General Sump. The boiler plant blowdown consists of backflush water, generated when the boilers are backflushed to prevent scale buildup. This water is also pumped to Tanks 6 and 7 of the General Sump. Tanks 6 and 7 contain only sludges from these three sources.

Sludge is allowed to accumulate in the tanks for about two weeks. It is then pumped as a slurry to the North Lime Sludge Pond. The bulk of the material comprising the slurry is sludge from the water softening operations. The Lime Sludge Ponds have been operated in this manner since the early 1950s. Based on this process knowledge as well as the resulting analysis of the sludge, it appears that

the lime sludge is relatively homogenous (uniform in composition). The Lime Sludge Ponds are presently classified as Solid Waste Management Units by OEPA.

Inactive Flyash Pile

The Inactive Flyash Pile is located about 2,000 feet southwest of the former Production Area and covers approximately 2 acres. Paddys Run forms the western boundary; the South Field lies to the east. The Inactive Flyash Pile and South Field are contiguous and lack a defined physical boundary. In appearance, this subunit resembles a relatively steep hill covered with shrubs and trees. The soil covering the southern half of the Inactive Flyash Pile is of unknown origin.

The operating history of the Inactive Flyash Pile is not well understood. The bulk of the waste material in the pile is reported to be bottom ash and flyash from the facility's boiler plant operations, commonly referred to as flyash. Based on a review of historical aerial photographs, flyash appears to have been taken by truck to an existing slope near Paddys Run and dumped. The photographs indicate that flyash disposal at this subunit had ceased by the mid-1960s. Various other wastes, including building rubble, gravel, asphalt, and process waste, were also deposited at the Inactive Flyash Pile.

South Field

The South Field is an 11-acre area that lies between the Inactive Flyash Pile and the Active Flyash Pile. A physical boundary with the Inactive Flyash Pile is not distinguishable. Currently, the South Field is relatively flat and is covered with grasses, shrubs, and trees.

The operational history of the South Field is neither well documented nor understood. It is not an engineered disposal site. A review of historical aerial photographs indicates that disposal may have been initiated in 1954 and continued until the mid-1960s. Disposal appears to have taken place in a random manner. Available documentation indicates that a number of wastes were disposed in the South Field, including construction and demolition materials, flyash, soils that may have been contaminated with low levels of radioactive materials, and possibly process wastes.

Active Flyash Pile

The Active Flyash Pile is bounded to the east and north by the Storm Sewer Outfall Ditch, and is separated from the South Field to the west by an unpaved road. The Active Flyash Pile appears as a

large, steep pile of black flyash, and covers about three acres. Wind screens and silt fences have been installed to prevent wind and water erosion, and a crusting agent has been applied. A crusting agent is applied to harden the surface of the Active Flyash Pile to minimize erosion and resuspension of dust. The operational history of the subunit is well understood.

Flyash from the site's coal-fired boiler plant was disposed at the Active Flyash Pile from the mid-1960s until December 1992. Flyash presently being generated at the FEMP is disposed at an approved, off-site facility. The waste at the Active Flyash Pile is comprised of about 70 percent bottom ash and 30 percent flyash. Small quantities of unburned coal and rock are present, as is typical of boiler ashes. Previous investigations have discussed the possibility that waste oils, which theoretically could contain PCBs or uranium, might have been applied to the Active Flyash Pile as a dust control measure. However, attempts to document this possibility have not been successful.

NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination at Operable Unit 2 subunits have been established through several environmental investigations. The investigations most relied on in this report are the Environmental Survey (ES), the Characterization Investigation Study (CIS), and the CERCLA Remedial Investigation. The ES and CIS primarily were focused on site-wide issues and were not intended to provide a detailed analysis of contamination related to Operable Unit 2 subunits. The ES data have not been validated; portions of the CIS data have been validated. The RI field investigations rigorously examined the nature and extent of contamination in Operable Unit 2 subunits and the potential for the spread of contamination into the various environmental media. All RI data were validated. The evaluation of the nature and extent of contamination is based primarily on RI data, and CIS data were used in a supplementary manner. ES data were used only for descriptive purposes. Neither ES nor CIS data were used in the fate and transport modeling for the baseline risk assessment.

The following sections briefly summarize the findings on the nature and extent of contamination.

Solid Waste Landfill

Trenching and boring activities in the Solid Waste Landfill have determined that cafeteria, laboratory, construction/maintenance, and manufacturing wastes were disposed in the landfill. One waste disposal cell and an evaporation pond were identified in historical photographs and trench

observations, but waste was observed in numerous other areas within the battery limits. The depth of waste is generally 10 feet with a maximum depth of 15 feet in the southeastern corner of the landfill.

Nineteen contaminants of concern (COCs) have been identified for the Solid Waste Landfill that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides, three metals, and six organic compounds. The extent of COCs in the Solid Waste Landfill is distributed throughout the surface and subsurface fill materials with the maximum levels in the southeastern corner of the landfill. The COCs were also detected in the glacial till beneath the landfill and in the perched groundwater near the southeast corner of the subunit. While uranium was detected above background in the Great Miami Aquifer, the levels were similar in upgradient and downgradient wells indicating that there is not a significant impact on the Great Miami Aquifer from the Solid Waste Landfill. The number of COCs detected in the surface water, sediment, and perched groundwater are fewer than those detected in the surface and subsurface soils.

The media pathways considered significant for the Solid Waste Landfill as a result of the modeling include air and perched water. Perched water was modeled under the Solid Waste Landfill because of a potential for household use of the perched water.

Lime Sludge Ponds

Field investigations of the Lime Sludge Ponds indicate that the sludge within the subunit is homogeneous. Sampling in the berm soils and glacial till beneath the ponds has determined that the soils have higher concentrations of most constituents than the sludge. This means that future impacts from the sludge upon the soil are not likely. Elevated concentrations of uranium and thorium were detected in downgradient perched groundwater wells, but samples collected from the K-65 Trench (outside of Operable Unit 2 boundaries) detected elevated radioisotope activities. The K-65 Trench is believed to be the source of the perched groundwater contamination.

Ten COCs have been identified for the Lime Sludge Ponds that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides. The extent of COCs in the Lime Sludge Ponds is limited mostly to the berm soils surrounding the ponds. Radionuclides and organics appear to have originated in the surface and berm soils. The COCs were also detected in the perched groundwater downgradient of the subunit, but the source of these contaminants is believed to be the K-65 Trench. No impact has been observed on the Great Miami Aquifer.

The media pathways considered significant for the Lime Sludge Ponds as a result of the modeling include the air and groundwater pathways. No surface water pathway exists near the Lime Sludge Ponds and all surface water is contained within the subunit. Perched water was modeled under the Lime Sludge Ponds because of a potential for household use of the perched water.

Inactive Flyash Pile

Field investigations of the Inactive Flyash Pile indicate that waste other than flyash were disposed of in the subunit. Sludge, clay tile drain pipe, wood, nails, wire, construction debris, and small amounts of organic waste were found in addition to flyash. Field measurements with an alpha-beta meter indicated that all materials except for flyash had elevated levels of radioactivity. The identified waste materials appear to be resting on or near the interface between the flyash and the native glacial overburden.

The occurrence of uranium contamination in the perched groundwater appears to be related to waste materials buried within or near this subunit. The perched groundwater appears to discharge through seeps into the Paddys Run drainage channel or directly into the Great Miami Aquifer through regions where the glacial overburden has been eroded. This means that a mechanism exists to transport uranium contamination vertically into the Great Miami Aquifer. Uranium contamination in the Great Miami Aquifer was not detected upgradient or from the northern part of the subunit. Uranium contamination was detected in two wells downgradient from the central part of the subunit. This suggests that a source of uranium contamination to the Great Miami Aquifer exists beneath the central part of the Inactive Flyash Pile.

Nine COCs have been identified for the Inactive Flyash Pile that contribute greater than one percent of the total risk for a medium. These COCs consist of seven radionuclides, one metal, and one organic compound. The extent of COCs in the Inactive Flyash Pile covers most of the surface and subsurface soils, surface water, sediment, and perched water sampled within the subunit. Radionuclides appear to be connected to non-flyash waste such as sludge, wood, and construction debris, whereas organics appear to be intermixed with the flyash, possibly from dust control spraying. Uranium is the only COC detected in the Great Miami Aquifer downgradient of the subunit.

The media pathways considered significant for the Inactive Flyash Pile as a result of the modeling include air, surface water, and groundwater pathways. Perched water as a source to the groundwater pathway was also considered significant.

South Field

Test trenches uncovered a range of waste materials including concrete, steel pipe, sheet steel, wood, and clay tile. The results of wipe samples taken from these materials indicate that they represent a potential source of the leaching of radionuclides to groundwater.

Twenty COCs have been identified for the South Field that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides, one metal, and nine organic compounds. The extent of COCs in the South Field covers most of the surface and subsurface soils, surface water, sediment, perched groundwater, and groundwater sampled within the subunit. Radionuclides and organics were detected in higher concentrations in the northern portion of the South Field. The COCs were also detected in the perched groundwater beneath the subunit and in the Great Miami Aquifer downgradient of the subunit.

The media pathways considered significant for the South Field as a result of the modeling include air, surface water, and groundwater pathways. Perched water as a source to the groundwater pathway was also considered significant.

Active Flyash Pile

The Active Flyash Pile contains only flyash from field observations and historical documentation. Interviews with former processing personnel indicated that organic compounds could have been sprayed on the flyash to reduce dust. The analytical results of the RI field investigation do not support such speculation.

Twelve COCs have been identified for the Active Flyash Pile that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides and two metals. The extent of COCs in the Active Flyash Pile covers most of the surface and subsurface soils, and sediment within the subunit. The COCs uranium-234, uranium-235/236, and uranium-238 were detected in the Great Miami Aquifer downgradient of the subunit.

The media pathways considered significant for the Active Flyash Pile as a result of the modeling include air, surface water, and groundwater pathways.

BASELINE RISK ASSESSMENT

The Operable Unit 2 baseline risk assessment accomplished the following for each subunit:

- Determination of the constituents of potential concern (CPCs)
- Assessment of the potential for and magnitude of constituent transport from Operable Unit 2 sources to potential points of human exposure
- Quantification of potential exposures to human receptors under current and future land use scenarios
- Characterization of the nature and magnitude of potential risks associated with Operable Unit 2, assuming there were no remedial action in the future
- Evaluation of the uncertainty associated with the risk estimations.

The Operable Unit 2 baseline risk assessment addresses only potential risks associated with waste subunits within the battery units of Operable Unit 2. It does not consider existing sources or contamination in soil, surface water, and sediment outside the boundaries of Operable Unit 2, nor does it consider groundwater contamination. Therefore risk quantified in the baseline risk assessment represents a portion of the total risk posed by the FEMP site. Total cumulative risk from all operable units will be addressed in the final Comprehensive Response Action Risk Evaluation (CRARE) prepared for Operable Unit 5. These risks will be evaluated in the Operable Unit 5 RI. Risks due to groundwater in this and other operable unit risk assessments are based on estimates of future concentrations which are based on modeling. This risk assessment does not consider the potential impacts on flora and fauna (ecological risks). Evaluation of site-wide ecological risks will take place in the Operable Unit 5 RI/FS; areas likely to be remediated on the basis of human health protection will not be evaluated.

Operable Unit 2 includes five subunits for which remedial decisions must be made. In order to facilitate the decisions, risk was quantified separately for each subunit. The specific risk assessment methodology followed was consistent across all subunits, and the cumulative risk from Operable Unit 2 sources was calculated.

Potential human exposure to risk is evaluated in the context of four and use scenarios: (1) current land use assuming DOE ownership with access control, (2) current land use without access controls, (3) future land use assuming federal ownership, and (4) future land use assuming private ownership. For all scenarios, it is assumed that no additional cleanup of Operable Unit 2 occurs beyond that which already has taken place.

The postulated human receptors of incremental risk for the current land use scenario with access controls include a trespassing youth, off-property residents, on-property groundskeeper, and users of the Great Miami River. Receptors of the current land use scenario without access controls include the user of meat and milk products from livestock grazing on Operable Unit 2. For the future land use scenario assuming federal ownership, the receptors are expanded trespasser, off-property farmers (evaluated under both federal and private ownership), and users of the Great Miami River. For the future land use scenario assuming private ownership, the receptors are on-property farmers, homebuilders (for South Field and Solid Waste Landfill only), and users of "perched" groundwater [isolated bodies of groundwater within the glacial till] (for Solid Waste Landfill and Lime Sludge Ponds only). Users of the Great Miami River (both current and future scenarios) were evaluated under three exclusive uses: (1) recreational, (2) agricultural, and (3) residential. For the future land use scenarios, the constituent concentrations at the specific geographical and temporal points of human exposures were determined by the application of approved air dispersion and surface water and groundwater transport computer simulation models.

Epidemiological evidence indicates that the typical human being has a risk of developing cancer of about one in three, or 3.3×10^{-1}. EPA has established a range of incremental lifetime cancer risk from 1×10^{-6} to 1×10^{-4}. This range is referred to as the target range and provides a point of reference for the risk estimates presented in the Operable Unit 2 baseline risk assessment. Accordingly, this baseline risk assessment presents the risks due to exposure to carcinogens in terms of incremental lifetime cancer risk (ILCR); that is, the additional risk to a given person, given a lifetime of exposure to Operable Unit 2 wastes and impacted media. Hazards due to exposure to noncarcinogenic constituent also are evaluated. Noncarcinogenic risks are reported as a hazard index (HI). HIs of greater than 1.0 or "above unity" indicate a concern for potential health effects.

To ensure that the most sensitive or most exposed individuals in the population are protected, EPA guidance provides for calculation of reasonable maximum exposure (RME), which is the maximum

exposure a person reasonably could receive from the waste site being evaluated. For example, in the Operable Unit 2 future land use scenario assuming private ownership, the on-property RME farmer (adult and child) builds a home on (where physically feasible) and actively farms the unremediated Operable Unit 2 waste units and is exposed to the following for each CPC:

- Inhalation of fugitive dust, volatile organic compounds, and gases
- Incidental ingestion, inhalation, and dermal contact while using groundwater (separate evaluations for Great Miami Aquifer and perched groundwater) in the home
- Consumption of foodstuffs grown on the waste site, including fruits and vegetables, and meat and milk
- Incidental ingestion, external radiation, and dermal contact with soil
- Inhalation of indoor radon

Thus, the RME receptors usually will have the highest estimated risks in a risk assessment. Risk and hazard results are also presented for a central tendency (CT) receptor, whose exposures are thought to be more typical of the average individual in the exposed population. For all subunits, future risks to off-property farmers (adult and child) were evaluated for federal or private ownership. A summary of the results from the risk assessment for each subunit is presented below. All site-related risks were calculated without accounting for (removing) the potential con tribution from natural background sources.

Solid Waste Landfill

For the current land use scenario, a total carcinogenic risk to a trespassing youth is 1.5×10^{-5} due to external radiation from radium-226, radium-228, thorium-228, and thorium-232 in surface soil. HI was 8.6 due primarily to the presence of uranium-total in surface water. Total risk to the on-property groundskeeper is within the same order of magnitude as the trespassing youth. Major contributors to risk for this receptor are the same as those to the trespassing youth with the addition of uranium-238 in soil. Off-property farmers have carcinogenic risks on the order of 10^{-8} and HIs of less than 1.0.

For the future land use scenario assuming private ownership, total carcinogenic risk to the on-property RME farmer was 2.8×10^{-3}. Total HI was less than 1.0. The greatest contributors to risk for this receptor were from radium-226, radium-228, thorium-228, and thorium-232 in surface soil

via external radiation. Risks exceeded the 1.0×10^{-3} level for perched groundwater users due primarily to radium-226, radium-228, thorium-228, thorium-232, and uranium-238 in surface soil.

For the future scenario having federal ownership, the expanded trespasser had a combined carcinogenic risk of 2.0×10^{-5} due mostly to external radiation from radium-226, radium-228, thorium-228, thorium-232, and uranium-238 in soil. Total HI is less than 1.0. Combined carcinogenic risk for off-property farmers (private and federal ownership) range from 10^{-6} to 10^{-9}. The off-property farmer under private ownership slightly exceeded 1.0×10^{-6} due primarily to the cumulative presence of various radionuclides in soil; no single radionuclide exceeded 1.0×10^{-6}.

Risks to the users of the Great Miami River (recreational, agricultural, and residential) were in the 1.0×10^{-7} to 1.0×10^{-10} range and HIs were below 1.0.

The media pathways with the most significant risk for COCs are related to inhalation and external radiation from soil and consumption of fruit and vegetables, milk and beef contaminated by soil. Two COCs, carbazole and technetium-99, contribute risk to the on-property resident farmer if perched groundwater is used for as a household drinking water source. Approximately 64 percent of the total risk to the on-property resident farmer is derived from four COCs: radium-226, radium-228, thorium-228, and thorium-232 in surface soil.

Lime Sludge Ponds

For the current land use scenario, a total carcinogenic risk to a trespassing youth was 1.1×10^{-5} due primarily to exposure to surface soil containing radium-226, radium-228, thorium-228, and thorium-232 in soil via external radiation. Total risk to the current on-property groundskeeper was 4.5×10^{-5} due mostly to the presence of cesium-137, radium-226, radium-228, thorium-228, thorium-232, and uranium-238 in surface soil. Total HIs for these receptors were less than 1.0. Carcinogenic risks to off-property residents were on the order of 10^{-7} to 10^{-8} and the total HI was less than 1.0.

For the future land use scenario assuming private ownership, the RME farmer has a total risk of 1.3×10^{-5} due primarily to the presence of thorium-230 and uranium-238 in surface soil which accounted for approximately 66 percent of the total receptor risk. Total HI is less than one for the farmer and on-property child.

For the future land use scenario with federal ownership, the expanded trespasser had a total risk of 2.2×10^{-5} due to radium-226, radium-228, thorium-228, and thorium-232 in surface soil which accounted for 88 percent of the total receptor risk. HI was less than 1.0. Off-property farmers (private and federal ownership) have carcinogenic risks on the order of 10^{-7} or less and HIs of less than 1.0. Risks from the Lime Sludge Ponds to the Great Miami River users was not quantified because the Lime Sludge Ponds pose no significant risk.

The media pathways with the most significant risk for COCs are related to ingestion, inhalation, and dermal contact of soils. No COCs were determined for perched groundwater even if perched groundwater is used for a household drinking water source. Approximately 77 percent of the total risk to the on-property resident farmer is derived from five COCs in surface soil: thorium-228, thorium-230, thorium-232, and uranium-238.

Inactive Flyash Pile

Because of the contiguous nature of the Inactive Flyash Pile and South Field, the complexity of the geology and lithology, and the patterns of groundwater flow in the area, it was not possible to completely separate these potential groundwater sources on other than an arbitrary basis. Therefore, the groundwater modeling for these subunits included simultaneous inputs from the entire area of these combined subunits. Hence, the risk contribution of the groundwater pathway is based on the combined effects of these subunits.

For the current land use scenario, total carcinogenic risks range from slightly greater than 10^{-5} for the trespassing youth to about 10^{-7} for off-property receptors. Total risk to the trespassing youth is 1.3×10^{-5} mostly due to the presence of radium-226, radium-228, and thorium-232 in surface soil which accounted for 74 percent of the total receptor risk. Risk to the on-property groundskeeper are on the same order of magnitude as the trespassing youth. Major contributors to risk for the on-property groundskeeper include radium-226, radium-228, and thorium-232 which accounted for approximately 87 percent of the total receptor risk. HIs for all current scenario receptors are less than 1.0.

For the future land use scenario assuming private ownership, the on-property RME farmer had a total risk of 1.5×10^{-3} and HI of 18. The major contributors of risk were from the estimated presence of uranium-234 and uranium-238 in groundwater, and consequently in irrigated milk and beef products

from livestock that are watered with groundwater contaminated from the combined Inactive Flyash Pile/South Field source area. The most significant contributors of the elevated HI was due to total uranium in groundwater.

For the future land use assuming federal ownership, the expanded trespasser has a total carcinogenic risk of 3.0×10^{-5} due primarily to the ingestion of surface soil containing radium-226, thorium-228, thorium-232, and arsenic which accounted for 86 percent of the total risk. Total HI was less than 1.0. The off-property farmers (private and federal ownership) exceeded 1.0×10^{-6} risk level. The major contributors of risk to the off-property farmers were from uranium-234 and uranium-238 in groundwater contaminated from the combined Inactive Flyash Pile/South Field source area which accounted for approximately 95 percent of the total farmer receptor risk and 85 percent of the total child receptor risk. Total HIs for the farmers were below 1.0, but for the child it was 2.2 due mostly to uranium-total in the groundwater.

Total estimated risk to future Great Miami River users are in the range of 1.0×10^{-6} to 1.0×10^{-5}. Major contributors to risk were from thorium-228, uranium-235/236, and radium-228. HIs are less than 1.0.

Pathways contributing most to risk included ingestion, inhalation, and dermal contact with groundwater. Approximately 75 percent of the total risk to the on-property RME farmer is derived from three COCs in groundwater: uranium-234, uranium-235/236, and uranium-238.

South Field

For the current land use scenario, total carcinogenic risks ranged on the order of 10^{-4} for the trespassing youth and on-property groundskeeper to about 10^{-7} for off-property receptors. Major contributors to total risk to the trespassing youth and on-property groundskeeper were mostly due to radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Total HI for the trespassing youth was 53 due primarily to the presence of uranium-total in surface water. HIs for all other current receptors were below 1.0.

For the future land use scenario assuming private ownership, the on-property RME farmer had a total carcinogenic risk of 3.4×10^{-2} while the resident child had a risk of 9.2×10^{-3}. The largest components of risk to the on-property farmers are from dust-affected beef and milk products

containing technetium-99, benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene. Total hazards for the on-property farmer and child were 23 and 63, respectively, due mostly to the presence of uranium-total in groundwater.

For the future land use assuming federal ownership, the expanded trespasser had a total carcinogenic risk of about 1.4 x 10^{-4} and HI of less than 1.0. The major contributor to risk was from radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Off-property farmers (private and federal ownership) had carcinogenic risks in the range of 10^{-6} to 10^{-4}. The largest component of risk to the off-property farmers was from uranium-234 and uranium-238 in groundwater which accounted for approximately 52 percent of the total receptor risk. For the off-property farmer child under private ownership, the primary contributors to total risk were from ingestion of beef and milk products affected by dust containing dibenzo(a,h)anthracene, benzo(a)pyrene, and Aroclor-1260. For the off-property child under federal ownership, the primary contributors to risk were from uranium-234 and uranium-238 in groundwater. Total HIs for the off-property farmers exceeded 1.0 due to the estimated presence of uranium-total in groundwater.

For the users of the Great Miami River, the total risk calculated for the recreational user was 4.2 x 10^{-6} with the risk due primarily to ingestion of fish contaminated with radium-226 and technetium-99 via the Great Miami River surface water pathway. For the Great Miami River agricultural user, total risk was 4.4 x 10^{-6} due primarily to the ingestion of beef and milk products affected by dust containing technetium-99 which accounts for 97 percent of the total receptor risk. Total receptor risk to the residential user was 6.3 x 10^{-8}. Total HIs for all of the Great Miami River user were below 1.0.

Approximately 60 percent of the risk to the on-property resident farmer is derived from five COCs: radium-226, radium-228, thorium-232 in surface soil and beef and milk products affected by dust containing technetium-99, benzo(a)pyrene, and dibenzo(a,h)anthracene. Pathways posing risk include external radiation, inhalation, and ingestion with surface soil, and ingestion of dust-affected beef and milk products.

Active Flyash Pile

For the current land use scenario, total carcinogenic risk to a trespassing youth was 2.6 x 10^{-5} due to the presence of radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Total risk to

the on-property groundskeeper was 8.0 x 10^{-5} due mostly to external radiation from radium-226, radium-228, thorium-228, and thorium-232 in surface soil and dermal contact with arsenic in surface soil which accounted for a combined 99.69 percent of the total receptor risk. Total HI for all current receptors are less than 1.0. Carcinogenic risks to off-property residents did not exceed 10^{-6} risk level.

For the future land use scenario assuming private ownership, the on-property RME farmer and child had total carcinogenic risks of 8.4 x 10^{-5} and 5.7 x 10^{-6}, respectively, due mostly to the presence of uranium-234 and uranium-238 in groundwater which accounted for 54 and 34 percent, respectively, of the total receptor risks. Additionally, homegrown produce irrigated with contaminated groundwater containing radium-226, strontium-90, and uranium-235/236 accounted for 28 and 29 percent of the total receptor risk for the RME farmer and child, respectively. Total HI for the RME farmer was less than 1.0, but for the child it was 2.8 due to uranium-total in groundwater.

For the future land use assuming federal ownership, the expanded trespasser had a total carcinogenic risk of 4.9 x 10^{-5} due mostly to the presence of radium-226, radium-228, thorium-228, thorium-232, and arsenic in surface soil. Total HI was less than 1.0. Off-property farmers (private and federal ownership) have carcinogenic risks greater than 1.0 x 10^{-6} due primarily to uranium-234 and uranium-238 in groundwater and homegrown produce irrigated with contaminated groundwater containing radium-226, strontium-90, and uranium-235/236. HIs were less than 1.0.

Total estimated risk to the future Great Miami River users were on the order of 10^{-9} risk for all these users. Total HIs were below 1.0.

The pathways which contribute the greatest risk to the Active Flyash Pile on-property receptor was dermal ingestion and dermal contact. Over 55 percent of the risk to the on-property resident farmer is derived from two COCs in groundwater: uranium-234 and uranium-238.

OPERABLE UNIT 2 CUMULATIVE RISK

Future land use receptors were evaluated for cumulative risk from the presence of contaminants within Operable Unit 2. It is emphasized that the risks and hazards presented are those resulting primarily from the three subunits contributing most to groundwater contamination: the Active Flyash Pile, South Field and Inactive Flyash Pile.

The greatest carcinogenic risk posed was to the RME on-property farmer which had a total risk of 3.3 x 10^{-2}. The major contributors to risk for the on-property receptor were from the ingestion of beef and milk products affected with dust containing technetium-99, benzo(a)pyrene, and dibenzo(a,h)anthracene which contributed a combined 51.6 percent of the total receptor risk. Total HI was 23 due mostly to beryllium in groundwater and homegrown produce irrigated with groundwater contaminated with uranium-total.

Total risk to the off-property farmer was on the order of 1.0 x 10^{-5} due primarily to uranium-234, uranium-235/236, and uranium-238 in groundwater. Total HI for the off-property farmer was 3.7 due primarily to the ingestion of homegrown produce irrigated with groundwater containing uranium-234, uranium-235/236, and uranium-238.

Total risk to the expanded trespasser was 8.5 x 10^{-5} due primarily to external radiation from radium-226, radium-228, thorium-228, and thorium-230 in surface soil which contributed 80.7 percent of the total receptor risk. Total HI for this receptor was below 1.0.

Approximately 85 percent of the total risk to the on-property farmer is attributed from six COCs in surface soil and dust affected beef and milk products: radium-226, thorium-228, and thorium-232 in surface soil, and technetium-99, benzo(a)pyrene, dibenzo(a,h)anthracene in dust affected beef and milk products.

Risk Assessment Uncertainty

Every quantitative risk assessment is subject to sources of uncertainty. To ensure that risk is not underestimated and that human health is protected, CERCLA guidance and the conventions followed in this report address areas of uncertainty through application of conservative (i.e., protective) assumptions. The greatest uncertainty associated with the Operable Unit 2 baseline risk assessment is due to the assumptions made to estimate constituent concentrations at the spatial and temporal points of human exposure. Specifically, the exposure point concentrations in groundwater, air, produce, and beef and milk for human receptors in the future are the most conservatively estimated. All risk and hazard estimates for future on-property residents are subject to uncertainty, and hence conservatism, because the future site ownership and access controls are unknown. Taken together and interactively, the uncertainties identified with site data, exposure parameters, fate and transport, toxicity assessment,

and risk characterization are judged to be high, having the potential to overestimate risk by two orders of magnitude or more.

One way to evaluate the degree of conservatism in the risk assessment methodology is to follow the risk estimation protocol, substituting natural background concentrations for the contaminants that were found, in place of the values actually measured at the waste site. This was done for the Operable Unit 2 land use and human exposure scenarios. The use of background constituent levels in the Operable Unit 2 risk assessment results in total carcinogenic risk for the on-property RME farmer on the South Field or Solid Waste Landfill of greater than 1.0×10^{-4}. The major contributors to the total background risk are from radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Combined they contribute 90 percent of the total risk.

Conclusions

This RI presents a detailed understanding of the nature and extent of the contamination of the individual subunits that comprise Operable Unit 2. The contaminant data are used for two major purposes: (1) after the application of rigorous validation and statistical procedures, the data are used to drive the contaminant fate and transport models used in the risk assessment, and (2) the types and quantities of contaminants are used in the FS in the screening of appropriate cleanup technologies and the development of specific remedial alternatives. The data collected for the Operable Unit 2 RI are completely adequate for both purposes and no data gaps have been identified.

The Operable Unit 2 baseline risk assessment utilizes a data set in which every data element has been validated for its intended usability. The fate and transport models are approved by EPA and calibrated to the specific site conditions. The risk assessment rigorously follows CERCLA guidance, the approved Risk Assessment Work Plan Addendum, and specific guidance to the FEMP from EPA Region V.

Remedial Action Objectives

The development of the following general remedial action objectives (RAOs) is based only on the results of the baseline risk assessment. The Operable Unit 2 FS will include a consideration of the ARARs for each subunit, and ARARs have the potential to significantly affect the remedial action objectives. For the Operable Unit 2 subunits requiring remedial action, feasible remedial action alternatives will be developed and evaluated in the FS Report to be issued for Operable Unit 2.

The 1991 Amended Consent Agreement defines Operable Unit 2 as other waste units: flyash piles, other south field disposal areas, lime sludge ponds, solid waste landfill, berms, liners and soil within the operable unit boundary. The remediation of existing contamination in the Great Miami Aquifer, perched water, and Paddys Run is not considered here; remediation of these media is within the scope of the Operable Unit 5 remedial actions. During remediation of Operable Unit 2, contaminated perched water will be controlled to prevent the recontamination of the areas being cleaned up. The treatment or disposal of the perched water will be coordinated with the remedial actions for Operable Unit 5. Also, during the remediation of Operable Unit 2, storm water will be controlled to prevent the spread of contaminants. The treatment or disposal of the storm water will be coordinated with the remedial actions for Operable Unit 5.

The RAOs for all subunits in Operable Unit 2 are to prevent the release or migration of contaminants from waste materials and contaminated soils that could potentially (1) affect future groundwater users (perched and aquifer) on the site, (2) be harmful as sources of external radiation, (3) prevent the availability of harmful waste materials or contaminated soils for inhalation or ingestion by on-property resident farmers, and (4) prevent the availability of harmful waste materials or contaminated soils for plant uptake, disposition on plants, or ingestion by animals raised for meat and milk products.

1.0 INTRODUCTION

This report documents the Remedial Investigation (RI) phase of the Remedial Investigation/Feasibility Study (RI/FS) for Operable Unit 2 at the U.S. Department of Energy (DOE) Fernald Environmental Management Project (FEMP) or "the Fernald site." The FEMP was known as the Feed Materials Production Center (FMPC) until August 23, 1991. Its primary function was the production of metallic uranium fuel elements, target cores, and other uranium products for use in weapons production reactors and other programs operated by the DOE. At times, thorium was also processed and stored at the facility. As a result of these processes, the facility generated both radioactive and non-radioactive hazardous wastes.

The FEMP is a 1,050 acre, government-owned, contractor-operated facility located in southwestern Ohio, about 18 miles northwest of downtown Cincinnati, Ohio. The facility is located north of Fernald, Ohio, a small farming community, and lies on the boundary between Hamilton and Butler counties (Figure 1-1). Of the total site area, 850 acres are in Crosby Township of Hamilton County, and 200 acres are in Ross and Morgan townships of Butler County.

In 1989, the Fernald site was placed on the National Priorities List (NPL) (Superfund List) as a result of past releases of hazardous waste as part of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Under CERCLA, the RI/FS is a process designed to investigate the extent of site contamination and risks to human health and the environment, and evaluate the potential remedial (cleanup) alternatives. The Fernald site is defined as all areas within the property boundary of the FEMP and any other areas that received released hazardous substances, pollutants, contaminants, or hazardous constituents from FEMP activities. The RI/FS is being conducted pursuant to the terms of a 1991 Amended Consent Agreement with the U.S. Environmental Protection Agency (EPA) to identify the most effective remedial actions to be undertaken at the FEMP. Operable Unit 2 is one of five operable units at the FEMP and consists of waste subunits with relatively large volumes of conventional industrial wastes that were assumed to contain small amounts of hazardous chemicals or radionuclides.

This section describes the purpose and organization of the report and presents a facility description and history of operations for the FEMP site, more specifically for the facilities included as part of Operable Unit 2. It also describes previous Operable Unit 2 studies and other relevant prior

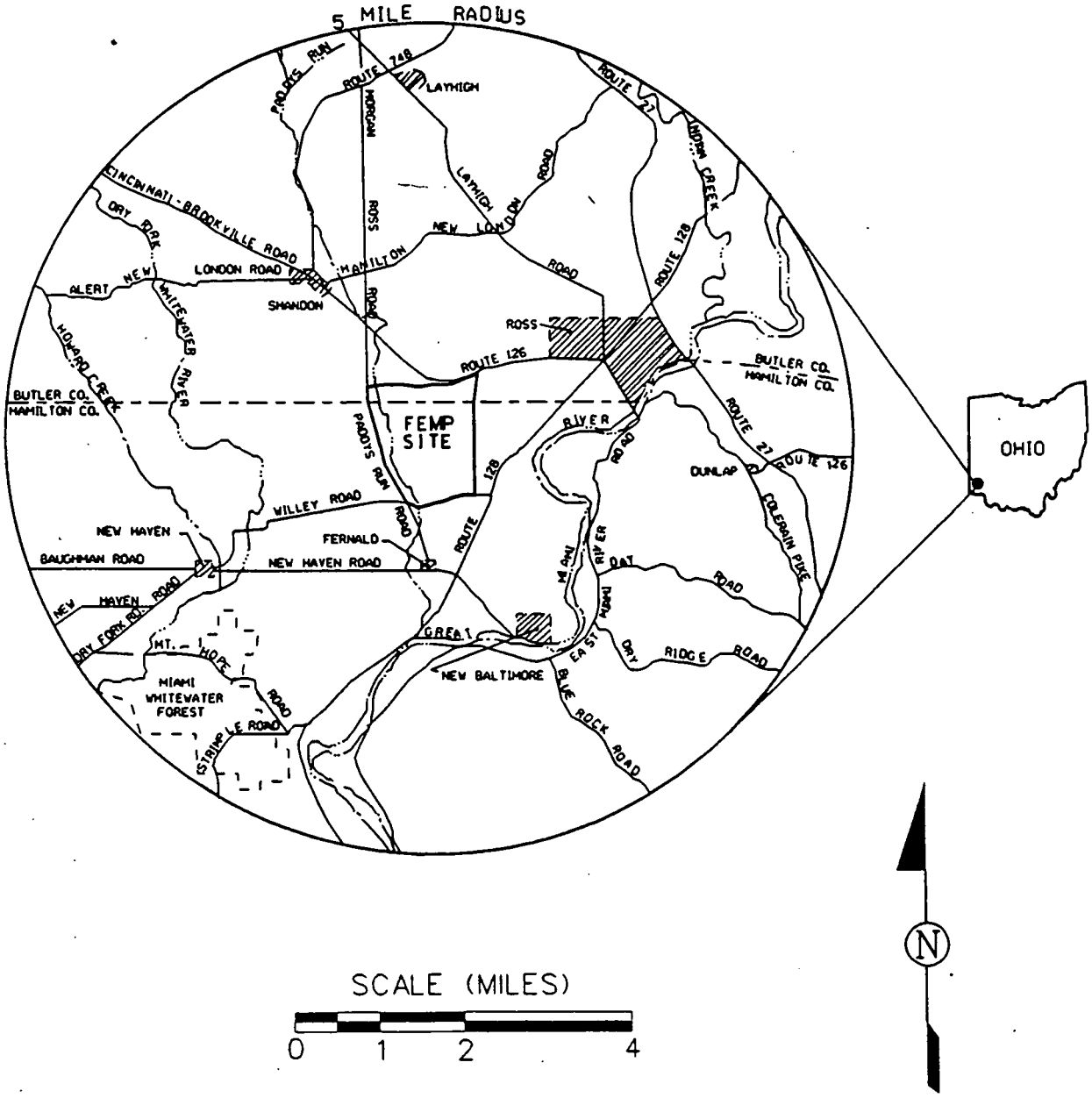

FIGURE 1-1
FEMP FACILITY
LOCATION MAP

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environmental investigations conducted at the FEMP. The overall objective of this section is to provide a historical and regional perspective to assist in evaluating potential environmental and human health impacts associated with Operable Unit 2.

1.1 PURPOSE OF REPORT

In the CERCLA remedial response process, a series of activities and subactivities are undertaken to provide a permanent resolution of actual or potential hazardous substance releases from a site. These activities consist of the RI, Feasibility Study (FS), Remedial Design (RD), Remedial Action (RA), and Operations and Maintenance (O&M). The purpose of the Operable Unit 2 RI is to gather data necessary to determine the nature and extent of contamination potentially posing significant risk to human health and/or the environment, and support the technical and cost analysis of alternatives carried out in the FS phase. Specifically, this report documents the investigations relating to Operable Unit 2; provides a detailed understanding of the nature and extent of contamination; determines the fate and transport of constituents of potential concern (CPC); and defines the risk posed to human receptors from Operable Unit 2 waste materials.

Under DOE regulation 10 Code of Federal Regulations (CFR) 1021, NEPA reviews are required for all DOE activities, including CERCLA actions. The NEPA/CERCLA integration plan, presented in DOE Order 5400.4, is designed to avoid duplicate effort and a larger commitment of resources needed to implement NEPA and CERCLA separately; to avoid conflicts in analysis and the choice of a remedial alternative; and to minimize the risk of delaying remedial actions on procedural grounds. The primary instrument for DOE's NEPA/CERCLA integration is the RI/FS process, supplemented as needed to meet the procedural and documentation requirements of NEPA.

This RI Report supports the Operable Unit 2 FS, which will evaluate the range of available remedial alternatives (including the no-action alternative) for Operable Unit 2 wastes and certain associated contaminated media. Results of the Operable Unit 2 FS will be reported in a separate document. The remedial alternatives will be evaluated for overall protectiveness of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long- and short-term effectiveness; reduction of toxicity, mobility, or volume; implementability; cost; and state and community acceptance. As mandated by the 1991 Amended Consent Agreement, the Operable Unit 2 FS will include a Comprehensive Response Action Risk Evaluation (CRARE) to

evaluate the cumulative residual risks resulting from each operable unit following remediation. The CRARE will include consideration of current and future use scenarios of the FEMP site.

To facilitate public participation in the remedy selection process, a Proposed Plan (PP) for Operable Unit 2 will be issued to the public for comment. The PP will present the proposed remedial action along with a summary of the RI findings and FS results. The PP will include an explanation of the alternatives considered and the preference for the proposed remedial action. After evaluating public comments on the PP, a Record of Decision (ROD) will be prepared to select the final remedial actions and provide a legal and technical basis for the selection actions.

Remaining remedial response activities consist of the RD/RA and O&M. The RD consists of the engineering design and preparation of the engineering drawings and specifications in a bid package for the implementation of the remedy. The RA is the actual implementation of the remedial measures through construction activities. After completion of the RA, any action necessary to ensure the sustained effectiveness of the applied remedy will be performed under the O&M phase.

1.2 HISTORY OF THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

The Atomic Energy Commission (AEC), predecessor to the U.S. Energy Research and Development Administration (ERDA) and then DOE, established the FMPC in conformance with AEC orders in the early 1950s. In 1951, National Lead Company of Ohio, Inc., (now NLO) entered into a contract with the AEC as the O&M contractor for the facility. This contract was effective until January 1, 1986.

The contractual relationship between NLO and DOE continued until January 1, 1986. Westinghouse Materials Company of Ohio (WMCO), a wholly-owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities for the site operations and facilities. Production ceased in the summer of 1989 due to a decline in uranium metal demand, and plant resources were focused on environmental cleanup activities. In June 1991, the site was officially closed as a federal production facility. Also in 1991, WMCO was renamed the Westinghouse Environmental Management Company of Ohio (WEMCO), and DOE renamed the site to Fernald Environmental Management Project to reflect the change in mission. On December 1, 1992, Fernald Environmental Restoration Management Company (FERMCO) assumed responsibility for the site

under the first Environmental Restoration Management Contract (ERMC) for DOE. FERMCO is a wholly-owned subsidiary of Fluor Daniel, Inc.

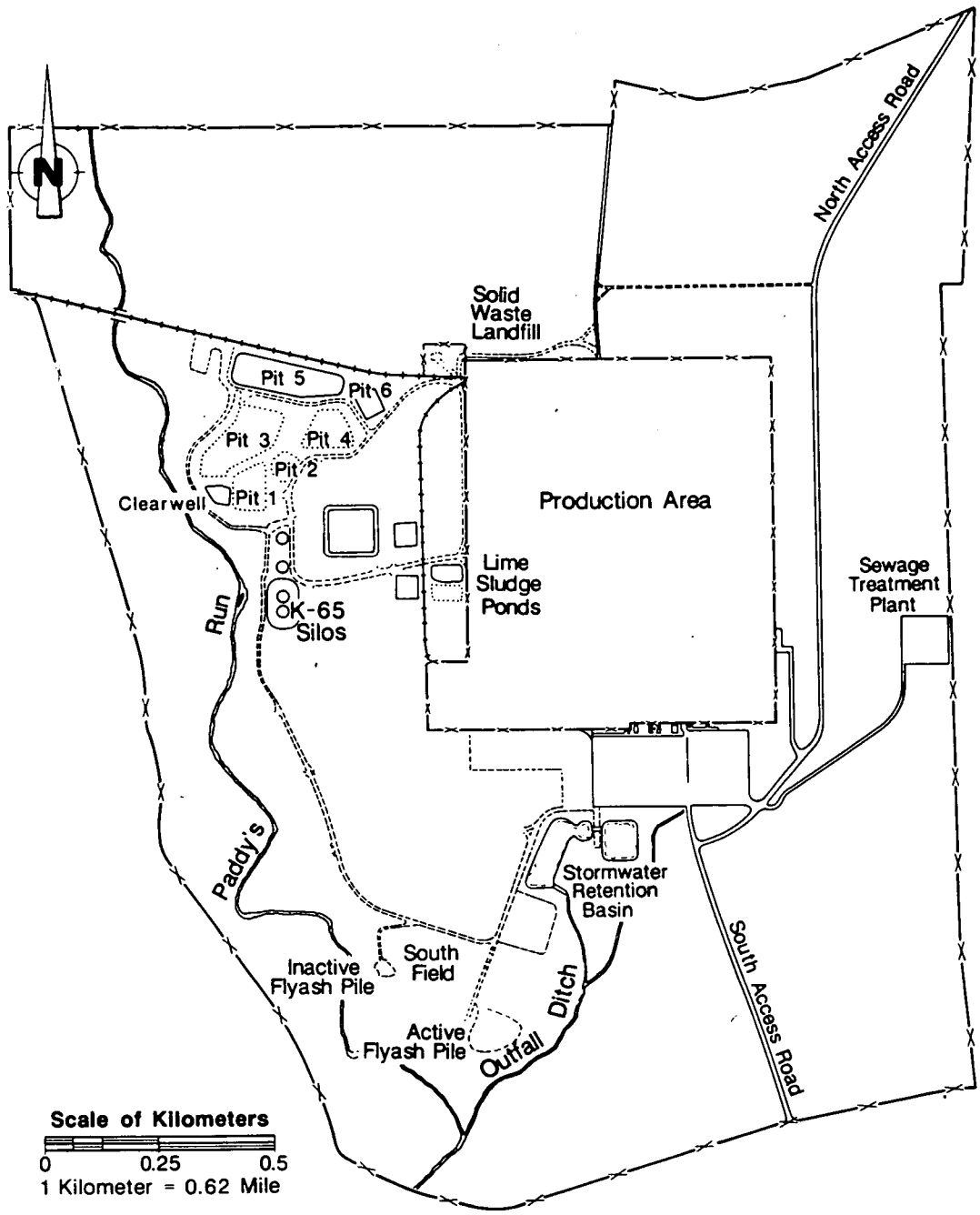
Production operations at the FMPC began in 1951 and were limited to a fenced, 136-acre tract of land known as the Production Area, located near the center of the site (Figure 1-2). The Waste Storage Area was constructed west of the Production Area to dispose of large quantity liquid and solid wastes and includes two of the Operable Unit 2 subunits. Prior to 1984, solid and slurried wastes from site processes were stored or disposed in the Waste Storage Area. Figure 1-3 presents the Waste Storage Area and identifies the battery limits of the Solid Waste Landfill and Lime Sludge Ponds.

The remaining subunits in Operable Unit 2 are located in an area to the southwest of the former Production Area (Figure 1-2). This area was used to dispose of construction rubble, boiler plant flyash and bottom ash, and other waste. Wastes stored within Operable Unit 2 are believed to be primarily generated from support operations and not from direct uranium production. Battery limits are defined as the boundaries of the investigation for sources contained in the Operable Unit 2 subunits.

1.2.1 FEMP Production Process

The primary mission of the FEMP during its 37 years of operation was the processing of "feed" materials to produce high purity uranium metal, explaining the site's original title, the Feed Materials Production Center. These high purity uranium metals were then shipped to other DOE facilities for use in the nation's weapons program (Figure 1-4). The following discussion is an overview of the production activities and materials handled at the FEMP.

Raw materials at the FEMP consisted of pitchblende ores obtained from mines in the Belgian Congo (an area now known as Zaire) and Australia; uranium concentrates (yellowcake) obtained from uranium mills in Canada and the United States; uranium tetrafluoride (green salt or UF_4) and uranium hexafluoride (UF_6) obtained from the DOE gaseous diffusion plants; uranium trioxide (UO_3) as a slightly enriched recycled material from the DOE Hanford Purex Plant; and recovered uranium-bearing residues from processing operations at the FEMP site and elsewhere. Enriched uranium is defined as uranium that contains a higher percentage of uranium-233 or -235 isotopes than that which occurs in natural uranium.



LEGEND

····· Covered Pit	×—× Fence
⊢—⊣—⊣ Railroad Spur	═══ Roadway

Figure 1-2: FEMP Site Map

GRAPHICS #2349

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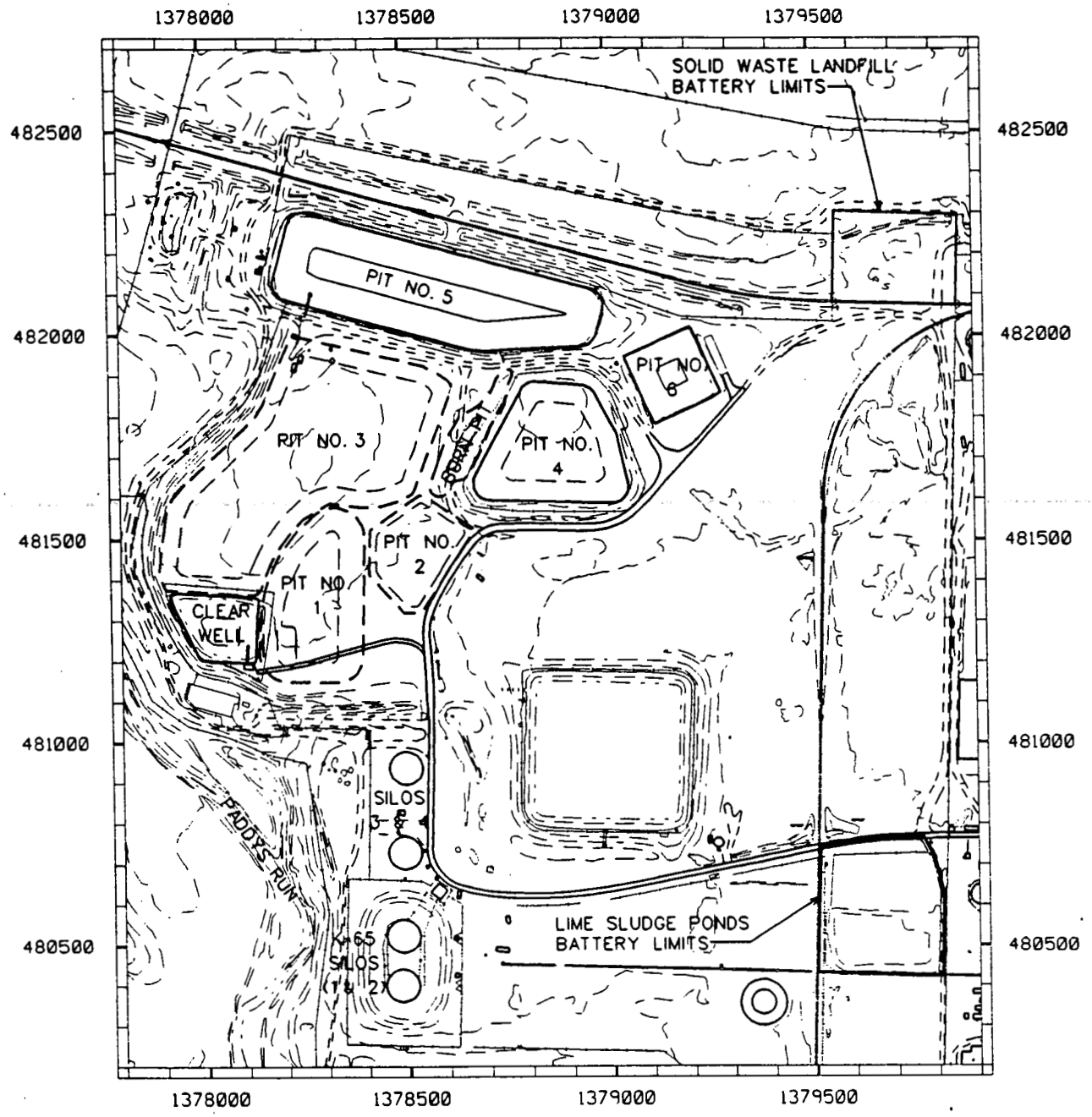


LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- BATTERY LIMITS
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)

0 200 400 800

FIGURE 1-3
WASTE STORAGE AREA

fig0103.dgn

(41)

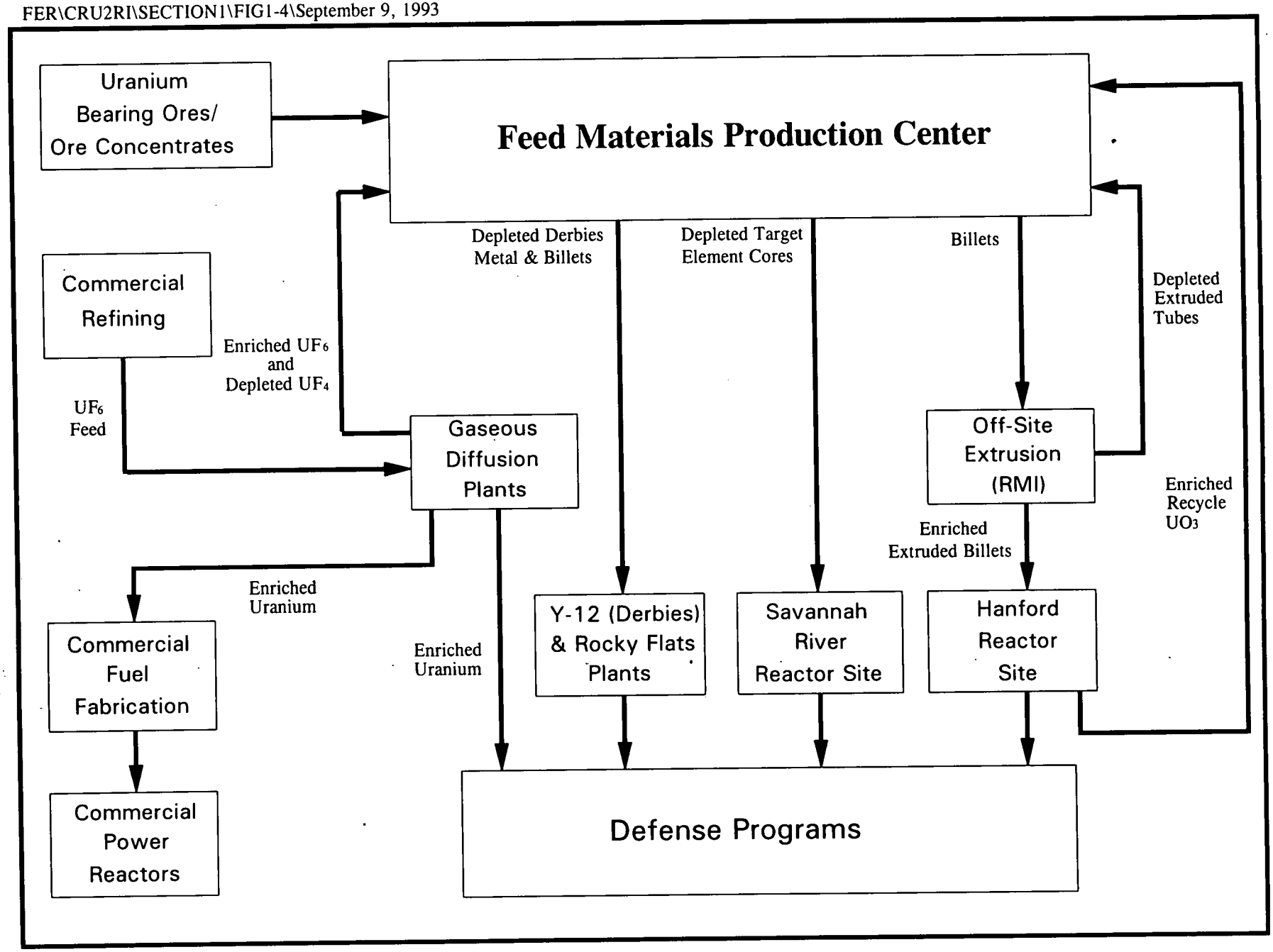


FIGURE 1-4. FMPC RELATIONSHIP TO DEFENSE PROGRAMS

The chemical and metallurgical processes for the manufacture of uranium metal products occurred in seven of the FEMP's more than 50 production, storage, and support buildings. The physical layout of those buildings in the former Production Area is shown in Figure 1-5, and a flow chart of the production process is illustrated in Figure 1-6. Much of the discussion of the refining process and handling of wastes is taken from the following documents and will not be specifically referenced in all instances in the text:

- "Uranium Production Technology" (Harrington and Ruehle 1959)
- "A Closer Look at Uranium Metal Production, A Technical Overview" (WMCO 1988)

Impure starting materials were first introduced into the process through the sampling plant (Plant 1) where they were sampled to determine the uranium concentration and the uranium enrichment status. Impure starting materials were transferred to the refinery (Plant 2/3) where they were dissolved in nitric acid; the uranium was purified through solvent extraction to yield a solution of uranyl nitrate. Uranyl nitrate solution was changed to uranium trioxide (UO_3) powder by evaporation and denitrification.

Uranium trioxide from Plant 2/3 was transported to the green salt plant (Plant 4) where it was converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. The UF_4 was then transported to Plant 5 (a metals production plant) where it was blended with magnesium metal granules and placed in a closed refractory-lined steel pot for heating and melting. The resulting product was a 300 to 375 pound piece of pure uranium metal and a by-product, magnesium fluoride slag. The uranium metal had the shape of a gentleman's top hat, or derby.

Some of the derbies were shipped directly to the Y-12 and Rocky Flats Plants. However, most remained in Plant 5 where they were remelted along with uranium scrap-metal from earlier machining operations and poured into graphite molds to form flat or cylindrical ingots. Flat ingots consisted of depleted uranium and were top-cropped, machined into billets, then shipped to Rocky Flats.

The cylindrical ingots consisted of either slightly enriched or depleted uranium. The ingots were center drilled into billets and then sent to Reactive Metals, Incorporated (RMI) in Ashtabula, Ohio. The enriched uranium billets were upset forged, machined, and then shipped to the DOE Hanford site. The depleted uranium billets were extruded into tubes and returned to the FMPC where they were cut into sections, heat treated, and machined to final dimensions. The completed tubes were

finally shipped to the DOE Savannah River site to be used as target element cores. Small amounts of thorium were processed at the FEMP on several occasions from 1954 through 1975. Thorium operations were conducted in Plants 1, 4, 6, 8, and 9, and the Pilot Plant. Although thorium materials are no longer being received for storage, the FEMP serves as the thorium repository for DOE and maintains storage facilities for a variety of thorium materials. Existing thorium inventories have now been declared as waste and are being shipped to DOE's Nevada Test Site (NTS) for disposal.

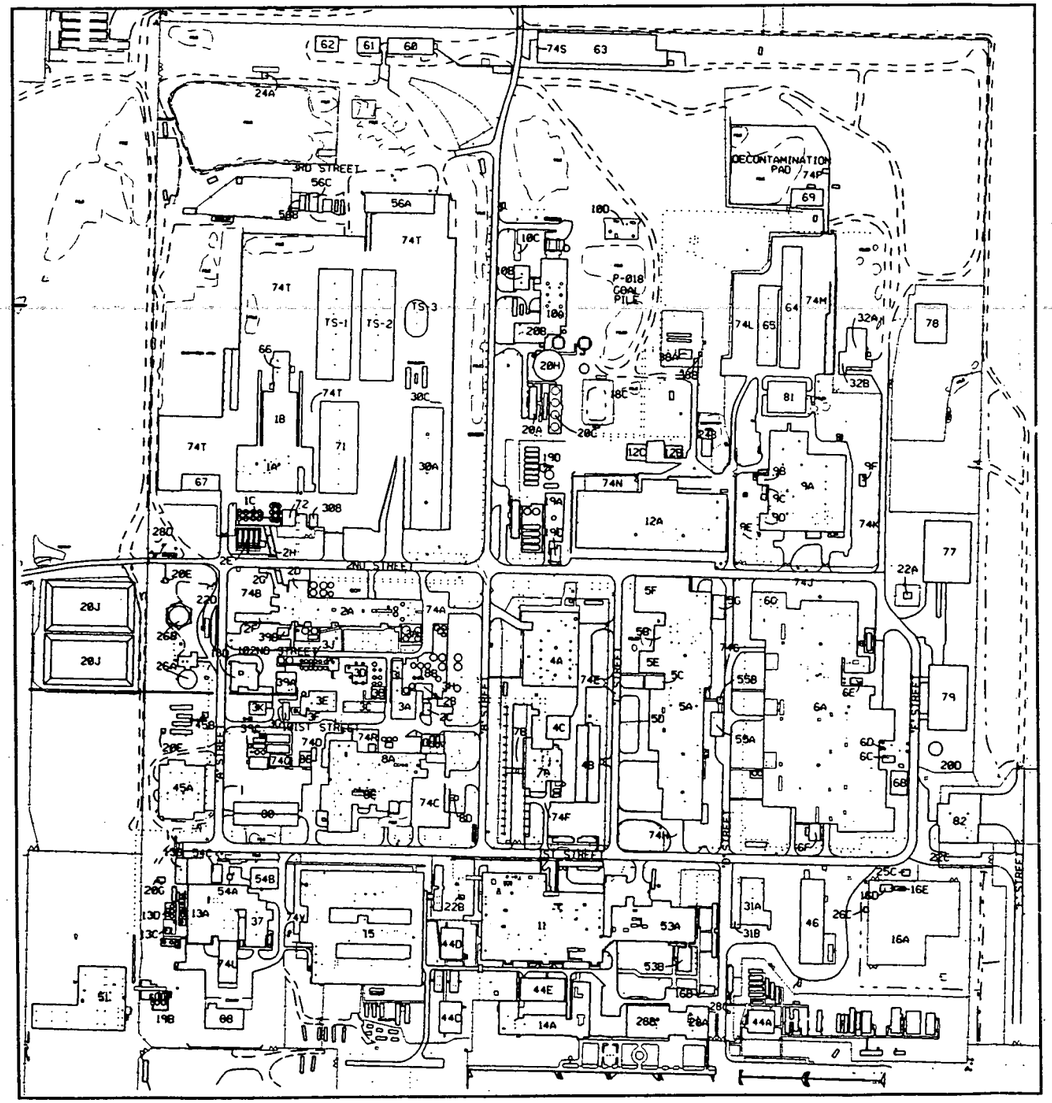
Production at the FEMP peaked in 1960 at approximately 12,000 metric tons of uranium per year. A product decline began in 1964 and reached a low in 1975 of about 1,230 tons. During the 1970s, consideration was given to closing the FEMP. Thus, capital improvements and staffing were minimized. The staffing level, which peaked at 2,891 personnel in 1956, slowly declined to 662 personnel in 1972 and then to 538 personnel in 1979.

In 1981, the FEMP once again began planning to accommodate increased production requirements. Production levels significantly increased and there was a rapid staff buildup for several years. The renewed need for uranium metal resulted in the implementation of a major facilities restoration program.

1.2.2 FEMP Compliance History

Current environmental investigations and cleanup activities are being directed through the CERCLA process and will meet ARARs. However, many other environmental regulations [e.g., NEPA, Resource Conservation and Recovery Act (RCRA), Clean Water Act (CWA), and Clean Air Act (CAA)] impact site activities. On-site activities will meet the substantive requirements of other regulations without complying with all of the administrative controls. CERCLA activities conducted off site and non-CERCLA on-site activities are required to comply with both the administrative and substantive requirements of the regulations. The following paragraphs describe a chronological history of regulatory events at the FEMP.

On October 13, 1978, President Carter signed Executive Order 12088 (Federal Compliance with Pollution Control Standards) mandating all DOE facilities to comply with existing environmental statutes and regulations including the CAA, CWA, and RCRA. Consequently, on March 9, 1985, EPA issued a Notice of Noncompliance to DOE identifying potential environmental impacts associated



FEMP SITE INDEX

TS-1 TENSION SUPPORT STRUCTURE #1
TS-2 TENSION SUPPORT STRUCTURE #2
TS-3 TENSION SUPPORT STRUCTURE #3
TS-4 TENSION SUPPORT STRUCTURE #4
TS-5 TENSION SUPPORT STRUCTURE #5
TS-6 TENSION SUPPORT STRUCTURE #6
1A PREPARATION PLANT
1B PLANT 1 STORAGE BLDG.
1C PLANT 1 ORE SILOS
2A ORE REFINERY PLANT
2B GENERAL/REFINERY SUMP CONTROL BLDG.
2C BULK LIME HANDLING BLDG.
2D METAL DISSOLVER BLDG.
2E NFS STORAGE & PUMP HOUSE
2F COLD SIDE ORE CONVEYOR
2G HOT SIDE ORE CONVEYOR
2H CONVEYOR TUNNEL (FROM PLANT 1)
3A MAINTENANCE BLDG.
3B OZONE BLDG.
3C NAR CONTROL HOUSE
3D NAR TOWERS
3E HOT RAFFINATE BLDG.
3F HARSHAW SYSTEM
3G REFRIGERATION BLDG.
3H REFINERY SUMP
3J COMBINED RAFFINATE TANKS
3K OLD COOLING WATER TOWER
3L ELECTRICAL POWER CENTER BLDG.
4A GREEN SALT PLANT
4B PLANT 4 WAREHOUSE
4C PLANT 4 MAINTENANCE BLDG.
5A METALS PRODUCTION PLANT
5B PLANT 5 INGOT PICKLING
5C PLANT 5 ELECTRICAL SUBSTATION
5D WEST DERBY BREAKOUT/SLAG MILLING
5E PLANT 5 FILTER BLDG.
5F PLANT 5 COVERED STORAGE PAD
5G PLANT 5 INGOT STORAGE SHELTER
6A METALS FABRICATION PLANT
6B PLANT 6 COVERED STORAGE AREA
6C PLANT 6 ELECTROSTATIC PRECIPITATOR (SOUTH)
6D PLANT 6 ELECTROSTATIC PRECIPITATOR (CENTRAL)
6E PLANT 6 ELECTROSTATIC PRECIPITATOR (NORTH)
6F PLANT 6 SALT OIL HEAT TREAT BLDG.
6G PLANT 6 SUMP BLDG.
7A PLANT 7
7B PLANT 7 OVERHEAD CRANE
8A RECOVERY PLANT
8B PLANT 8 MAINTENANCE BLDG.
8C ROTARY KILN/DRUM RECONDITIONING
8D PLANT 8 RAILROAD FILTER BLDG.
8E DRUM CONVEYOR SHELTER
8F PLANT 8 OLD DRUM WASHER
9A SPECIAL PRODUCTS PLANT
9B PLANT 9 SUMP TREATMENT FACILITY
9C PLANT 9 DUST COLLECTOR
9D PLANT 9 SUBSTATION
9E PLANT 9 CYLINDER SHED
9F PLANT 9 ELECTROSTATIC PRECIPITATOR
10A BOILER PLANT
10B BOILER PLANT MAINTENANCE BLDG.
10C WET SALT STORAGE BBM
10D CONTAMINATED OIL/GRAPHITE BURN PAD
10E UTILITIES HEAVY EQUIP. BLDG. (PROPOSED)
11 SERVICE BLDG.
12A NAR MAINTENANCE BLDG.
12B CYLINDER STORAGE BLDG.
12C LUMBER STORAGE BLDG.
12D MAINTENANCE BLDG. WAREHOUSE (PROPOSED)
13A PILOT PLANT WET SIDE
13B PILOT PLANT MAINTENANCE BLDG.
13C SUMP PUMP HOUSE
13D PILOT PLANT THORIUM TANK FARM
14A ADMINISTRATION BLDG.
14B BLDG. 14 COC GENERATOR SET
15A LABORATORY
15B LABORATORY CHEMICAL STORAGE BLDG.
16A MAIN ELECTRICAL STATION
16B ELECTRICAL SUBSTATION
16C ELECTRICAL PANELS & TRANSFORMER
16D MAIN ELECTRICAL SWITCH HOUSE
16E MAIN ELECTRICAL TRANSFORMERS
16F TRAILER SUBSTATION #1
16G TRAILER SUBSTATION #2
16H 10 PLEXS NORTH SUBSTATION
16J 10 PLEXS SOUTH SUBSTATION
16A BDN SURGE LAGOON
16B GENERAL SUMP
16C COAL PILE RUNOFF BASIN
16D BIODENITRIFICATION TOWERS
16E STORM WATER RETENTION BASINS
16F PIT #5 SLUICE GATE
16G CLEARWELL PUMP HOUSE
16H BDN EFFLUENT TREATMENT FACILITY
16J LOW NITRATE TANK
16K HIGH NITRATE TANK
16M HIGH NITRATE STORAGE TANK
16N WASTE PIT AREA STORM WATER RUNOFF CONTROL
16P DISSOLVED OXYGEN BLDG.
16Q MAINT VALVE HOUSE
16A MAIN TANK FARM
16B PILOT PLANT AMMONIA TANK FARM
16C TANK FARM CONTROL HOUSE
16D OLD NORTH TANK FARM
16E TANK FARM LIME SLITTER BLDG.
20A PUMP STATION & POWER CENTER
20B WATER PLANT
20C COOLING TOWERS
20D ELEVATED POTABLE STORAGE TANK
20E WELL HOUSE #1
20F WELL HOUSE #2
20G WELL HOUSE #3
20H PROCESS WATER STORAGE TANK
20J LIME SLURRY PITS
22A GAS METER BLDG.
22B STORM SEWER LIFT STATION
22C TRUCK SCALE
22D SCALE HOUSE & WDGH SCALE
22E UTILITY TRENCH TO PIT AREA
23 METEOROLOGICAL TOWER
24A RAILROAD SCALE HOUSE
24B RAILROAD ENGINE HOUSE
25A CHLORINATION BLDG.
25B U.H. #175/EFF. LINE/SAMPLING BLDG.
25C SEWAGE LIFT STATION BLDG.
25D U.V. DISINFECTION BLDG.
25E DIGESTER & CONTROL BLDG.
25F SLUDGE DRYING BEDS
25G PRIMARY SETTLING BASINS
25H TRICKLING FILTERS
25J 10 PLEXS SEWAGE LIFT STATION
26A PUMP HOUSE-HP FIRE PROTECTION
26B ELEVATED WATER STORAGE TANK
26C MAIN ELECTRICAL STRAINER HOUSE
28A SECURITY BLDG.
28B HUMAN RESOURCES BLDG.
28C GUARD POST ON SOUTH END OF "D" STR.
28D GUARD POST ON WEST END OF "2ND" STR.
30A CHEMICAL WAREHOUSE
30B DRUM STORAGE WAREHOUSE
30C OLD TEN TON SCALE
31A ENGINE HOUSE/GARAGE
31B OLD TRUCK SCALE
32A MAGNESIUM STORAGE BLDG.
32B BLDG. 32 COVERED LOADING DOCK
34A K-65 STORAGE TANK (NORTH)
34B K-65 STORAGE TANK (SOUTH)
34C RTS BLDG.
35A METAL OXIDE STORAGE TANK (NORTH)
35B METAL OXIDE STORAGE TANK (SOUTH)
37 PILOT PLANT ANNEX
38A PROPANE STORAGE
38B CYLINDER FILLING STATION
39A INCINERATOR BLDG.
39B WASTE OIL DECANT SHELTER
39C INCINERATOR SPRINKLER RISER HOUSE
39D SEWAGE TREATMENT PLANT INCINERATOR
44A TRAILER COMPLEX (6-PLEX)
44C TRAILER COMPLEX (7-PLEX S.)
44D TRAILER COMPLEX (7-PLEX N.)
44E TRAILER COMPLEX (10 PLEX)
45A RUST ENGINEERING BLDG.
45B UTILITY SHED EAST OF RUST TRAILERS
46 HEAVY EQUIPMENT BLDG.
51 SDI TO FOUR REDUCTION FACILITY #2
53A HEALTH & SAFETY BLDG.
53B IN-VIVO BLDG.
54A SDI TO FOUR REDUCTION FACILITY #1
54B PILOT PLANT SHELTER
54C PILOT PLANT DISSOCIATOR SHELTER
55A SLAG RECYCLING BLDG.
55B SLAG RECYCLING PIT/ELEVATOR
56A CP STORAGE WAREHOUSE
56B STORAGE SHED (WEST)
56C STORAGE SHED (EAST)
60 QUONSET HUT #1
61 QUONSET HUT #2
62 QUONSET HUT #3
63 KC-2 WAREHOUSE
64 THORIUM WAREHOUSE
65 (OLD) PLANT 5 WAREHOUSE
66 DRUM RECONDITIONING BLDG.
67 PLANT 1 THORIUM WAREHOUSE
68 PILOT PLANT WAREHOUSE
69 DECONTAMINATION BLDG.
71 GENERAL IN-PROCESS WAREHOUSE
72 DRUM STORAGE BUILDING
73A FIRE BRIGADE TRAINING CENTER BLDG.
73B FIRE TRAINING POND
73C FIRE TRAINING TANK
73D FIRE TRAINING BURN TROUGH
73E CONFINED SPACE BURN TANK
74A PLANT 2 EAST PAD
74B PLANT 2 WEST PAD
74C PLANT 8 EAST PAD
74D PLANT 8 WEST PAD
74E PLANT 4 PAD
74F PLANT 7 PAD
74G PLANT 5 EAST PAD
74H PLANT 5 SOUTH PAD
74J PLANT 6 PADS
74K PLANT 9 PAD
74L BUILDING 65 WEST PAD
74M BUILDING 64 EAST PAD & R.R. DOCK
74N BUILDING 12 NORTH PAD
74P DECONTAMINATION PAD
74Q PLANT 8 OLD METAL DISSOLVER PAD
74R PLANT 8 NORTH PAD
74S BUILDING 63 WEST PAD
74T PLANT 1 STORAGE PAD
74U PILOT PLANT PAD
74V LABORATORY PAD
74W INCINERATOR BLDG. PAD
77 FINISHED PRODUCTS WAREHOUSE (4A)
78 O.S.D. BUILDING
79 PLANT 6 WAREHOUSE
80 PLANT 8 WAREHOUSE
81 PLANT 9 WAREHOUSE
82 RECEIVING/INCOMING MAT'LS. INSP.
88 CLEARWELL LINE
89 PARKING LOTS
T76 INTERIM OFFICE SPACE
T77 INTERIM OFFICE SPACE
T80 INTERIM OFFICE SPACE
T81 INTERIM OFFICE SPACE

LEGEND

- ROADS
- STREAM
- BATTERY LIMITS
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 200 400 800

FIGURE 1-5
FORMER PRODUCTION AREA LAYOUT

fig0105.dgn

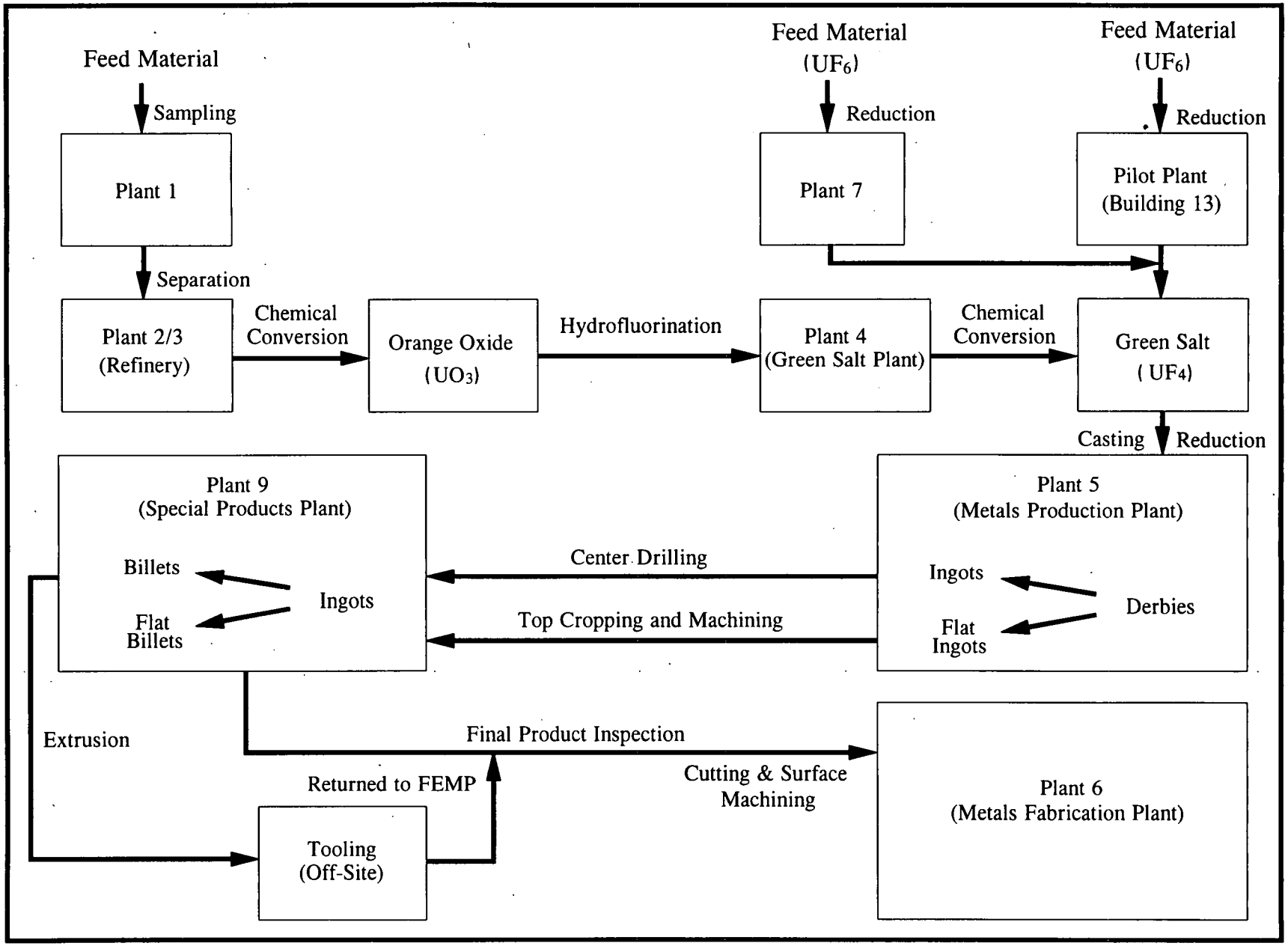


FIGURE 1-6 FEMP URANIUM METAL PRODUCTION PROCESS FLOW DIAGRAM

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with the FEMP's past and ongoing operations. Between April 1985 and July 1986, conferences were held between DOE and EPA representatives to discuss the issues and to identify steps to achieve and maintain environmental compliance.

A groundwater detection monitoring program for Waste Pit 4, an Operable Unit 1 area located in the Waste Storage Area, was initiated in August 1985 pursuant to the substantive and administrative RCRA, Subtitle C groundwater monitoring requirements. The detection monitoring program was required because of the disposal of a hazardous waste, barium salts, in Waste Pit 4 after 1980.

On July 18, 1986 a Federal Facility Compliance Agreement (FFCA), detailing actions to be taken by DOE to assess environmental impacts associated with the FEMP, was jointly signed by DOE and EPA. The FFCA was entered into to ensure compliance with existing environmental statutes and regulations. In particular, the FFCA required DOE to thoroughly and adequately investigate past and continuing activities at the FEMP to formulate, assess, and implement appropriate remedial response actions. In response to the FFCA, a RI/FS was initiated pursuant to CERCLA as defined by the National Oil and Hazardous Substances Pollution Contingency Plan, known as the National Contingency Plan (NCP), and amended by the 1986 Superfund Amendment and Reauthorization Act (SARA). The FEMP developed a CERCLA RI/FS Work Plan, Quality Assurance Project Plan, Health and Safety Plan (DOE 1987a), a RCRA Assessment Monitoring Plan for groundwater (DOE 1987b), and RCRA Part A (DOE 1984) and B (DOE 1985) permit applications.

The Ohio Environmental Protection Agency (OEPA) brought suit against the DOE on March 11, 1986 for alleged violations of state RCRA and CWA regulations. The suit was settled when DOE entered into a Consent Decree with the State of Ohio on December 2, 1988. The Consent Decree outlined specific actions necessary to attain compliance with RCRA and CWA regulations, including characterization and proper management of hazardous waste, groundwater monitoring of RCRA regulated units, and control of wastewater discharges and storm water runoff.

The FEMP was added to the NPL on November 21, 1989 [54 Federal Register (FR) 48184]. On June 29, 1990, a Consent Agreement (the 1990 Consent Agreement), amending the 1986 FFCA, was signed by the DOE and EPA. The agreement included continued compliance with the FFCA, the division of the site into five operable units, and an outline of activities and schedules for the RI/FS and ROD for each operable unit in accordance with the requirements of Sections 106(a) and 120 of

CERCLA. The 1990 Consent Agreement was revised in September 1991 to address additional environmental issues and revise the CERCLA schedules. The revised Consent Agreement is referred to as the 1991 Amended Consent Agreement.

In December 1990, amendments were proposed to update the Consent Decree of 1988 to reflect the new agreement between EPA and DOE (i.e., the 1990 Consent Agreement) and to resolve compliance issues raised by the OEPA. The Stipulated Amended Consent Decree was signed on January 22, 1993.

The 1991 Amended Consent Agreement was modified on April 9, 1993 by an agreement between EPA and DOE resolving a dispute concerning EPA's denial of DOE's request for an extension of time to submit Operable Unit 2 documents. This agreement established new schedules extending the submittal dates of the Operable Unit 2 RI, FS/PP, and draft ROD, and also accelerated Operable Unit 1, Operable Unit 3, and Operable Unit 5 draft ROD submission dates by 30 days each.

A Notice of Intent to prepare an Environmental Impact Statement (EIS) for the FEMP RI/FS was published in the Federal Register (55 FR 20183, May 15, 1990). In this notice, it was proposed that:

- An RI/FS-EIS is the appropriate level of NEPA documentation for the "lead" operable unit, (i.e., Operable Unit 4).
- NEPA/CERCLA integration will be provided in the remaining operable unit RI/FS-NEPA reports. These documents will reference the lead RI/FS-EIS and will present impacts specific to the operable units and update site-wide and cumulative impacts as necessary.

As identified in the Notice of Intent, the FS and PP for the earliest scheduled operable unit, Operable Unit 4, will be issued as an FS/PP-EIS. The FS/PP-EIS will examine the environmental impacts associated with Operable Unit 4 remedial activities as well as the cumulative impacts (Operable Unit 4 FS/PP-EIS, Appendix I) associated with the implementation of remedial actions for all five operable units at the FEMP. An additional element of NEPA compliance is the FEMP Site-Wide Characterization Report (DOE 1993), which supplements the Operable Unit 4 FF/PP-EIS by providing an assessment of cumulative environmental impacts associated with the existing conditions at the FEMP on a site-wide basis.

The Operable Unit 2 FS and PP will be coordinated with the Operable Unit 4 FS/PP-EIS for purposes of NEPA integration. The cumulative impact analysis presented in the Operable Unit 4 EIS will be updated and included in the Operable Unit 2 FS/PP-EA as Appendix G. The Operable Unit 2 RI Report will be incorporated by reference in the Operable Unit 2 FS and PP. This RI Report includes the characterization of Operable Unit 2 and, hence, will support the necessary description of the affected environment in the Operable Unit 2 NEPA evaluation. This report also provides the Baseline Risk Assessment that will support the evaluation of the no-action alternative for Operable Unit 2.

1.3 FEMP OPERABLE UNITS

To promote a more structured and expeditious cleanup of the FEMP, the facility and related environmental issues have been partitioned into five study areas called operable units. An operable unit is a definition to logically group similar environmental issues at a cleanup site. FEMP operable unit study areas are depicted in Figure 1-7. Separate RI/FS documentation is being issued for each of the five operable units at the FEMP.

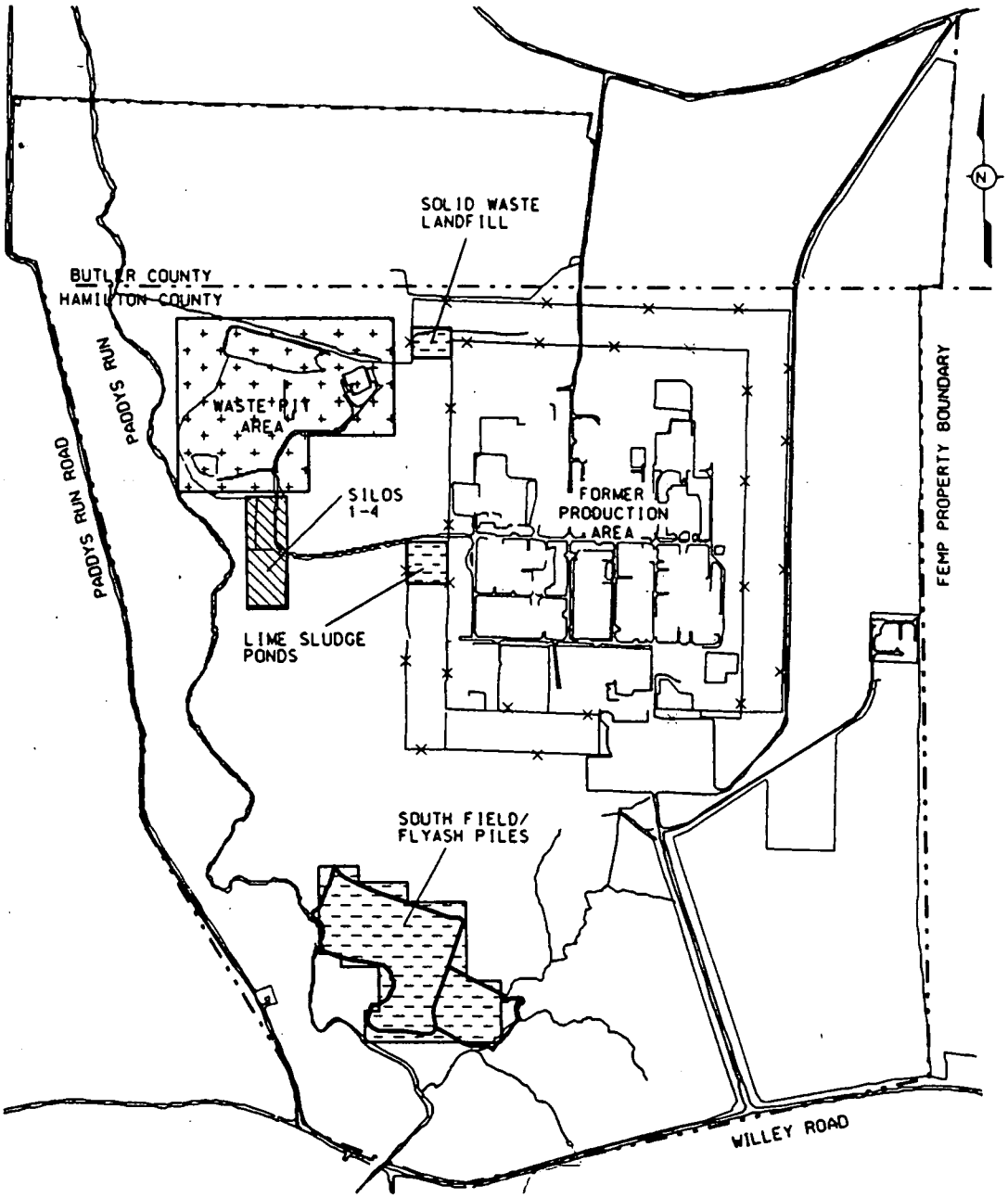
FEMP operable units are as follows:

- Operable Unit 1 - Waste Pit Area
- Operable Unit 2 - Other Waste Units
- Operable Unit 3 - Former Production Area
- Operable Unit 4 - Silos 1-4
- Operable Unit 5 - Environmental Media

Operable Unit 1 consists of on-site facilities that were used during uranium production for storage of low-level radioactive waste. The operable unit covers approximately 37 acres in the Waste Storage Area and consists of:

- Waste Pits 1 through 6
- Waste pit liners
- Berms
- The Clearwell
- The Burn Pit

Waste Pits 1 through 6, located west of the former Production Area, contain a variety of liquid and solid wastes that were generated by the eight separate operations plants at the site. Pits 1 through 4 are covered with earth, and Pits 5 and 6 are covered with water. The Clearwell was a settling pond, and the Burn Pit contains residue from burned refuse.



LEGEND

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

SCALE

0 1200 2400 FEET

NOTE

OPERABLE UNIT 3 INCLUDES ALL BUILDINGS, PIPELINES, AND ABOVEGROUND STRUCTURES IN THE FORMER PRODUCTION AREA. OPERABLE UNIT 5 INCLUDES GROUNDWATER, SURFACE WATER, SOILS, SEDIMENTS, FLORA AND FAUNA IN THE REGIONAL AREA AS WELL AS THE FORMER PRODUCTION AREA.

fig0107.dgn

FIGURE 1-7
RI/FS OPERABLE UNITS

000081

Operable Unit 2 consists of those facilities used for the storage or disposal of solid wastes from the nonprocess site operations. These waste subunits are:

- Solid Waste Landfill
- North and South Lime Sludge Ponds
- Inactive Flyash Pile
- South Field
- Active Flyash Pile
- Berms, liners, and soils within the Operable Unit 2 boundary

These waste subunits are discussed in detail in Section 1.3 and throughout this report.

Operable Unit 3 includes all plants and facilities that were involved in producing uranium metal products and in processing thorium for other DOE programs. The former Production Area and production-associated facilities and equipment (includes all above-grade improvements) included in Operable Unit 3 are:

- All structures
- Utilities
- Tanks
- Waste
- K-65 slurry line
- Fire training facilities
- Scrap metal piles
- Coal pile
- Equipment
- Drums
- Solid waste
- Effluent lines
- Wastewater treatment facilities
- Thorium
- Feedstocks
- Product

Operable Unit 4 is defined as the geographic area that includes:

- The two K-65 silos (Silos 1 and 2)
- The metal oxide silo (Silo 3)
- The empty Silo 4
- The decant sump system
- The buried transfer trench
- Soils and perched water that lie above the Great Miami Aquifer within the Operable Unit 4 boundary.

Operable Unit 4 is partially fenced and bounded by an exclusion zone that surrounds Silos 1 and 2 and extends to the north, towards Silo 3. Silos 1 and 2 are concrete storage structures that contain radium-bearing residues from past DOE operations. Silo 3 received only dry materials that are primarily metal oxides. Silo 4 was never used and, therefore, is not considered to be a past, current, or future source of contaminant release to the environment.

Operable Unit 5 consists of environmental media that can serve as pathways for transporting contaminants. The environmental media that make up Operable Unit 5 are:

- Soils
- Flora and fauna
- Surface water and sediments
- Groundwater (including perched groundwater)

Soils not addressed in the other operable units will be considered as part of this operable unit. Investigations into the flora and fauna include terrestrial vegetation and animals, aquatic communities in the Great Miami River and Paddys Run, locally grown produce and crops, and cattle grazing on potentially affected land areas.

Surface water channels included in Operable Unit 5 are the Great Miami River, Paddys Run, and the Storm Sewer Outfall Ditch. The Great Miami Aquifer underlying the facility is a major source of drinking water and has been declared a sole-source aquifer by EPA Region V (53 FR 25670).

1.4 FEMP OPERABLE UNIT INTERFACES

The RIs for each operable unit will determine the current and future impacts that the respective waste units have on the environment and the risk posed to human health from those impacts. The RI activities for Operable Units 1 through 4 are specific and not directly related to other operable unit activities. The Operable Unit 5 RI will assess the impacts of site production operations on environmental media; its RI activities are coordinated with the RI/FS activities related to other operable units.

The Operable Unit 2 RI characterizes the nature and extent of contamination in environmental media within the five subunits (Section 4.0). Impacts to perched water and the Great Miami Aquifer from waste subunit releases are presented. Data pertaining to physical and chemical characterization of environmental media outside Operable Unit 2 are presented and discussed as necessary to define the nature and extent of contamination within Operable Unit 2. The Operable Unit 5 RI will determine the full nature and extent of contaminants in the Great Miami Aquifer and in soils outside the battery limits (boundaries that define an area of responsibility) of the Operable Unit 2 waste subunits.

The Operable Unit 2 RI has investigated the fate and transport of constituents in air, surface water, and groundwater released from its waste subunits to determine exposure levels for risk assessment.

The fate and transport assessment (Section 5.0) includes analysis of contaminant migration to off-site receptors. The Operable Unit 5 RI will determine transport of constituents from site-wide to off-site receptors. A complete assessment of fate and transport of constituents in air, surface water, and groundwater at the FEMP will be reported in the Operable Unit 5 RI Report.

The Operable Unit 2 Baseline Risk Assessment (presented in Appendix B and summarized in Section 6.0) addresses only the risks to human health associated with the waste subunits within Operable Unit 2. Risks due to waste material and associated contamination in groundwater, surface water, sediment, and soil are considered. All risks due to existing groundwater contamination outside the Operable Unit 2 battery limits will be evaluated as part of the Operable Unit 5 RI/FS.

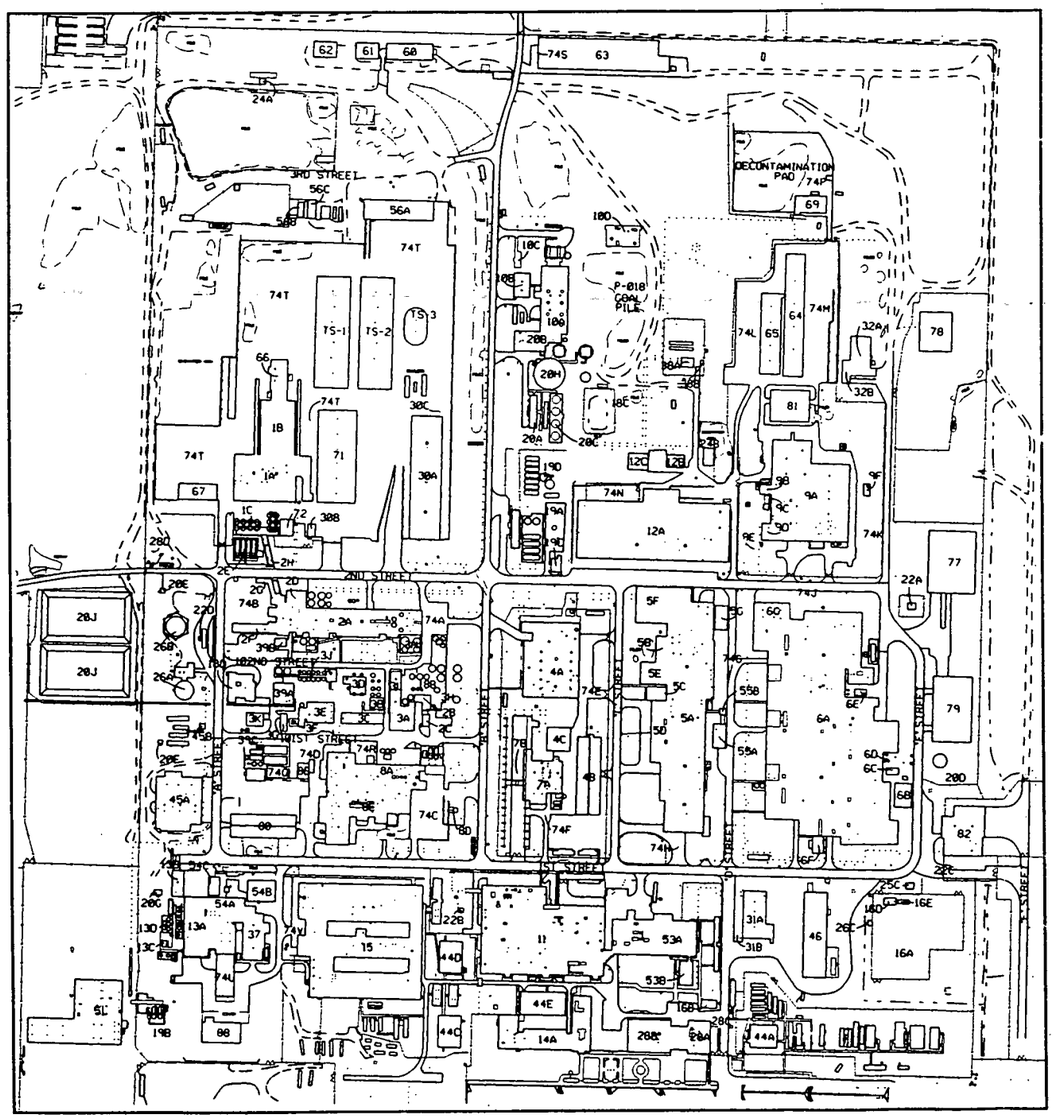
Ecological risks are not addressed in the Operable Unit 2 Baseline Risk Assessment. Baseline ecological risks for the Fernald site will be addressed in the Site-Wide Ecological Risk Assessment to be submitted as part of the Operable Unit 5 RI/FS. The site-wide ecological risk assessment will address only on-site and off-site areas not likely to be remediated on the basis of human health concerns. Since significant areas within Operable Unit 2 are likely to be remediated based on human health concerns, ecological risks are not evaluated in the Operable Unit 2 RI. However, the FS/PP-EA will contain a qualitative evaluation of residual ecological risks associated with Operable Unit 2 as agreed to by the U.S. EPA in their concurrence with the Ecological Risk Assessment Strategy (Saric to Craig, October 1993).

1.5 PREVIOUS REGIONAL INVESTIGATIONS AND SITE MONITORING

Numerous environmental investigations have been conducted in and around the FEMP site by DOE and other organizations. During operation of the FEMP, air, groundwater, surface water, soil, and biota were routinely monitored. The following paragraphs describe the data from these previous activities that were used for scoping the RI/FS and preparing the RI/FS Work Plan. Because of data quality and validation issues, the historical data have been used as general information for screening and support of nature and extent but will not be used directly in support of fate and transport modeling or risk assessment.

1.5.1 Meteorological Monitoring

The Miami Conservancy District has collected precipitation records for the Miami River Valley since the early 1900s (Houck 1921). Meteorological records have also been collected at the



FEMP SITE INDEX

TS-1 TENSION SUPPORT STRUCTURE #1
TS-2 TENSION SUPPORT STRUCTURE #2
TS-3 TENSION SUPPORT STRUCTURE #3
TS-4 TENSION SUPPORT STRUCTURE #4
TS-5 TENSION SUPPORT STRUCTURE #5
TS-6 TENSION SUPPORT STRUCTURE #6
1A PREPARATION PLANT
1B PLANT 1 STORAGE BLDG.
1C PLANT 1 ORE SILOS
2A ORE REFINERY PLANT
2B GENERAL/REFINERY SUMP CONTROL BLDG.
2C BULK LIME HANDLING BLDG.
2D METAL DISSOLVER BLDG.
2E HF3 STORAGE & PUMP HOUSE
2F COLD SIDE ORE CONVEYOR
2G HOT SIDE ORE CONVEYOR
2H CONVEYOR TUNNEL (FROM PLANT 1)
3A MAINTENANCE BLDG.
3B OZONE BLDG.
3C NAR CONTROL HOUSE
3D NAR TOWERS
3E HOT RAFFINATE BLDG.
3F NARSHAW SYSTEM
3G REFRIGERATION BLDG.
3H REFINERY SUMP
3J COMBINED RAFFINATE TANKS
3K OLD COOLING WATER TOWER
3L ELECTRICAL POWER CENTER BLDG.
4A GREEN SALT PLANT
4B PLANT 4 WAREHOUSE
4C PLANT 4 MAINTENANCE BLDG.
5A METALS PRODUCTION PLANT
5B PLANT 5 INGOT PICKLING
5C PLANT 5 ELECTRICAL SUBSTATION
5D WEST DERBY BREAKOUT/SLAG MILLING
5E PLANT 5 FILTER BLDG.
5F PLANT 5 COVERED STORAGE PAD
5G PLANT 5 INGOT STORAGE SHELTER
6A METALS FABRICATION PLANT
6B PLANT 6 COVERED STORAGE AREA
6C PLANT 6 ELECTROSTATIC PRECIPITATOR (SOUTH)
6D PLANT 6 ELECTROSTATIC PRECIPITATOR (CENTRAL)
6E PLANT 6 ELECTROSTATIC PRECIPITATOR (NORTH)
6F PLANT 6 SALT OIL HEAT TREAT BLDG.
6G PLANT 6 SUMP BLDG.
7A PLANT 7
7B PLANT 7 OVERHEAD CRANE
8A RECOVERY PLANT
8B PLANT 8 MAINTENANCE BLDG.
8C ROTARY KILN/DRUM RECONDITIONING
8D PLANT 8 RAILROAD FILTER BLDG.
8E DRUM CONVEYOR SHELTER
8F PLANT 8 OLD DRUM WASHER
9A SPECIAL PRODUCTS PLANT
9B PLANT 9 SUMP TREATMENT FACILITY
9C PLANT 9 DUST COLLECTOR
9D PLANT 9 SUBSTATION
9E PLANT 9 CYLINDER SHED
9F PLANT 9 ELECTROSTATIC PRECIPITATOR
10A BOILER PLANT
10B BOILER PLANT MAINTENANCE BLDG.
10C WET SALT STORAGE BIN
10D CONTAMINATED OIL/GRAPHITE BURN PAD
10E UTILITIES HEAVY EQUIP. BLDG. (PROPOSED)
11 SERVICE BLDG.
12A MAIN MAINTENANCE BLDG.
12B CYLINDER STORAGE BLDG.
12C LUMBER STORAGE BLDG.
12D MAINTENANCE BLDG. WAREHOUSE (PROPOSED)
13A PILOT PLANT WET SIDE
13B PILOT PLANT MAINTENANCE BLDG.
13C SUMP PUMP HOUSE
13D PILOT PLANT THORIUM TANK FARM
14A ADMINISTRATION BLDG.
14B BLDG. 14 EOC GENERATOR SET
15A LABORATORY
15B LABORATORY CHEMICAL STORAGE BLDG.
16A MAIN ELECTRICAL STATION
16B ELECTRICAL SUBSTATION
16C ELECTRICAL PANELS & TRANSFORMER
16D MAIN ELECTRICAL SWITCH HOUSE
16E MAIN ELECTRICAL TRANSFORMERS
16F TRAILER SUBSTATION #1
16G TRAILER SUBSTATION #2
16H 10 PLEXES NORTH SUBSTATION
16J 10 PLEXES SOUTH SUBSTATION
18A BOH SURGE LAGOON
18B GENERAL SUMP
18C COAL PILE RUNOFF BASIN
18D BIODENITRIFICATION TOWERS
18E STORM WATER RETENTION BASINS
18F PIT #5 SLUICE GATE
18G CLEARWELL PUMP HOUSE
18H BOH EFFLUENT TREATMENT FACILITY
18J METHANOL TANK
18K LOW NITRATE TANK
18L HIGH NITRATE TANK
18M HIGH NITRATE STORAGE TANK
18N WASTE PIT AREA STORM WATER RUNOFF CONTROL
18P DISSOLVED OXYGEN BLDG.
19A MAIN TANK FARM
19B PILOT PLANT AMMONIA TANK FARM
19C TANK FARM CONTROL HOUSE
19D OLD NORTH TANK FARM
19E TANK FARM LINE SUTTER BLDG.
20A PUMP STATION & POWER CENTER
20B WATER PLANT
20C COOLING TOWERS
20D ELEVATED POTABLE STORAGE TANK
20E WELL HOUSE #1
20F WELL HOUSE #2
20G WELL HOUSE #3
20H PROCESS WATER STORAGE TANK
20J LIME SLURRY PITS
22A GAS METER BLDG.
22B STORM SEWER LIFT STATION
22C TRUCK SCALE
22D SCALE HOUSE & WEIGH SCALE
22E UTILITY TRENCH TO PIT AREA
23 METEOROLOGICAL TOWER
24A RAILROAD SCALE HOUSE
24B RAILROAD ENGINE HOUSE
25A CHLORINATION BLDG.
25B M.H. #175/EFF. LINE/SAMPLING BLDG.
25C SEWAGE LIFT STATION BLDG.
25D U.V. DISINFECTION BLDG.
25E DIGESTER & CONTROL BLDG.
25F SLUDGE DRYING BEDS
25G PRIMARY SETTLING BASINS
25H TRICKLING FILTERS
25J 10 PLEXES SEWAGE LIFT STATION
26A PUMP HOUSE-HP FIRE PROTECTION
26B ELEVATED WATER STORAGE TANK
26C MAIN ELECTRICAL STRAINER HOUSE
28A SECURITY BLDG.
28B HUMAN RESOURCES BLDG.
28C GUARD POST ON SOUTH END OF "D" STR.
28D GUARD POST ON WEST END OF "2ND" STR.
30A CHEMICAL WAREHOUSE
30B DRUM STORAGE WAREHOUSE
30C OLD TEN TON SCALE
31A ENGINE HOUSE/GARAGE
31B OLD TRUCK SCALE
32A MAGNESIUM STORAGE BLDG.
32B BLDG. 32 COVERED LOADING DOCK
34A K-65 STORAGE TANK (NORTH)
34B K-65 STORAGE TANK (SOUTH)
34C RTS BLDG.
35A METAL OXIDE STORAGE TANK (NORTH)
35B METAL OXIDE STORAGE TANK (SOUTH)
37 PILOT PLANT ANNEX
38A PROPANE STORAGE
38B CYLINDER FILLING STATION
39A INCINERATOR BLDG.
39B WASTE OIL DECANT SHELTER
39C INCINERATOR SPRINKLER RISER HOUSE
39D SEWAGE TREATMENT PLANT INCINERATOR
44A TRAILER COMPLEX (6-PLEX)
44C TRAILER COMPLEX (7-PLEX S.)
44D TRAILER COMPLEX (7-PLEX N.)
44E TRAILER COMPLEX (10 PLEX)
45A RUST ENGINEERING BLDG.
45B UTILITY SHED EAST OF RUST TRAILERS
46 HEAVY EQUIPMENT BLDG.
51 SDI TO FOUR REDUCTION FACILITY #2
53A HEALTH & SAFETY BLDG.
53B IN-VIVO BLDG.
54A SDI TO FOUR REDUCTION FACILITY #1
54B PILOT PLANT SHELTER
54C PILOT PLANT DISSOCIATOR SHELTER
55A SLAG RECYCLING BLDG.
55B SLAG RECYCLING PIT/ELEVATOR
56A CP STORAGE WAREHOUSE
56B STORAGE SHED (WEST)
56C STORAGE SHED (EAST)
60 QUONSET HUT #1
61 QUONSET HUT #2
62 QUONSET HUT #3
63 KC-2 WAREHOUSE
64 THORIUM WAREHOUSE
65 (OLD) PLANT 5 WAREHOUSE
66 DRUM RECONDITIONING BLDG.
67 PLANT 1 THORIUM WAREHOUSE
68 PILOT PLANT WAREHOUSE
69 DECONTAMINATION BLDG.
71 GENERAL IN-PROCESS WAREHOUSE
72 DRUM STORAGE BUILDING
73A FIRE BRIGADE TRAINING CENTER BLDG.
73B FIRE TRAINING POND
73C FIRE TRAINING TANK
73D FIRE TRAINING BURN TROUGH
73E CONFINED SPACE BURN TANK
74A PLANT 2 EAST PAD
74B PLANT 2 WEST PAD
74C PLANT 8 EAST PAD
74D PLANT 8 WEST PAD
74E PLANT 4 PAD
74F PLANT 7 PAD
74G PLANT 5 EAST PAD
74H PLANT 5 SOUTH PAD
74J PLANT 6 PADS
74K PLANT 9 PAD
74L BUILDING 65 WEST PAD
74M BUILDING 64 EAST PAD & R.R. DOCK
74N BUILDING 12 NORTH PAD
74P DECONTAMINATION PAD
74Q PLANT 8 OLD METAL DISSOLVER PAD
74R PLANT 8 NORTH PAD
74S BUILDING 63 WEST PAD
74T PLANT 1 STORAGE PAD
74U PILOT PLANT PAD
74V LABORATORY PAD
74W INCINERATOR BLDG. PAD
77 FINISHED PRODUCTS WAREHOUSE (4A)
78 D & D BUILDING
79 PLANT 6 WAREHOUSE
80 PLANT 8 WAREHOUSE
81 PLANT 9 WAREHOUSE
82 RECEIVING/INCOMING MAT'LS. INSP.
88 CLEARWELL LINE
89 PARKING LOTS
T76 INTERIM OFFICE SPACE
T77 INTERIM OFFICE SPACE
T80 INTERIM OFFICE SPACE
T81 INTERIM OFFICE SPACE

LEGEND

ROADS
STREAM
BATTERY LIMITS
FENCE
RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 200 400 800

FIGURE 1-5
FORMER PRODUCTION AREA LAYOUT

fig0105.dgn

Cincinnati/Northern Kentucky International Airport since 1975. The FEMP installed a 60 meter meteorological tower on site and southwest of the former Production Area in 1986 to collect site specific meteorological data.

Meteorological records for regional and site specific weather patterns are comprehensive and provide suitable information for the Operable Unit 2 RI. Meteorological records have been used in surface water evaluations, air transport modeling, and hydrogeologic assessments.

1.5.2 Surface Soil Investigation

During 1986 and 1987, a Characterization Investigation Study (CIS) was performed at the FEMP site. The CIS involved the investigation of the FEMP waste storage areas, including the Operable Unit 2 Study Area and the area surrounding the flyash piles. During the CIS, samples were collected from the waste units, surrounding surface soils, and drainages leading to Paddys Run. The surface soil sample results from the samples collected during the CIS have been used in a supplementary manner to evaluate the nature and extent of contamination in Operable Unit 2.

1.5.3 Geologic Investigations

Geologic investigations of the area that surrounds and includes the FEMP site have contributed substantial information to the RI/FS investigation. Fenneman (1916) performed an extensive survey of the geology in the Cincinnati area. This report is among the first that describes in detail the interbedded limestone and shale bedrock and its mantle of glaciofluvial and alluvial sediments that constitute the buried-channel aquifers in southwestern Ohio. Later investigators such as Durrell (1961) supported Fenneman's observations.

The shape of the buried-channel aquifer was further refined by Watkins and Spieker (1971) via geophysical surveys of the area around the Fernald site. More recent information includes various maps of the geology of Hamilton and Butler Counties, Ohio, as well as individual quadrangle maps of areas located in those counties (Leow 1985; Vormelker 1985; Ford 1974; Swinford in preparation). Maps showing the extent and age of glacial till in the Operable Unit 4 Study Area have also been produced (Brockman 1988). The Soil Conservation Service (USDA 1980, 1982) has performed detailed soil surveys of Butler and Hamilton counties in Ohio, including the environs of the FEMP site.

The previous geologic studies have provided an adequate regional geological evaluation for the FEMP site. The Operable Unit 2 RI utilized the previous studies to develop the regional and site-wide geology and to guide more detailed geologic investigations of the Operable Unit 2 waste subunits.

1.5.4 Surface Water and Sediment Investigations

The Miami Conservancy District has kept runoff records for the Miami River Valley since the early 1900s (Houck 1921). Flood information for the Great Miami River and Paddys Run is available from the Federal Emergency Management Agency (FEMA 1982). Additional information on the Great Miami River has been well documented with respect to flow duration and water quality (Cross and Hedges 1959; OEPA 1982).

Flow from the Great Miami River drainage basin is monitored by the U.S. Geological Survey (USGS) using a gaging station on the Great Miami River at Hamilton, Ohio. Flow regulation on the Great Miami River has been studied by Spieker (1968a); Paddys Run data have been compiled by Dames and Moore (1985a). Realignments and other modifications of Paddys Run and its tributaries on the FEMP site have been documented by Dove (1961) and WMCO (1987). Surface water quality data have been collected for the FEMP area for the period 1950 through the present as part of the site environmental monitoring program. The OEPA collected water quality data during the period 1977 through 1983.

In 1986, the FEMP performed a comprehensive radiological survey of the sediment in Paddys Run. The survey included a walkover scan, with hand-held radiation detection instrumentation, of the creek bed from above the facility to the confluence of the creek with the Great Miami River. Sediment samples were collected and analyzed at points in the creek bed displaying elevated radiological readings.

In 1988, under the terms of a Director's Findings and Orders issued by the State of Ohio, further sampling was performed. Samples were collected from a series of drainage ditches and storm water manholes on the FEMP property.

Previous surface water investigations provided sufficient information to develop regional data for use in the Operable Unit 2 RI Report. Additional studies required to support the Operable Unit 2 RI

include an evaluation of the 100-year and 500-year floodplain of Paddys Run. The floodplain evaluation for Paddys Run was completed in October 1993.

1.5.5 Hydrogeologic Investigations

Dove (1961) and Spieker (1968a) described the general hydrology and hydrogeology of the Great Miami Aquifer in the lower Great Miami River Valley. These studies document recharge rates, permeabilities of various lithologies, and other aquifer characteristics. These studies also discussed groundwater and surface water interactions, specifically for the Great Miami River and Paddys Run. Other studies of the regional valley-fill aquifer in the vicinity of the FEMP site include a study by the Miami Conservancy District (1985), several studies by the Ohio Department of Natural Resources (Walker 1986; Walton and Schaefer 1956), and various contracted studies (GeoTrans 1985; Dames and Moore 1985a; ATEC Associates, Inc. 1982). Two other studies by Spieker (1968b and 1868c) deal with the potential effects of increased groundwater pumping and future development of the groundwater resources, respectively. The Miami Conservancy District (1992) also performed a study on the effects of FEMP pumping centers on the Great Miami Aquifer.

The Operable Unit 2 RI used the referenced information to develop the regional and site-wide hydrogeology. The operable unit-specific hydrogeologic properties of the vadose zone and perched groundwater above the Great Miami Aquifer were not a focus of previous studies, and Operable Unit 2 RI activities were developed to address the characterization of the geologic formations in Operable Unit 2. Also, the Operable Unit 2 RI activities collected new hydrogeologic information to supplement previous findings.

1.5.6 Vegetation and Wildlife Studies

Vegetation and wildlife in the FEMP Study Area have been studied and characterized by NLO/DOE, WEMCO, and OEPA. Battelle (1977) performed an environmental impact assessment for the DOE that included impacts on terrestrial and aquatic ecosystems. WMCO performed two studies of the fish that are indigenous to Paddys Run and the Great Miami River in the vicinity of the FEMP site (WMCO 1986, 1987). The OEPA performed a comprehensive study (1982) of the aquatic environment in the Great Miami River. A survey study by Facemire et al. (1990), under contract to WMCO, described the general terrestrial and aquatic environments of the FEMP site and surrounding areas. The database compiled in the Facemire study is the most complete characterization of the

environmental resources available and will be used along with the other referenced sources in the Operable Unit 5 ecological baseline risk assessment.

1.5.7 Environmental Monitoring

Environmental monitoring has been conducted at the FEMP site since the late 1950s as part of ongoing efforts at the facility to protect the health and safety of nearby residents. The monitoring entailed a broad range of activities related to analytical sampling of surface water, sediment, groundwater, soils, and air. These activities have been identified over the years in response to the changing requirements of the facility and evolving regulations.

Water sampling and uranium analysis of the Great Miami River and Paddys Run have been conducted since 1955. Beginning in 1974, sediment was sampled and analyzed for uranium in the Great Miami River and on-site locations in Paddys Run and the Storm Sewer Outfall Ditch. Off-site sediment sampling in Paddys Run was first conducted in 1985.

Groundwater monitoring has been performed since the early 1960s. Monitoring from 1960 through 1980 focused primarily on detecting contaminants that may affect the quality of the site production wells. Groundwater monitoring expanded during the 1980s to include monitoring for off-site contamination and home-owner well water quality. A continuous sampling and analysis program to comply with the requirements of RCRA was initiated in 1985. Soil sampling for total uranium has been performed on and off site since 1970. The focus of this sampling was to determine air deposition from production operations.

Gummed-film testing of airborne deposition was conducted on site from 1952 to 1965. This testing was used to determine uranium deposition from air as a function of distance from the center of the Production Area. Environmental monitoring for direct radiation and airborne radionuclide concentrations has been conducted at the boundaries of the FEMP site beyond the facility property since the 1950s. Prior to 1958, samples from off-site locations were taken infrequently for short periods of time. Samples were routinely obtained at the perimeter of the Production Area from 1958 through 1971. In 1971, site property boundary stations were established. In the mid-1980s, permanent air monitoring stations at off-site locations were established.

During the period of January 1985 through 1988, the Ohio Department of Health (ODH), through a cooperative agreement with DOE, conducted a special environmental monitoring program on and around the FEMP site (ODH 1988). The program included the collection of more than 300 water samples from area wells, cisterns, and surface waters including ponds; 34 soil samples; the measurement of direct radiation levels at 40 locations; and measurement of environmental radon at 16 on-site locations and 25 off-site locations.

The results of environmental monitoring conducted at the FEMP site were collected and stored in site records whenever possible. Environmental monitoring data have been used for contamination studies such as the site Annual Environmental Report, currently known as the Site Environmental Report. Discussions of the environmental monitoring program data sets utilized in the description of the nature and extent of contamination associated with Operable Unit 2 are presented in Section 2.0.

1.5.8 Contamination Release Studies

Dove and Norris (1951) were the first to describe the possible fate of chemical and radionuclide releases that infiltrate the groundwater of the Great Miami Aquifer. Eye (1961) reported on the potential for groundwater pollution as a result of production activities. Spieker and Norris (1962) investigated radionuclide contamination of the groundwater and the transport of the contaminated water through the Fernald, Ohio area. NLO reported on the results of the FMPC Ground Contamination Study Committee in 1962. In 1977, the DOE conducted an assessment of environmental impacts from site operations (DOE 1977), and NLO performed a study on the radioactive waste storage area (NLO 1977).

Battelle Laboratories was contracted by NLO to conduct an environmental study in 1981 (Battelle 1981). NLO (Spenceley 1983) performed an internal investigation to distinguish between contamination caused by FEMP activities and other sources. Sedam (1984) investigated the occurrence of uranium in the groundwater in the vicinity of the FEMP site for DOE.

Other environmental contamination studies were conducted by DOE (1985a, 1987), Oak Ridge Associated Universities (ORAU 1985), and various FEMP-related committees (WMCO 1986, 1987; Fleming and Ross 1984). The DOE and ORAU documents include environmental impact assessments and environmental surveys. Internal study reports by NLO and WMCO include the annual Environmental Monitoring Reports and the Aquifer Contamination Control Reports (NLO 1965

through 1985). Additionally, the ODH has documented radionuclide contamination in private wells in the FEMP area (ODH 1988). In 1988, under the terms of a Director's Findings and Orders issued by the State of Ohio, the FMPC performed sampling at a series of drainage ditches and storm water manholes on the FEMP property. Previous sediment investigations guided the development of Operable Unit 2 RI sampling plans.

An environmental study was performed by Dames and Moore in 1985 to determine the source of uranium contamination in off-site wells. The study performed surface water, sediment, and groundwater sampling. The study concluded that a source of groundwater contamination in the Great Miami Aquifer was due to storm water runoff into the Storm Sewer Outfall Ditch and Paddys Run. The study also developed a groundwater model to predict future concentrations of uranium in groundwater.

In the mid-1980s, the FEMP contracted two environmental investigations that provided the majority of historical data used to supplement the Operable Unit 2 RI data. The first study, the Environmental Survey of the FEMP, was part of a larger DOE-wide environmental survey announced by the U.S. Secretary of Energy on September 18, 1985. The purpose of the survey at each DOE facility, including the FEMP, was to identify existing environmental concerns and areas of environmental risk. Environmental concerns at that time were defined as:

- Concerns resulting from DOE operations where pollutants or hazardous materials exist in the air, surface water, groundwater, or soil in concentrations that pose or may pose a hazard to human health or the environment.
- Conditions at a DOE facility that pose or may pose a hazard to human health or the environment.

Levels of contaminants that constituted an environmental concern were generally those that exceeded federal, state, or local statutes and regulations for release, contamination, or exposure to such materials. The survey also evaluated the potential for some unregulated materials, if present, to create an environmental concern.

The Environmental Survey sampling and analysis program was intended only to confirm the presence of contamination in selected locations. It was not intended to characterize the extent of contamination, define the rate of contaminant movement, identify specific isolated incidents of

noncompliance, or analyze environmental management practices. The Environmental Survey sampled surface media, subsurface media, and groundwater across the site.

The second study conducted was the Characterization Investigation Study (CIS) (Weston 1987a, b, and c and 1988). Selected investigations of the waste storage areas were performed to provide additional data to characterize the nature and extent of contamination. The investigations pertinent to Operable Unit 2 include the Geophysical Survey (Weston 1987a), Chemical and Radiological Analysis of Waste Storage Pits (Weston 1987b), Radiological Survey of Surface Soils (Weston 1987c) and the Geotechnical Evaluation of Material Properties of Waste Pit Materials (Weston 1988).

The historical investigations differ in scope and data quality. Most were focused on site-wide contamination issues. Data that are relevant to the Operable Unit 2 evaluations were utilized to supplement data collected for the RI. Discussions of contaminant data sets utilized in the description of the nature and extent of contamination associated with Operable Unit 2 are presented in Section 2.0.

1.5.9 Historical Photographs of the FEMP

Historical aerial photographs of the FEMP were presented in a 1988 EPA Report (Sitton 1988). Additional aerial photographs were obtained to understand the operational history of the Operable Unit 2 waste subunits and to identify locations for sample collection. Aerial photographs relating to each subunit will be discussed in Section 1.6.

1.6 DESCRIPTION OF OPERABLE UNIT 2

Operable Unit 2 incorporates waste subunits with relatively large volumes of waste presumed to contain small quantities of hazardous materials and radionuclides. Battery limits for the Operable Unit 2 waste subunits have been identified to coordinate soil media remediation with Operable Unit 5 and are presented in Table 1-1. Battery limits are boundaries that define the area of responsibility. Since the physical separation between the Inactive Flyash Pile and the South Field is not clearly defined, the two subunits have been grouped together.

TABLE 1-1

BATTERY LIMITS FOR OPERABLE UNIT 2 SUBUNITS

Solid Waste Landfill	- Fence lines to the north and east - Railroad to the south - Former fence line to the west
Lime Sludge Ponds	- Roadway to the north and east - Railroad on the west - K-65 Slurry Line to the south
Inactive Flyash Pile/South Field	- Access roadway to the north and east - Drainage ditch along the northwest perimeter - Paddys Run bank to the west - Nearby fence and roadway to the south
Active Flyash Pile	- Access roadway to the west - Drainage ditch to the east and south - 50 feet from toe of the slope to the north

For sources of contamination within the battery limits, the Operable Unit 2 RI characterizes the waste materials; determines the impact of contaminants on the surface water, soils, air, and groundwater; defines the potential pathways for human exposure; and assesses the risk to the public through a baseline risk assessment. These activities are completed for each waste subunit, and the cumulative risk from all Operable Unit 2 waste subunits is presented. The Operable Unit 2 RI does not address site-wide characterization of nature and extent of groundwater contamination or air contamination. The Operable Unit 2 RI also does not address site-wide evaluation of ecological and human health risks. These subjects are within the scope of the Operable Unit 5 RI Report and the CRARE, respectively.

1.6.1 History of Operable Unit 2

The FEMP was divided into five operable units in 1989 after the site was placed on the NPL and during the negotiation of the 1990 Consent Agreement. In March 1991, EPA approved the Operable Unit 2 Initial Screening of Alternatives, the first step in the RI/FS process (DOE 1991). This document included development and screening of technologies and process options that were potentially applicable to remediation of the specific wastes present in Operable Unit 2. Five potential remedial alternatives were evaluated for each subunit.

The Operable Unit 2 Treatability Study investigated the effectiveness of solidification techniques for possible use in the final remedial action for Operable Unit 2 wastes. The purpose of a treatability

study is to provide information needed for the detailed analysis of alternatives in the FS and subsequent selection of remedial action.

In accordance with the 1991 Amended Consent Agreement, DOE submitted a Draft Operable Unit 2 RI Report to the EPA and OEPA on October 19, 1992. This draft document was based on results of previous environmental investigations conducted up to 1987 as discussed in Section 1.2.5, and RI/FS sampling completed from 1987 through 1992 as discussed in Section 2.0. The RI/FS sampling was performed according to a series of work plans and work plan addenda. The "Work Plan for Conducting the Site-Wide Remedial Investigation and Feasibility Study of the Feed Materials Production Center" (the RI/FS Work Plan) was approved in March 1988 and included a Work Plan, Sampling Plan, Quality Assurance Project Plan, Health and Safety Plan, Data Management Plan, and Community Relations Plan for the entire site. The document change requests (DCRs) in Table 1-2 contain addenda that were specific to the Operable Unit 2 subunits.

TABLE 1-2
OPERABLE UNIT 2 RELATED DCRs

DCR No. Title	Effective Date
DCR 13 - Surface Soil Sampling	9/05/89
DCR 14 - Installation Plan for Additional Wells for the RI/FS	1/05/89
DCR 33 - Production and Additional Suspect Areas Work Plan	10/4/89
DCR 38 - Additional Monitoring Well Program for the RI/FS Work Plan	3/23/90
DCR 39 - South Plume Groundwater Sampling for the RI/FS Work Plan	4/24/90
DCR 44 - Additional Monitoring Well Program for the RI/FS Work Plan	6/20/90

The trenching investigations conducted in 1992 in the Solid Waste Landfill and the South Field were based on the "Work Plan Addendum for Excavation of Trenches in the Operable Unit 2 Solid Waste Landfill, FEMP RI/FS" (February 1992) and DCR 33.

EPA disapproved the initial submittal of the Draft Operable Unit 2 RI Report because the data collected for the report were not "adequate to characterize the sources of contamination, or determine if the sources are contributing to the contamination of the various media." The OEPA commented that the data were incomplete and that the report failed to determine if any of the waste subunits are contributing to groundwater contamination.

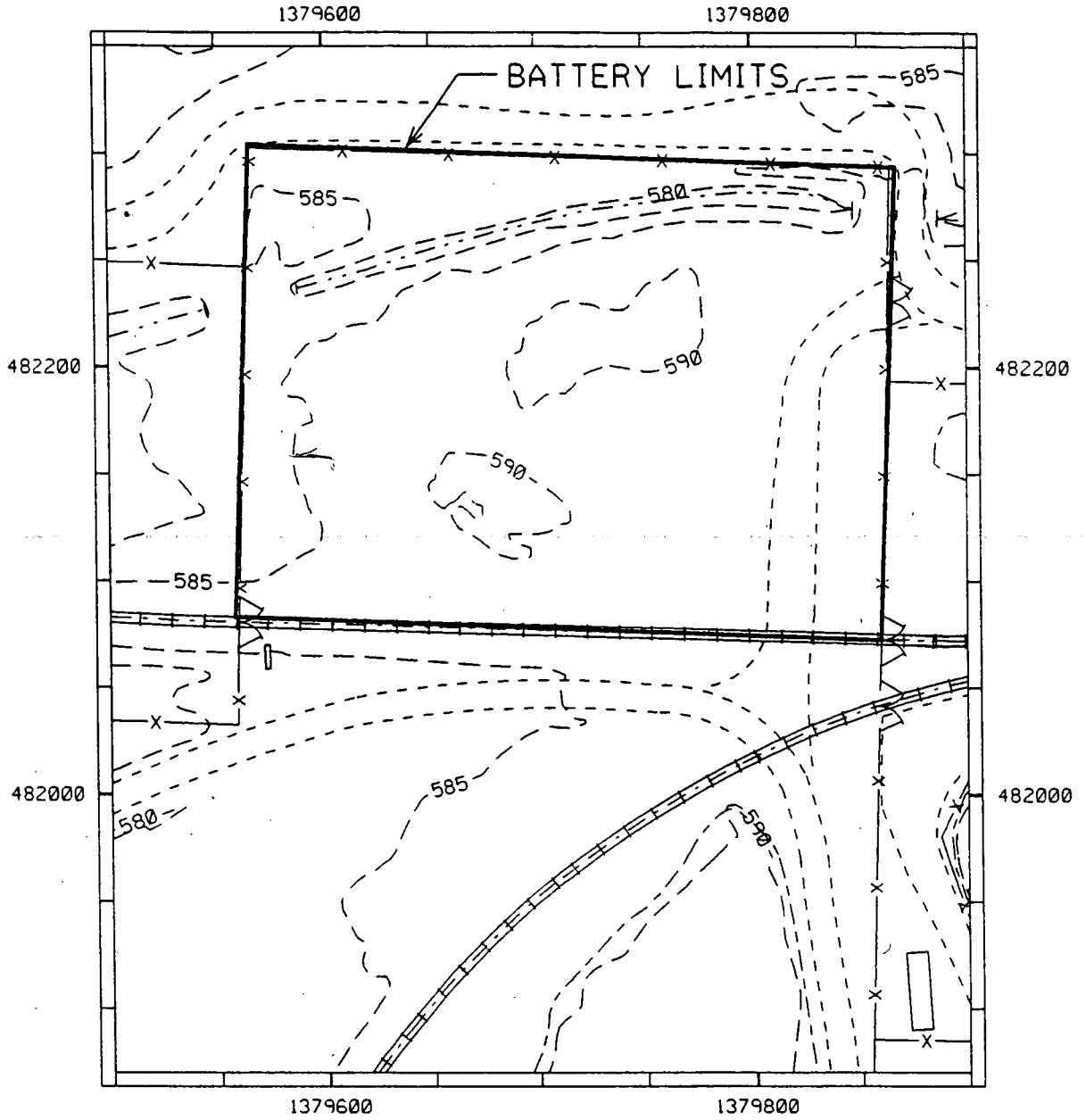
Based on EPA and OEPA review comments (December 17, 1992) to the Draft Operable Unit 2 RI Report and responses to those comments submitted by DOE (February 7, 1993), additional field investigations were planned and completed at the Operable Unit 2 waste subunits from April through July 1993. These additional investigations were defined in the Operable Unit 2 Sampling and Analysis Plan (SAP) submitted to EPA in April 1993. The objectives of the additional investigations were to further characterize the nature and extent of contamination of the various media for fate and transport modeling and risk assessment; determine and quantify the impacts of the waste subunits on groundwater; and develop remedial alternatives.

1.6.2 Solid Waste Landfill

The Solid Waste Landfill is located in the northeast corner of the Waste Storage Area (Figure 1-8). This landfill, a flat rectangular area of approximately one acre, has been inactive since 1986. A soil cover has been placed over the disposal area. A drainage ditch serving the northwest portion of the former Production Area is located in the northern portion of the Solid Waste Landfill. This drainage ditch has been identified as a jurisdictional wetland (EBASCO 1993).

The operational history of the Solid Waste Landfill is not well documented. The facility was planned as a sanitary landfill for non-burnable trash with up to five cells and an evaporation pond planned according to design drawings. Limited operation records state that dumping commenced on June 19, 1974, with dumping planned for two to three times weekly. According to records, the evaporation pond was to collect drainage from the exposed dumping area. The Solid Waste Landfill reportedly was used for the disposal of cafeteria waste, rubbish, and other types of wastes from FMPC nonprocess areas and on-site construction/demolition activities. Interviews conducted with former employees of the FEMP revealed no new relevant information. A review of historical site aerial photographs indicates that activity at the Solid Waste Landfill may have occurred as early as 1954. It is thought that the landfill was organized into an original disposal area, one to five individual waste disposal cells, and an evaporation pond which served as a surface water drainage pond. One disposal

6505



NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 40 80 160

LEGEND
575 ELEVATION CONTOURS
ROADS
STREAM
BATTERY LIMITS
FENCE
RAILROAD

FIGURE 1-8
SOLID WASTE LANDFILL

fig0108.dgn

21 21

000095

cell has been confirmed from an aerial photograph taken in November 1974. Historical aerial photographs from November 1974 to April 1976 show a drainage pond on the west side of the landfill area; however, it is not present in photographs later than 1980.

Aerial photographs from November 1974 to 1976 indicate that a stock pile of an aggregate material covered the northeast quarter of the site. Materials reportedly buried at the Solid Waste Landfill include non-burnable and nonradioactive solid wastes generated on FEMP property, nonradioactive construction-related rubble, and double-bagged and bulk quantities of nonradioactive asbestos. Field investigation results, however, indicate that some apparent process wastes have been placed in the landfill. The following wastes were encountered during a trenching investigation in 1992:

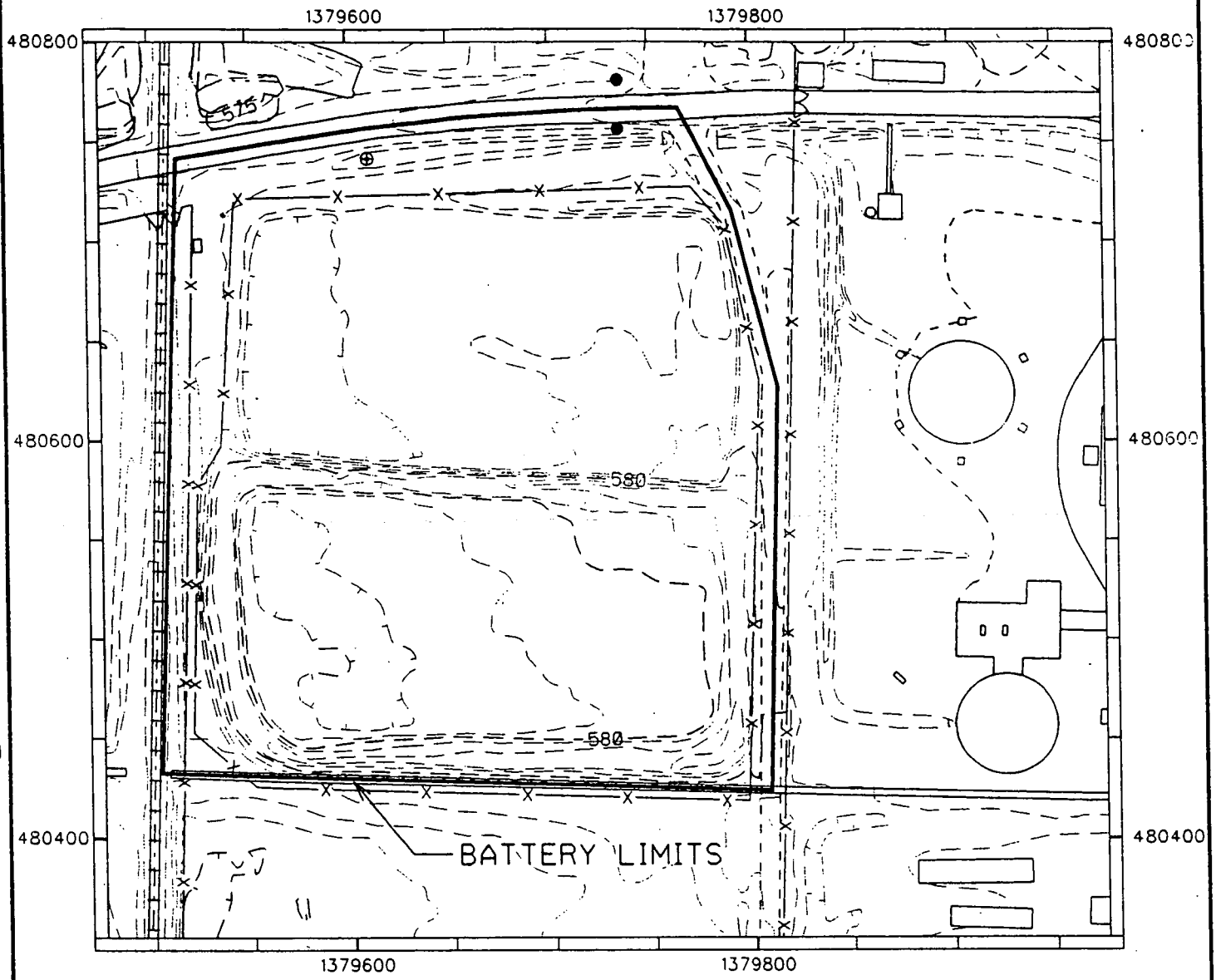
- Burnable wastes - bagged trash and wood
- Possibly burnable wastes - respirator cartridges, asphalt roofing materials, medical wastes, firehoses, and rubber hoses/belts
- Non-burnable wastes - unidentified high-activity waste, medicine vials, bagged asbestos, ceramic tiles, possible magnesium fluoride, glass acid bottles, steel cables/cans, paint cans, and copper tubing

Nonradioactive, nonhazardous general refuse is now shipped for disposal to approved, off-site locations.

Sections 2.3 and 4.2 present the characterization and nature and extent of contamination of the Solid Waste Landfill.

1.6.3 Lime Sludge Ponds

The North and South Lime Sludge Ponds are two unlined, rectangular ponds, each measuring approximately 125 by 225 feet, and are located in the southeast corner of the Waste Storage Area (Figure 1-9). Wastes that were disposed of in the North and South Lime Sludge Ponds originated from water plant operations, coal pile storm water runoff, and boiler plant blowdown. The waste from the water plant operations is generated from a water softening process, which consists of the addition of lime and aluminum sulfate to precipitate calcium and magnesium salts. Approximately one cubic yard of lime sludge is generated on a daily basis and is pumped to Tanks 6 and 7 of the General Sump. Solids from coal pile storm water runoff are allowed to settle in a retention basin, and the remaining decant is pumped to Tanks 6 and 7 of the General Sump. Boiler plant blowdown



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- STREAM
- BATTERY LIMITS
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100

FIGURE 1-9
LIME SLUDGE PONDS

fig0109.dgn

consists of backflush water from the boilers at the coal plant. The boilers are backflushed to prevent scale build-up. This water is also sent to Tanks 6 and 7 of the General Sump.

Currently, sludge from the above three sources is allowed to accumulate in the General Sump for approximately two weeks. While there, the sludge is partially dewatered and polymers are added to induce sludge thickening. After two weeks, the resultant slurry is pumped to the North Lime Sludge Pond. Although this waste is from three distinct waste streams, the bulk of the slurry is lime sludge from the water treatment process. Over time, the solids in the slurry settle in the Lime Sludge Pond and the remaining decant is pumped from the pond back through the General Sump where it is sampled and analyzed. Based on the analytical results, the water is discharged directly to the Great Miami River or treated as required prior to discharge. The Lime Sludge Ponds have been operated in this manner since the early 1950's. The lime sludge is, therefore, considered to be relatively homogeneous.

The South Lime Sludge Pond is full and has been inactive since the mid-1960s; it is now overgrown with grasses and shrubs. The North Lime Sludge Pond is currently in use. A new water treatment system, which will eliminate lime sludge generation, is scheduled to become operational in January 1995. The west side of the North Lime Sludge Pond is usually covered with 1 to 2 feet of water, depending mainly on precipitation. The remaining area is dry and covered with sparse vegetation.

The Lime Sludge Ponds were identified as RCRA Subtitle C Hazardous Waste Management Units (HWMUs) in the FEMP RCRA permit application of June 1991, based on the belief that the ponds received a F-listed hazardous waste, 1,1,1-trichloroethane (TCA), after July 26, 1982. This belief was based on an assumption that TCA was discharged to the water treatment system at a concentration greater than 25 parts per million (ppm). Based upon revised calculations, on May 13, 1993, FERMCO proposed that the FEMP permit application be modified to reclassify the Lime Sludge Ponds as Solid Waste Management Units (SWMUs). OEPA concurred with the reclassification on June 7, 1993.

Sections 2.4 and 4.3 present the characterization and nature and extent of contamination of the Lime Sludge Ponds.

1.6.4 Inactive Flyash Pile

The Inactive Flyash Pile is located approximately 2,000 feet southwest of the former Production Area. The pile covers roughly two acres with Paddys Run as the western boundary (Figure 1-10). The operating history of this subunit is not well understood. The Inactive Flyash Pile and the South Field are contiguous without a clearly defined boundary between the two subunits. Based on a review of historical photos (EPA 1988b) and borehole logs (Weston 1988), the northern portion of this waste area is located adjacent to a presently buried drainage ditch leading to Paddys Run. Beginning in 1957, flyash appears to have been trucked to the working face of the flyash pile and dumped. Historical aerial photographs from September 1962 indicate that dumping of flyash in the Inactive Flyash Pile was in two working piles. The photographs indicate that flyash disposal at this location ceased by the mid-1960s. Drill cuttings and water from RI/FS borings outside the former Production Area and Waste Storage Area, including off-property wells, were disposed of on the Inactive Flyash Pile until March 1990. Composite samples of the water from these borings were analyzed to ensure that total uranium was below a WMCO established action limit.

Based on information provided by WEMCO, 1,500 to 2,000 tons per year of flyash were generated during the period of disposal; however, an unknown quantity of flyash was also disposed of in the Burn Pit and Pit 3 within Operable Unit 1 (Weston 1988). The Inactive Flyash Pile is currently covered with vegetation and soil of unknown origin.

Previous investigations have mentioned that waste oils (possibly containing uranium or PCBs) may have been spread on the flyash in this waste area to control dust (DOE 1988a; Weston 1987b). Attempts to document this have been unsuccessful. An objective of this RI is to determine if uranium detected in the vicinity of the pile is a result of such activities. Nonprocess wastes from the FEMP and building rubble such as concrete, gravel, asphalt, masonry, and steel rebar from on-site construction/demolition activities were also discarded in the Inactive Flyash Pile (DOE 1988a; Weston 1987b) and are visible along embankments surrounding the subunit. Transite containing asbestos was also deposited in the Inactive Flyash Pile. Field investigation results also reveal that some apparent process waste may have been placed in the subunit.

Section 1.7 discusses two removal actions that were performed at the Inactive Flyash Pile. Sections 2.5 and 4.4 present the characterization and nature and extent of contamination of the Inactive Flyash Pile.

1.6.5 South Field

The South Field is an 11-acre area that lies between the Active Flyash Pile and the Inactive Flyash Pile. The actual boundary with the Inactive Flyash Pile is not clearly defined (Figure 1-10). The operational history of the South Field is neither well documented nor understood. This area was reportedly used as a burial site for FEMP nonprocess wastes such as flyash, on-site construction/demolition rubble, including debris from the razing of the old administration building (DOE 1988a; Weston 1987b), and soils that may have contained low levels of radioactivity. The South Field was not an engineered disposal site. Historical information and aerial photographs indicate that its use was on an as-needed basis. Disposal in the South Field apparently was performed in a random manner, thus the thickness of fill and the nature of waste are variable. Discrete mounds of waste material are visible in an aerial photograph taken in March 1957.

The southwest border of the South Field slopes toward the west and was used as the backstop for a firing range for FEMP security personnel over a period of 35 years. Lead ammunition used during target practice is deposited along the southwest border of the South Field (see Section 1.7.1).

A review of historical aerial photographs, topographical maps, and borehole logs (Weston 1988) was undertaken to estimate boundaries of waste deposition and filled areas. Pre-construction aerial photographs taken in 1938 and 1950 show a north-to-south trenching drainage that was filled and used as a haul road. Aerial photographs taken from 1954 to 1964 show this haul road. This road is the approximate western limit for the South Field. Disposal activities in the South Field appear to have ceased during the mid-1960s. Currently, the South Field is covered with grasses, shrubs, and trees.

Section 1.7 discusses a removal site evaluation (RSE) and a removal action that were performed at the South Field. Sections 2.5 and 4.5 present the characterization and nature and extent of contamination of the South Field.

1.6.6 Active Flyash Pile

This waste disposal area is located just east of the South Field and is bounded on the east and south by the Storm Sewer Outfall Ditch (Figure 1-10). The Active Flyash Pile has a surface area of approximately three acres and has received flyash waste since the mid-1960s. The operational history of this unit is well understood. The flyash pile has a crusting agent sprayed upon the surface as a

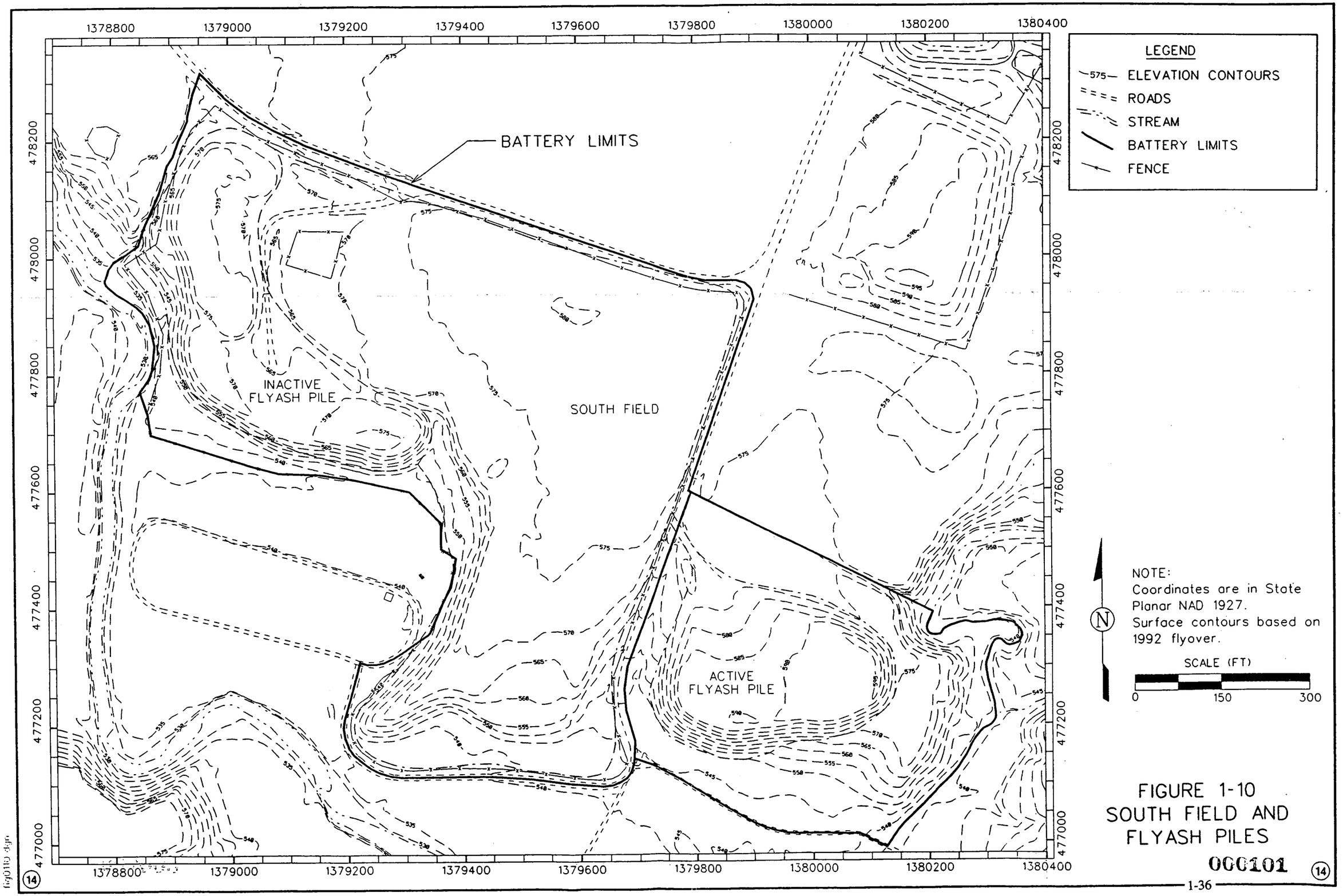


FIGURE 1-10
SOUTH FIELD AND
FLYASH PILES

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means of dust control. A silt fence has been constructed at the base of the pile to prevent storm water transport of the flyash off the pile.

Flyash from the FEMP coal-fired boiler plant was disposed of at the Active Flyash Pile. Flyash waste is comprised of 70 percent bottom ash collected below the boilers; the remaining 30 percent is a combination of precipitator ash collected from pollution control devices and flyash removed from the middle levels of the boiler. Some unburned coal and rock are also present in small quantities in the active flyash material. Since December 1992, newly generated flyash has been transported off site to a licensed disposal facility. Previous investigations have mentioned that waste oils (possibly containing uranium or PCBs) may have been spread on the flyash in this waste area to control dust (DOE 1988a; Weston 1987b). Attempts to document this practice have been unsuccessful. An objective of this RI to determine if uranium or PCBs detected in the pile are a result of such activities.

Section 1.7 discusses a removal action that was performed at the Active Flyash Pile. Sections 2.6 and 4.6 present the characterization and nature and extent of contamination of the Active Flyash Pile.

1.7 OPERABLE UNIT 2 CERCLA ACTIONS

A RSE and a removal action are CERCLA actions that are performed before the final remediation is implemented to protect the public health, welfare, or the environment from a release or threat of release of hazardous substances. A RSE is conducted to determine if a removal action is warranted. This section discusses the RSE and removal actions that were conducted at the Operable Unit 2 subunits.

1.7.1 Firing Range Removal Site Evaluation

A RSE was conducted to assess lead contamination in the South Field firing range and to determine whether the nature and extent of contamination warranted a removal action. In January and February 1992, vertical and horizontal borings were completed in the western embankment of the South Field, just east of the FEMP running track/firing range. It was determined from the sampling results that a removal action was not necessary.

1.7.2 Active Flyash Pile Control Removal Action (Removal No. 10)

The objective of the Active Flyash Pile Control Removal Action, a time-critical removal action, was to mitigate the wind and water erosion of the Active Flyash Pile. This was accomplished by implementing the following controls: (1) installation of a silt trap made from permeable geotextile fabric around the entire perimeter of the pile at the toe of the slope; (2) installation of a wind barrier made from high-density polyethylene around the top perimeter of the flyash pile; (3) alteration of the active working surface to minimize the noncompacted area and to prevent an increase in the maximum height of the existing pile; (4) minor regrading of the outer berm and compacting the nonworking top surfaces of the flyash pile; (5) application of water, foam, and binding-type dust-control agents on side slopes and top; and (6) periodic inspection and necessary maintenance identified during inspection. Planning and design of the removal action began in December 1991 and implementation was completed in June 1992. Periodic routine inspections and necessary maintenance are ongoing.

1.7.3 Inactive Flyash Pile/South Field Disposal Area Control Removal Action (Removal No. 8)

The Inactive Flyash Pile/South Field Disposal Area Control Removal Action consisted of the installation of ropes, fences, and warning signs around the perimeter of these waste areas to control access. During the course of the removal action, walk-over radiation surveys were conducted over the entire area to define locations that should be delineated as regulated areas. Implementation began in September 1991. Phase I of the activities, which included fencing and roping the areas to be controlled, was completed in December 1991. Phase II, which included surveying the area for additional hot spots, was completed on June 30, 1992.

1.7.4 Paddys Run Erosion Control Removal Action

A time-critical removal action was implemented in Paddys Run to provide bank stabilization adjacent to the Inactive Flyash Pile. Continued erosion of the bank could have undermined the Inactive Flyash Pile's western slope and resulted in a discharge of contamination into Paddys Run.

During late April and early May 1993, interim slope improvement was performed with the installation of a weighted berm to address the erosion problem. This interim action constituted Phase I of the removal action. Phase II was completed during September 1993 when additional riprap stone was installed at the top and toe of the weighted berm. The additional height was sufficient to cover the

exposed soil face adjacent to Paddys Run, and toe protection was added to insure the long-term stability of the berm.

1.8 ORGANIZATION OF REPORT

This RI Report was prepared in accordance with the latest EPA guidance (EPA 1988) and recommended format. The report consists of an Executive Summary, Sections 1.0 through 7.0, and appendices.

The environmental investigations of the site and each Operable Unit 2 waste area are presented in Section 2.0. This includes a discussion of the characterization of each media (surface soil, waste material, subsurface soil, surface water, sediment, and groundwater) and a summary of the geological and geophysical investigations that were performed. The Phase II field program is explained in detail in this section.

Section 3.0 describes the physical characteristics of the site and the Operable Unit 2 Study Area. Meteorological, topographical, geological, hyrogeological, and ecological data is presented for the FEMP site. The specific topography, geology, and hydrogeology of each Operable Unit 2 waste subunit are also discussed and illustrated.

Section 4.0 presents the results of the RI investigations identified in Section 2.0. The characterization of the nature and extent of contamination associated with each of the five Operable Unit 2 waste subunits is also presented. A summary of detected analytes is included in this section.

Section 5.0 summarizes the contaminant fate and transport modeling for contaminants originating from Operable Unit 2. Modeling results for air, groundwater, and surface water are presented for each subunit. A detailed discussion of the fate and transport modeling is presented in Appendix A.

Section 6.0 summarizes the significant findings of the Baseline Risk Assessment for Operable Unit 2. The detailed Baseline Risk Assessment is included as Appendix B of this RI Report.

Section 7.0 summarizes the results, evaluations, and conclusions made from the Operable Unit 2 data.

Appendices C through G consist of tables of chemical and radiological data specific to each of the Operable Unit 2 waste areas. Each appendix contains data for surface media, subsurface media, surface water, sediments, and groundwater data from all Operable Unit 2 investigations. Also included in each of these appendices are boring logs, monitoring well construction records, biological resources data, geotechnical data, water elevation data, and on-site screening results. The results of Operable Unit 2 hydraulic testing are presented in Appendix H.

2.0 OPERABLE UNIT 2 INVESTIGATIONS

This section discusses previous site investigation data useful to the Operable Unit 2 RI and the field programs that have been implemented to address RI/FS data requirements. Data requirements for the Phase II Field Investigation were defined by scoping the RI objectives and evaluating available information. The data requirements for the RI objectives and an index identifying the specific section of the report in which the data are presented are given in Table 2-1. Because the objectives, sampling methods, and analytical procedures differed among the sampling programs, the data usability with respect to the Operable Unit 2 RI is discussed.

Studies of the waste units that make up Operable Unit 2 began as early as 1985; data from the following two investigations were used to provide a preliminary characterization of the Operable Unit 2 waste areas to assist in developing RI sampling plans: the Environmental Survey conducted from 1986 to 1987 and the CIS conducted from 1987 to 1988.

2.1 PREVIOUS INVESTIGATIONS

Other previous investigations and environmental monitoring performed at the FEMP were site-wide in scope and their objectives did not include an assessment of Operable Unit 2 specific waste units. The Environmental Survey and the CIS were the only two previous investigations that performed sampling in the Operable Unit 2 waste subunit areas.

2.1.1 Environmental Survey

The Environmental Survey of the FEMP was part of a larger DOE-wide environmental survey announced by the U.S. Secretary of Energy on September 18, 1985. The purpose of the survey at each DOE facility, including the FEMP, was to identify existing environmental concerns and areas of environmental risk. Environmental concerns at that time were defined as:

- concerns resulting from DOE operations where pollutants or hazardous materials exist in the air, surface water, groundwater, or soil in concentrations that pose or may pose a hazard to human health or the environment.
- conditions at a DOE facility that pose or may pose a hazard to human health or the environment.

TABLE 2-1

DATA REQUIREMENTS FOR THE RI/FS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Objective	Data Requirement	Source of Data	Section(s) Presented
Physical Characteristics	Prevailing Winds	Cincinnati and Dayton Airports, FEMP Meteorological Tower	3.1.1
	Precipitation and Evaporation	Cincinnati and Dayton Airports, FEMP Meteorological Tower, Miami Conservancy District	3.1.1
	Temperature	Cincinnati and Dayton Airports, FEMP Meteorological Tower	3.1.1
	Topography	Historical Pre-Construction Surveyed Map, Aerial Photography	3.1.2
	Surface Water Hydrology	Miami Conservancy District, United States Geological Survey (USGS), Federal Emergency Management Agency (FEMA)	3.1.2
	Regional Geology and Groundwater Hydrogeology	USGS, Ohio Department of Natural Resources, Ohio Geologic Society, Operable Unit 2 RI	3.1.3
	Regional Soil Characteristics	United States Department of Agriculture, RI field investigations	3.1.4
	Demography	Ohio Department of Development Ohio-Kentucky-Indiana Regional Council of Governments	3.1.5
	Ecology	United States Forest Service, Shelford, Facemire	3.1.6
	Subunit Specific Geology and Hydrogeology	CIS, RI field investigations	3.2 - 3.5
Nature and Extent of Contamination	Background Concentrations	RI field investigations	4.1
	Subunit Specific Volume and Physical Characteristics of Waste	FEMP Process Knowledge, RI field investigations	4.2 - 4.6

TABLE 2-1
(Continued)

Objective	Data Requirement	Source of Data	Section(s) Presented
Nature and Extent of Contamination (cont.)	Subunit Specific Surface Water and Sediment	FEMP Environmental Monitoring, and RI field investigations	4.2 - 4.6
	Subunit Specific Surface Material (waste, fill, or soil)	Environmental Survey, CIS, RI field investigations	4.2 - 4.6
	Subunit Specific Subsurface Material (waste, fill, or soil)	CIS, RI field investigations and process knowledge	4.2 - 4.6
	Subunit Specific Groundwater	Environmental Monitoring, and RI field investigations	4.0
Fate and Transport	Geotechnical	RI field investigations	4.2 - 4.6
	Geochemical	RI field investigations	4.2 - 4.6
	Source Loading	RI field investigations	4.2 - 4.6
	Calibration Assessment	CIS, RI field investigations	5.0
Risk Assessment	Exposure Point Concentration	RI analytical data, transport modeling	4.0, 5.0
Evaluation of Alternative	Chemicals of Concern	RI field investigations	4.0
	Exposure Route(s) and Receptor(s)	Risk Assessment	6.0
	Volumes or Areas of Media	RI field investigations; fate and transport modeling	4.0, 5.0
	Geotechnical	RI field investigations	4.0

Levels of contaminants that constituted an environmental concern were generally those that exceeded federal, state, or local statutes and regulations for release of, contamination by, or exposure to such materials. The survey also evaluated the potential for some unregulated materials, if present, to create an environmental concern. The objective of the Environmental Survey sampling and analysis program was to confirm the presence of contamination in selected locations using limited sampling. It was not intended to characterize the full extent of contamination or rate of contaminant movement, to identify specific isolated incidents of noncompliance, or to analyze environmental management practices.

The Environmental Survey samples included: surface media from Operable Unit 2 waste areas taken by collecting composite and grab samples, subsurface media by collecting grab samples using hand augers and open trenches, and groundwater when encountered in open trenches. Since the sample locations were not surveyed, positions can only be approximated. Environmental Survey analytical laboratory result packages did not contain sufficient documentation to perform validation. Due to these uncertainties, the Environmental Survey data were used during the RI/FS only to guide field activities. Environmental Survey analytical data were not used to determine nature and extent of contamination, contaminant fate and transport, or risk assessment (see Table 2-1). Analytical results for the Environmental Survey samples are provided in Appendices C through G.

2.1.2 Characterization Investigation Study

The CIS was comprised of selected investigations of the waste storage areas to provide a preliminary Operable Unit 2 characterization of the nature and extent of contamination. The investigations pertinent to Operable Unit 2 are:

- Geophysical Survey (Weston 1987a)
- Geotechnical Evaluation of Material Properties of Waste Pit Materials (Weston 1988)
- Chemical and Radiological Analysis of Waste Storage Pits (Weston 1987b)
- Radiological Survey of Surface Soils (Weston 1987c)

The objective of the CIS Geophysical and Geotechnical Surveys was to provide preliminary information on waste volumes and shallow stratigraphy for optimizing the placement of soil borings and groundwater monitoring wells at the Fernald site, and more specifically, to identify locations that were potentially hazardous for drilling because of buried steel drums and tanks. Magnetic surveys were performed in the Solid Waste Landfill and the South Lime Sludge Pond using an EG&G Geometrics Model G-856 portable proton precession magnetometer. Electromagnetic terrain

conductivity (EM) surveys were performed in all Operable Unit 2 waste areas using Geonics, Ltd. EM 31 and EM 34-3 terrain conductivity meters. Ground-penetrating radar (GPR) surveys were performed at the Solid Waste Landfill and the South Lime Sludge Pond using the Geophysical Survey Systems, Inc., S/R System 8.

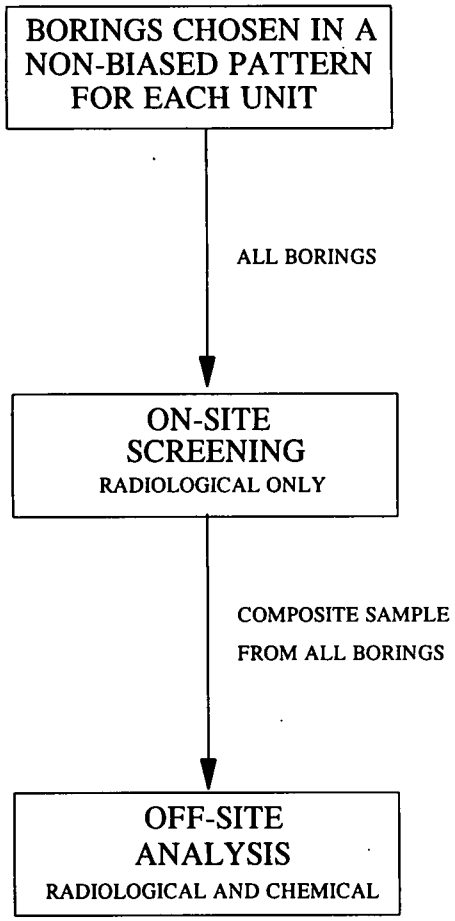
Additionally, during March 1987 through April 1987, samples from the Solid Waste Landfill and the Lime Sludge Ponds were collected for a geotechnical evaluation of material properties. The samples were collected with a split-spoon sampler and were analyzed for grain size, specific gravity, Atterberg limits, and moisture content.

The CIS chemical and radiological analyses of the waste storage pits were completed by collecting soil samples from soil borings installed in the waste areas to determine a preliminary vertical distribution of chemical and radiological constituents. Soil borings that were drilled in the fill material of each Operable Unit 2 waste are listed in Table 2-2. The original intent was to distribute the borings evenly within each waste area, but boring locations were adjusted based on the results of the geophysical surveys to avoid areas with high potential for buried metal objects. Borings were advanced until native soil was encountered. Table 2-2 summarizes the subsurface sample collection methodology for the Operable Unit 2 waste area from each boring. A sample interval of approximately one foot was used to collect samples for on-site radiological screening. The samples were then composited for each boring and sent to an off-site laboratory for analysis. These composite samples were analyzed for organics, inorganics, radionuclides, and RCRA characteristics (in the Solid Waste Landfill and Lime Sludge Ponds).

The objective of the CIS Radiological Survey of Surface Soils was to provide a systematic survey of surface media throughout the Solid Waste Landfill, Lime Sludge Ponds, Inactive Flyash Pile, and associated on-site drainages within the Operable Unit 2 Study Area to determine the locations(s) of areas with elevated radionuclide activity. Before surface samples were collected, a gamma radiation measurement was made on the surface using a field instrument for detecting low energy radiation (FIDLER). An Eberline SPA-3 scintillation probe was used in both the Inactive Flyash Pile and South Field. Areas of field correlated levels of 35 picoCuries per gram (pCi/g) or greater were sampled and screened on site for radionuclides. Those samples with the highest screening levels were sent off site for analysis. Table 2-3 summarizes the sample collection methodology for the Operable

TABLE 2-2

CIS RADIOLOGICAL SURVEY OF SUBSURFACE SOILS



SAMPLE SUMMARY
NUMBER OF SAMPLES

	SOLID WASTE LANDFILL	LIME SLUDGE PONDS	INACTIVE FLYASH PILE/SOUTH FIELD	ACTIVE FLYASH PILE
Number Of Borings	6	6	12	1
Range of Boring Depth Below Ground Surface	8-18 ft	North Pond: 6-8 ft (below Residue/water Surface) South Pond: 8-9 ft	8-34 ft	8-16 ft
Number of On-site Samples	66	42	139	7
Number of Composite Samples	7	6	12	1

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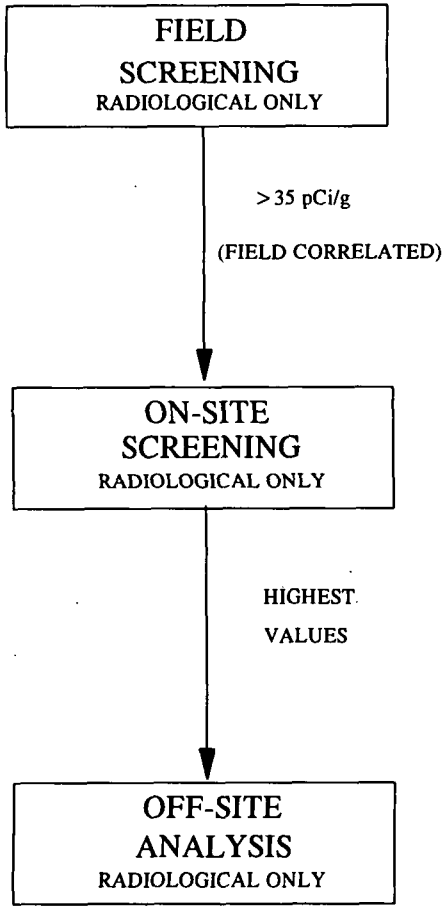
TABLE 2-3

CIS RADIOLOGICAL SURVEY OF SURFACE AND NEAR-SURFACE SOILS



SAMPLE SUMMARY NUMBER OF SAMPLES

	SOLID WASTE LANDFILL		LIME SLUDGE PONDS		INACTIVE FLYASH PILE/SOUTH FIELD		ACTIVE FLYASH PILE	
	Surface		Surface		Surface		Surface	
Fidler	838		146		3637		522	
Beta Gamma	69		54		209		-	
Exposure rate	7		5		19		5	
Number of On-site Samples	Surface	Near-surface	Surface	Near-surface	Surface	Near-surface	Surface	Near-surface
	16	3	21	8	90	125	6	5
Number of Off-site Samples	Surface	Near-surface	Surface	Near-surface	Surface	Near-surface	Surface	Near-surface
	-	1	3	-	17	16	-	1

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Unit 2 waste area. The analytical results from the CIS sampling program are presented in Appendices C through G.

The geophysical and radiological CIS data were used to guide the planning of RI field activities. A portion of the analytical results for the CIS could be validated and were considered as supplementary information. The CIS data were not used in contaminant fate and transport modeling or risk assessment.

2.2 RI FIELD INVESTIGATIONS

The RI/FS investigative activities that pertain to Operable Unit 2 were conducted in two phases. All RI field investigation activities conducted from 1988 through 1992 are referenced collectively as the Phase I Field Investigation (Phase I). Additional field investigations carried out in 1993 are referenced as the Phase II Field Investigation (Phase II).

2.2.1 Phase I Field Investigation

Phase I was carried out according to objectives and procedures outlined in the following documents:

- RI/FS Sampling Plan, Volume 1, and the Quality Assurance Project Plan, Volume 4, of the "Remedial Investigation and Feasibility Study Work Plan," Revision 3, March 1988
- "Remedial Investigation Work Plan Addendum - Production and Additional Suspect Areas Work Plan," Revision 1 (Document Change Request No. 33, October 1989)
- "Operable Unit 2 Sampling and Analysis Plan Addendum" (Document Change Request No. 41, Rev. D, July 1991)
- Addenda to Volume 1 of the RI/FS Work Plan

Work plan addenda that apply to Operable Unit 2 are: (1) the Production and Additional Suspect Areas Work Plan that cover trenching and sampling of the South Field, (2) a number of addenda that cover the installation and sampling of monitoring wells adjacent to the Operable Unit 2 waste areas, and (3) the Operable Unit 2 Sampling and Analysis Plan Addendum that cover drilling and sampling of the contents of the waste areas. The latter work plan, the only addendum that focused specifically on Operable Unit 2, outlines samples to be collected to fill specific data gaps in the Operable Unit 2 investigation.

In summary, the Phase I field sampling activities included surface and subsurface media, surface water and sediment, geotechnical, and groundwater. The specific Phase I field activities are discussed and sampling locations are illustrated in Sections 2.3 through 2.6. Analytical data collected for Phase I field activities have been validated and were used to determine nature and extent of contamination, complete contaminant fate and transport modeling, and perform the baseline risk assessment.

The objectives and methods of sample collection carried out in Phase I are described in the sections below. Additional details of sample collection and sample management protocols may be found in the Quality Assurance Project Plan (QAPP) and the Sampling Plan of the RI/FS Work Plan (1988b). For some waste areas, the term "study area" is attached to the name of the waste area, indicating that some sample locations outside the battery limits of the waste area are being considered because of their proximity to that waste area.

2.2.1.1 Phase I Surface Media Investigation

Under this task, as outlined in the site-wide RI/FS Work Plan, Revision 3 (DOE 1988b), five surface media samples were collected in and around Operable Unit 2 areas. Three were collected near the Solid Waste Landfill using the results of a radiation survey that was conducted prior to the surface media sampling (biased samples). At other locations where elevated radionuclide levels were not measured, grid sampling was performed to collect nonbiased samples (Sample Nos. 5001 and 5017). The three biased samples collected near the Solid Waste Landfill were located outside the battery limits of Operable Unit 2 and will be considered by Operable Unit 5. Sample No. 5017 was collected near the Inactive Flyash Pile and Sample No. 5001 was collected near the South Field; however, results of both samples were rejected during data validation.

2.2.1.2 Phase I Surface Water/Sediment Investigation

The site-wide RI/FS surface water and sediment sampling program included Paddys Run, seepage from the eastern embankment of Paddys Run, the Great Miami River, and a number of drainages across the Fernald site. Surface water and sediment samples were collected from various seeps and trenches within Operable Unit 2. Table 2-4 summarizes the surface water and sediment samples collected during Phase I. Appendices C through G provide more detailed sampling information by subunit.

TABLE 2-4

SUMMARY OF PHASE I RI/FS SURFACE WATER AND SEDIMENT SAMPLING FOR OPERABLE UNIT 2 FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Unit	Number of Sediment Samples	Analytical Parameters	Number of Surface Water Samples	Analytical Parameters
Solid Waste Landfill	1	Radionuclides	2	Radionuclides Organics. Inorganics Pesticides/PCBs General Chemistry
Lime Sludge Ponds	None	--	4	Radionuclides Organics Inorganics Pesticides/PCBs General Chemistry
Inactive Flyash Pile	6	Radionculides Organics Inorganics Pesticides/PCBs	7	Radionuclides Organics Inorganics Pesticides/PCBs General Chemistry
South Field	None	--	None	--
Active Flyash Pile	4	Radionuclides Organics Inorganics Pesticides/PCBs General Chemistry	12	Radionuclides Inorganics General Chemistry

2.2.1.3 Phase I Subsurface Media Investigation

Subsurface media samples were collected during execution of each of the RI work plans. Subsurface media samples were collected during the drilling of monitoring wells, from trenches excavated in the South Field and Solid Waste Landfill, and from all borings completed in the subunits. Table 2-5 summarizes subsurface media samples that were submitted to an off-site laboratory for analysis.

Six trenches were excavated in the South Field in 1990 to evaluate areas that had not been previously sampled. Forty-two subsurface samples were collected from location numbers 1455 through 1472. Trenches were approximately 50 feet long and placed in an approximate north-south orientation throughout the northern and eastern portions of the South Field where building rubble was thought to be buried. Trenching continued until native soil was encountered. Depths of the trenches ranged from 3.75 to 5.75 feet. Samples for radionuclide analysis were collected from the bottom of the fill material and from the native soil immediately below fill material at the north, south, and middle locations of each trench.

In 1991, additional borings were drilled in each of the Operable Unit 2 waste areas using continuous flight hollow-stem augers. Continuous split-spoon samples were collected in 1.5- to 2-foot increments.

In 1992, two additional trenches were excavated northwest of the South Field/Inactive Flyash Pile area in the pine plantation. The purpose of these trenches was to investigate three historical trenches observed in a 1954 aerial photograph. It was determined that no burial activity occurred in that area. Four subsurface samples were collected from one trench for analysis.

Also in 1992, three exploration trenches were excavated in the Solid Waste Landfill. The purpose of these trenches was to visually characterize the waste disposed in the Solid Waste Landfill. Five leachate samples were collected from the trenches.

2.2.1.4 Phase I Groundwater Investigation

Forty-nine monitoring wells were installed within and adjacent to the Operable Unit 2 waste areas to determine if contaminants were present in perched water or the Great Miami Aquifer. Table 2-6 summarizes groundwater samples collected from these wells. Appendices C through G provide more detailed information by subunit.

TABLE 2-5

SUMMARY OF PHASE I RI/FS PHASE I FIELD INVESTIGATION SUBSURFACE MEDIA SAMPLING WITHIN OPERABLE UNIT 2 WASTE AREA LIMITS FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Unit	No. of Sample Locations	Sample Depth (feet)	Analytical Parameter	No. of Analyses
Solid Waste Landfill	10	0 - 96.5	Radionuclides	23
			Inorganics	16
			Organics	19 (3 dioxins only)
			General Chemistry	10 (4 sulfide only, 6 TOC only)
			EP Toxicity	3
			TCLP	8 (2 organics only)
Lime Sludge Ponds	5	0 - 46.5	Radionuclides	6
			Inorganics	2
			Organics	2
			General Chemistry	2 (sulfide only)
			TCLP	2
Inactive Flyash Pile	12	0 - 116.5	Radionuclides	21 (1 Total uranium and thorium only)
			Inorganics	12
			Organics	16
			General Chemistry	6 (TOC only)
			EP Toxicity	1
			TCLP	10 (1 metals only)
South Field	48	0 - 141.5	Radionuclides	121 (9 Total uranium only)
			Inorganics	17
			Organics	17
			TCLP	14 (5 organics only)
Active Flyash Pile	11	0 - 106.5	Radionuclides	28 (8 Total uranium only)
			Inorganics	11
			Organics	13
			General Chemistry	5 (TOC only)
			EP Toxicity	3 (1 metals only)
			TCLP	11 (1 organics only)

TABLE 2-6

SUMMARY OF RI/FS PHASE I FIELD INVESTIGATION GROUNDWATER SAMPLING WITHIN AND ADJACENT TO OPERABLE UNIT 2 WASTE AREAS FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Unit	No. of Wells	Sample Depth (Well Series)	Analytical Parameters	No. of Analyses
Solid Waste Landfill	7	1000, 2000, 3000	Radionuclides	43 (1 Total uranium only)
			Inorganics	36
			Organics	15 (6 VOCs only)
			General Chemistry	40 (4 sulfide only)
Lime Sludge Ponds	7	1000, 2000	Radionuclides	21 (3 Total uranium only)
			Inorganics	17
			Organics	2 (1 VOCs only)
			General Chemistry	23 (6 nitrate only)
Inactive Flyash Pile	9	1000, 2000, 3000, 4000	Radionuclides	26
			Inorganics	26
			Organics	4
			General Chemistry	23
South Field	19	1000, 2000, 3000, 4000	Radionuclides	56 (5 Total uranium only, 1 Gross Alpha/Beta only)
			Inorganics	47
			Organics	8 (1 VOCs only)
			General Chemistry	53 (6 nitrate only)
Active Flyash Pile	7	1000, 2000, 3000	Radionuclides	30
			Inorganics	27
			Organics	0
			General Chemistry	27

The depth of a Fernald site well and location in the water-bearing zone in which it was completed (screened) are denoted by the first digit of the well number. Wells completed in the perched groundwater within the glacial overburden are denoted as 1000-series wells. Wells completed in the upper portion of the Great Miami Aquifer are denoted as 2000-series wells. The 3000-series wells are completed in the upper portion of the Great Miami Aquifer, immediately above a layer of blue clay which separates the upper and lower portion of the aquifer. The 4000-series wells are completed in the Great Miami Aquifer beneath the layer of blue clay. Sometimes a group of two or more wells of different depths are completed at the same location to sample different water-bearing zones; these groups are called well clusters. On-site monitoring wells were installed between 1985 and 1993 using cable-tool drilling techniques, with the exception of the 1000-series wells, which were typically drilled using hollow-stem continuous flight augers.

The Operable Unit 2 groundwater investigation examined the potential for release of contaminants to groundwater from the Solid Waste Landfill, Lime Sludge Ponds, Active Flyash Pile, Inactive Flyash Pile, and South Field. Releases from other operable unit study areas and the determination of rate and the resultant extent of contamination from other operable unit waste areas were not evaluated.

Monitoring wells 1014, 1016, 2014, 2016, 3014, and 3016 were installed prior to the RI/FS as part of the Groundwater Study Task C by Dames & Moore (1985a). A total of 27 monitoring wells were installed within the Operable Unit 2 Study Areas during Phase I (see Figures 2-2 [page 2-48], 2-8 [page 2-61], and 2-14 [page 2-80]). The locations were selected on the basis of data gaps identified from previous groundwater studies and on sampling results from the existing wells.

Monitoring Well 1433 was installed in the South Field in August 1992 as part of Phase I to collect leachate/perched groundwater for analysis and assist in determining the source of uranium contamination found in the Great Miami Aquifer around Monitoring Well 2046.

2.2.1.5 Phase I Geotechnical Investigation

In-place density measurements using the nuclear density technique were made on the wastes in each of the five subunits of Operable Unit 2. An expanded suite of geotechnical analyses required to support the FS was performed on subsurface samples from the Active and Inactive Flyash piles. These analyses included the following:

- Grain size, American Society for Testing and Materials (ASTM D-422)
- Atterberg limits, ASTM D-4318
- Moisture content, ASTM D-2216
- Specific gravity, ASTM D-854
- Standard proctor, ASTM D-698
- Relative density, ASTM D-2049
- 1-D consolidation, ASTM D-2435
- Permeability, EPA METHOD 9100 (SW 846)
- In-place density, ASTM D-2922, D-2167, or D-1556

Additional RI sampling and analyses were undertaken to meet the objectives of the Operable Unit 2 RI. This supplemental Phase II sampling resulted from review comments received from EPA and OEPA (December 17, 1992) on the October 1992 version of the Draft RI Report for Operable Unit 2 and responses to those comments by DOE (February 7, 1993).

2.2.2 Phase II Field Investigations

A sampling program was implemented in 1993 to meet the additional data requirements. The scope of Phase II field activities for the RI included sampling of all media. Field activities were defined by identifying data requirements not fulfilled by previous sampling efforts. Development of data requirements and sampling objectives is summarized in the SAP for the RI/FS Work Plan Addendum for Operable Unit 2 (DOE 1993b). A list of variances to the SAP is provided in Table 2-7.

2.2.2.1 Phase II Field Investigation Data Requirements

The Phase II Field Investigation data requirements were developed by defining the information required to achieve the RI objectives. The specific data requirement resultant field activities are presented for each Operable Unit 2 waste unit in Sections 2.3 through 2.6.

2.2.2.2 Phase II Field Investigation Methods

Procedures used during the field operations were defined by the FEMP program plans, procedures, and EPA guidance. FEMP program plans, specifically the Draft (at the time) Site-Wide CERCLA Quality Assurance Project Plan (SCQ), QAPP, Site-Wide RI/FS Work Plan, and FEMP Site Characterization/Data Management (SC/DM) Department and Environmental Monitoring Section Standard Operating Procedures were used as guidance documents. EPA procedure reference sources include the "Compendium of Superfund Field Operations Methods" and "Hazardous Waste Site Disposal Operations."

TABLE 2-7

VARIANCE REQUESTS
SAMPLING AND ANALYSIS PLAN FOR
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Variance Request Number	Summary	Justification
CRU2-93-1	Unused	Not required
CRU2-93-2	Preselect screen size and filter pack, and proceed with 2000-series well installation without receipt of sieve analysis results. Variance to SCQ, which states that the size of screen openings and filter pack shall be determined based on the effective grain size of the monitored zone.	Review of existing 2000-series wells indicates they were completed with 0.010-inch screen and a medium to coarse grain filter sand; a paper prepared by ASI/IT presented justification for obtaining turbidity-free groundwater samples from existing wells of similar construction.
CRU2-93-3	Relocate Hydropunch™ boring 11018 in South Field. Variance to the SAP, which states ten Hydropunch™ borings will be completed at specific locations in the South Field regardless of findings during field activities.	Groundwater gradient information indicates that the new proposed location is more directly upgradient of well 1516, which has exhibited high concentrations of total uranium in past sampling events. The new proposed location would be more effective in determining the source of this contamination.
CRU2-93-4	Relocate monitoring well 1941 from central part of South Field to north central South Field. Variance to SAP.	Field data indicated that perched groundwater was not encountered in a Hydropunch™ at the SAP original location. Significant uranium contamination of perched groundwater was encountered in hydropunches at the new proposed 1941 location.
CRU2-93-5	Collect six additional soil gas samples (AA-3, A-2, A-4, C-1, CD-1, and D-1) from the Solid Waste Landfill based on field data. Field data exhibited high organic vapor concentrations at the selected locations; analyze for VOC's by EPA Method T-014. Variance to the SAP.	A more focused second round of selected sampling and analysis was performed to confirm the results of the initial round and collect data to determine the location of several discretionary borings.

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TABLE 2-7
(Continued)

Variance Request Number	Summary	Justification
CRU2-93-6	Complete a Hydropunch™ boring (11029) that will penetrate the Great Miami Aquifer at the proposed 2944 monitoring well location using hollow stem auger drilling. Variance is to SCQ, which requires installation of large diameter temporary casing in areas, even where contamination is NOT suspected.	To select monitor well location for uncontaminated upgradient conditions, pre-evaluation of the proposed 2944 location for presence of contaminants is necessary. A temporary casing is not necessary due to data from adjacent boring 1966, which indicates that the subsurface has no perched water or elevated radioactive readings.
CRU2-93-7	Drilling of Hydropunch™ borings (11019, 11020, 11021, 11022, 11023) in southern portion of South Field without continuous split barrel soil sampling. Variance to SAP.	The Hydropunches™ will be located in the vicinity of previous Hydropunch™ and monitoring well locations making the available data sufficient for lithological interpretation.
CRU2-93-8	Relocate monitoring well 1954 from Inactive Flyash Pile to South Field. Variance to SAP.	Perched groundwater was encountered at the new proposed location and not at the old location.
CRU2-93-9	Drill additional Hydropunch™ (11047) north of Inactive Flyash Pile in field. Variance to SAP.	Define uncontaminated groundwater at the most northerly perched groundwater boundary near the Inactive Flyash Pile. Groundwater contamination was detected in the most upgradient Hydropunch™ samples collected from Inactive Flyash Pile.
CRU2-93-10	Drill additional Hydropunch™ (11028) in South Field at boring location 1965 with hollow stem auger to further determine uncontaminated conditions prior to locating monitoring well 2944. Variance to SAP.	Previous investigation indicates no perched water conditions or radioactive soil contamination; previous Hydropunch™ indicated Great Miami Aquifer radioactive contamination (Variance CRU2-93-6).
CRU2-93-11	Complete 10 additional borings (11048, 11049, 11050, 11051, 11052, 11053 11054, 11055, 11056, and 11057) at the Inactive Flyash Pile to further define vertical and horizontal extent of contamination. Variance to SAP.	Previous investigation indicates contamination sources which need to be further defined horizontally and vertically.
CRU2-93-12	Delete surface water and sediment sample SF-SW-04,and SF-SD-04. Variance to SAP.	Surface water and sediment did not exist at the proposed location.
CRU2-93-13	Collect additional targeted samples to provide data used in chemical fate and transport modeling for subunits (K_d samples). Variance to SAP.	Literature derived values for the distribution coefficient of U-Total have not proved satisfactory in predicting the migration of radionuclides in a transport computer model.

TABLE 2-7
(Continued)

Variance Request Number	Summary	Justification
CRU2-93-14	Obtain procedural changes for screening, sampling, sample analysis, and surveying of Lime Sludge Ponds and South Field investigative trenches. Variance to SAP.	Based on site specific conditions, procedures are more explicitly defined to provide the desired results.
CRU2-93-15	Perform additional Hydropunch™ boring (11030) with hollow stem auger drilling in the Great Miami Aquifer in the South Field, 75 feet northeast of boring location 1964 to further determine uncontaminated conditions for locating monitoring well 2944. Variance to SAP.	Previous investigation indicates no perched water conditions or radioactive soil contamination; previous Hydropunch™ indicated Great Miami Aquifer radioactive contamination (Variance CRU2-93-10).
CRU2-93-16	Perform additional Hydropunch™ borings (11082, 11083, and 11084) and install additional monitoring well (11085) east of the South Field (next to Great Miami Aquifer Well No. 2385). Variance to SAP.	Investigation of perched zone in north end of South Field indicates contamination. Further definition of horizontal extent toward the east is required.
CRU2-93-17	Install additional 2000-series monitoring well (2954) adjacent to 1954. Variance to SAP.	Investigation of Inactive Flyash indicates possible source of Great Miami Aquifer contamination, which needs further definition. Well is downgradient of Inactive Flyash Pile.
CRU2-93-18	Perform an additional soil boring (11040) in the Solid Waste Landfill. Variance to SAP.	Obtain a lithological description of the deep part (> 40 feet deep) of till beneath the Landfill, which has not been accomplished in the past.
CRU2-93-19	Obtain core samples of unearthed concrete debris and analyze for radiological contaminants. Variance to SAP.	Determine penetration of radioactivity into the concrete debris to determine handling and disposal requirements.
CRU2-93-20	Collect seven additional surface water samples from the outfall ditch west of the Inactive Flyash Pile. Variance to SAP.	More accurately define the source of radioactivity observed in early on-site analyses.
CRU2-93-21	Extend the depth (6-inches) of hand augering in boring 1963, Lime Sludge Ponds, and move LSP-SS-10 location 30 feet west of LSP-SS-09. Variance to SAP.	Extending the depth will not adversely impact the integrity of the underlying soil, and moving the proposed location for LSP-SS-10 will improve the safety of the sampling crew.
CRU2-93-22	Collect soil samples from areas exhibiting the highest radiological field screening results in each trench excavation for on-site radionuclide screening (i.e., thorium, radium, uranium, and gross characteristics). Trenching will continue until the anomaly is adequately identified. Variance to SAP.	Previous analytical results for the South Field indicate these are the contaminants of concern and the on-site lab can provide the quality levels necessary. Trenching activity is being conducted to visually identify the anomalies detected from the geophysical survey.

000123

TABLE 2-7
(Continued)

Variance Request Number	Summary	Justification
CRU2-93-23	Install additional monitoring well (11032) north of the South Field. Variance to SAP.	Define uncontaminated groundwater at the upgradient perched groundwater boundary near to the South Field. Groundwater contamination has been detected in the most upgradient areas investigated within the South Field.
CRU2-93-24	Obtain approval for data validation to deviate from procedure SSOP-1004. Variance to SCQ.	The IT laboratory contract did not stipulate SCQ-type radiological QC requirements and thus, the new database is not in place and SSOP-1004 was not implemented at the time the samples were taken.
CRU2-93-25	Perform five additional soil borings (11036, 11037, 11038, 11039, 11040) in the Solid Waste Landfill. Variance to SAP.	Previous investigation indicates contamination which needs further definition of nature and extent.
CRU2-93-26	Collect three additional surface water samples from the ditch east and north of South Field. Variance to SAP.	More accurately define the potential surface migration of contaminants to complete fate and transport modeling.

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2.2.2.2.1 Phase II Geophysical Survey

Magnetic and EM conductivity surveys were conducted in the South Field to locate buried ferrometallic materials and areas of elevated conductivity that represent potentially contaminated metal debris and reinforced concrete rubble. Instruments consisted of a EDA Omni Plus proton precession magnetic gradiometer and a Geonics EM-31 DL terrain conductivity meter (with Omni digital data logger). Spatial control was established with a 20-foot by 20-foot grid. Magnetometer data were collected at all grid points with the instrument aligned with the magnetic north direction. EM conductivity data were collected at all grid points with the instrument boom aligned with the north-south grid axis. The EM survey was performed in both the vertical and horizontal dipole to further evaluate near surface disturbances. The locations of all known metallic surface features were recorded and considered in data interpretation. Trenching and subsurface media sampling were performed at the ten strongest anomalies.

2.2.2.2.2 Phase II Soil Gas Survey

A soil gas survey was completed to locate sources of organic contamination in the Solid Waste Landfill. Forty-seven gas samples were collected from 50 proposed locations by driving a hollow stainless steel probe equipped with an extraction point approximately three feet into the subsurface materials. A vacuum was then applied to the probe to extract soil gas into Tedlar bags for screening with an organic vapor meter (OVM) and organic vapor analyzer (OVA). Based on these results, five samples were selected and sent to an off-site laboratory for organic analysis by EPA Method TO-14. Gas sampling points were located on a grid based on the reported east-west orientation of disposal cells in the landfill. Sampling points were located with an east-west spacing of 50 feet and a north-south spacing of 20 feet. A soil gas survey was conducted only for the Solid Waste Landfill because it is the only subunit that historically received organic waste (i.e., cafeteria waste)."

2.2.2.2.3 Phase II Surface Media Sampling

Surface media sampling locations were selected based on criteria established for each subunit investigation. All surface soil samples were screened in the field for volatile organic vapor with a photoionization detector (HNu) and screened with a beta/gamma pancake probe survey instrument for radiation. All samples were visually described, and all sample collection points were surveyed to define the surface elevation and the north and east location. Samples which exhibit screening levels greater than 10 times background were considered "elevated" and were considered for further laboratory analysis. Table 2-8 summarizes the surface samples collected and analytical parameters.

TABLE 2-8

SUMMARY OF RI/FS PHASE II FIELD INVESTIGATION SURFACE MEDIA SAMPLES WITHIN OPERABLE UNIT 2 WASTE AREAS FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Unit	No. of Sample Locations	Sample Depth (feet)	Analytical Parameters	No. of Analyses
Solid Waste Landfill	12	0 - 0.5	Radionuclides	12
			HSL	12
			On-Site Screening	0
			Geotechnical	1
Lime Sludge Ponds	14	0 - 0.5	Radionuclides	14
			HSL	15 (1 Pest/PCBs only)
			On-Site Screening	4
			Geotechnical	1
Inactive Flyash Pile	7	0 - 0.5	Radionuclides	7
			HSL	7
			On-Site Screening	0
			Geotechnical	1
South Field	21	0 - 0.5	Radionuclides	21
			HSL	21
			On-Site Screening	0
			Geotechnical	0
Active Flyash Pile	14	0 - 0.5	Radionuclides	14
			HSL	14
			On-Site Screening	0
			Geotechnical	2

2.2.2.2.4 Phase II Subsurface Media Sampling

Soil and waste borings were completed using a truck-mounted hollow-stem auger drill rig and split-spoon or Shelby™ tube type sampler. Subsurface media were collected from monitoring well soil samples and Hydropunch™ borings. Continuous samples were collected in advance of the hollow-stem auger from six inches below surface to a planned total depth. All samples were field screened with beta/gamma and photoionization detectors, and values were recorded. Depending on the subunit, various samples of both fill and glacial till with the highest above background radiological response were analyzed at an off-site contract laboratory. Table 2-9 summarizes subsurface samples collected and analytical parameters.

After sampling objectives were accomplished, each boring not completed as a monitoring well was plugged with Volclay grout from the bottom to surface through the hollow stem auger or via a tremie pipe. After the grout settled, a minimum of a 12-inch cement plug was placed in the hole.

Hand augering was used to collect near surface soil and sludge samples in the Lime Sludge Ponds subunit. Wastes identified for possible sampling were field screened with a photoionization detector and alpha-beta meter. If field screening results indicated that a sample should be taken, the sample for volatile analyses was collected first.

All soil samples were visually described. A sample was collected for toxicity characteristic leaching procedure (TCLP) analysis if the sample contained significant volatile organic vapor readings. The sample from each boring with the highest reading from the photoionization detector was also analyzed for the analytes in the Target Analyte List (TAL) 20.03.05 C (see Section 2.2.2.3, Table 2-13). Samples of elevated radioactivity (10 times background and above) were candidates for on-site screening by gamma spectrometry to quantify radionuclide activities for uranium, thorium, and radium.

2.2.2.2.5 Phase II Trench Investigations

Excavations using a backhoe were completed at suspect locations in the South Field and Lime Sludge Ponds to determine if rubble/debris might be a source of contamination to surrounding subsoils and groundwater. Ten South Field trenching locations were selected according to anomalous electromagnetic data (see Section 2.2.2.2.1). A trench at the Lime Sludge Ponds subunit was located adjacent to the existing K-65 Slurry Line. Excavation procedures for trenching, screening, sampling,

TABLE 2-9

SUMMARY OF RI/FS PHASE II
FIELD INVESTIGATION SUBSURFACE SOIL SAMPLING
WITHIN OPERABLE UNIT 2 WASTE AREAS
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Unit	No. of Sample Locations	Sample Depth (feet)	Analytical Parameters	No. of Analyses
Solid Waste Landfill	25	0 - 78.0	Radionuclides	36
			HSL	38 (1 VOCs only)
			TCLP	6 (2 metals only)
			Geotechnical	49
			On-Site Screening	14
Lime Sludge Ponds	30	0 - 18.5	Radionuclides	33
			HSL	36 (2 VOCs only)
			TCLP	8
			Geotechnical	42
			On-Site Screening	14
Inactive Flyash Pile	26	0 - 65.0	Radionuclides	24
			HSL	35 (2 VOCs only)
			TCLP	6
			Geotechnical	15
			On-Site Screening	70
South Field	48	0 - 65.0	Radionuclides	45
			HSL	42
			TCLP	0
			Geotechnical	34
			On-Site Screening	44
Active Flyash Pile	4	0 - 60.0	Radionuclides	12
			HSL	12
			TCLP	4
			Geotechnical	6
			On-Site Screening	0

backfilling, and regrading are defined in the SAP for the RI/FS Work Plan Addendum for Operable Unit 2.

South Field trenching began at the center point of an anomaly and proceeded toward either end to a maximum depth of 15 feet. The trenches were excavated by segments. If groundwater was encountered during trenching, that segment of the trench was temporarily abandoned, the backhoe was moved to another position along the centerline, and a new excavation was begun.

Soil debris or waste material was taken from the bucket of the backhoe for sampling. Sample locations were selected in the field by the project geologist based upon radiological and organic vapor screening and upon visual descriptions. During and following excavation of the trench, the project geologist constructed a cross-section profile of one sidewall of each trench. Cross sections showed all significant soil, subsoil and unconsolidated material, and differentiated depositional, lithologic, or visual differences revealed in the trenches. Areas of fill, debris, or other obvious cultural-related fill material were clearly labeled and shown on the cross sections (see Tables D-18B and F-18B in Appendices D and F). In addition, the trench excavations were photographed.

Upon completion of the cross sections, if sidewalls were stable, a vertical radiological survey of one of the trench sidewalls was performed. This survey was performed with a SPA-3 probe. The results were recorded on the project geologist's trench cross sections. As material was removed, samples were collected from the backhoe bucket and screened. Undisturbed native materials were sampled only if screening detected elevated (greater than 10 times background) readings. If no previous disturbance of the soils or soil material was evident and no elevated field readings were observed, no samples were collected. Five trenching samples from three trenches were submitted to an off-site contract laboratory.

Upon completion of the investigation at each trench, the trench was backfilled with the materials which were removed during the excavation; no clean fill was imported for trenching purposes. The area was then graded and returned to its approximate original contour and slope. Trenching was accomplished at a minimum rate of one trench per day.

2.2.2.2.6 Phase II Hydropunch™ Groundwater Sampling

Hydropunch™ sampling was performed in conjunction with hollow-stem auger drilling to collect groundwater samples with a bailer from saturated till deposits. Thirty-five groundwater samples were analyzed for total uranium by laser phosphorimetry in the on-site laboratory. These analyses provided a total uranium concentration value for characterization purposes, typically within 24 hours of collection. The detection limit varied depending upon the concentrations of total uranium, but was at or below 0.10 ppm. The objective was to define saturated soil conditions and determine approximate boundaries of groundwater uranium contamination prior to selecting monitor well locations.

The procedure was to drill borings and collect soil samples for lithologic description. The expected depth to water at the sampling site was estimated from nearby wells, and a Hydropunch™ sample was collected once saturated conditions were encountered in soil samples recovered from the borings. Hydropunch™ samples were not collected if clay soil or unsaturated soil conditions were encountered. These conditions typically do not yield sufficient water in a timely manner to justify sampling activities. The Hydropunch™ locations were numbered consecutively and, unlike monitoring well designations, were not intended to distinguish the depth of groundwater collection.

2.2.2.2.7 Phase II Monitoring Well Installations

Eleven monitoring wells in perched water formations (1000-series wells) were drilled with a truck-mounted auger rig using nominal 8-inch or 10-inch hollow stem augers as available. Continuous 18-inch long split-spoon samples were collected in advance of the auger through the till to an approximate maximum depth of 20 feet. Wells were completed using two-inch diameter, 316 stainless steel risers and 0.010-inch slotted screen across the perched water interval. Filter pack material was well-sorted quartz sand, ranging between 10-20 mesh (coarse) and 20-40 mesh (medium).

Thirteen monitoring wells in the upper Great Miami Aquifer (2000-series wells) were drilled by cable-tool methods, using a nominal 10-inch diameter drill casing. Continuous 18-inch long split-spoon samples were taken in the glacial till and at five-foot intervals in sand and gravel of the upper Great Miami Aquifer. Wells monitoring the Great Miami Aquifer in waste or contaminated areas required the advance placement of a shallow surface casing. Depending upon the combined thickness of the fill and till, approximately 35 feet of nominal 12-inch inner-diameter (ID) steel surface casing was cemented in place within a boring of 14 to 16 inches. The cement was allowed to cure for a

minimum of 24 hours before continuation of drilling to the planned total depth with an 8-inch ID casing.

Wells were completed using four-inch diameter 316 stainless steel slotted screen (15-feet) and riser. Either a 0.010-inch or 0.020-inch screen and medium or coarse quartz sand filter pack as defined in the RCRA Groundwater Monitoring Plan (DOE 1991b) were installed based on field classification of the formation material or sieve analysis. However, for expedience, 0.010 inch screens were installed in lieu of sieve analyses, which commonly required a minimum of 24 hours to complete.

2.2.2.2.8 Phase II Groundwater Level Measurements and Sampling

At least three complete rounds of groundwater level measurements from the existing monitoring wells in each subunit were taken at two week intervals during the Phase II Field Investigation. After the well installations were complete in each subunit, a final round of measurements was taken from both the existing and newly installed wells. All groundwater level measurements for each round were collected within a 24-hour period of consistent weather conditions to minimize changes due to atmospheric and precipitation effects. In addition, groundwater levels were recorded for all new wells at the time of completion and after well development. All measurements were recorded to the nearest 0.01 feet. Individual monitoring well hydrographs characterized whether water levels had reached equilibrium.

One round of groundwater sampling was conducted within 24 hours of developing the newly drilled monitoring wells and within 24 hours of purging the existing wells. Equipment included bailers, surge blocks, pumps, and hoses. All wells were developed to achieve turbidity-free water (less than five turbidity units); no less than five times the standing water in the well (casing volume) was purged during development. Existing wells were purged of at least three times volume, depending upon available rates of recharge. Samples were collected according to the SCQ and RI/FS QAPP. Water levels were measured using a Hazco Water Level Meter and recorded in all new and existing wells prior to sampling to establish baseline information. Field measurements of water temperature, pH, conductivity, and dissolved oxygen were taken and recorded. Groundwater samples were properly preserved and transferred under chain of custody protocols to the contract RI/FS laboratory for the designated analyses. Table 2-10 summarizes the groundwater samples collected and analytical parameters.

TABLE 2-10

SUMMARY OF RI/FS PHASE II FIELD INVESTIGATION GROUNDWATER SAMPLES WITHIN OPERABLE UNIT 2 WASTE AREAS FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Unit	No. of Wells	Sample Depth (Well Series)	Analytical Parameters	No. of Analyses
Solid Waste Landfill	16[a]	1000, 2000	Radionuclides	20
			HSL	20 (6 metals only)[b] (2 metals and cyanide only)
			On-Site Screening	20
Lime Sludge Ponds	10	1000, 2000	Radionuclides	20
			HSL	21 (5 metals only) (3 metals and cyanide only) (1 VOCs and TOC only)
			On-Site Screening	15
Inactive Flyash Pile	5	1000, 2000	Radionuclides	6
			HSL	6 (1 metals only)
			On-Site Screening	6
South Field	16	1000, 2000	Radionuclides	25
			HSL	26 (7 metals only) (2 metals and cyanide only) (1 VOCs and TOC only)
			On-Site Screening	20
Active Flyash Pile	6	1000, 2000	Radionuclides	6
			HSL	6 (1 metals, VOCs, and cyanide only)
			On-Site Screening	7

[a] Four of these locations are not wells, but are groundwater samples collected from borings.
[b] Samples were collected from some locations and analyzed for unfiltered metals and/or unfiltered cyanide in addition to the samples analyzed for full radionuclides and full HSL.

2.2.2.2.9 Phase II Surface Water and Sediment Sampling

Surface water sampling was accomplished by the use of a grab bottle or, where necessary, a length of rope or an extension pole was attached to the grab bottle. The sample was then transferred to the sample containers allowing minimal disturbance. Field determinations of temperature, conductivity, and pH were made on aliquots of the selected sample. Sampled water was placed into the appropriate container with preservative where required, capped, and placed into a cooler. Ten surface water samples were collected for risk assessment purposes and shipped unfiltered to the laboratory.

Unconsolidated sediment was collected using a glass or plastic grab bottle. The sediment was allowed to dewater prior to emplacement into the sample collection container. Once the sediment settled, the water sample was decanted into the sample container. During the sample dewatering period, the sample underwent field screening for radiological activity and the presence of organic contamination.

For sediment samples to be taken at nonflowing surface water locations, sampling consisted of obtaining bottom sediments with a stainless steel trowel. For sampling locations where the standing water was too deep for trowel sampling, a stainless steel bucket auger was used. For flowing surface water bodies, samples were collected from the downstream positions first, followed by the upstream samples. Table 2-11 summarizes the surface water and sediment samples collected and the analytical parameters.

2.2.2.2.10 Phase II Geotechnical Sampling

Geotechnical tests were conducted to characterize the engineering properties of the soil and waste material from the Operable Unit 2 subunits. Soil and waste material samples were collected from borings completed by truck-mounted hollow-stem auger drill rigs and by means of split-spoon or Shelby™ tube type samplers. Samples were selectively analyzed for specific gravity, liquid limit, plasticity index, natural moisture content, particle size and distribution, maximum density, optimum moisture content and color, and physical state. Table 2-9 includes a breakdown of geotechnical samples by subunit.

2.2.2.2.11 Phase II Project Surveying

Locations of sampling points, borings, and wells were surveyed by a Registered Professional Land Surveyor. All surveyed locations are accurate to the nearest 0.01 feet vertical accuracy and 0.10 feet horizontal accuracy. Survey points were located and integrated into the existing FEMP Geographic

TABLE 2-11

SUMMARY OF RI/FS PHASE II FIELD INVESTIGATION SURFACE WATER/SEDIMENT SAMPLES WITHIN OPERABLE UNIT 2 WASTE AREAS FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Unit	No. of Sample Locations	Analytical Parameters	No. of Analyses
		SURFACE WATER	
Solid Waste Landfill	3	Radionuclides	2
		HSL	2
		On-Site Screening	3
Lime Sludge Ponds	2	Radionuclides	2
		HSL	2
		On-Site Screening	3
Inactive Flyash Pile	11	Radionuclides	6
		HSL	6
		On-Site Screening	15
South Field	6	Radionuclides	2
		HSL	2
		On-Site Screening	6
Active Flyash Pile	1	Radionuclides	1
		HSL	1
		On-Site Screening	1
		SEDIMENT	
Solid Waste Landfill	2	Radionuclides	2
		HSL	2
		Geotechnical	2
		On-Site Screening	4
Lime Sludge Ponds	0	Radionuclides	0
		HSL	0
		Geotechnical	0
		On-Site Screening	0
Inactive Flyash Pile	3	Radionuclides	4
		HSL	6
		Geotechnical	2
		On-Site Screening	0
South Field	3	Radionuclides	3
		HSL	3
		Geotechnical	2
		On-Site Screening	3
Active Flyash Pile	1	Radionuclides	1
		HSL	1
		Geotechnical	0
		On-Site Screening	0

Information System (GIS) and incorporated into the site database. The basis for map coordinates is the State Planar North American Datum (1927).

2.2.2.2.12 Phase II Field Quality Assurance Sampling

Field quality assurance (QA) samples were collected during the sampling program for each of the Operable Unit 2 subunit investigations. Trip and preservative blanks were provided by the QA group and the remaining samples were prepared or collected by the sampling teams. The QA sample types and requirements are:

- Trip blank samples for volatile organic analyses (VOA) were prepared in a controlled environment by pouring distilled water meeting the ASTM Type II standards into 40 milliliter (mL) vials. A trip blank for VOA accompanied each sampling team during each day's sampling to the field location and was shipped to the laboratory with the field samples for analyses. Trip blanks were required during sampling events for all media types when the target analytes included volatile organics for analytical support levels (ASLs) C, D, and E.

- Field blank samples were prepared for every 10 groundwater and/or surface water samples and analyzed for the same target analytes specified for the field sample collected during the sampling event. The 1/10 frequency of field blanks is based on the number of groundwater/surface water samples collected from each Operable Unit 2 subunit. A field blank sample was prepared at the sampling site by the field team by pouring deionized/organic free water into the appropriate sample containers.

- An equipment rinsate sample was collected for every 20 field samples of any media type following decontamination of the sampling equipment. Rinsate samples were collected after a sampling event entailing Full Hazardous Substance List (HSL) and Full Radioisotope parameters and in conjunction with sampling events having the highest potential for contamination coming in contact with the equipment. This assessed the effectiveness of the field decontamination procedures.

- Duplicate water samples were collected at a frequency of 1 per every 20 groundwater or surface water samples. The duplicate samples were collected at sampling locations which were known or suspected of being contaminated. These samples were assigned a unique sample number and sent to the laboratory as a blind sample. No duplicate soil samples were collected due to the lack of an effective field compositing technique which would produce meaningful data where discrepancies could absolutely be considered a laboratory precision problem.

- One preservative blank for each type of preservative used was prepared and analyzed for the respective parameters of interest. This consisted of an analyses of separate ASTM Type II water samples preserved with each respective acid and base preservative. The hydrochloric (HCl) acid-preserved sample was analyzed for volatile organic compounds, the sodium hydroxide (NaOH) preserved sample for cyanide, and the nitric acid (HNO^3) preserved sample for metals.

- Container blanks were not included in the QA samples since all containers used for RI/FS sampling activities were precleaned by the manufacturer and had a certificate of analysis for each lot of containers.

2.2.2.2.13 Phase II Sample Collection Documentation

Surface water and groundwater samples collected in the field were documented on the Sample Collection Log and Water Quality Field Collection Report forms. The collection of soil and subsoil materials were documented on the Sample Collection Log, Visual Classification of Soils, and Subsurface Soil Sample Collection Log. In addition to these forms, daily field activities were recorded on the Field Activity Daily Log form. Examples of these forms are found in Appendix B of the FEMP SCQ.

Consistent with standard FEMP RI/FS practice, a unique six-digit sample number was assigned to each collected sample. Specific number ranges were allocated for each Operable Unit 2 subunit being characterized. Each sample container was affixed with a RI/FS label containing, at a minimum, the information specified on Form 7-2, Appendix B of the FEMP SCQ.

Sample custody procedures as outlined in the FEMP SCQ were adhered to throughout the sample handling process from field collection to shipment or delivery of the samples to the laboratory. A combined Request for Analysis/Chain of Custody (RFA/CC) record was used to document collection data, chain of custody, and the analytical parameters requested for each sample in accordance with FEMP RI/FS Procedure FPP-401. The Site-Wide Analysis Request/Custody Record (SAR/CR) form was completed for all samples delivered to the on-site sample processing laboratory.

2.2.2.2.14 Investigation Derived Waste Handling/Storage/Disposal

During field work, wastes were generated in the form of excess surface water, sediment, sludge and solid wastes sampling media, contaminated well purge water, contaminated sampling equipment, contaminated drilling equipment, contaminated personal protective equipment (PPE), drill cuttings, and decontamination.

Contaminated drill cuttings from auger drilling and cable tool drilling were placed in clean 55-gallon drums and labeled according to project and location of origin. Contaminated PPE consisting of disposable items were labeled as radiological wastes and placed in designated disposal containers, labeled, and sent to the appropriate interim storage location.

Decontamination of drilling and sampling equipment was performed at authorized FEMP Decontamination Areas. Fluids and solid material residuals were handled in accordance with the normal operation of that facility's contamination treatment/control devices. Well sampling purge water was disposed of in the General Sump.

Material excavated during trenching was backfilled into the trench it was removed from; no clean fill was added.

2.2.2.3 Phase II Analytical Methods

Project specific TALs were developed for analytes of interest for the Operable Unit 2 RI. The TALs were based on the following data gaps from previous investigations:

- The lack of sufficient characterization data in some portions of the subunits.
- The need for consistency with the Operable Unit 5 investigation, particularly when addressing fate and transport modeling and risk assessment.
- The need to define source areas and the upgradient and downgradient extent of groundwater contaminant migration across the Inactive Flyash Pile, South Field, and Active Flyash Pile areas.

The TAL 20.03.05 A is equivalent to total uranium screening at the FEMP laboratory. The other Phase II project specific TALs are provided in Tables 2-12 through 2-15. These analyses were performed by IT Corporation Analytical Service, an off-site contract laboratory. The analytes that compose TAL 20.03.05 B and TAL 20.03.05 C are referred to as the Full HSL and Full Radioisotope lists. Because TAL 20.03.05 B is for aqueous matrix samples and TAL 20.02.05 C is for solid matrix samples, general chemistry parameters are included in TAL 20.03.05 B only.

EPA contract laboratory program (CLP) or SW-846 methods were followed for organic and inorganic analyses. Analytical methods for radioisotopes followed performance-based criteria cited directly by the SCQ. In all cases, the laboratory generated a CLP data package or equivalent for non-CLP analytes such as general wet chemistry. The goal of the analytical documentation was to provide CLP data packages for all samples that were able to be validated to ASL C, with 10 percent ASL D validation for each matrix.

TABLE 2-12

FEMP RI/FS TAL 20.03.05 B
OPERABLE UNIT 2 TARGET ANALYTE LIST
PHASE II FIELD INVESTIGATION
GROUNDWATER AND SURFACE WATER SAMPLES

FULL HAZARDOUS SUBSTANCE LIST (HSL)			
Inorganics			
aluminum	chromium (total)	manganese	silver
antimony	cobalt	mercury	sodium
arsenic	copper	molybdenum	thallium
barium	cyanide	nickel	vanadium
beryllium	iron	potassium	zinc
cadmium	lead	selenium	
calcium	magnesium	silicon	
Volatile Organics			
1,1-dichloroethane	2-hexanone	chlorobenzene	tetrachloroethene
1,1-dichloroethene	4-methyl-2-pentanone	chloroethane	toluene
1,1,1-trichloroethane	acetone	chloroform	total xylenes
1,1,2-trichloroethane	benzene	chloromethane	trans-1,3-dichloropropene
1,1,2,2-tetrachloroethane	bromodichloromethane	cis-1,3-dichloropropene	trichloroethene
1,2-dichloroethane	bromoform	dibromochloromethane	vinyl acetate
1,2-dichloroethylene	bromomethane	ethylbenzene	vinyl chloride
1,2-dichloropropane	carbon disulfide	methylene chloride	
2-butanone	carbon tetrachloride	styrene	
Semivolatile Organics			
1,2-dichlorobenzene	2-nitroaniline	2,6-dinitrotoluene	4-nitroaniline
1,2,4-trichlorobenzene	2-nitrophenol	3-nitroaniline	4-nitrophenol
1,3-dichlorobenzene	2,4-dichlorophenol	3,3-dichlorobenzidine	4,6-dinitro-2-methylphenol
1,4-dichlorobenzene	2,4-dimethylphenol	4-bromophenyl phenyl ether	acenaphthene
2-chloronaphthalene	2,4-dinitrophenol	4-chloro-3-methylphenol	acenaphthylene
2-chlorophenol	2,4-dinitrotoluene	4-chloroaniline	anthracene
2-methylnaphthalene	2,4,5-trichlorophenol	4-chlorophenyl phenyl ether	benzoic acid
2-methylphenol	2,4,6-trichlorophenol	4-methylphenol	benzo(a)anthracene

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TABLE 2-12
(Continued)

FULL HAZARDOUS SUBSTANCE LIST (HSL)			
Semivolatile Organics (Continued)			
benzo(a)pyrene	butyl benzyl phthalate	fluoranthene	nitrobenzene
benzo(b)fluoranthene	carbazole	fluorene	n-nitroso-di-n-propylamine
benzo(g,h,i)perylene	chrysene	hexachlorobenzene	n-nitrosodiphenylamine
benzo(k)fluoranthene	dibenzofuran	hexachlorobutadiene	pentachlorophenol
benzyl alcohol	dibenzo(a,h)anthracene	hexachlorocyclopentadiene	phenanthrene
bis(2-chloroethoxy)methane	diethyl phthalate	hexachloroethane	phenol
bis(2-chloroethyl)ether	dimethyl phthalate	indeno(1,2,3-cd)pyrene	pyrene
bis(2-chloroisopropyl) ether	di-n-butyl phthalate	isophorone	
bis(2-ethylhexyl)phthalate	di-n-octyl phthalate	naphthalene	
Pesticides / PCBs			
4,4'-DDD	aroclor 1221	delta-BHC	endrin ketone
4,4'-DDE	aroclor 1232	dieldrin	gamma-BHC
4,4'-DDT	aroclor 1242	endosulfan sulfate	gamma-chlordane
aldrin	aroclor 1248	endosulfan-I	heptachlor
alpha-BHC	aroclor 1254	endosulfan-II	heptachlor epoxide
alpha-chlordane	aroclor 1260	endrin	methoxychlor
aroclor 1016	beta-BHC	endrin aldehyde	toxaphene
GENERAL GROUNDWATER QUALITY			
alkalinity	fluoride	phosphate	total organic carbon (TOC)
ammonia	nitrate	sulfate	total organic halogens (TOX)
chloride	phenols	sulfide	total organic nitrogen (TON)
FULL RADIOLOGICAL			
cesium 137	plutonium 239/240	technetium 99	total uranium
gross alpha	radium 226	thorium 228	uranium 234
gross beta	radium 228	thorium 230	uranium 235/236
neptunium 237	ruthenium 106	thorium 232	uranium 238
plutonium 238	strontium 90	total thorium	

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TABLE 2-13

FEMP RI/FS TAL 20.03.05 C
OPERABLE UNIT 2 TARGET ANALYTE LIST
PHASE II FIELD INVESTIGATION
SOIL, SLUDGE, SEDIMENT, AND WASTE SAMPLES

FULL HAZARDOUS SUBSTANCE LIST (HSL)			
Inorganics			
aluminum	chromium (total)	manganese	silver
antimony	cobalt	mercury	sodium
arsenic	copper	molybdenum	thallium
barium	cyanide	nickel	vanadium
beryllium	iron	potassium	zinc
cadmium	lead	selenium	
calcium	magnesium	silicon	
Volatile Organics			
1,1-dichloroethane	2-hexanone	chlorobenzene	tetrachloroethene
1,1-dichloroethene	4-methyl-2-pentanone	chloroethane	toluene
1,1,1-trichloroethane	acetone	chloroform	total xylenes
1,1,2-trichloroethane	benzene	chloromethane	trans-1,3-dichloropropene
1,1,2,2-tetrachloroethane	bromodichloromethane	cis-1,3-dichloropropene	trichloroethene
1,2-dichloroethane	bromoform	dibromochloromethane	vinylacetate
1,2-dichloroethylene	bromomethane	ethylbenzene	vinylchloride
1,2-dichloropropane	carbon disulfide	methylenechloride	
2-butanone	carbon tetrachloride	styrene	
Semivolatile Organics			
1,2-dichlorobenzene	2-methylnaphthalene	2,4-dinitrophenol	3,3-dichlorobenzidine
1,2,4-trichlorobenzene	2-methylphenol	2,4-dinitrotoluene	4-bromophenyl phenylether
1,3-dichlorobenzene	2-nitroaniline	2,4,5-trichlorophenol	4-chloro-3-methylphenol
1,4-dichlorobenzene	2-nitrophenol	2,4,6-trichlorophenol	4-chloroaniline
2-chloronaphthalene	2,4-dichlorophenol	2,6-dinitrotoluene	4-chlorophenyl-phenyl ether
2-chlorophenol	2,4-dimethylphenol	3-nitroaniline	4-methylphenol

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TABLE 2-13
(Continued)

FULL HAZARDOUS SUBSTANCE LIST (HSL) (continued)			
Semivolatile Organics (Continued)			
4-nitroaniline	benzo(k)fluoranthene	diethylphthalate	isophorone
4-nitrophenol	benzyl alcohol	dimethylphthalate	naphthalene
4,6-dinitro-2-methylphenol	bis(2-chloroethoxy)methane	di-n-butyl phthalate	nitrobenzene
acenaphthene	bis(2-chloroethyl)ether	di-n-octyl phthalate	n-nitroso-di-n-propylamine
acenaphthylene	bis(2-chloroisopropyl) ether	fluoranthene	n-nitrosodiphenylamine
anthracene	bis(2-ethylhexyl)phthalate	fluorene	pentachlorophenol
benzoic acid	butyl benzyl phthalate	hexachlorobenzene	phenanthrene
benzo(a)anthracene	carbazole	hexachlorobutadiene	phenol
benzo(a)pyrene	chrysene	hexachlorocyclopentadiene	pyrene
benzo(b)fluoranthene	dibenzofuran	hexachloroethane	
benzo(g,h,i)perylene	dibenzo(a,h)anthracene	indeno(1,2,3-cd)pyrene	
Pesticides / PCBs			
4,4'-DDD	aroclor 1221	delta-BHC	endrin ketone
4,4'-DDE	aroclor 1232	dieldrin	gamma-BHC
4,4'-DDT	aroclor 1242	endosulfan sulfate	gamma-chlordane
aldrin	aroclor 1248	endosulfan-I	heptachlor
alpha-BHC	aroclor 1254	endosulfan-II	heptachlor epoxide
alpha-chlordane	aroclor 1260	endrin	methoxychlor
aroclor 1016	beta-BHC	endrin aldehyde	toxaphene
FULL RADIOLOGICAL			
cesium 137	plutonium 239/240	technetium 99	total uranium
gross alpha	radium 226	thorium 228	uranium 234
gross beta	radium 228	thorium 230	uranium 235/236
neptunium 237	ruthenium 106	thorium 232	uranium 238
plutonium 238	strontium 90	total thorium	

000141

TABLE 2-14

OPERABLE UNIT 2 TARGET ANALYTE LIST
PHASE II FIELD INVESIGATION
GEOTECHNICAL TESTING
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

FEMP RI/FS TAL 20.03.05 D		
General Chemistry		
total organic carbon		
Geotechnical		
specific gravity	liquid limit	particle size - hydrometer
water/moisture content	plastic limit	sieve analysis

FEMP RI/FS TAL 20.03.05 E
one dimensional consolidation

FEMP RI/FS TAL 20.03.05 F
permeability (constant head)

FEMP RI/FS TAL 20.03.05 G		
unconfined compressive strength	direct shear - slow	CU triaxial (3pts)

FEMP RI/FS TAL 20.03.05 J
dry unit weight

TABLE 2-15

OPERABLE UNIT 2 TARGET ANALYTE LIST
PHASE II FIELD INVESTIGATION
TOXICITY CHARACTERISTIC LEACHING PROCEDURE
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

FEMP RI/FS TAL 20.03.05 H			
Inorganics			
arsenic	cadmium	lead	selenium
barium	chromium	mercury	silver
Volatile Organics			
1,1-dichloroethene	benzene	chloroform	vinyl chloride
1,2-dichloroethane	carbon tetrachloride	tetrachloroethene	
2-butanone	chlorobenzene	trichloroethene	
Semivolatile Organics			
1,4-dichlorobenzene	2,4,6-trichlorophenol	hexachlorobutadiene	pyridine
2-methylphenol	3-methylphenol	hexachloroethane	
2,4-dinitrotoluene	4-methylphenol	nitrobenzene	
2,4,5-trichlorophenol	hexachlorobenzene	pentachlorophenol	
Herbicides			
2,4-D	2,4,5-TP		
Pesticides			
alpha-chlordane	gamma-BHC	heptachlor	methoxychlor
endrin	gamma-chlordane	heptachlor epoxide	toxaphene

FEMP RI/FS TAL 20.03.05 I			
Inorganics			
arsenic	cadmium	lead	selenium
barium	chromium	mercury	silver
Additional Inorganics			
copper	iron	manganese	zinc
Volatile Organics			
1,1-dichloroethene	benzene	chloroform	vinyl chloride
1,2-dichloroethane	carbon tetrachloride	tetrachloroethene	
2-butanone	chlorobenzene	trichloroethene	
Semivolatile Organics			
1,4-dichlorobenzene	2,4,6-trichlorophenol	hexachlorobutadiene	pyridine
2-methylphenol	3-methylphenol	hexachloroethane	
2,4-dinitrotoluene	4-methylphenol	nitrobenzene	
2,4,5-trichlorophenol	hexachlorobenzene	pentachlorophenol	
Herbicides			
2,4-D	2,4,5-TP		
Pesticides			
alpha-chlordane	gamma-BHC	heptachlor	methoxychlor
endrin	gamma-chlordane	heptachlor epoxide	toxaphene

2.2.2.4 Phase II Data Validation Methods

RI/FS data, which is used as the basis for remedial action decision-making, has been validated. This section presents discussions of the data validation process for the RI/FS.

Data validation is an independent, systematic process of evaluating data to provide confirmation that the data is of the technical quality necessary to meet its intended use, and assure that a legally defendable "road map" can be established to trace each sample from the time it is collected in the field to its ultimate end use. To verify that the analytical data met its data quality objectives (DQOs) and to determine compliance with appropriate and applicable procedures, the validation process examines field measurements, sampling and handling procedures, laboratory analysis and reporting, and any nonconformities and discrepancies in the data. Data qualifiers are assigned to the analytical data to alert the user of any nonconformances to quality assurance/quality control (QA/QC) requirements. The list of qualifiers assigned and their definitions is provided in Table 2-16.

The level of quality required depends on the intended use of the data, which in turn dictates the appropriate level or extent of validation. The FEMP SCQ classifies data into one of five ASLs as described in Table 2-17.

The validation program is divided into two phases. The first phase considers field data, which is collected at ASL A or B. The second phase deals with analytical data, which is collected at ASL C, D, or E. For most of the organic and inorganic data, reviews are performed under the CLP Statement of Work, corresponding to data collected at ASL D. Data reported under a Certificate of Analysis (COA) are reviewed and qualified as ASL C. Radiological data are normally qualified based on deliverables provided for ASL E. Separate evaluations are conducted for radiological, organic, and inorganic analytes.

2.2.2.5 Phase II Data Management Methods

Once the samples were collected and sent to the appropriate laboratory for analysis, field information was collected and reviewed to verify that all required field information was received. Copies of all appropriate records were made and the originals were stored in a secure place. Copies of the field records were used for data entry into the Site-Wide Environmental Database (SED) and for data

TABLE 2-16

Data Qualifiers and Definitions

DATA QUALIFIERS AND DEFINITIONS	
J	Analyte was analyzed for and positively identified, but the associated numerical value may not be consistent with the amount present in the environmental sample. Data should be seriously considered for making decisions and are usable for many purposes.
N	Analysis indicates that an analyte is present and there are strong indications that the identity is correct.
R	Data are unusable for any purpose. Analyte was analyzed for, but the presence or absence of the analyte was not verified. Resampling and reanalysis are necessary to confirm or deny presence of the analyte.
U	Analyte was analyzed for and was not present above the level of the associated value. Associated numerical value indicates the approximate concentration necessary to detect the analyte in the sample.
UJ	This is a combination of the "U" and "J" qualifiers. Analyte was analyzed for and was not present above the level of the associated value. The associated value may not accurately or precisely represent the concentration necessary to detect the analyte in the sample. If a decision requires quantitation of the analyte close to the associated numerical level, reanalysis or alternative analytical methods should be considered.

(Notation from QAPP March 1992)

TABLE 2-17
ANALYTICAL SUPPORT LEVELS

Support Level	Description	Typical Data Uses
A	*Qualitative Field Analysis* - This level is characterized by the use of portable instruments that can provide real-time data to assist in the optimization of sampling point locations and in providing health and safety support. Data can be generated regarding the presence or absence of contaminants (e.g., radionuclides, volatiles) at sampling locations. Analogous to EPA analytical level 1.	• Site characterization • Monitoring during implementation • Establishing worker protective equipment
B	*Qualitative, Semi-Quantitative, and Quantitative Analyses* - This level may include the use of more sophisticated screening techniques, such as portable analytical instruments that can be used on site (close-support laboratories). Depending upon the types of contaminants, sample matrix, and QC checks applied, qualitative and quantitative data can be obtained. Analogous to EPA analytical level 2.	• Site characterization • Evaluation of alternatives • Engineering design • Monitoring during implementation
C	*Quantitative with fully defined QA/QC* - Laboratory analyses generated with full QA/QC checks of types and frequencies specified for ASL D according to FEMP-specified analytical protocols for radiological and nonradiological parameters. The analytical methods are identical to ASL D for QA/QC sample analysis and method performance criteria. However, the data package does not typically contain raw instrument output but does include summaries of QA/QC sample results. ASL C may be used when analyses require a rigid, well-defined protocol, but where other information is available, so that a complete raw data package validation effort is not required. Laboratories are required to retain raw instrument data to upgrade ASL C reports to ASL D in the project file. Analogous to EPA analytical level 3.	• Risk assessment • Site characterization • Evaluation of alternatives • Engineering design • Monitoring during implementation
D	*Confirmational with complete QA/QC and reporting* - Provides data generated with a full complement of QA/QC checks of specified types and frequencies according to FEMP-specified analytical protocols for radiological and nonradiological parameters. The data package includes raw instrument output for validation. These data may be used to confirm data gathered at ASLs B and C, and when full validation of raw data is required. Analogous to EPA analytical level 4.	• Risk assessment • Evaluation of alternatives • Engineering design
E	*Nonstandard* - Analyses by nonstandard protocols that often require method development or validation (e.g., when extracting detection limits or analysis of an unusual chemical compound is required). New methods may be developed for ASL E data to allow for parameters or matrices that cannot be analyzed by existing standard methods. Analogous to EPA analytical level 5.	• Risk assessment

validation if the analyses generated for the task are either ASL C, D, and/or E. Field records generated for ASL B analyses were also validated when the project specific plan specified that results and data required validation.

After the completed laboratory analyses of the samples were received, the following activities took place:

- Verification that all required deliverables were received.
- Verification that contract performance requirements were met.
- Analytical data were entered into the SED.
- Data packages were reproduced for use in data validation and the original data packages were stored in a secure location.

The data was validated according to standard validation protocols. The data was qualified, data validation summaries were generated, and validation checklists were added to the data package. The validated data packages were then copied for use in data entry and the originals were stored in a secure location. The data validation qualifiers were entered into the SED.

Once data entry was completed, a printout of the SED was compared to the analytical and validation information to verify the accuracy of the database. After the verification of the database was complete, access to the data was limited and changes required documentation and approval. All subsequent RI activities accessed the controlled database to ensure correct data was being used.

2.3 ENVIRONMENTAL CHARACTERIZATION INFORMATION FOR THE SOLID WASTE LANDFILL

The Solid Waste Landfill has been preliminarily characterized by the Environmental Survey and CIS Sampling Program followed by characterization by the RI/FS Sampling Program. The following sections discuss the sample locations and analytical parameters from each of these sampling programs. Results of these sampling programs are presented in Appendix C.

2.3.1 Surface Sampling

As part of the Environmental Survey (DOE 1988a), four surface media samples (0620, 0621, 0622, and 0623) were composited from the Solid Waste Landfill. These samples were analyzed for radionuclides, total uranium, asbestos, TCLP metals, and PCBs. All but one of the samples (000623) were also analyzed for VOCs. It is unknown as to why this sample was not analyzed for VOCs.

During the CIS (Weston 1987c), four surface media samples were collected, two within the Solid Waste Landfill and two north of the Solid Waste Landfill, for on-site gamma spectroscopy analysis for cesium-137, radium-226, ruthenium-106, thorium-232, and uranium-238. Based on this initial screening, four surface media samples (46-238, 46-348, 46-349, and 46-362) were sent off site to be analyzed for 16 radionuclides. Locations of the samples that were analyzed off site are shown on Figure 2-1.

The objectives of RI/FS surface media (soil) sampling (1991-1993) in the Solid Waste Landfill were to:

- Characterize the nature and extent of contamination in the cover soils for risk assessment purposes.
- Provide data to evaluate the potential for exposure via the direct contact pathway.
- Provide data to evaluate the potential for exposure via the air migration pathway.

Twelve surface locations (SWL-SS-01 through SWL-SS-12) distributed across the landfill area were sampled during the Phase II Field Investigation in the Solid Waste Landfill (Figure 2-1a). Each location had one sample analyzed for full HSL and full radiological parameters (TAL 20.03.05 C).

2.3.2 Subsurface Sampling

During the Environmental Survey, Test Pit No. 8 was excavated on the west side of the Solid Waste Landfill and the south side of the drainage ditch. The pit was not surveyed; therefore, the precise location is unknown. Samples were collected in the pit from depths of 3.5 and 6.5 feet and were analyzed for radionuclides, total uranium, and TCLP metals.

During March and April 1987, six borings (49-01 through 49-06) were completed in the Solid Waste Landfill for the CIS (Weston 1987b). Split-spoon samples were collected at 1- to 2-foot intervals and

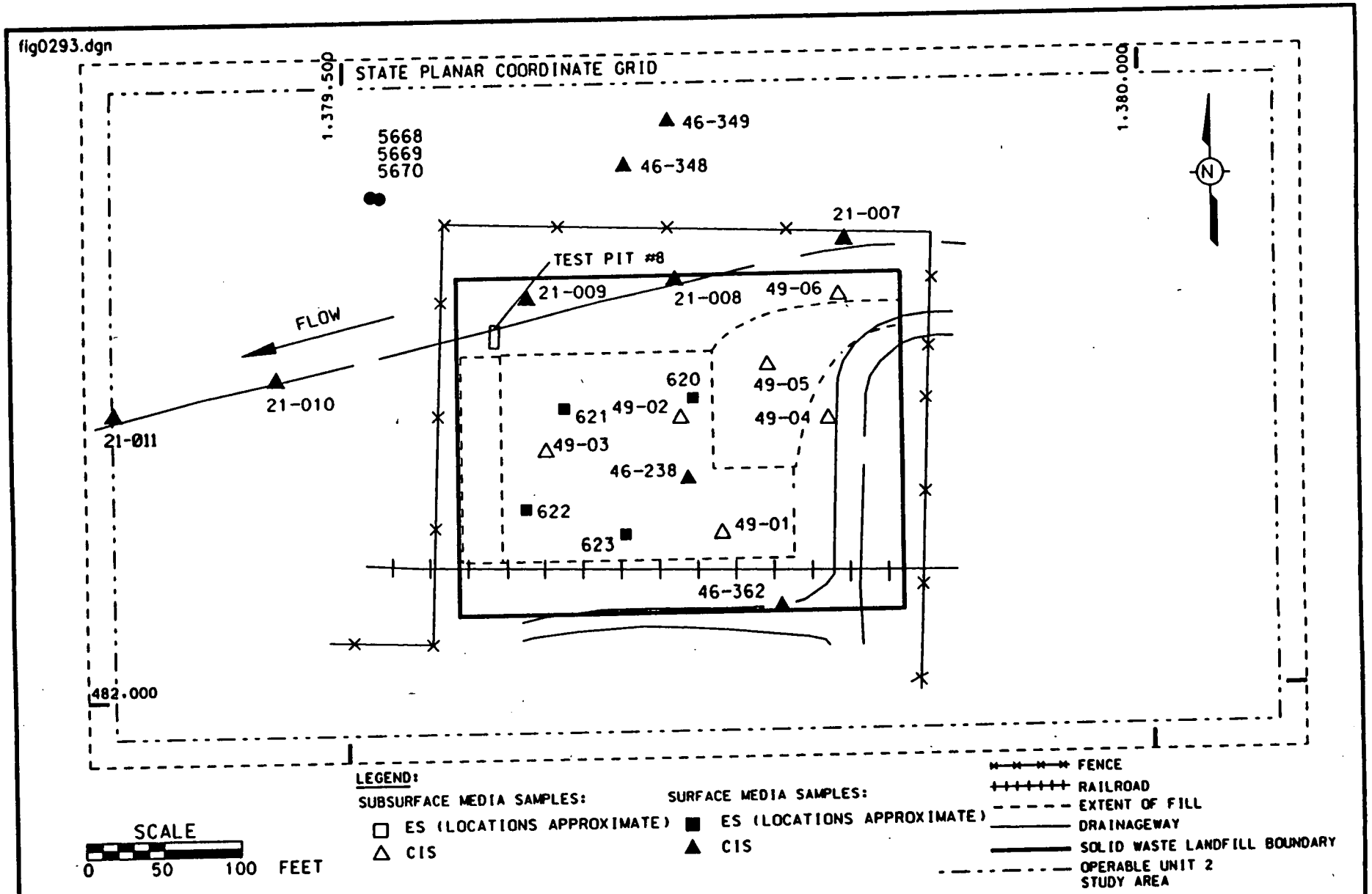

FIGURE 2-1
CIS AND ES SAMPLE LOCATIONS
IN THE SOLID WASTE LANDFILL AREA

000149

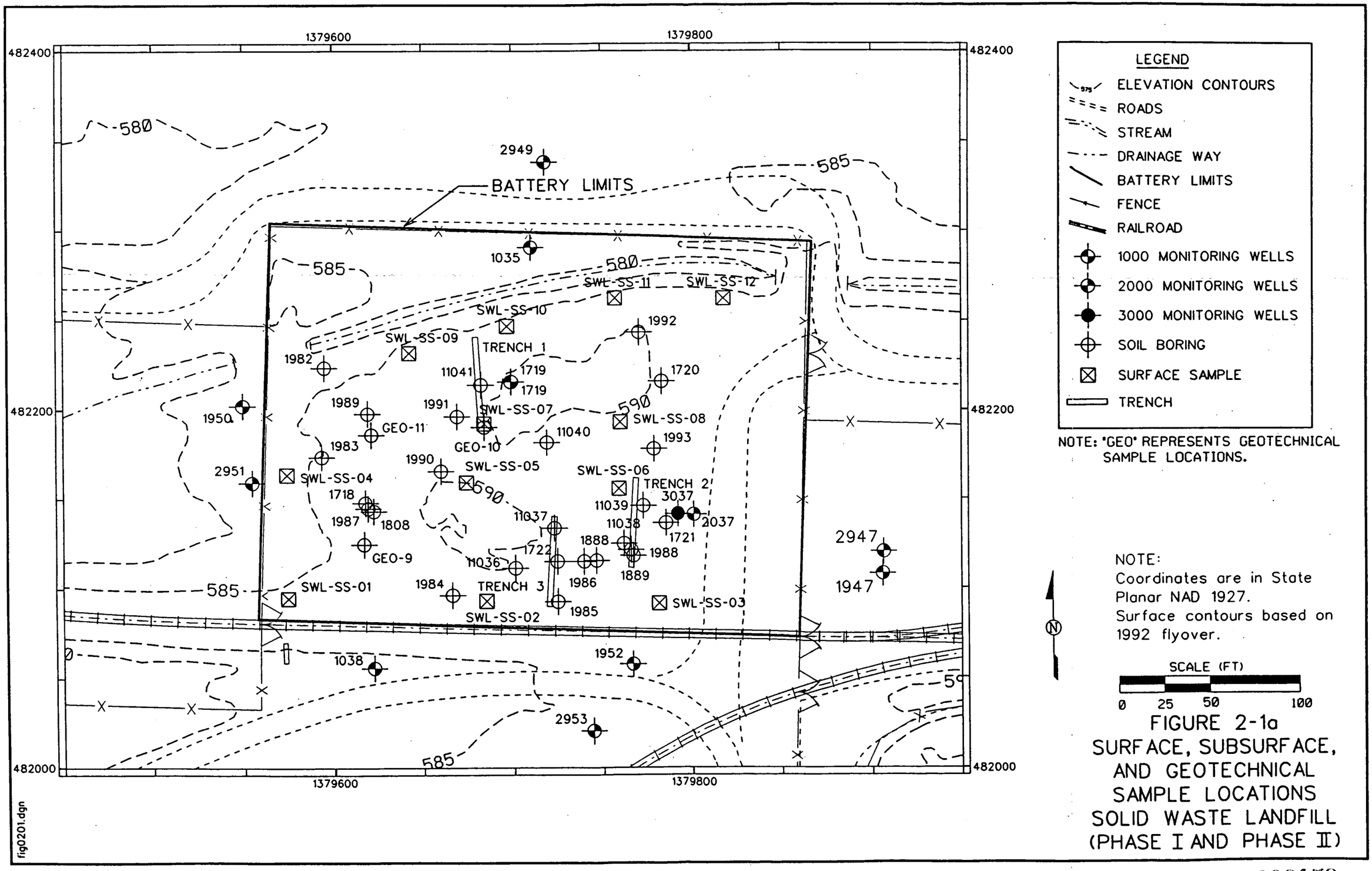

FIGURE 2-1a
SURFACE, SUBSURFACE, AND GEOTECHNICAL SAMPLE LOCATIONS
SOLID WASTE LANDFILL
(PHASE I AND PHASE II)

were analyzed for radium-226, thorium-232, and uranium-238 at the on-site gamma spectroscopy laboratory. The purpose of this sampling was to develop activity profiles for these three radionuclides. Composite samples were also collected from each boring and sent to off-site laboratories for chemical and radiological analyses. Chemical analyses included VOCs, semivolatile organic compounds (SVOCs), pesticide/PCBs, metals, extraction procedure (EP) Toxicity, reactivity, ignitability, and corrosivity. Locations of the samples that were analyzed off site are shown on Figure 2-1.

During 1988, three borings (1035, 1038, and 3037) were drilled near the Solid Waste Landfill as a part of the site-wide monitoring well installation program (Figure 2-1a). A total of five samples were collected from these borings and were analyzed for radionuclides.

The objectives of RI/FS subsurface media (soil) sampling in the Solid Waste Landfill were to:

- Characterize the physical nature of buried waste materials in the landfill and improve the conceptual model for waste deposition.
- Characterize the nature and extent of contamination, particularly in the suspect evaporation pond area and the waste cells (see Section 4.0).
- Determine fill depths and volumes.
- Determine whether contaminants have migrated from fill into underlying native soils.
- Provide data to support the modeling of contaminant migration from the Solid Waste Landfill.

During July and August 1991, six borings (1718, 1808, 1719, 1720, 1721, and 1722) were drilled during the Phase I Field Investigation (Figure 2-1a). Boring Nos. 1888 and 1889 were drilled in 1992 (Figure 2-1a). Boring Nos. 1718 and 1808 were placed within the abandoned evaporation pond near CIS Boring No. 49-03 (Figure 2-1), where elevated concentrations of radionuclides were detected in the CIS composite sample. Samples were collected from the shallow fill, deep fill, and underlying native soils of each boring. These samples were analyzed for different combinations of radionuclides, total uranium, total thorium, dioxins/furans, herbicide organics, organophosphorus pesticides, pesticides/polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), SVOCs, metals, TCLP, and EP Toxicity.

TCLP VOC/SVOC samples were collected from the portion of the boring that displayed the highest HNu reading during screening. When there was no Hnu reading, samples were collected from the midpoint of the boring. A composite sample from each boring was analyzed for the remainder of the TCLP analytes. The purpose of TCLP analysis was to determine whether the waste met criteria for regulation under RCRA and to determine leaching and transport potentials for waste transport modeling.

Subsurface samples were taken from 26 borings (1947, 1950, 1952, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 11036, 11037, 11038, 11039, 11040, 11041, 2037, 2947, 2949, 2951, and 2953) in the Solid Waste Landfill as part of the Phase II Field Investigation (Figure 2-1a). A total of 37 samples were analyzed for full HSL and full radiological parameters. In addition, six samples were taken for TCLP analysis. Fourteen subsurface soil screening samples were collected and analyzed for total uranium at the on-site laboratory. Three subsurface soil screening samples were collected and analyzed for gross alpha and beta.

2.3.3 Surface Water and Sediment Sampling

Sediment samples were collected during the CIS (Weston 1987b) at five locations (21-007 through 21-011) in the drainageway and analyzed for cesium-137, radium-226, ruthenium-106, thorium-232, and uranium-238 at the on-site gamma spectroscopy laboratory. Sample Location 21-009 was selected for off-site analysis of 16 radionuclides because it showed the highest results from the on-site analysis. These sample locations are shown on Figure 2-1.

Storm water runoff and seepage from the landfill appears to reach the drainage ditch just north of the landfill (Figure 2-2). This drainage flows westerly toward Paddys Run. The objective of surface water and sediment sampling in the Solid Waste Landfill Study Area was to determine whether contaminants from the landfill migrated from the area via the surface water pathway.

Two surface water samples were collected during the Phase I Field Investigation from one location (ASIT-021) in the drainageway to the north of the Solid Waste Landfill. One sample was analyzed for radionuclides, total uranium, pesticides/PCBs, VOCs, SVOCs, metals, and general chemistry. The other sample was analyzed for radionuclides and total uranium only.

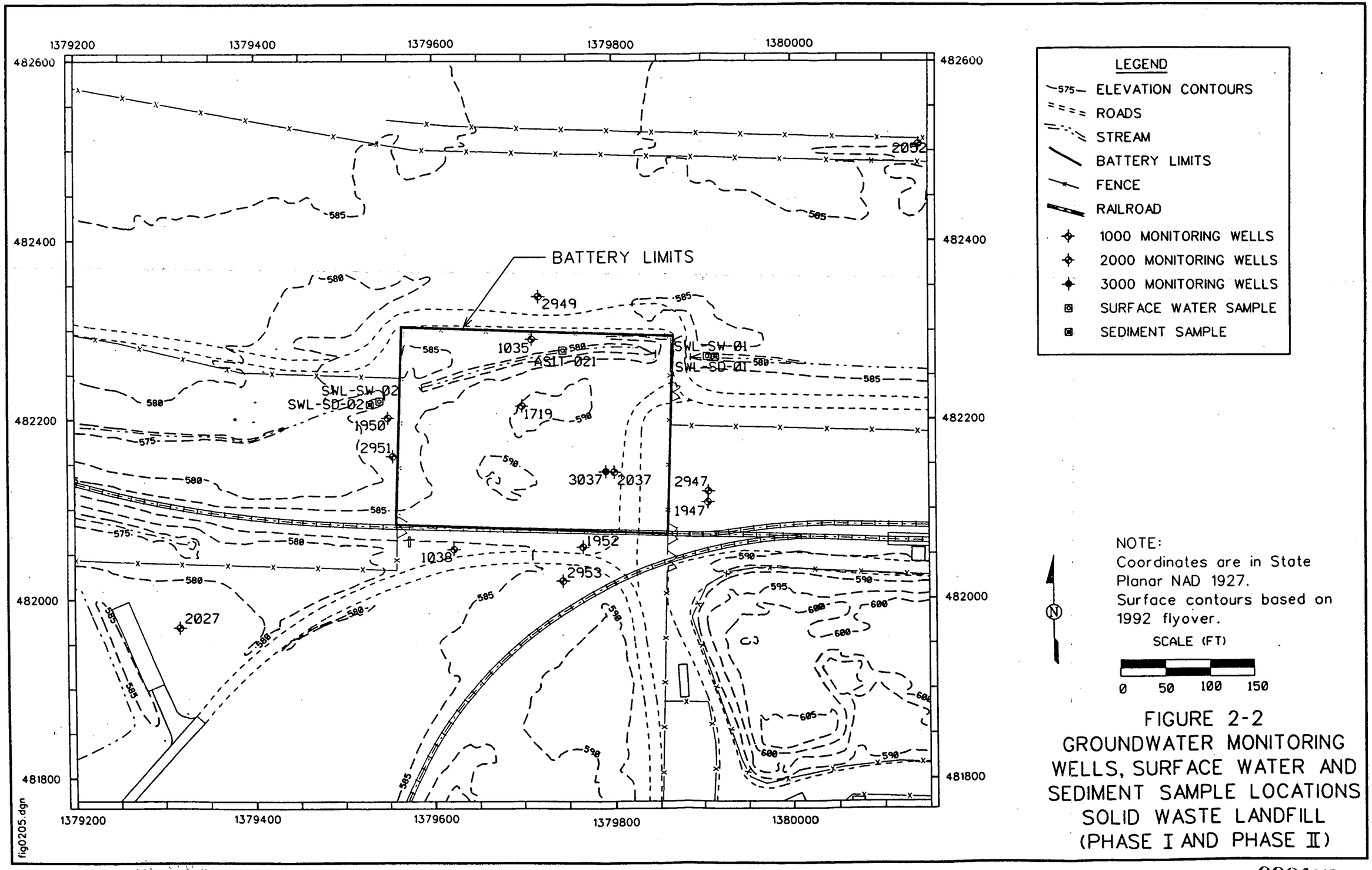

FIGURE 2-2
GROUNDWATER MONITORING WELLS, SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
SOLID WASTE LANDFILL
(PHASE I AND PHASE II)

Surface water (SWL-SW-01 and SWL-SW-02) and sediment (SWL-SD-01 and SWL-SD-02) samples were taken both upstream and downstream of the Solid Waste Landfill during the Phase II Field Investigation (Figure 2-2). One sample from each location was analyzed for full HSL and full radiological parameters. The water samples were also analyzed for general chemistry. Two surface water screening samples were collected at the same locations where full samples were collected. In addition, one surface water screening sample was collected at Boring No. 1947. Four sediment screening samples were collected at location SWL-SD-01. The screening samples were analyzed for total uranium at the on-site laboratory.

2.3.4 Groundwater Investigations

Three leachate samples were collected from Test Pit No. 8, which was excavated during the Environmental Survey (Figure 2-1). The exact sampling location within the pit is not known because the Environmental Survey locations were not surveyed. One leachate sample was analyzed for radionuclides while the other two were analyzed for total uranium and metals.

The objectives of RI/FS groundwater sampling in the Solid Waste Landfill Study Area were to:

- Determine contaminant impacts to perched groundwater in the landfill.
- Characterize the hydrology of the perched groundwater zone.
- Complete the physical characterization of, and determine contaminant impacts to, the upper regional aquifer.

Seven monitoring wells (1035, 1037, 1038, 2027, 2037, 2052, and 3037) were installed in the vicinity of the Solid Waste Landfill during the Phase I Field Investigation (Figure 2-2). Monitoring Well 1037, located in a cluster with 2037 and 3037, was plugged and abandoned because of concerns about installation practices. The monitoring wells were screened in the perched water and in the top and bottom of the Upper Great Miami Aquifer. These wells were sampled periodically during 1988 through 1990 and were analyzed for different combinations of radionuclides, total uranium, total thorium, dioxins/furans, herbicide organics, pesticides/PCBs, VOCs, SVOCs, metals, and general chemistry. Boring No. 1719, which was drilled in May 1992, was converted to a perched groundwater monitoring well. This well was sampled and analyzed for total uranium, VOCs, metals, and general chemistry. Detail on the sampling frequency and parameters for each well is included in Table C-12 of Appendix C.

During July 1992, three trenches (Trench 1, Trench 2, and Trench 3) were excavated in the Solid Waste Landfill (Figure 2-1a) to locate and visually inspect the buried materials (DOE 1992e). A total of five in situ leachate samples were collected from the three trenches and four were analyzed for radionuclides, herbicide organics, dioxins/furans, VOCs, SVOCs, pesticides/PCBs, metals, and general chemistry. The fifth sample was analyzed for SVOCs and pesticides/PCBs only.

During the Phase II Field Investigation, three 1000-series wells (1947, 1950, and 1952) and four 2000-series wells (2947, 2949, 2951, and 2953) were completed (Figure 2-2), and wells installed under the RI/FS Phase I and Phase II Field Investigations were sampled. Samples were analyzed for full HSL, full radiological, and general chemistry parameters at an off-site laboratory or for total uranium screening at the on-site laboratory. Well 1719 was planned to be sampled, but at the time of sampling, the well was found to be dry.

Water samples were also collected using a bailer from soil borings during the RI/FS Phase II Field Investigation if sufficient seepage occurred during drilling. Samples from Boring Nos. 1985, 11037, 11039, and 11040 were collected and analyzed for total uranium at the on-site laboratory.

2.3.5 Geotechnical Investigations

During the Weston CIS Boring Program (Weston 1988), a composite sample was collected from Boring No. 49-03 from a depth of 0 to 18 feet. This sample was analyzed for specific gravity, liquid limit, plasticity index, natural moisture content, particle size and distribution, maximum dry density, optimum moisture content and color, and physical state. An additional CIS composite sample was collected from a depth of 0 to 12 feet, but the CIS report did not specify the exact location. Due to being composited, these samples and other composited samples had limited use in guiding the RI Field Investigation.

In 1991, the Phase I RI/FS sampling team measured in-place density at three locations (GEO-9, GEO-10 and GEO-11) in the Solid Waste Landfill by ASTM Method D-2922 for nuclear density measurements (Figure 2-1a). Wet density, dry density, and moisture content were measured at each sampling location.

During the Phase II Field Investigation, geotechnical samples were collected from SWL-SD-02, SWL-SS-02, and 12 of the subsurface borings (1947, 1950, 1952, 1982, 1983, 1984, 1986, 1988,

1989, 1990, 1992, and 2949). The samples from these locations were analyzed for different combinations of specific gravity, water content, liquid limit, plastic limit, sieve analysis, hydrometer analysis, consolidated isotropic undrained triaxial, direct shear, and dry unit weight. Sample intervals and exact analytical parameters are presented in Table C-20 of Appendix C.

2.3.6 Soil Gas Survey

A soil gas survey was performed in the Solid Waste Landfill to locate sources of organic contamination in the shallow disturbed surface that were detected during trenching activities. Forty-seven soil gas samples were collected from fifty proposed locations in a grid pattern across the surface of the Solid Waste Landfill.

Figure 2-3 shows the grid and sample locations. Forty-seven of the fifty proposed locations were measured in the field using an OVM and OVA. Samples were then collected in Tedlar bags and screened at the on-site laboratory using an OVM and OVA to measure total VOCs and methane, respectively. The five locations with the highest detections of total VOCs and one new location (CD-1) were sampled and sent to an off-site laboratory for a gas chromatography/mass spectrometry (GC/MS) scan (EPA Method TO-14). The results of the soil gas survey were used to select locations for borings intended to collect subsurface samples of waste material.

2.3.7 Geophysical Survey

The CIS performed geophysical surveys of the Solid Waste Landfill. Three types of geophysical methods were used to survey the Solid Waste Landfill: magnetic, EM, and GPR. Magnetic data measurements were conducted on a 25 by 25 foot grid with the sensor oriented in a northerly direction. Figure 2-4 represents the magnetic grid locations for the Solid Waste Landfill. The EM survey was conducted on a 50 by 25 foot grid, with 50 feet separating the north-to-south trending profiles. The EM survey was performed in both the vertical and horizontal dipole to further evaluate rear surface disturbances. Additional data points were surveyed on a 25 foot grid between the 50 foot grid lines when anomalies were detected. The grid locations for the EM survey are identified in Figure 2-5. The GPR survey was performed on a 25 by 25 foot grid and is identified in Figure 2-6.

2.4 ENVIRONMENTAL CHARACTERIZATION INFORMATION FOR THE LIME SLUDGE PONDS

The Lime Sludge Ponds have been preliminarily characterized by the Environmental Survey and CIS Sampling Program, followed by characterization by the RI/FS Sampling Program. The following sections discuss the sample locations and analytical parameters for each of these sampling programs. Results of these sampling programs are presented in Appendix D.

2.4.1 Surface Sampling

During the Environmental Survey, 12 surface media samples were collected from four locations (0616, 0617, 0618, and 0619) in the South Lime Sludge Pond (Figure 2-7). Each location had samples analyzed for radionuclides, total uranium, VOCs, and TCLP metals.

As part of the CIS radiological survey of surface soils, ten samples were collected and analyzed for 16 radionuclides. Seven of these samples (46-534, 46-542, 46-543, 46-544, 23-005, 46-526, and 46-527) were collected at four locations along the K-65 Slurry Line (Weston 1987c). This slurry line, which lies in a 3.5-foot-deep concrete trench, was used to pump waste from the former Production Area to the K-65 silos. Two surface samples (23-012 and 23-013) were taken in the western portion of the South Lime Sludge Pond and one sample (46-187) was collected about 40 feet north of the North Lime Sludge Pond. Locations of the samples that were analyzed off site are shown on Figure 2-7.

The objectives of RI/FS surface media (including soil and lime sludge residue) sampling at the Lime Sludge Ponds were to:

- Determine surface contamination of the roadways at the north edge of subunit.
- Provide data to evaluate the potential for exposure via the direct contact pathway.
- Provide data to evaluate the potential for exposure via the air migration pathway.

Surface media samples were collected from 14 locations (LSP-TR-01, LSP-TR-02, and LSP-SS-03 through LSP-SS-14) in the North and South Lime Sludge Ponds under the Phase II Field Investigation (Figure 2-7a). Fourteen samples from these locations were analyzed for full HSL and full radiological analysis. One sample was analyzed for pesticides/PCBs only, making a total of 15 samples for off-site analysis. Screening samples were collected from four locations (LSP-TR-01,

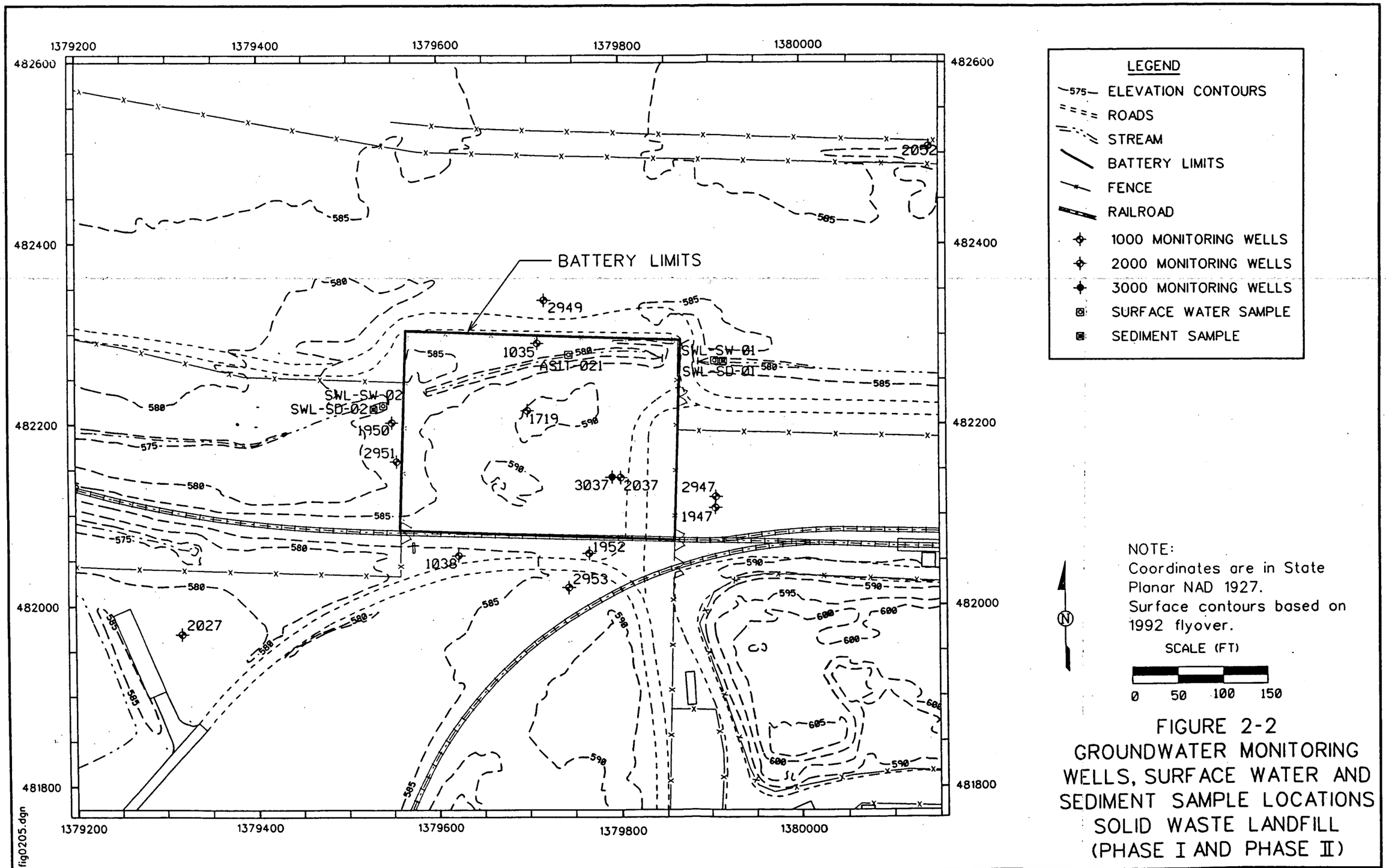

FIGURE 2-2
GROUNDWATER MONITORING WELLS, SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
SOLID WASTE LANDFILL
(PHASE I AND PHASE II)

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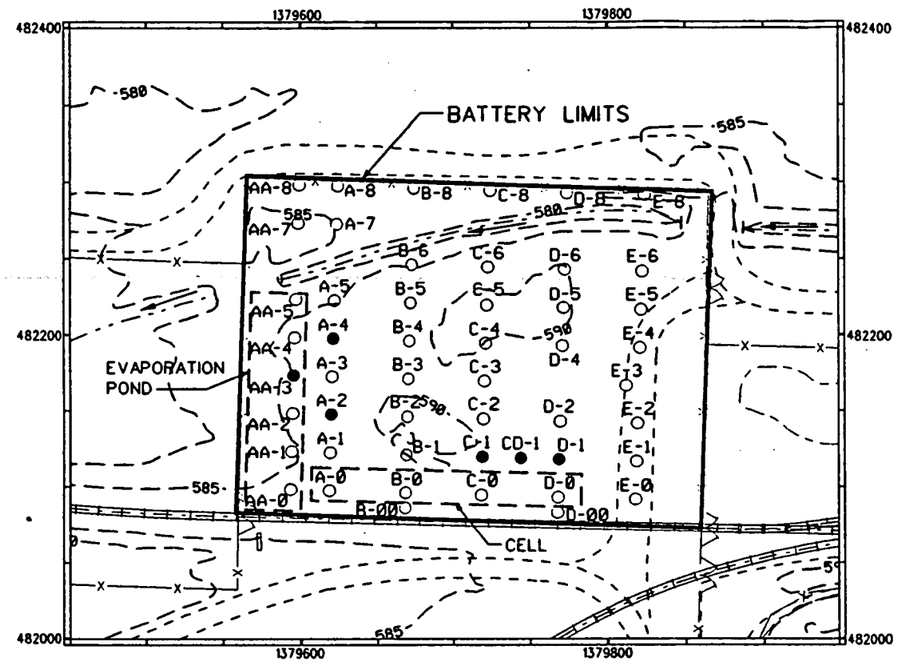


LOCATION	TOTAL VOC (ppm)	TOTAL METHANE (ppm)
A-0	22.0	44.0*
A-1	37.0	8.2*
A-2	21.0	100.0*
A-3	40.6	1000.0*
A-4	38.2	1320.0*
A-5	0.0	4.0*
A-7	0.0*	0.0*
A-8	10.0*	12.0*

LOCATION	TOTAL VOC (ppm)	TOTAL METHANE (ppm)
C-0	80.0*	89.0*
C-1	60.0	1000.0*
C-2	0.0	126.0*
C-3	0.0	136.0*
C-4	0.0	0.0*
C-5	0.0	0.0*
C-6	0.2	0.0*
C-8	0.0*	0.0*

LOCATION	TOTAL VOC (ppm)	TOTAL METHANE (ppm)
E-0	0.0*	24.0*
E-1	0.0	2.0, 0.0*
E-2	0.0	71.0, 36.0*
E-3	0.0	6.0, 0.6*
E-4	0.0	6.0, 0.0*
E-5	0.0	5.0, 2.0*
E-6	0.0	6.0, 0.0*
E-8	0.0*	0.0*

LOCATION	TOTAL VOC (ppm)	TOTAL METHANE (ppm)
B-00	6.8	26.0*
B-0	4.8	48.0*
B-1	4.6	8.9*
B-2	7.0	8.8*
B-3	7.0	420.0*
B-4	0.7	92.0*
B-5	0.3	0.0*
B-6	0.0*	0.0*
B-8	NA	NA

LOCATION	TOTAL VOC (ppm)	TOTAL METHANE (ppm)
D-00	NA	NA
D-0	1.3	2.0, 1000.0*
D-1	767.0	110.0, 100.0*
D-2	0.7	27.0, 27.0*
D-4	0.0	160.0, 100.0*
D-5	0.4	0.0, 0.0*
D-6	2.0	2.0, 0.0*
D-8	NA	NA

LOCATION	TOTAL VOC (ppm)	TOTAL METHANE (ppm)
AA-0	12.0*	14.0*
AA-1	38.0*	42.0*
AA-2	68.0*	74.0*
AA-3	82.0*	98.0*
AA-4	7.8*	7.2*
AA-5	12.0*	12.0*
AA-7	0.0*	0.0*
AA-8	0.0*	0.0*

LEGEND

- 575 — ELEVATION CONTOURS
- ROADS
- STREAM
- DRAINAGE
- FENCE
- RAILROAD
- o SOIL GAS SURVEY SAMPLE LOCATIONS ANALYZED
- ● SOIL GAS SURVEY SAMPLE LOCATION SENT FOR LABORATORY ANALYSIS

* INDICATES TEDLAR BAG READINGS

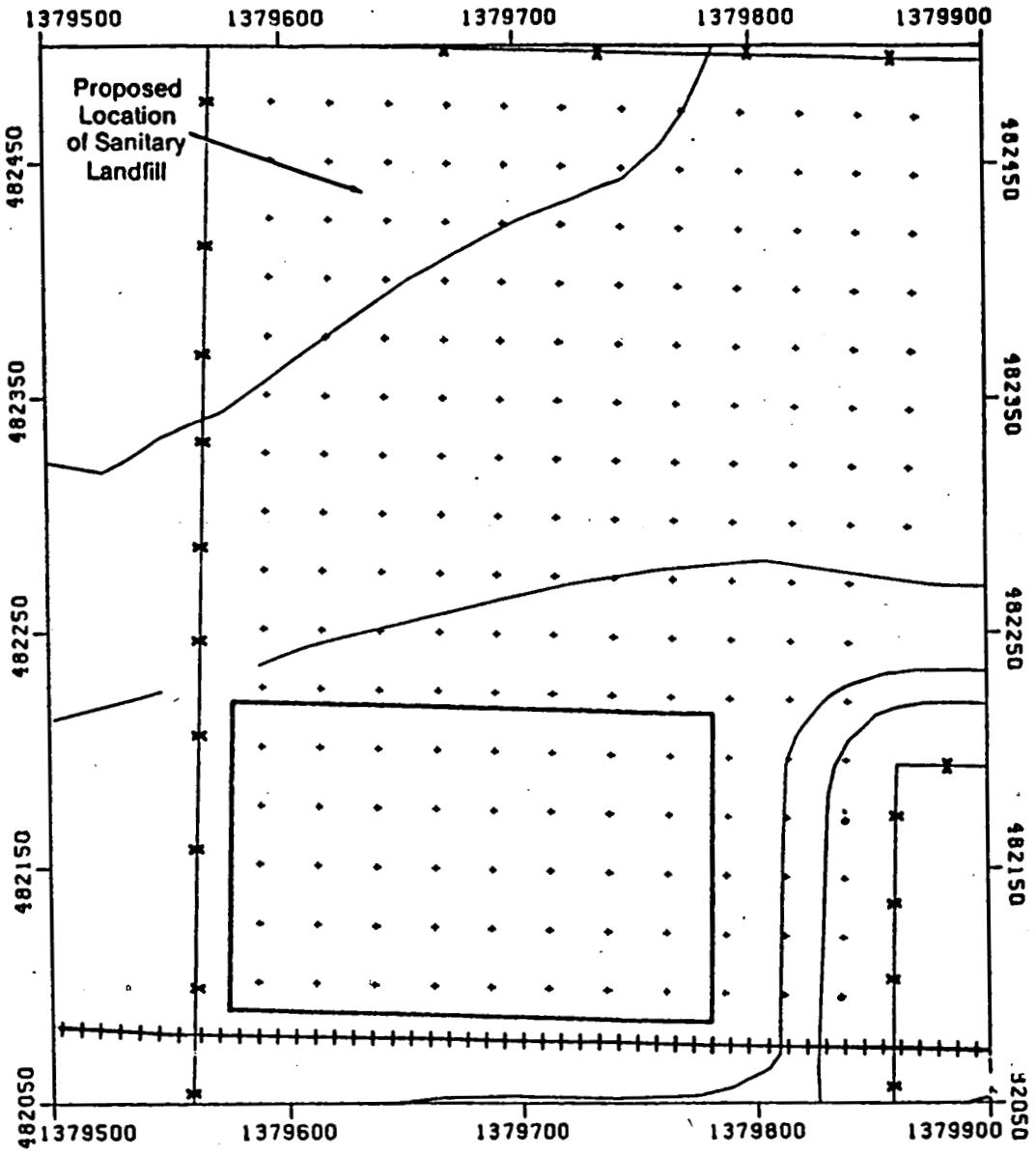
NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

N

SCALE (FT)
0 25 50 100 150 200

FIGURE 2-3
SOIL GAS SURVEY
SCREENING RESULTS
SOLID WASTE LANDFILL

fig0203.dgn



Legend

- + Data Point Location
- Approximate Sanitary Landfill Boundary
- Fence
- Railroad Tracks
- Hydrology

STATE PLANE COORDINATE SYSTEM

OHIO SOUTH ZONE

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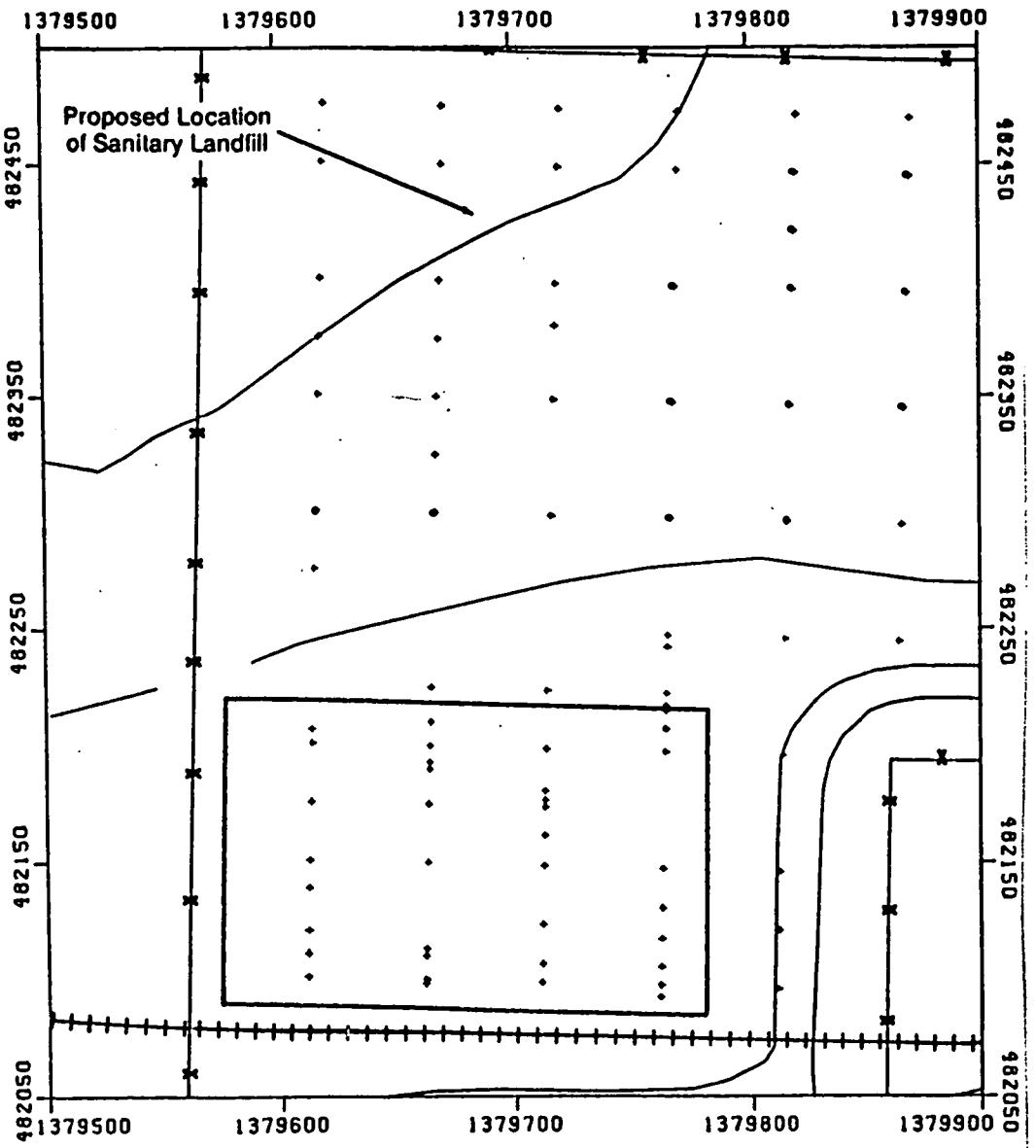
FIGURE 2-4
CIS MAGNETIC SURVEY
DATA POINTS
SOLID WASTE LANDFILL

fig0299.dgn

21

000159



Legend
+ Data Point Location
Approximate Sanitary Landfill Boundary
Fence
Railroad Tracks
Hydrology

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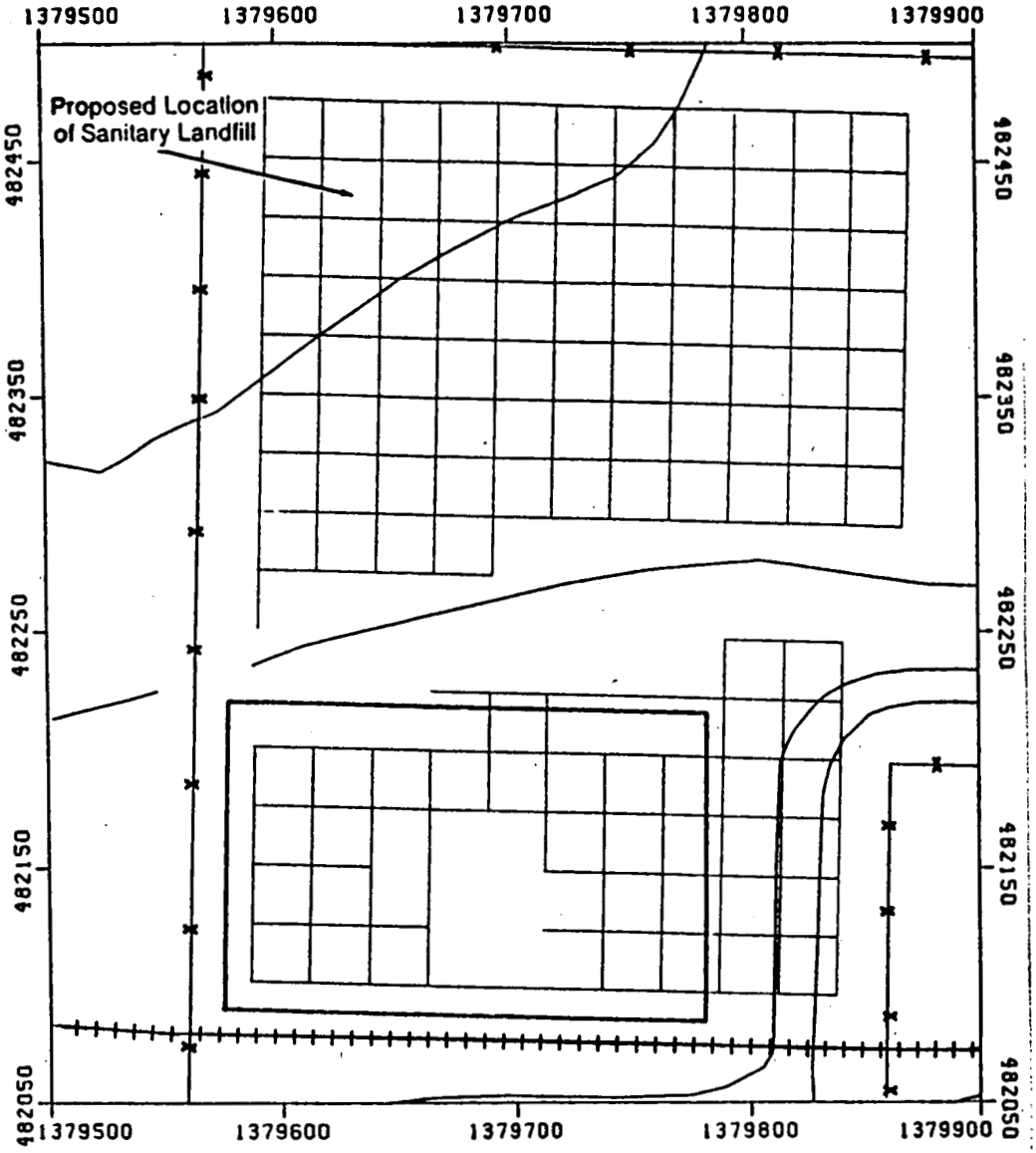
FIGURE 2-5
CIS ELECTROMAGNETIC SURVEY DATA POINTS
SOLID WASTE LANDFILL

fig0208.dgn

21

21



Legend

- GPR Profile Location
- Approximate Sanitary Landfill Boundary
- Fence
- Railroad Tracks
- Hydrology

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FIGURE 2-6
CIS GROUND PENETRATING RADAR SURVEY PROFILE LOCATIONS SOLID WASTE LANDFILL

fig0209.dgn

21

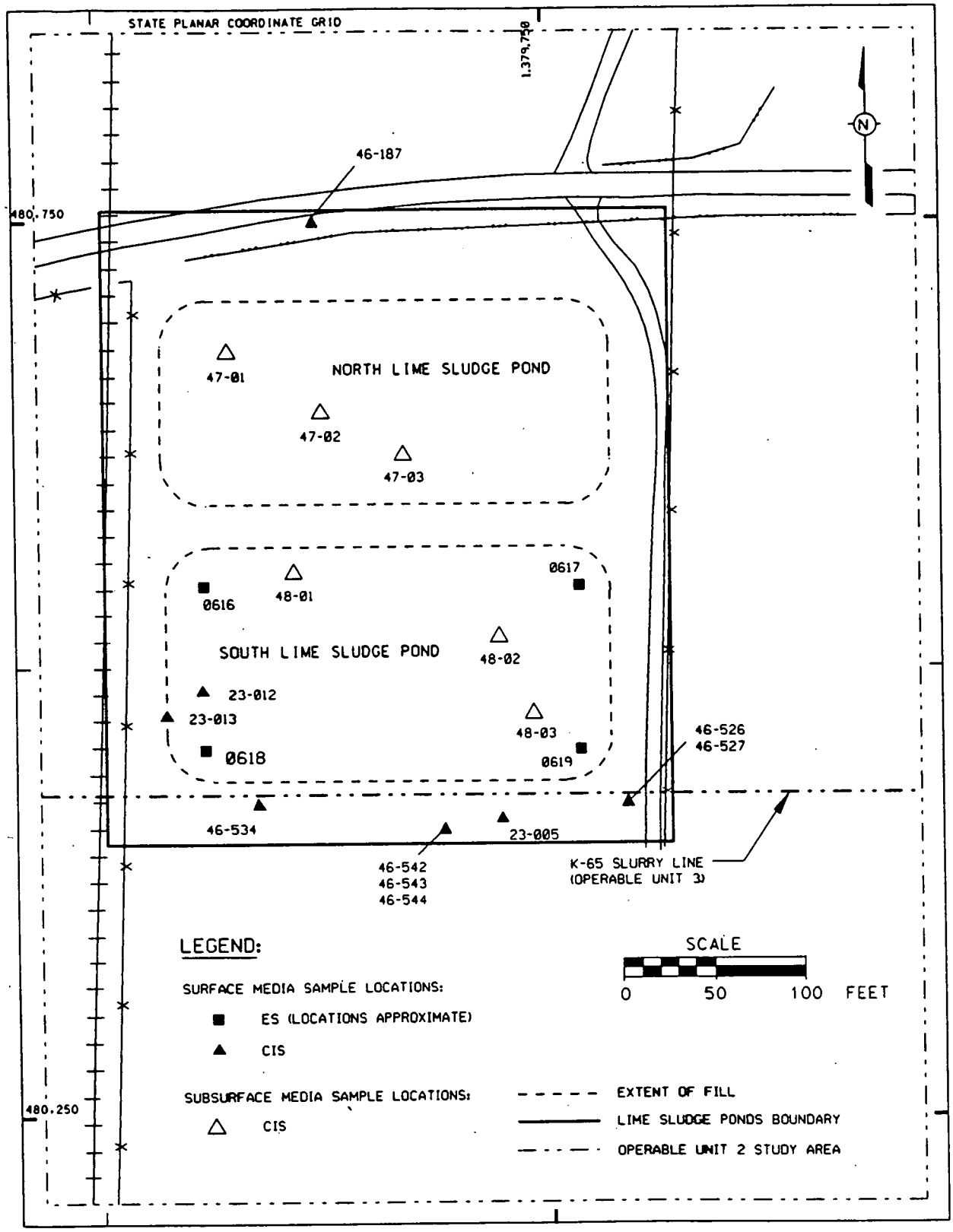


fig0294.dgn

FIGURE 2-7
CIS AND ES SAMPLE LOCATIONS
IN LIME SLUDGE PONDS AREA

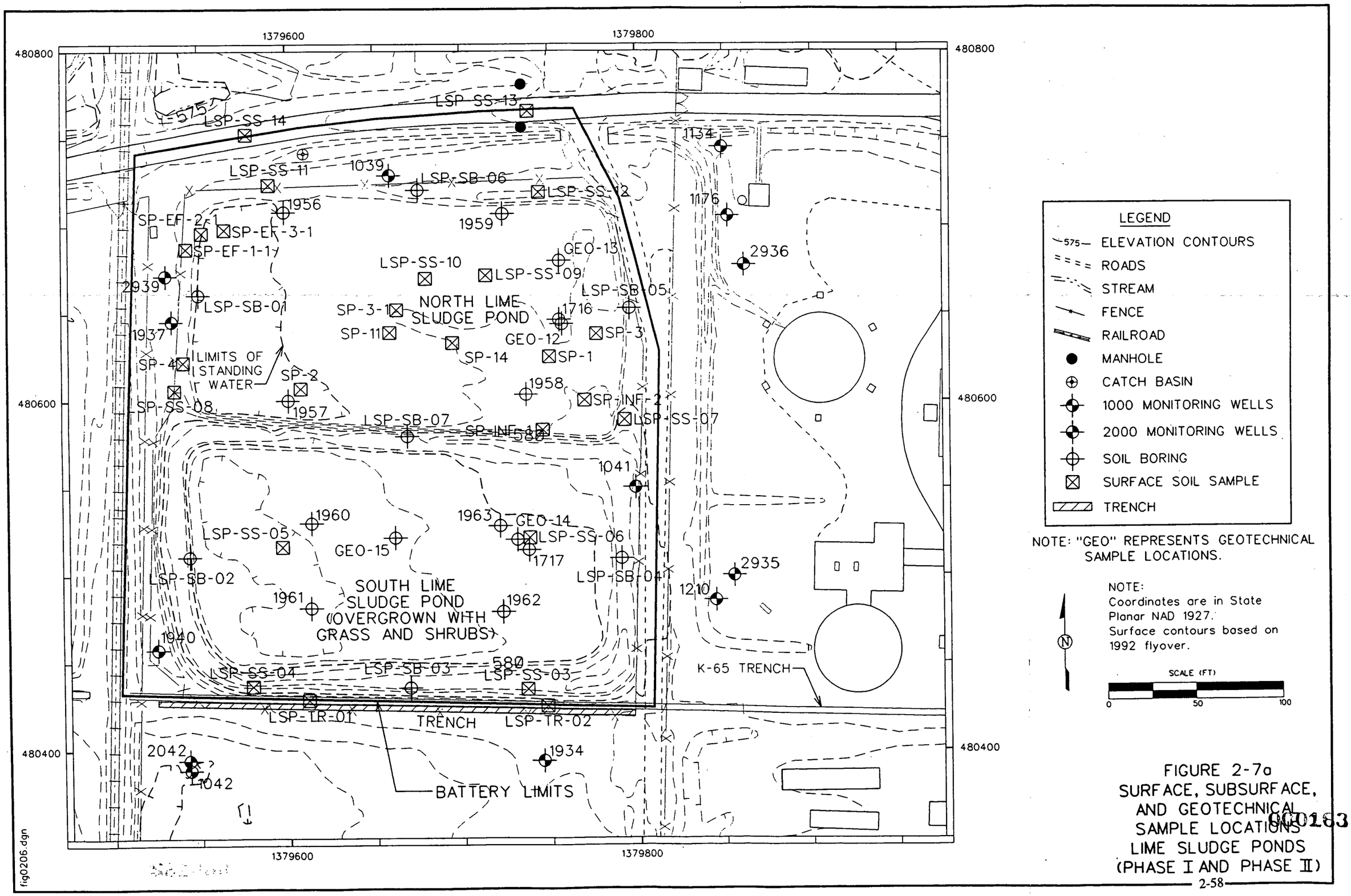


FIGURE 2-7a
SURFACE, SUBSURFACE, AND GEOTECHNICAL SAMPLE LOCATIONS
LIME SLUDGE PONDS
(PHASE I AND PHASE II)

000183

LSP-TR-02, LSP-SS-03, and LSP-SS-04) and sent to the on-site laboratory for total uranium analysis. A screening sample from LSP-TR-02 was analyzed for gamma activity by gamma spectroscopy.

2.4.2 Subsurface Sampling

During the CIS boring program (Weston 1987b), three borings (47-01, 47-02, and 47-03) were drilled in the North Lime Sludge Pond and three in the South Lime Sludge Pond (48-01, 48-02, and 48-03) (Figure 2-7). Profile samples were collected from the North Pond at 6- to 20-inch depth increments and from the South Pond at 1-foot depth increments. These were analyzed for radium-226, thorium-232, and uranium-238 at the on-site laboratory to evaluate the vertical distribution of radionuclides. One composite sample from each of the six borings was also collected and shipped to an off-site laboratory for analyses of radionuclides, VOCs, SVOCs, pesticides/PCBs, metals, EP toxicity metals, and the RCRA characteristics of ignitability, reactivity, and corrosivity.

In 1990, three borings (1039, 1041, and 2042) were drilled adjacent to the Lime Sludge Ponds as part of the site-wide monitoring well installation program (Figure 2-7a). One sample was collected from the glacial overburden sequence in each of these borings for radiological analysis. In addition, a soil sample was collected from the underlying sand and gravel in Boring No. 2042 for radiological analysis.

Objectives of RI/FS subsurface media (including soil and lime sludge residue) sampling at the Lime Sludge Ponds were to:

- Characterize the nature and extent of contamination within the ponds, berms, and underlying soil.
- Determine fill depths and volumes.
- Provide data to support the modeling of contaminant migration from the Lime Sludge Ponds, particularly vertical contaminant migration from the K-65 trench.

In 1991, as part of the Phase I Field Investigation, samples were collected from one hand-augured boring in each pond. The locations for Boring No. 1716 in the North Pond and Boring No. 1717 in the South Pond (Figure 2-7a) were selected at random, since the waste deposited in each pond was assumed to be evenly mixed within horizontal layers. In each boring, a grab sample was taken at approximately two feet below the surface and analyzed for radionuclides, total uranium, total thorium,

dioxins/furans, herbicide organics, VOCs, SVOCs, pesticides/PCBs, and metals. A second sample from each boring was analyzed for TCLP.

In March 1992, WEMCO conducted a RCRA facility assessment of the North Lime Sludge Pond. As part of this assessment, lime sludge residue samples were collected from 13 locations (SP-EF-1-1, SP-EF-2-1, SP-EF-3-1, SP-INF-1, SP-INF-2, SP-1, SP-2, SP-3, SP-3-1, SP-4, SP-10, SP-11, and SP-14) (Figure 2-7a). At seven of these locations, a single sample was collected, typically from the top one to three feet of residue. At six locations, samples were collected at multiple depths (depth is measured from the pond water/residue interface). Samples were analyzed for VOCs and TCLP.

During the Phase II Field Investigation, 14 borings (1934, 1937, 1940, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1963, 2935, 2936, and 2939) were drilled in the Lime Sludge Pond area (Figure 2-7a). Eight borings were located in the ponds and seven were advanced into the berms surrounding the ponds. Twenty samples from these borings were analyzed for full HSL and full radiological parameters. In addition, one sample from each boring in the ponds was taken for TCLP analysis and six samples were collected for on-site total uranium screening. Fourteen near-surface soil samples (6 to 12 inches) were also collected from LSP-SS-03, -04, -07, -08, -11, -12, and LSP-SB-01 through LSP-SB-07) and analyzed for full HSL and full radiological parameters (Figure 2-7a). Six near-surface samples were collected for on-site total uranium screening.

A trench was excavated parallel to the K-65 Slurry Line that traverses east to west along the southern battery limits of the Lime Sludge Ponds. The trench was excavated to evaluate the impact of the K-65 Slurry Line on the surrounding soil and groundwater. Two soil samples were collected from the trench and analyzed for full HSL and full radiological parameters. Two soil samples were collected and sent to the on-site laboratory for total uranium, thorium, and radium screening.

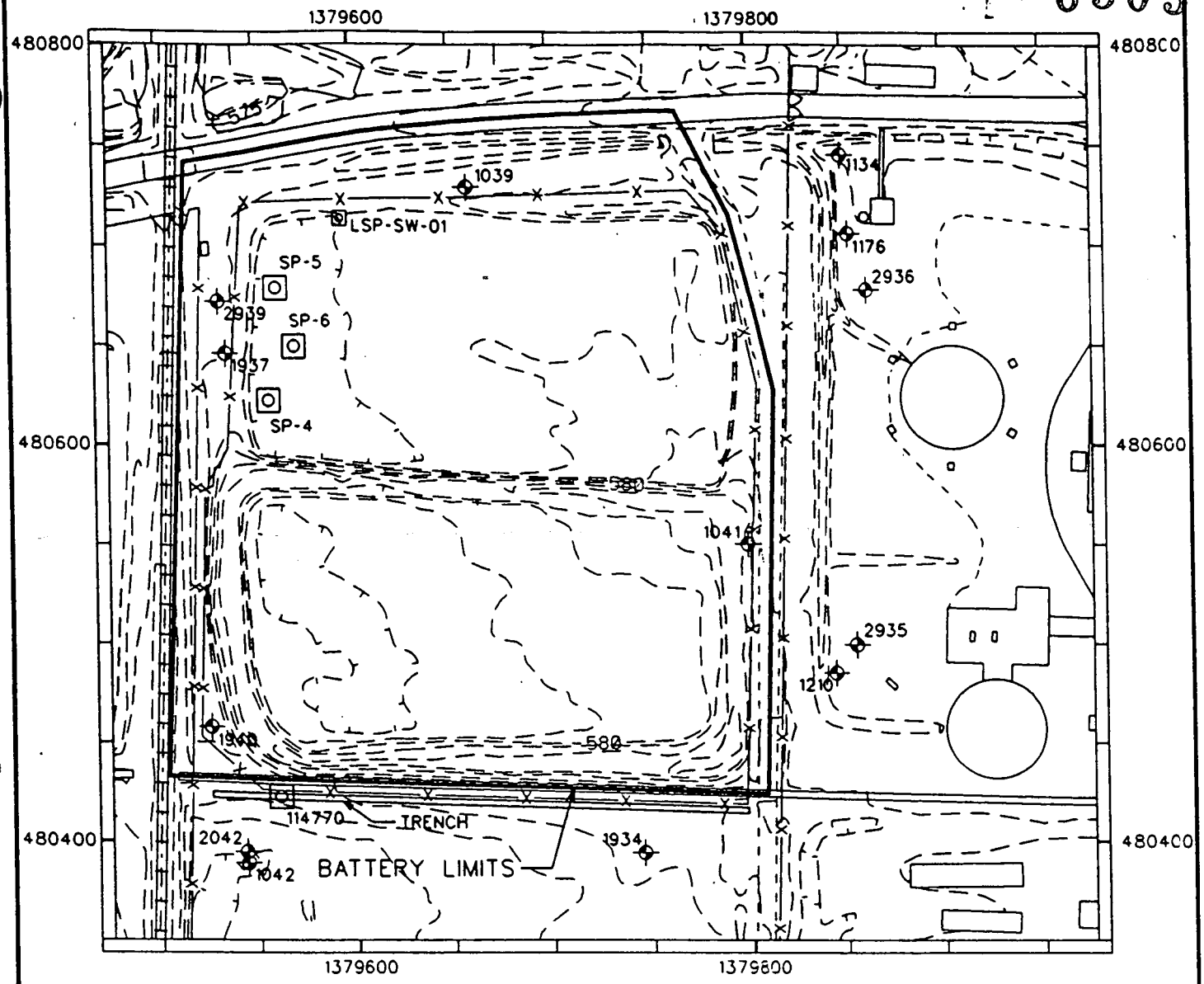
2.4.3 Surface Water Sampling

During the March 1992 RCRA Facility Assessment, three surface water samples were collected at SP-4, SP-5, and SP-6 (Figure 2-8). These samples were analyzed for VOCs and TCLP.

The objectives of RI/FS surface water sampling in the North Lime Sludge Pond were to:

- Characterize the nature of the contamination of surface water in the ponds to complete the risk assessment.

6505



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- 1000 MONITORING WELLS
- 2000 MONITORING WELLS
- 3000 MONITORING WELLS
- 4000 MONITORING WELLS
- SURFACE WATER SAMPLE
- SEDIMENT SAMPLE

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100

FIGURE 2-8
MONITORING WELLS, SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
LIME SLUDGE PONDS
(PHASE I AND PHASE II)

fig0207.dgn

- Provide data to evaluate the potential for contaminants to leach into underlying soils and groundwater from the ponds.

During the Phase I Field Investigation, four surface water samples were collected from the standing water in the North Lime Sludge Pond and analyzed for different combinations of radionuclides, total uranium, total thorium, VOCs, SVOCs, pesticides/PCBs, herbicide organics, metals, and general chemistry. No water samples were taken from the South Pond because it does not contain standing water.

Four additional surface water samples were taken from location LSP-SW-01 during the Phase II Field Investigation (Figure 2-8). Two of these samples were analyzed off site for full HSL, full radiological, and general chemistry parameters, and the other two were screened for total uranium and the on-site laboratory. An additional surface water sample (114770) was collected during the excavation of the trench parallel to the K-65 Slurry Line (Figure 2-8). It was sent to the on-site laboratory for total uranium screening.

Because the ponds are bermed on all sides, no sediment could be carried away from the subunit. Therefore, no sediment samples were collected.

2.4.4 Groundwater Investigations

The objectives of groundwater sampling in the Lime Sludge Pond Study Area were to:

- Determine if contaminants from the ponds have migrated to shallow or deep groundwater.
- Characterize perched groundwater that could be encountered during remediation of the ponds.
- Determine the impact of the K-65 Slurry Line on shallow groundwater.

Seven monitoring wells (1039, 1041, 1042, 1134, 1176, 1210, and 2042) were completed during Phase I in the general vicinity of the Lime Sludge Ponds (Figure 2-8). Well No. 1176 was a dry well and therefore, was never sampled. These wells were screened in the perched water, and the Upper Great Miami Aquifer. Samples were collected periodically from 1988 to 1990 and analyzed for different combinations of radionuclides, total uranium, total thorium, VOCs, SVOCs, pesticides/PCBs, metals, and general chemistry parameters. Detail on the sampling frequency and parameters for each well is included in Table D-11 of Appendix D.

As part of the Phase II Field Investigation, three 1000-series wells (1934, 1937, and 1940) and three 2000-series wells (2935, 2936, and 2939) were installed around the Lime Sludge Ponds area (Figure 2-8). Samples were collected from these new wells and from the wells installed under the RI/FS Phase I Field Investigation. Samples from each well were analyzed for full HSL, full radiological, and general chemistry parameters. Additional samples were collected from each well for on-site total uranium screening. It was planned to take samples from Well Nos. 1134, 1176, 1210, and 1229, but 1176 and 1210 were completely dry, 1134 was purged dry and did not recover, and 1229 was found to have a bent casing due to a surface vehicle collision.

RCRA quarterly groundwater monitoring was performed on the Lime Sludge Ponds wells during 1991 and 1992. Because the results cannot be validated to the same level as the RI/FS data, it is considered a secondary source of information and was not used in the preparation of this report.

2.4.5 Geotechnical Investigations

During the CIS boring program (Weston 1988), one sample from the North Lime Sludge Pond and two samples from the South Lime Sludge Pond were collected for geotechnical evaluation. Samples from the North Lime Sludge Pond were collected from the 0- to 5.5-foot depth interval and those from the South Pond were collected from the 0- to 12-foot and the 2- to 11.2-foot depth intervals. The exact location of these samples was not specified in the CIS report so they are not illustrated on Figure 2-7. The testing parameters included specific gravity, liquid limit, plasticity index, natural moisture content, particle size distribution, maximum dry density, optimum moisture content, color, and physical state.

In October 1991, in-place density was measured at two locations in each pond (GEO 12, GEO 13, GEO 14, and GEO 15) by the nuclear density measurement methods (ASTM Method D-2922) as part of RI/FS Phase I sampling (Figure 2-7a). Wet density, dry density, and moisture content were measured at each sampling location.

Twenty-seven geotechnical samples were taken from LSP-SS-06, LSP-SB-01, LSP-SB-04, LSP-SB-07, and all monitoring well and soil borings completed as part of the RI/FS Phase II Field Investigation (Figure 2-7a). The samples from these locations were taken from varying depths and were analyzed for different combinations of specific gravity, water content, liquid limit, plastic limit,

sieve analysis, hydrometer analysis, consolidated isotropic undrained triaxial, direct shear, and dry unit weight.

2.4.6 Geophysical Survey

The CIS performed geophysical surveys of the South Lime Sludge Pond. No geophysical surveys were performed in the North Lime Sludge Pond since it was a completely saturated media and would not support any weight. Three types of geophysical methods were used to survey the South Lime Sludge Pond: magnetic, EM, and GPR. Magnetic data measurements were conducted on a 25 by 25 foot grid with the sensor oriented in a northerly direction. Figure 2-9 represents the grid locations for the South Lime Sludge Pond. The EM survey was conducted on a 50 by 25 foot grid, with 50 feet separating the north-to-south trending profiles. The EM survey was performed in both vertical and horizontal dipole to further evaluate near surface disturbances. Additional data points were surveyed on a 25 foot grid between the 50 foot grid lines when anomalies were detected. The grid locations for the EM survey are identified in Figure 2-10. The GPR survey was performed on a 25 by 25 foot grid. The GPR survey grid is identified in Figure 2-11.

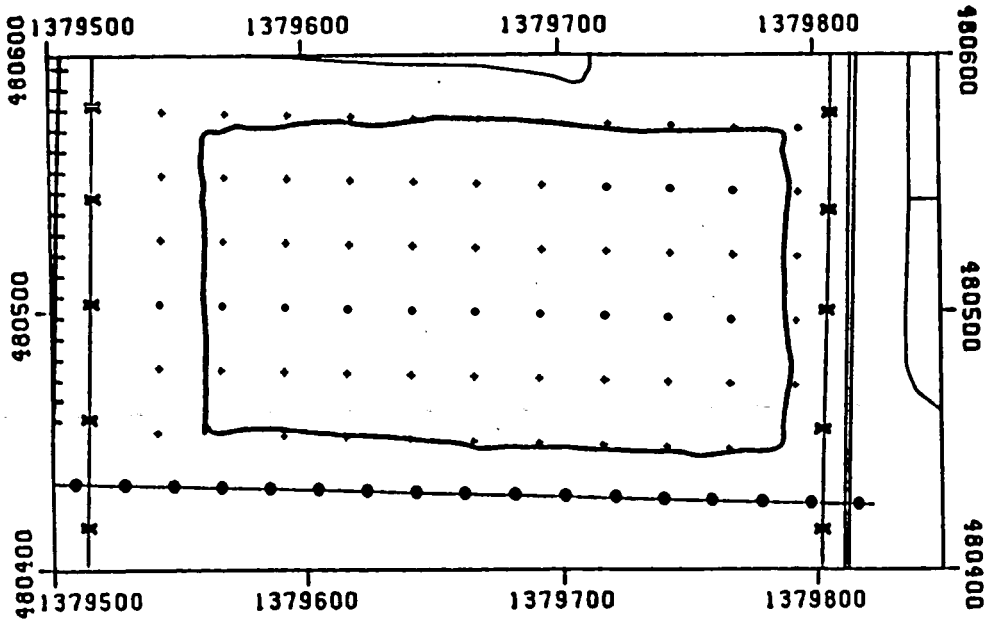
2.5 ENVIRONMENTAL CHARACTERIZATION INFORMATION FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD

The Inactive Flyash Pile and South Field has been preliminarily characterized by the Environmental Survey and CIS Sampling Program followed by characterization by the RI/FS Sampling Program. The following sections discuss the sample locations and analytical parameters from each of these sampling programs. Results of these sampling programs are presented in Appendices E and F.

2.5.1 Surface Sampling

During the Environmental Survey (DOE 1988a), a radiological survey in the Inactive Flyash Pile and the South Field was conducted using an Eberline PG-2 and PRM-5-3. Based on elevated radiation levels measured at ground surface, three surface media samples (0111, 0113, and 0114) were collected from the Inactive Flyash Pile and five (0108, 0109, 0110, 0112, and 0115) from the South Field (Figure 2-12a). These samples were analyzed for radionuclides, total uranium, asbestos, VOCs, and TCLP metals.

During the CIS, a FIDLER was used to conduct a radiological survey to estimate uranium-238 activities in surface media. Based on these estimates, surface media samples were collected from the



Legend

- + Data Point Location
- Approximate Boundary of South Lime Sludge Pond
- Fence
- Railroad Tracks
- Pipeline
- Hydrology

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FIGURE 2-9
TOTAL MAGNETIC INTENSITY
DATA CONTROL POINT
POSTINGS MAP OF THE
SOUTH LIME SLUDGE POND

fig0212.dg

(31) 000170 (31)

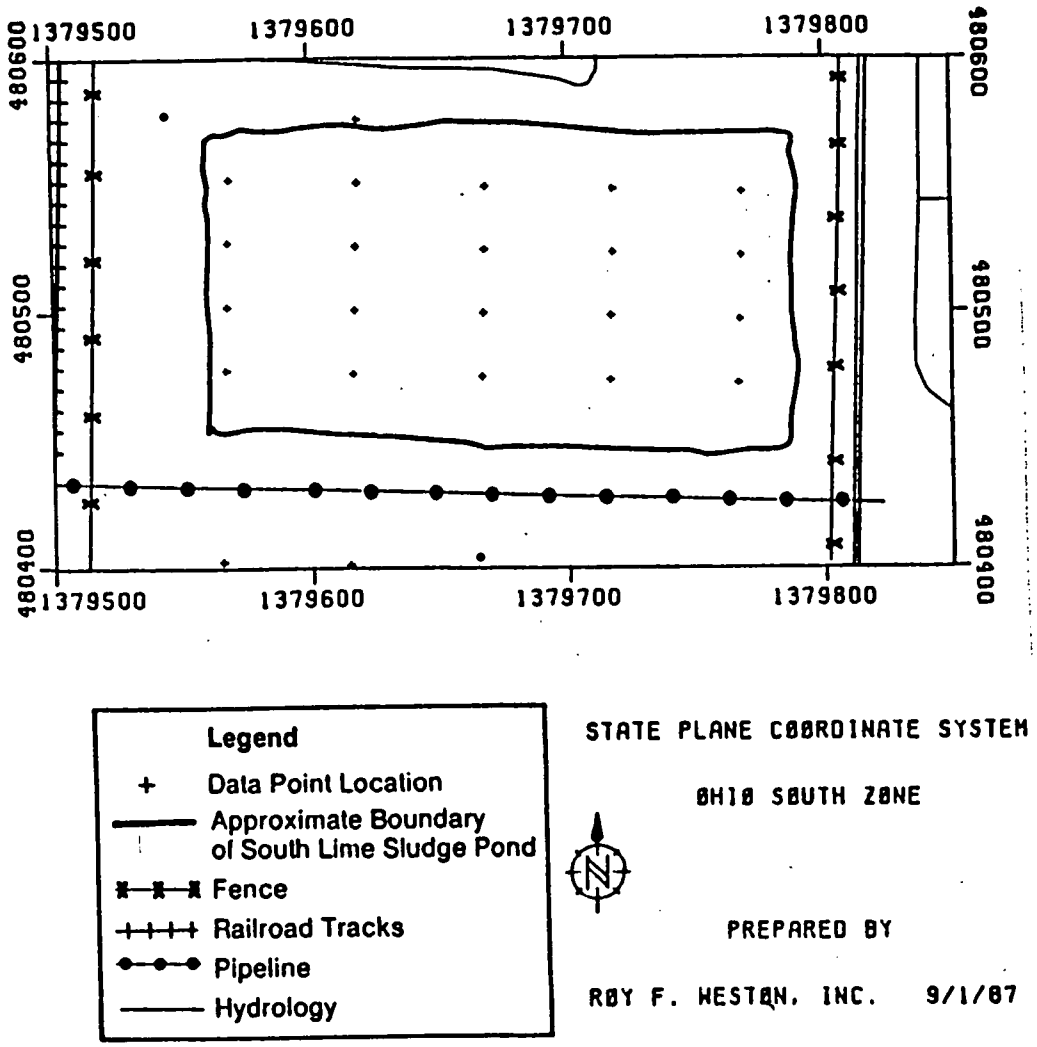


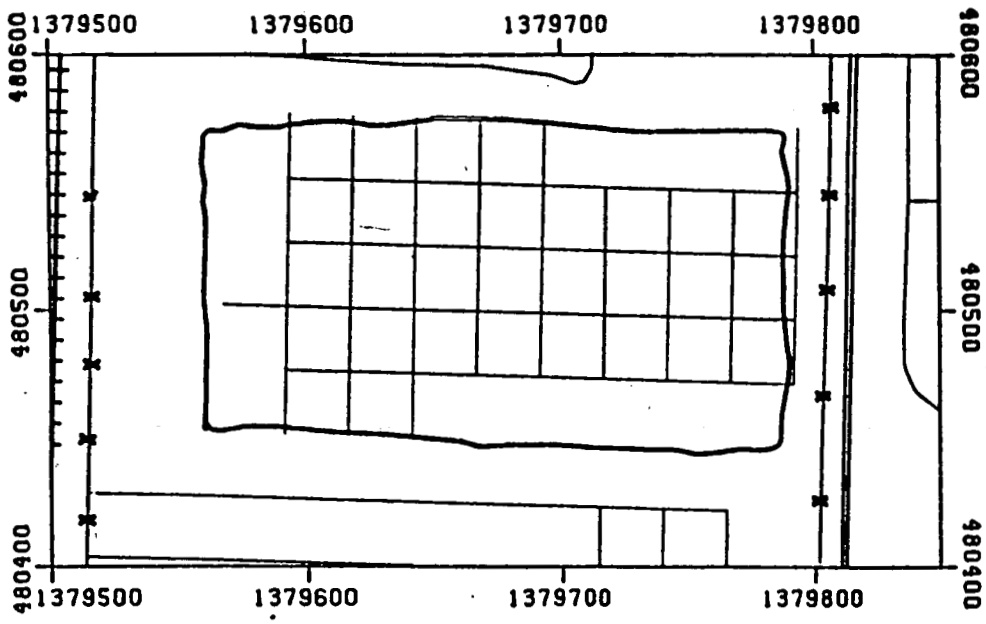
FIGURE 2-10
EM 31 DATA CONTROL POINT POSTINGS MAP OF THE SOUTH LIME SLUDGE POND

fig0298.dgn

31

000171

31



Legend

- GPR Profile Location
- Approximate Sanitary Landfill Boundary
- Fence
- Railroad Tracks

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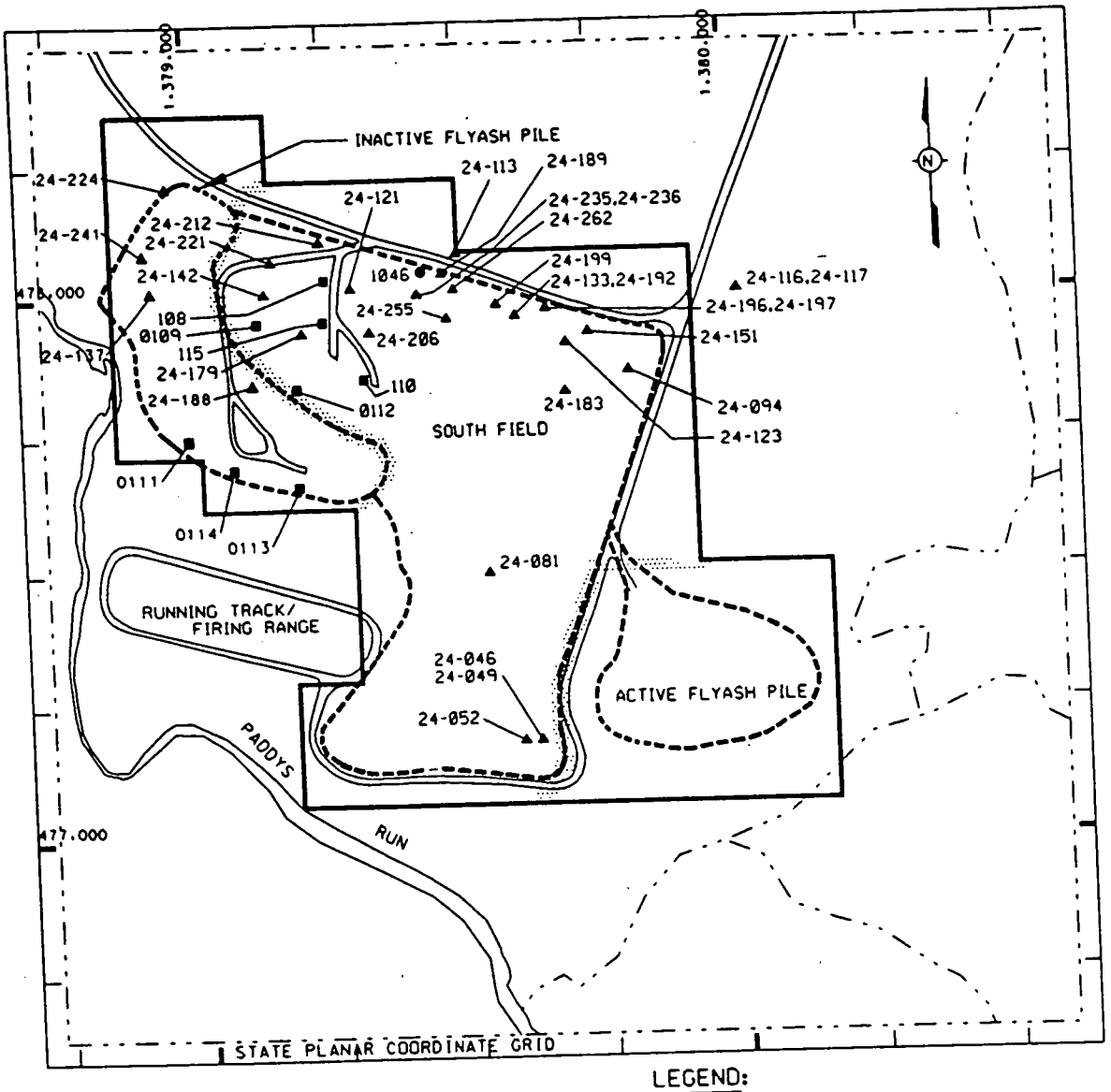
FIGURE 2-11
GROUND PENETRATING
RADAR BASE MAP OF THE
SOUTH LIME SLUDGE POND

fig0297.dgn

(31) 000172 (31)



LEGEND:

SURFACE MEDIA SAMPLING LOCATIONS:

- ■ ES (LOCATION APPROXIMATE)
- ▲ CIS
- EXTENT OF FILL
- FLYASH/SOUTH FIELD BOUNDARY
- BOUNDARY BETWEEN FLYASH PILES AND SOUTH FIELD
- OPERABLE UNIT 2 STUDY AREA

SCALE
0 125 250 FEET

fig0295.dgn

FIGURE 2-12a
CIS AND ES SURFACE SOIL SAMPLE LOCATIONS
IN SOUTH FIELD/INACTIVE FLYASH PILE AREA

000173

Inactive Flyash Pile and South Field at depth intervals from 0- to 0.16 feet, 0.16- to 0.5-feet, 0.5- to 1- feet, and 1- to 1.5-feet (Weston 1987c). Additionally, samples were taken along the steep berm on the northwestern perimeter of the South Field adjacent to the Inactive Flyash Pile where gamma-ray measurements, taken with a scintillometer (SPA-3), were statistically greater than background (i.e., greater than three standard deviations above background). The on-site gamma spectrometry laboratory was used to analyze all samples for cesium-137, radium-226, ruthenium-106, thorium-232, and uranium-238. Tables E-18B and F-15B of Appendices E and F report results for the on-site surface sample screening. Based on this initial screening, four samples from the Inactive Flyash Pile and 27 samples from the South Field were selected for off-site analysis for 16 radionuclides (Figure 2-12a).

The objectives of RI/FS surface media (including flyash) sampling at the Inactive Flyash Pile and South Field were to:

- Characterize the nature of contamination in surface media and flyash.
- Provide data to evaluate the potential for exposure via the direct contact pathway.
- Provide data to evaluate the potential for migration via the air pathway.

Two surface soil samples (05001 and 5017) were collected from the Inactive Flyash Pile/South Field area during Phase I field activities, but the analytical results of both samples were rejected during data validation.

Seven surface samples (IFP-SS-01 through IFP-SS-07) were collected during the Phase II Field Investigation from the Inactive Flyash Pile. Twenty-one surface samples were collected from locations in the South Field (SF-SB-01 through SF-SB-09, SF-SS-10, SF-SS-11, SF-SB-12 through SF-SB-15, and SF-SS-16 through SF-SB-21) [Figure 2-12 (see Volume 2, Oversized Figures)]. These samples were analyzed for full HSL and full radiological parameters. Three South Field surface soil samples from Locations SF-SS-17, -18 and -21 were analyzed for gross alpha and gross beta at the on-site laboratory.

2.5.2 Subsurface Sampling

During the Environmental Survey (DOE 1988a), subsurface media samples from two hand-auger borings were collected in the Inactive Flyash Pile. Sample Nos. 0605, 0607, 0608, and 0609 were

collected at five-foot depths from a boring located near the center of the Inactive Flyash Pile. Sample No. 0604 was collected from another boring located in the southeastern part of the Inactive Flyash Pile from the depth interval of 0- to 2-feet (Figure 2-12b). These samples were analyzed for radionuclides, total uranium, asbestos, VOCs, and TCLP metals.

Also during the Environmental Survey, nine grab samples were collected from the South Field from four trenches (Test Pits 1014 through 1017) that were excavated (Figure 2-12b). The trench locations were selected based on prior radiological surveys. The locations are estimated because the trenches were not surveyed at the time of excavation. These trenches were oriented north to south and varied in depth from 2 to 10 feet. Two samples each were collected from Test Pits 1014, 1016, and 1017, and three samples were collected from Test Pit 1015. Eight of the samples were analyzed for radionuclides, total uranium, and TCLP metals. The ninth sample from Test Pit 1015 was analyzed for VOCs only.

Twelve borings were completed in the Inactive Flyash Pile and South Field (24-01 through 24-12) during the CIS (Weston 1987b); split samples were collected at one-foot intervals to depths ranging from 4 feet at Boring No. 24-04 to 34 feet at Boring No. 24-11 (Figure 2-12b). The boring locations were selected based upon radiological surveys indicating elevated levels of radionuclides at the surface location. Geotechnical survey data was reviewed to avoid areas with a high potential for buried metal objects which were potentially considered to be buried drums. Samples from the borings were analyzed at the on-site gamma spectrometry laboratory for radium-226, thorium-232, and uranium-238 to evaluate the vertical distribution of these radionuclides. A composite sample from each boring was analyzed for radionuclides, VOCs, SVOCs, pesticides/PCBs, metals, and EP toxicity.

During 1988, four borings (1016, 1047, 2047, and 4016) were drilled near the northern and southern boundaries of the Inactive Flyash Pile, and five borings (1046, 2046, 3046, 2385, and 3385) were completed near the northern boundary of the South Field as part of the site-wide monitoring well installation program [Figure 2-12 (see Volume 2, Oversized Figures)]. One sample each was collected from each of the Boring Nos. 1016, 1047, and 2047 and analyzed for radionuclides; the sample collected from Boring No. 2047 was also analyzed for total uranium. Three samples were collected from Boring No. 4016 and were analyzed for radionuclides and total uranium. Out of a total of nine samples from the South Field borings, seven samples were analyzed for radionuclides. The other sample (from Boring No. 2046) was analyzed for total uranium only.

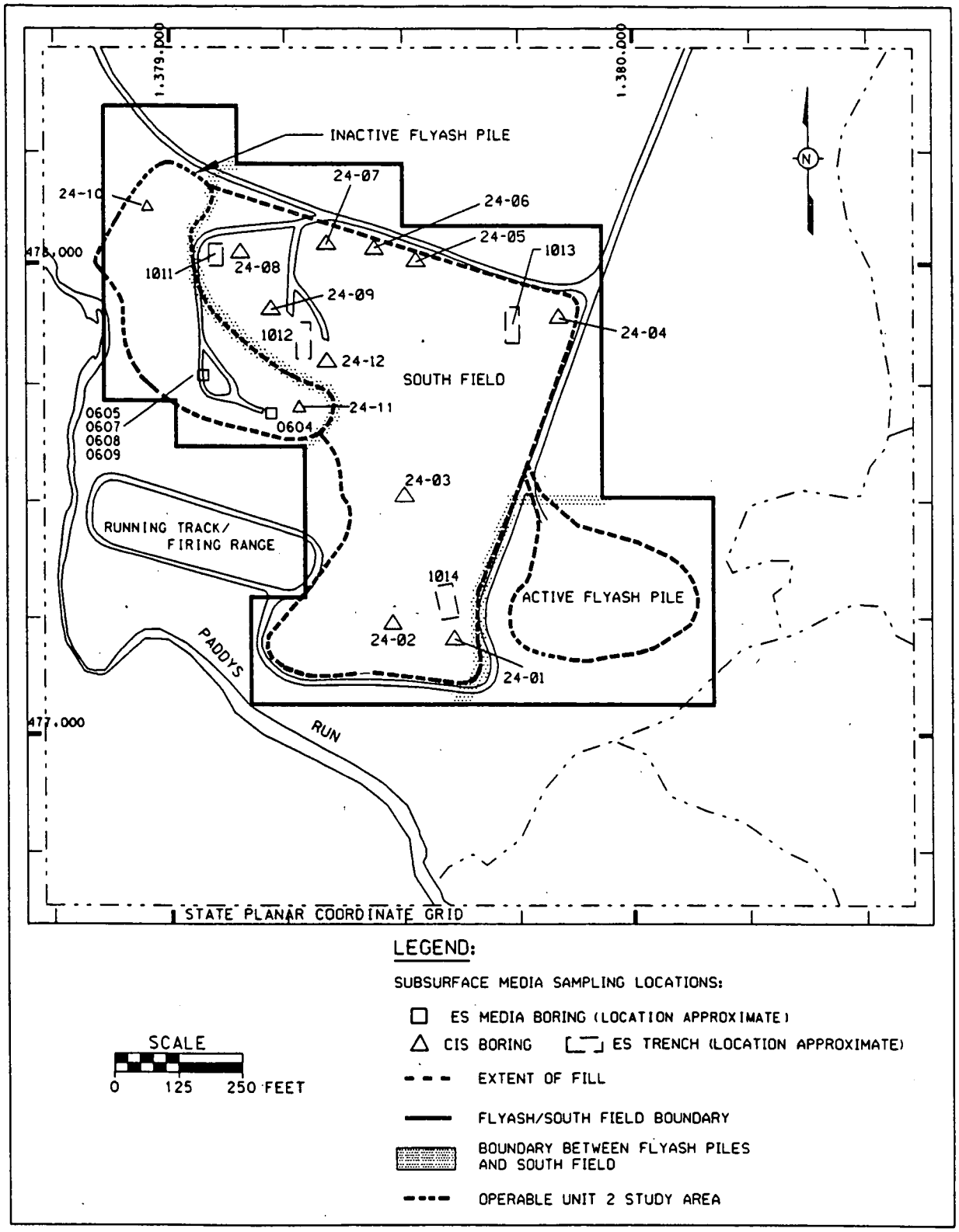


fig0296.dgn

FIGURE 2-12b
CIS AND ES SUBSURFACE SOIL SAMPLE LOCATIONS
IN SOUTH FIELD/INACTIVE FLYASH PILE AREA

000176

During the installation of Piezometer Wells 1516, 1517, and 1518 (1518 is located just south of the South Field and is not shown in Figure 2-12), samples were collected at 1- to 2-foot intervals to a depth of 20 feet [Figure 2-12 (see Volume 2, Oversized Figures)]. Fifty-one samples were analyzed for radionuclides, total uranium, and total thorium. One additional sample from Boring No. 1516 was analyzed for TCLP.

The objectives of RI/FS subsurface media sampling (including flyash and underlying native soil) in the Inactive Flyash Pile and South Field were to:

- Characterize the physical nature of buried waste materials in the Inactive Flyash Pile and South Field.
- Determine the nature and extent of contamination.
- Determine fill depths and volumes.
- Determine whether contaminants have migrated from the fill into the underlying native soils.
- Provide data to support the modeling of contaminant migration from the Inactive Flyash Pile and South Field.

Because previous sampling had not sufficiently quantified the vertical distribution of contaminants in the Inactive Flyash Pile to meet the study objectives, seven additional borings (1708, 1709, 1710, 1711, 1791, 1849, and 1850) were drilled in 1991 during the Phase I Field Investigation to further characterize the nature of the fill and the underlying native soil [Figure 2-12 (see Volume 2, Oversized Figures)]. Except for Boring No. 1791 (which only had two profile samples collected), samples were collected from the shallow fill, the deep fill, and the underlying native soils. These samples were analyzed for different combinations of radionuclides, total uranium, total thorium pesticides/PCBs, VOCs, SVOCs, metals, TCLP, EP toxicity, and total organic carbon (TOC). The TCLP VOC/SVOC sample was collected from the portion of the boring that displayed the highest HNu reading during screening. TCLP samples from borings for which there were no HNu readings were collected from the midpoint of the boring. A composite sample from each boring (except 1709, 1849, and 1850) was analyzed for the remainder of the TCLP analytes. The purpose of TCLP analysis was to determine whether the waste met criteria for regulation under RCRA and to determine leaching and transport potentials for waste transport modeling.

Twelve additional borings were also completed in the South Field [Figure 2-12 (see Volume 2, Oversized Figures)]. For Boring Nos. 1712 through 1715, one sample from each was collected at the 1.5 to 2.0 foot depth interval and was analyzed for TCLP. Samples from Borings Nos. 1792 and 1793 were sampled at 5-foot intervals until native soil was encountered. A total of five samples from Boring No. 1792 and one sample from Boring No. 1793 were analyzed for dioxins/furans, VOCs, SVOCs, pesticides/PCBs, and metals. At the base of each of these two borings, above the native soil, a sample was collected for TCLP analysis. At Boring Nos. 1794 and 1795, a subsurface media sample was collected from approximately the 1- to 2-foot depth interval and another from the 4- to 5-foot depth interval (or from the base of fill if the fill was less than 5 feet thick). These samples were analyzed for dioxins/furans, VOCs, SVOCs, pesticides/PCBs, and metals. One sample was collected from Boring No. 1794 and two samples from Boring No. 1795 for TCLP analysis. Boring Nos. 1882, 1883, 1884 (shown as GEO-6), and 1885 each had one sample taken for TCLP analysis.

Six trenches were excavated during the South Field Phase I Field Investigation from the surface through the fill and into the underlying native soil. The trenches, with an approximate north to south orientation, were 50 feet long, and their depths ranged from 3.75 to 5.75 feet. Samples from these trenches were collected from the bottom of the fill as well as from the native soil immediately below the fill at the north, south, and middle of each trench (Locations 1455 through 1472) [Figure 2-12 (see Volume 2, Oversized Figures)]. Trench traces are not shown but are included by the sample locations. Fill samples were screened in the field for VOCs using a portable photoionization detector to further identify sources of contamination and for health and safety protocols. The samples were analyzed for radionuclides, total uranium, and total thorium in order to characterize the nature of radionuclide contamination in both the fill and the underlying native soil. The fill samples from the middle of each trench (Locations 1456, 1459, 1462, 1465, 1468, and 1471) were also analyzed for VOCs, SVOCs, pesticides/PCBs, and metals.

In early 1992, one sample was collected from Boring No. 2401 during the installation of a monitoring well. This boring is located in the South Field near the South Field/Inactive Flyash Pile boundary [Figure 2-12 (see Volume 2, Oversized Figures)]. The sample was analyzed for total uranium and total thorium.

In January and February 1992, six vertical borings (SP-1 through SP-6) were completed to a depth of 5 feet in the abandoned FEMP Firing Range as part of the removal site evaluation conducted by

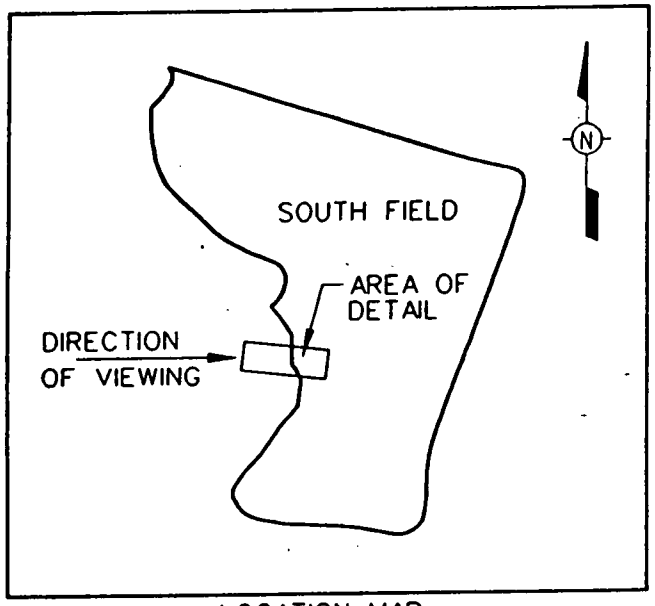
WEMCO (Figure 2-12c). Samples were collected from consecutive 1-foot intervals, with an additional sample collected from the 0.0- to 0.5-foot interval. In the approximate center of the firing zone, a 50-foot horizontal boring (SP-7) was drilled into the embankment; successive 5-foot intervals were sampled. In addition, two surface soil samples (SP-8 and SP-9) were taken from the flat area between the firing line and the embankment. Each sample was sieved to capture spent lead ammunition fragments greater than 2 millimeters in diameter. Material that passed through the sieve was analyzed for TCLP lead (DOE 1992c).

In November 1992, one soil sample was collected during the installation of Well 1433 in the South Field [Figure 2-12 (see Volume 2, Oversized Figures)]. The sample was analyzed for radionuclides.

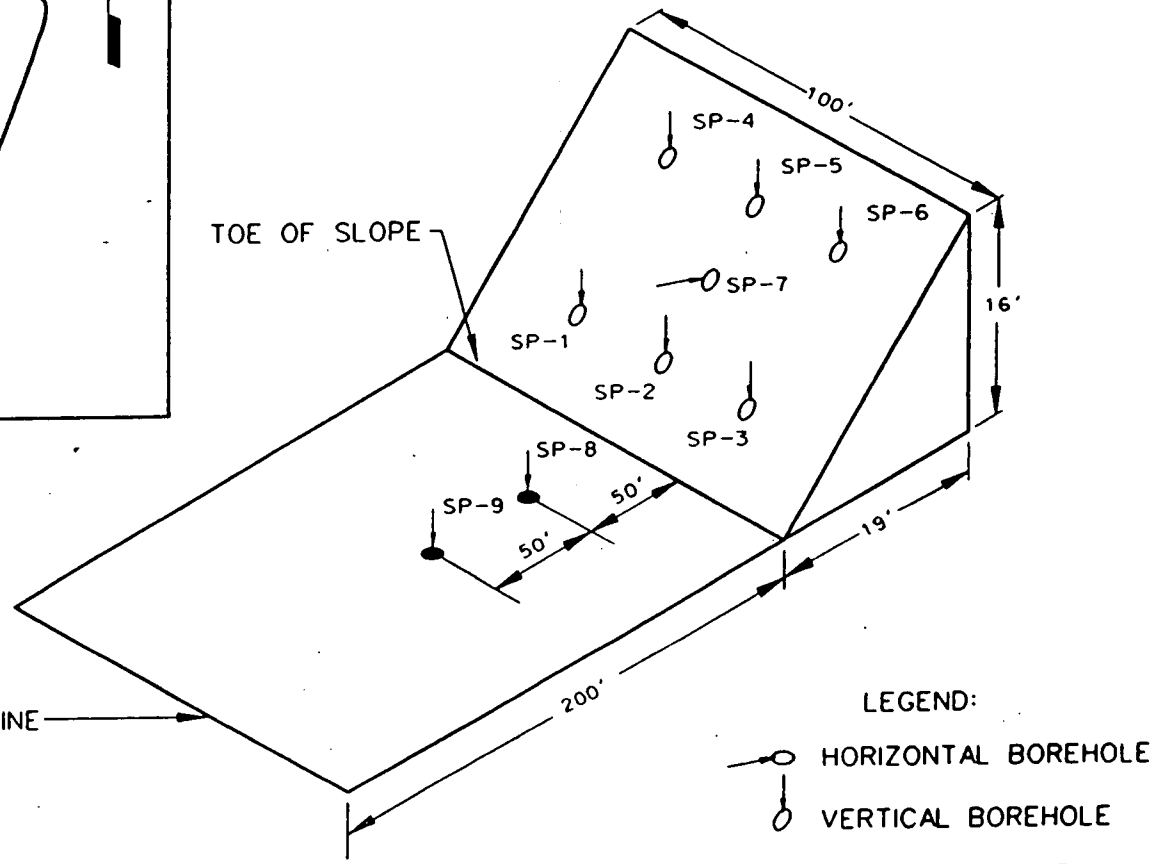
During the Phase II Field Investigation, subsurface samples were collected from 11 borings (1994 through 1998 and 11052 through 11057), 14 Hydropunch™ borings (1999, 11000 though 11008, and 11048 through 11051), and one monitoring well boring (2955) in the Inactive Flyash Pile [Figure 2-12 (see Volume 2, Oversized Figures)]. Eighteen samples from Boring Nos. 1994 through 1998 were analyzed for full HSL and full radiological parameters. Five additional samples were analyzed for subsets of full HSL and full radiological parameters. Each of these borings has one TCLP sample, except Boring No. 1998, which has two. Boring No. 11052 has one sample for full HSL and full radiological parameters and Boring Nos. 11054 through 11057 each have two samples analyzed for VOCs, SVOCs, and pesticides/PCBs only. In addition, 36 samples from the 11 Inactive Flyash Pile borings were sent to the on-site laboratory for total uranium screening. Three samples from the Inactive Flyash Pile Hydropunch™ borings were sent off site for full HSL and full radiological analysis. Thirty-three samples from the Hydropunch™ borings were sent to the on-site laboratory for total uranium screening. One sample from monitoring well Boring No. 2955 was sent to the on-site laboratory for total uranium screening. A complete summary of Inactive Flyash Pile Phase II subsurface samples, including sample intervals, is provided in Table E-1B of Appendix E.

During the Phase II Field Investigation, near-surface soil samples (6 to 12 inches) were collected from 11 South Field locations (SF-SB-03 through -06, -08, -09, -12, and -15, and SF-SS-10, -11, and -19) [Figure 2-12 (see Volume 2, Oversized Figures)]. These samples were analyzed off site for full HSL and full radiological parameters.

fig0292.dgn



LOCATION MAP



NOT TO SCALE

FIGURE 2-12c
SUBSURFACE SAMPLING LOCATIONS FOR
FIRING RANGE REMOVAL SITE EVALUATION

Subsurface samples were collected from the South Field from 15 borings (1964 through 1972, 1975 through 1978, and 11186 through 11188), 11 Hydropunch™ borings (11009 through 11018, and 11027), and six monitoring well borings (1941, 1942, 2943, 2944, 2945, and 2954) [Figure 2-12 (see Volume 2, Oversized Figures)]. Two samples from each boring were analyzed off-site for full HSL and full radiological parameters and one sample from each was sent to the on-site laboratory for total uranium screening. Nineteen samples from the Hydropunch™ borings were sent to the on-site laboratory for total uranium screening. One sample from each monitoring well boring, except Boring No. 2945, was sent to the on-site laboratory for total uranium screening. Geotechnical samples were only collected from Boring No. 2945. A complete summary of South Field Phase II subsurface samples, including sample intervals, is provided in Table F-1B of Appendix F.

Ten of the most significant geophysical anomalies located by nonintrusive EM and magnetometry measurements (see Section 2.5.6) were investigated by excavation, observation, and screening for total organic vapors and radioactivity. Samples from areas exhibiting high readings were collected from Trenches 1, 2, and 4 and sent off site for full HSL and full radiological analysis. Five samples from Trenches 1, 2, 4, and 5 were also collected for total uranium screening at the on-site laboratory. No samples were collected from the remaining trenches because no anomalous readings were found at that location. In addition to soil samples, 16 surface wipe samples were collected from debris in Trenches 1, 2, and 4. These samples were analyzed on site for uranium and thorium. Three concrete core samples were collected from debris in Trenches 1 and 2 and analyzed for total uranium, thorium, and radium.

2.5.3 Surface Water and Sediment Sampling

The objective of surface water and sediment sampling in the Inactive Flyash Pile and South Field was to determine whether contaminants from the waste area are migrating across its boundaries via the surface water pathway. The topography of the Inactive Flyash Pile is such that runoff flows west toward Paddys Run, east into the drainage ditch separating the Inactive Flyash Pile from the South Field, and south toward the running track. Topography of the South Field directs runoff east into a drainage ditch and south where it has no defined channel and appears to seep into the ground at the southeast corner of the subunit.

Sediments were sampled at two locations (53-001 and 53-002) west of the Inactive Flyash Pile as part of the CIS (Weston 1987b) (Figure 2-12a). The two samples were analyzed for cesium-137,

radium-226, ruthenium-106, thorium-232, and uranium-238 at the on-site gamma spectroscopy laboratory. Based on those results, neither was selected for more extensive off-site laboratory analysis.

An additional objective for surface water and sediment sampling in the Inactive Flyash Pile and South Field was to assess potential surface migration pathways for risk assessment purposes. As part of the Phase I Field Investigation, sediments were sampled at two locations west of the Inactive Flyash Pile (ASIT-008 and ASIT-009) (Figure 2-13). Two surface water samples were also collected at ASIT-009. Sediment and surface water samples were analyzed for radium-226, radium-228, total uranium, gross alpha, and gross beta, while one surface water sample was also analyzed for metals and general chemistry.

Surface water samples were collected from 11 locations around the Inactive Flyash Pile during the Phase II Field Investigation (Figure 2-13). Six samples from IFP-SW-02, -03, and -04 were analyzed for full HSL, full radiological, and general groundwater quality parameters. Fifteen surface water samples were sent to the on-site laboratory for total uranium screening. Six sediment samples were also collected at three locations in the Inactive Flyash Pile (Figure 2-13). Four samples were analyzed for full HSL and full radiological parameters and two samples were analyzed for full HSL only. No samples were collected at IFP-SW-01 or IFP-SD-01 because no surface water or sediments were present.

Samples were also collected during the Phase II Field Investigation from the South Field at five surface water and three sediment sample locations (Figure 2-13). Two surface water samples from SF-SW-01 and -02 were analyzed off site for full HSL, full radiological, and general chemistry parameters. Six surface water samples from all locations were analyzed at the on-site laboratory for total uranium. It was planned to take surface water samples from two additional locations (SF-SW-03 and SF-SW-04) but there was no surface water present at the time of sampling. One additional surface water sample was collected from the surface of Hydropunch™ Boring No. 11018 and sent to the on-site laboratory for total uranium screening.

One sediment sample from each of three locations was analyzed for full HSL, full radiological, and general chemistry parameters. Another sample from each location was sent to the on-site laboratory

for total uranium screening. One additional location was identified for sediment sampling (SF-SD-04) but there was no sediment present at that location.

2.5.4 Groundwater Investigations

The objectives of groundwater sampling in the Inactive Flyash Pile and South Field were to:

- Characterize the hydrogeology of perched groundwater aquifer.
- Determine if contaminants from the Inactive Flyash Pile and South Field appear to have migrated to shallow or deep groundwater.
- Determine if any contaminant that may have entered the shallow or deep groundwater are migrating away (off site) from the Inactive Flyash Pile/South Field area.

During the Phase I Field Investigation, two monitoring wells (1047 and 2047) were installed outside of north boundary of the Inactive Flyash Pile and four (1016, 2016, 3016, and 4016) at the south boundary (all in the Great Miami Aquifer) (Figure 2-14). The South Field had three monitoring wells (1046, 2046, and 3046) installed at the northern boundary, six (1065, 2048, 2065, 2385, 3065, and 3385) beyond the eastern boundary, eight (1014, 1516, 1517, 1518, 2014, 3014, 3045, and 4014) south of the area, and one (4016) southwest of the South Field (Figure 2-14). These wells are screened in perched water of the glacial overburden, the Upper Great Miami Aquifer, and the Lower Great Miami Aquifer. They were sampled periodically during 1988 through 1990 and were analyzed for different combinations of radionuclides, total uranium, total thorium, pesticides/PCBs, VOCs, SVOCs, metals, and general chemistry. Wells 1711, 2402, and 3402 were installed in 1991 and 1992 in the Inactive Flyash Pile area. Well 1711 was sampled only once under the Phase I Field Investigation and was analyzed for metals. Four samples from 2402 and 3402 were analyzed for metals and general chemistry. One sample from 2402 was also analyzed for radionuclides. Two wells (1433 and 2401) were installed in the northwest corner of the South Field in 1991 and 1992. Two samples from 1433 were analyzed for radionuclides, pesticides/PCBs, VOCs, SVOCs, metals, and general chemistry. One sample was analyzed for radionuclides only. One sample from 2401 was analyzed for metals and general chemistry. Detail on the sampling frequency and parameters for each well is included in Table E-12 of Appendix E and Table F-11 of Appendix F.

One additional well (2955) was installed south of Well No. 1711 in the Inactive Flyash Pile during the Phase II Field Investigation. Five 1000-series (1941, 1942, 1954, 11032, and 11085) and four 2000-series (2943, 2944, 2945, and 2954) wells were installed in the South Field during the Phase II

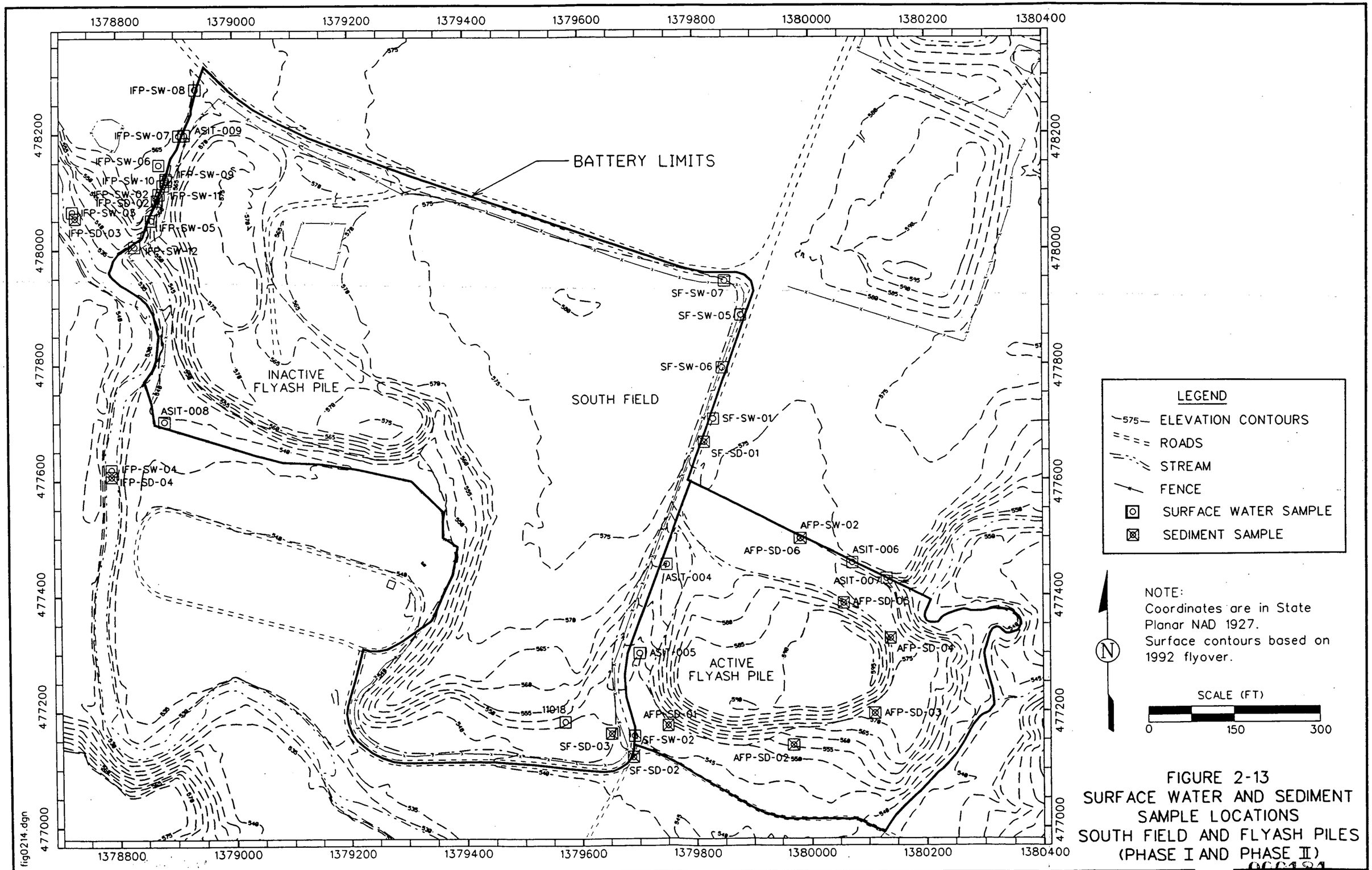


FIGURE 2-13
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
SOUTH FIELD AND FLYASH PILES
(PHASE I AND PHASE II)

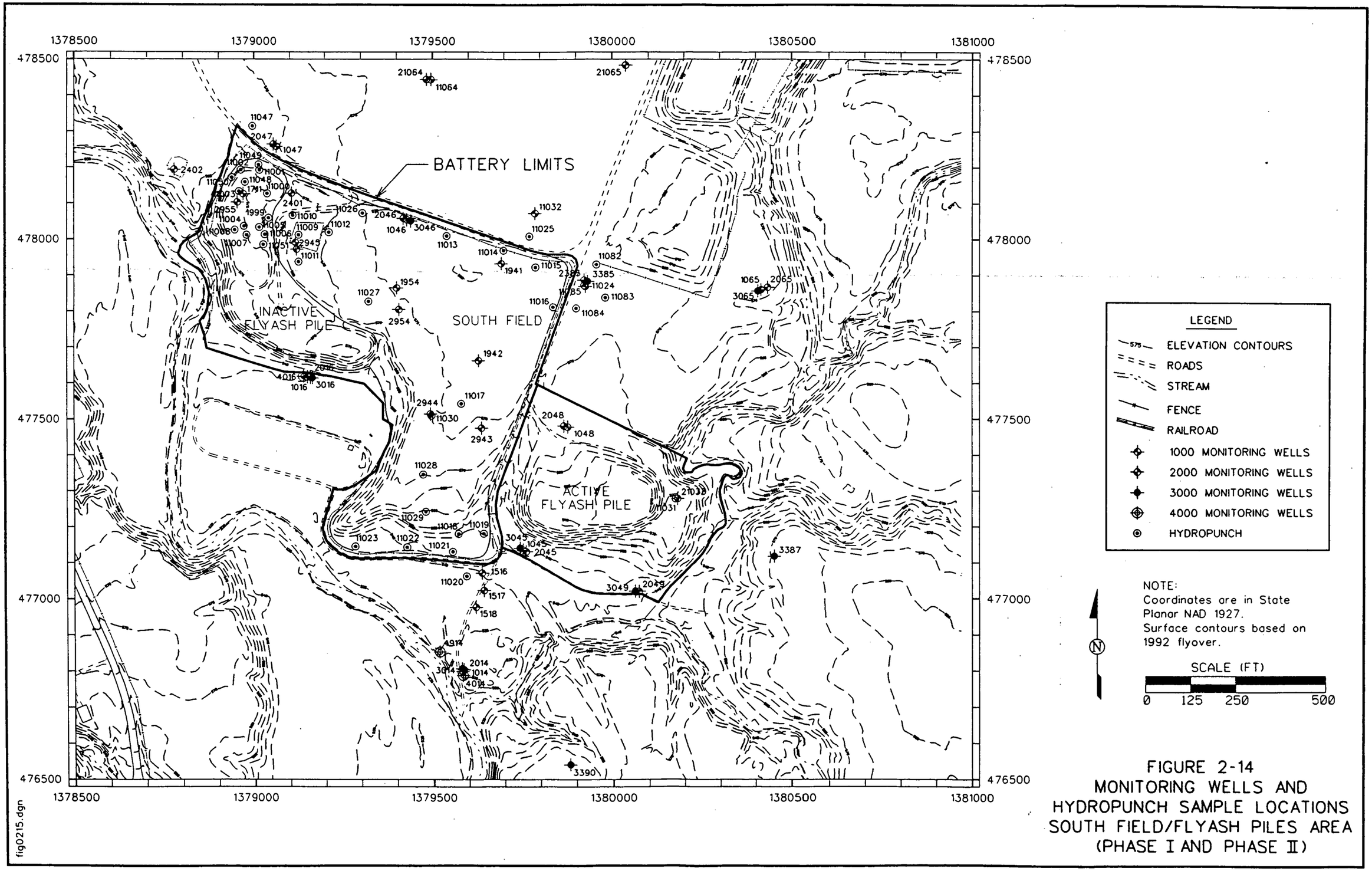


FIGURE 2-14
MONITORING WELLS AND HYDROPUNCH SAMPLE LOCATIONS
SOUTH FIELD/FLYASH PILES AREA
(PHASE I AND PHASE II)

field activities. Following completion of Phase II wells, all of the wells, including the Phase I and the ten Phase II wells, in the Inactive Flyash Pile and South Field were sampled and analyzed for full HSL, full radiological, and general groundwater quality parameters. At least one sample from each well was collected for on-site screening for total uranium. Total uranium screening samples were also collected from 12 Hydropunch™ borings that were completed in the Inactive Flyash Pile and 23 Hydropunch™ borings in the South Field (Figure 2-14). Groundwater samples were not collected from five Hydropunch™ borings (11005, 11006, 11008, 11011, and 11017) because they were dry.

2.5.5 Geotechnical Investigations

In October 1991, the in-place density was measured by ASTM Method D-2922 at two locations in the Inactive Flyash Pile (GEO 4 and GEO 5) and three locations in the South Field (GEO 6, GEO 7, and GEO 8) during the Phase I Field Investigation [Figure 2-12 (see Volume 2, Oversized Figures)]. Wet density, dry density, and moisture content were measured at each location. Shelby™ tube samples for geotechnical analysis were collected from Inactive Flyash Pile Boring No. 1708. These samples were collected from the 7.5- to 12-foot depth interval and were analyzed for moisture content, specific gravity, and particle size distribution.

Geotechnical sampling was also completed during the Phase II Field Investigation. Inactive Flyash Pile samples were collected from IFP-SD-02 (Figure 2-13), IFP-SS-05, and Boring Nos. 1994, 1995, 1996, 1997, and 1998 [Figure 2-12 (see Volume 2, Oversized Figures)]. South Field geotechnical samples were collected from SF-SD-02 and Boring Nos. 1964, 1965, 1966, 1968, 1969, 1970, 11187 (1974), 1975, 1977, and 2945. The samples from these locations were taken from varying depths and were analyzed for different combinations of specific gravity, water content, liquid limit, plastic limit, sieve analysis, hydrometer analysis, consolidated isotropic undrained triaxial, hydraulic conductivity, and direct shear and dry unit weight.

2.5.6 Geophysical Survey

The CIS performed a geophysical survey of the Inactive Flyash Pile and South Field. The EM method was used for this geophysical survey. The EM survey was conducted on a 50 by 25 foot grid, with 50 feet separating the north-to-south trending profiles. The EM survey was performed in both the vertical and horizontal dipole to further evaluate near surface disturbances. Additional data points were surveyed on a 25 foot grid between the 50 foot grid lines when anomalies were detected.

The survey grids for two EM methods (EM 31 and EM 34-3) are provided in Figures 2-15 through 2-17.

During the Phase II Field Investigation, nonintrusive EM and magnetometry measurements were conducted in the South Field on a 20 by 20 foot grid to locate buried metal and thus, waste disposal trenches. The Magnetics Geophysical survey was performed using the EDA OMNI plus proton precession magnetic gradiometer. The EM Conductivity survey was performed using the GEONICS EM-31 DC terrain conductivity meter with an OMNI digital data logger. Data was downloaded to portable computers, processed by contouring with Geosoft™ mapping system to provide vertical magnetic gradient, EM conductivity values, and in-phase component values. Ten of the most significant geophysical anomalies were investigated by excavation, observation, and screening for total organic vapors and radioactivity.

2.6 ENVIRONMENTAL CHARACTERIZATION INFORMATION FOR THE ACTIVE FLYASH PILE

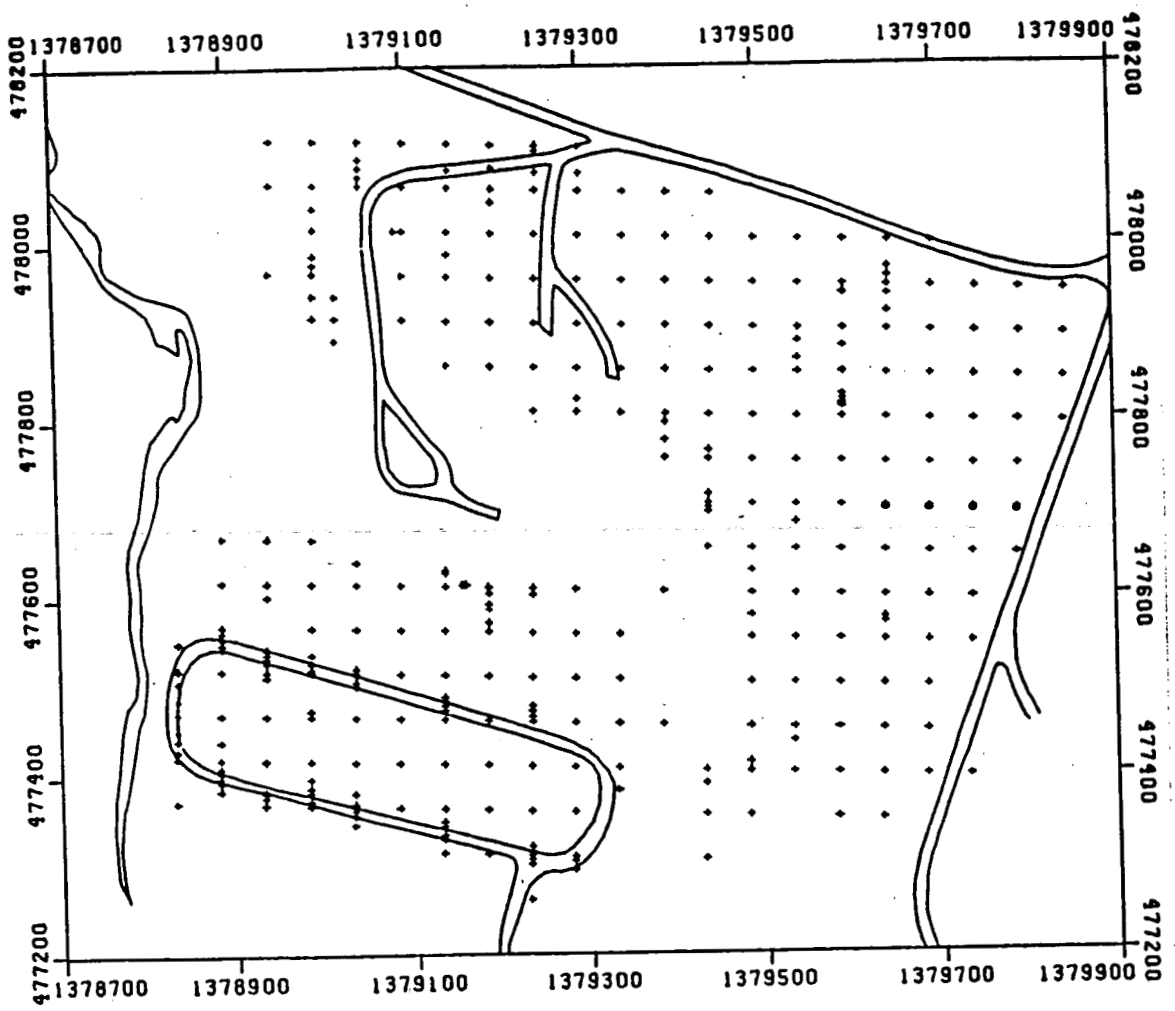
The Active Flyash Pile has been preliminarily characterized by the Environmental Survey and CIS Sampling Program, followed by characterization by the RI/FS Sampling Program. The following sections discuss the sample locations and analytical parameters for each of these sampling programs. Result of these sampling programs are presented in Appendix G.

2.6.1 Surface Sampling

During the Environmental Survey, surface media from eight locations (0100 through 0107) across the waste area were sampled. These samples were analyzed for asbestos, TCLP metals, VOCs, radionuclides, and total uranium. Four CIS surface soil samples were collected from around the Active Flyash Pile (25-013, 25-014, 25-015, and 25-022) and were analyzed for radionuclides. Flyash media from the Active Flyash Pile was not sampled for during either the CIS or the Phase I Field Investigation.

The overall objectives of Phase II RI/FS surface media sampling (including flyash) in the Active Flyash Pile were to:

- Characterize the nature of contamination in surface media and flyash.
- Provide data to evaluate the potential for exposure via the direct contact pathway.



STATE PLANE COORDINATE SYSTEM

OHIO SOUTH ZONE

Legend
+ Data Point Location
—— Hydrology

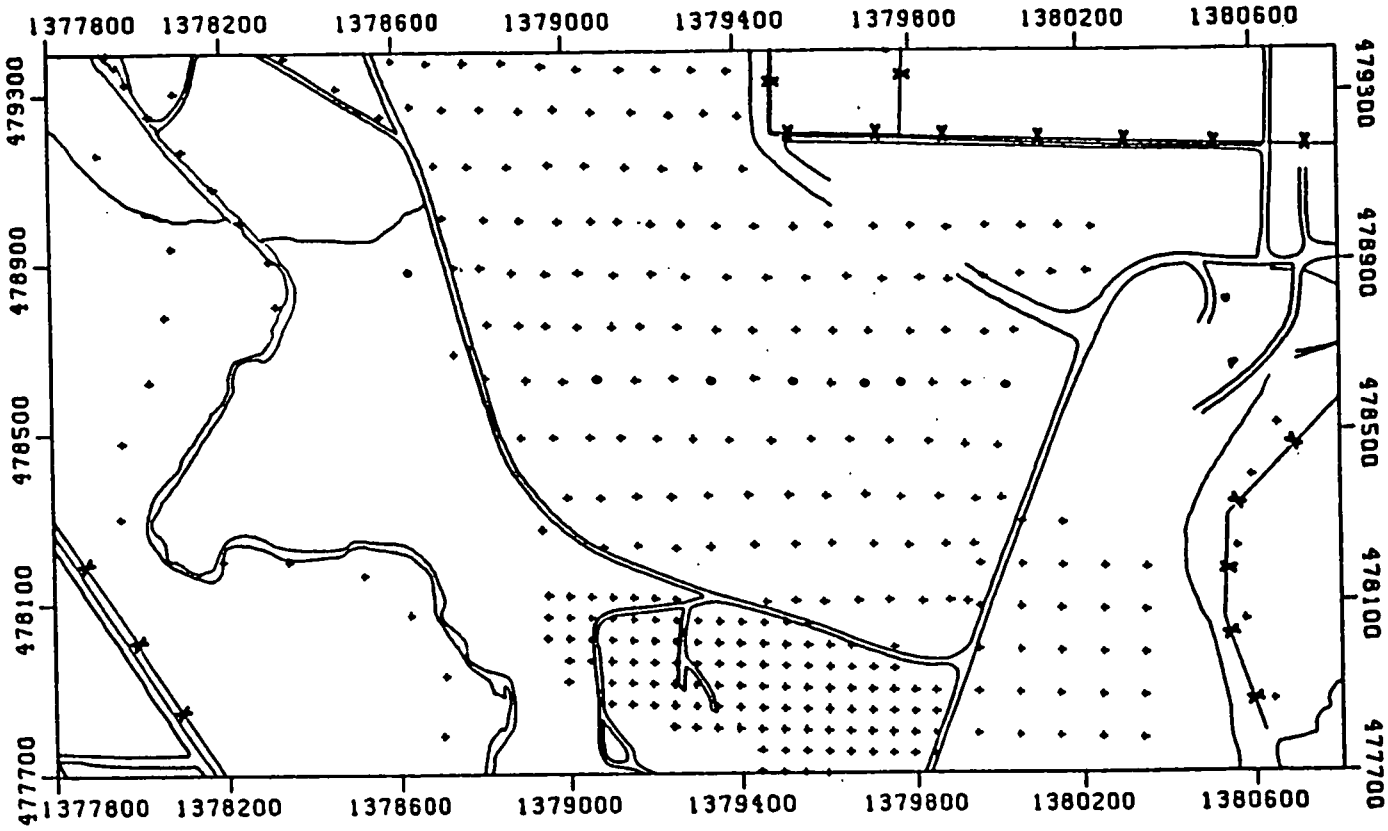
PREPARED BY

ROY F. WESTON, INC. 9/1/87

FIGURE 2-15
EM 31 DATA CONTROL POINT POSTINGS MAP OF THE SOUTH FIELD/INACTIVE FLYASH PILE AREA

fig0219.dgn

21



STATE PLANE COORDINATE SYSTEM

OHIO SOUTH ZONE

PREPARED BY

ROY F. WESTON, INC. 9/1/87

Legend

+ Data Point Location

Fence

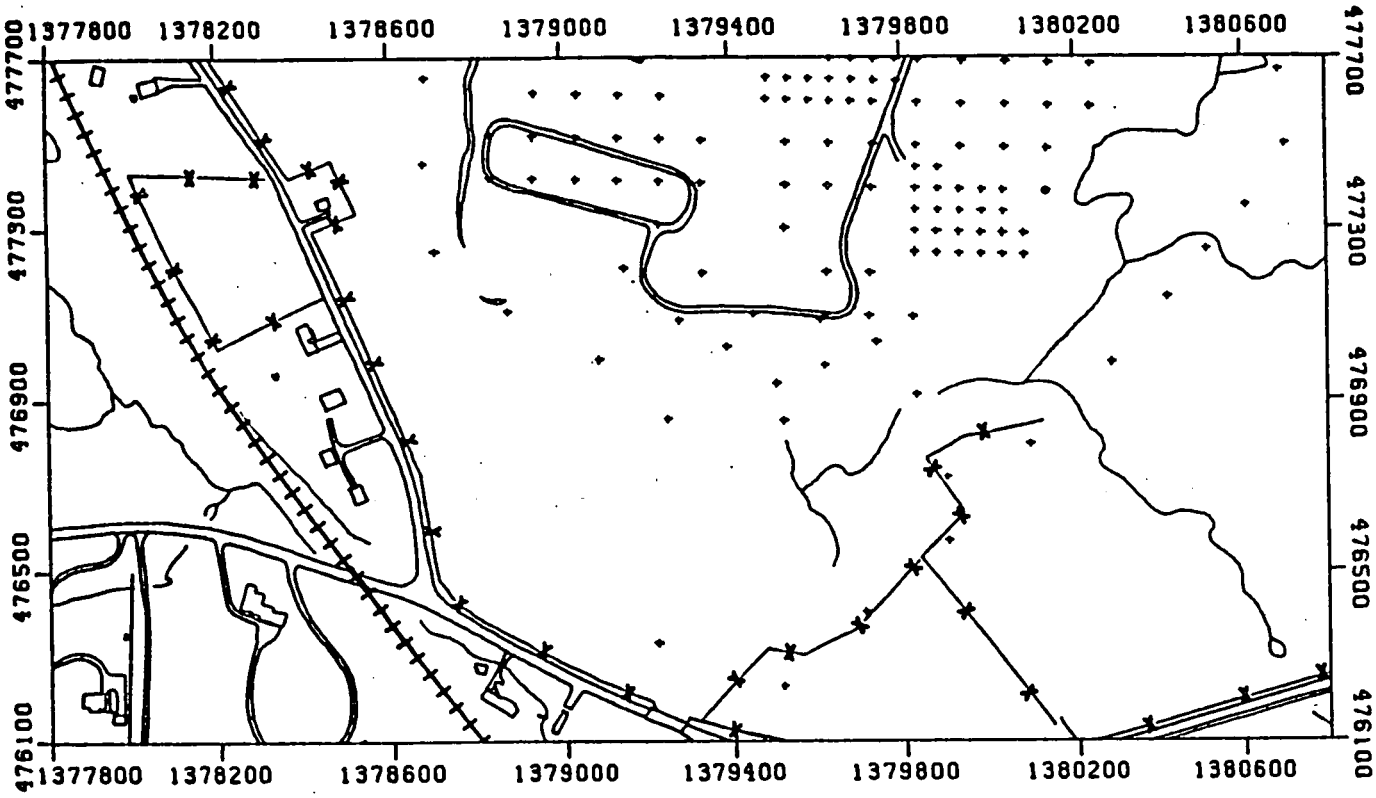
Hydrology

FIGURE 2-16
EM 34-3 DATA CONTROL POINT POSTINGS MAP OF THE SOUTH FIELD/INACTIVE FLYASH PILE AREA

fig0220.dgn

31 000189

31



Legend

+ Data Point Location
Fence
Railroad Tracks
Hydrology

STATE PLANE COORDINATE SYSTEM

OHIO SOUTH ZONE

PREPARED BY

ROY F. WESTON, INC. 9/1/87

FIGURE 2-17
EM 34-3 DATA CONTROL POINT POSTINGS MAP OF THE SOUTH FIELD/ACTIVE FLYASH PILE AREA

fig0221.dgn

(31) (31)

000190

- Provide data to evaluate the potential for migration via the air pathway.

To address the shortage of surface samples that could be used for nature and extent or risk analysis, samples were taken from 14 locations (1979, 1980, 1981, AFP-SD-01 through -05, and AFP-SS-01 through -06) on and around the Active Flyash Pile during the Phase II Field Investigation [Figure 2-12 (see Volume 2, Oversized Figures)]. One sample from each location was analyzed for full HSL and full radiological parameters. PCBs were included in the suite of analytes to attempt to determine if PCB-contaminated waste oils may have been used to control dust at the Active Flyash Pile. As the flyash is considered homogeneous, the flyash samples taken in the pile were also considered to represent surface samples.

2.6.2 Subsurface Sampling

As part of the Environmental Survey, three subsurface media samples were collected from a boring at one location in the Active Flyash Pile. Samples Nos. 0601, 0602, and 0603 were taken at depths of 0 to 5 feet, 5 to 11 feet, and 11 to 13.5 feet, respectively, and were analyzed for asbestos, TCLP metals, VOCs, radionuclides, and total uranium. Two subsurface samples for off-site analysis were taken during the CIS. One sample was analyzed for pesticides/PCBs and metals. The other sample was a composite of Boring No. 25-01 and was analyzed for radionuclides. The sample location was south of the Active Flyash Pile in the Storm Sewer Outfall Drainage Channel.

During 1987 and 1988, five borings were drilled outside of the fill area (1048, 2048, 1045, 2045 and 3045) as part of the site-wide groundwater installation program [Figure 2-12 (see Volume 2, Oversized Figures)]. A total of six subsurface samples were collected from these borings and were analyzed for radionuclides. Three of these samples were also analyzed for total uranium and one for total thorium.

The objectives of RI/FS subsurface media sampling (including flyash and underlying native soil) in the Active Flyash Pile were to:

- Characterize the physical nature of buried waste materials in the Active Flyash Pile.
- Characterize the nature and extent of contamination.
- Determine fill depths and volumes.
- Determine whether contaminants have migrated from fill into the underlying native soils.

- Provide data to support the modeling of contaminant migration from the Active Flyash Pile.

Because previous sampling had not sufficiently quantified the vertical distribution of contaminants, five borings (1723, 1724, 1726, 1820, and 1846) were drilled under the Phase I Field Investigation to further characterize the nature of the fill and the underlying native soil [Figure 2-12 (see Volume 2, Oversized Figures)]. Samples from Boring No. 1725, shown in the northern portion of the Active Flyash Pile, were compromised in the sampling protocol, so the boring was redrilled. Boring No. 1820 was located directly next to the abandoned Boring No. 1725. Except in the case of Boring No. 1846 (which only had two samples, both taken within the flyash), samples were collected from the shallow fill, deep fill, and the underlying native soils. These samples were analyzed for different combinations of analytes including radionuclides, total uranium, total thorium, pesticides/PCBs, VOCs, SVOCs, EP Toxicity, TCLP, metals, and general chemistry. The TCLP VOC/SVOC samples were collected from the portion of the boring that displayed the highest HNu reading during field screening. When there was no HNu reading, samples were collected from the midpoint of the boring. A composite sample from each boring (except 1846) was analyzed for the remainder of the TCLP analytes. The purpose of TCLP analysis was to determine whether the waste met criteria for regulation under OEPA and to determine leaching and transport potentials for waste transport modeling.

Three additional borings (1979, 1980, and 1981) were advanced in the Active Flyash Pile under the Phase II Field Investigation [Figure 2-12 (see Volume 2, Oversized Figures)]. Twelve samples from these borings were analyzed for full HSL and full radiological parameters and one sample from each boring was analyzed for TCLP.

2.6.3 Surface Water and Sediment Sampling

The objective of surface water and sediment sampling in the Active Flyash Pile Study Area was to determine if contaminants from the Active Flyash Pile migrated via the surface water pathway. The topography of Active Flyash Pile is such that surface runoff is radial, so surface water and sediments were sampled during the Phase I Field Investigation at two location (ASIT-004 and ASIT-005) to the west of the Pile and two locations to the northeast (ASIT-007 and ASIT-008) (Figure 2-13). Four surface water samples were analyzed for radionuclides, total uranium, and total thorium. Two samples were analyzed for radium-226, radium-228, total uranium, gross alpha, gross beta, metals, and general chemistry. The remaining six samples were analyzed for radium-226, radium-228, total

uranium, gross alpha, and gross beta only. All four sediment samples were analyzed for radium-226, radium-228, total uranium, gross alpha, and gross beta. One sample (from ASIT-007) was also analyzed for pesticides/PCBs, VOCs, SVOCs, metals, and general chemistry.

Additional surface water and sediment samples were taken during the Phase II Field Investigation (Figure 2-13). One surface water sample was taken from the north of the Active Flyash Pile (AFP-SW-02) and analyzed for full HSL, full radionuclides, and general chemistry parameters. An additional surface water sample was collected from the same location and sent to the on-site laboratory for total uranium screening. One sediment sampling location (AFP-SD-06) was positioned in the drainage ditch to the north of the Active Flyash Pile. The sample was analyzed for full HSL and full radiological parameters. Five other sediment samples were collected in the field (AFP-SD-01 through AFP-SD-05) but an evaluation of the material determined that they were flyash material, not sediment.

2.6.4 Groundwater Investigations

Seven wells were installed in the Active Flyash Pile during the Phase I Field Investigation (1045, 1048, 2045, 2048, 2049, 3045, and 3049) (Figure 2-14). These wells were sampled periodically during 1988 through 1990 and were analyzed for different combinations of radionuclides, total uranium, total thorium, metals, and general chemistry. Detail on the sampling frequency and parameters for each well is included in Table G-11 of Appendix G.

One additional 2000-series well (21033) was installed during the Phase II Field Investigation (Figure 2-14). This well and five previously installed wells (1045, 1048, 2045, 2048, and 2049) were sampled and analyzed for full HSL, full radiological, general groundwater quality parameters. One sample from each well (except Well No. 2045) was sent to the on-site laboratory for total uranium screening. Well No. 1045 had two samples analyzed on site for total uranium and one sample analyzed off site for full radiological, VOCs, and metals.

2.6.5 Geotechnical Investigations

In October 1991, in-place density was measured at three locations (GEO 1, GEO 2, and GEO 3) by ASTM Method D-2922 during the Phase I Field Investigation [Figure 2-12 (see Volume 2, Oversized Figures)]. Wet density, dry density, and moisture content were measured at each location. Also during this program, a Shelby™ tube sample for geotechnical analysis was collected from Boring

No. 1724 [Figure 2-12 (see Volume 2, Oversized Figures)]. These samples were collected from the 12- to 14.5-foot depth interval and were analyzed for moisture content, specific gravity, and grain size distribution.

Geotechnical samples were taken from AFP-SD-01, AFP-SS-01, and Boring Nos. 1979, 1980, and 1981 [Figure 2-12 (see Volume 2, Oversized Figures)]. The samples from these locations were taken from varying depths and were analyzed for different combinations of specific gravity, water content, liquid limit, plastic limit, sieve analysis, hydrometer analysis, consolidated isotropic undrained triaxial, direct shear, and dry unit weight.

2.6.6 Geophysical Survey

The CIS performed a geophysical survey of the Active Flyash Pile. The EM method was used for this geophysical survey. The EM survey was conducted on a 50 by 25 foot grid, with 50 feet separating the north-to-south trending profiles. The EM survey was performed in both the vertical and horizontal dipole to further evaluate near surface disturbances. Additional data points were surveyed on a 25 foot grid between the 50 foot grid lines when anomalies were detected. The survey grid is indicated in Figures 2-15 through 2-17.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

3.1 SITE-WIDE CHARACTERISTICS

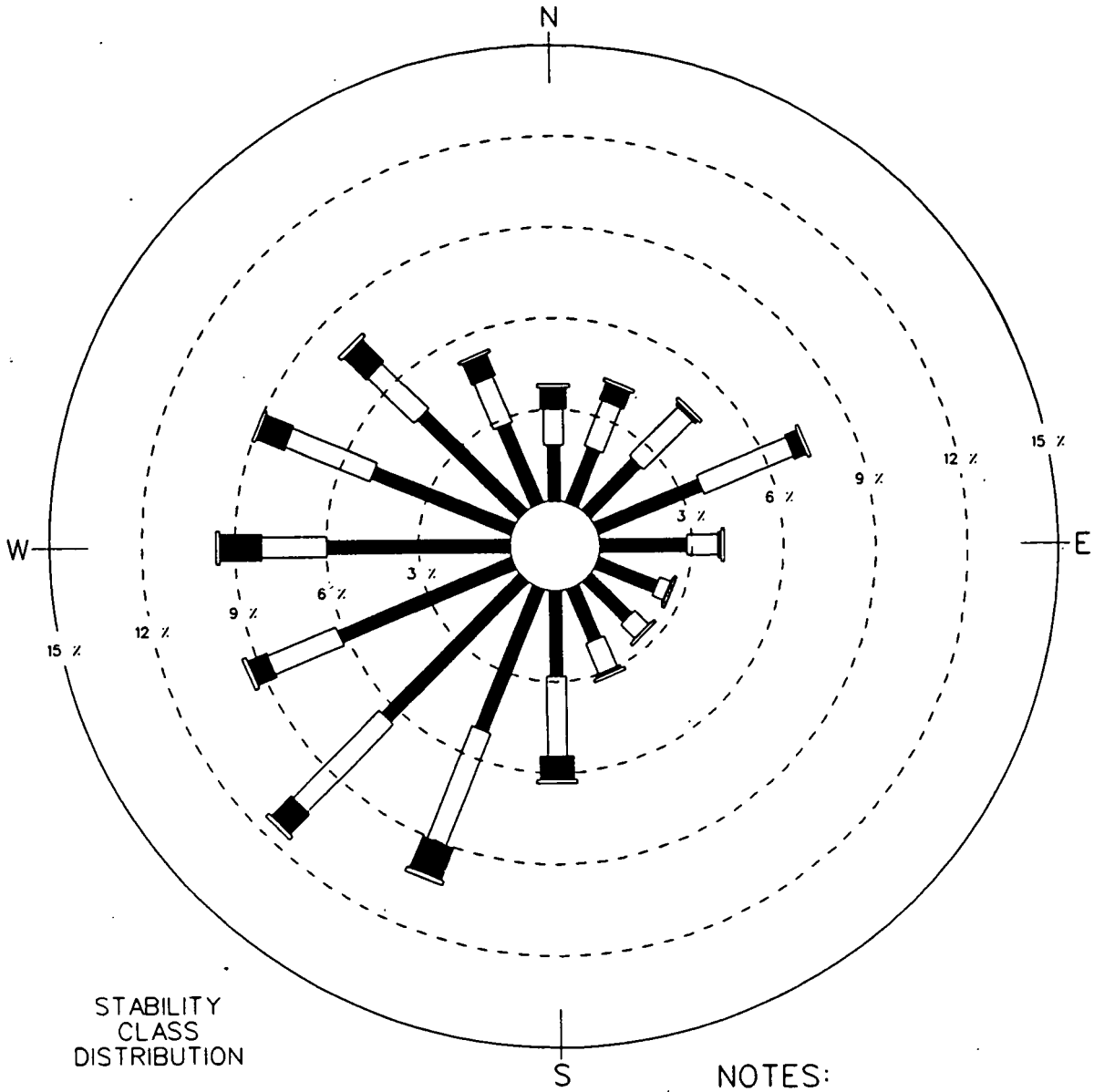
Physical characteristics include the meteorological, geological, and hydrological environment surrounding the FEMP Study Area. Physical characteristics also can represent man-made features that affect meteorology, geology, or hydrology. The evaluation of physical characteristics is significant to the RI process because the nature, extent, transport, and risk of a contaminant are related to the physical characteristics. This section describes the physical characteristics relating to Operable Unit 2. Some of these physical characteristics are presented on a site-wide basis such as meteorology, topography and surface water hydrology, and demography. These site-wide characteristics are discussed first. Physical characteristics relating to specific Operable Unit 2 waste subunits such as detailed lithology, stratigraphy, and vadose zone hydrogeology are discussed by subunit.

3.1.1 Meteorology

Information on the local climate was obtained from two primary sources. The first source is an on-property meteorological system installed at the FEMP in 1986. The second source is the National Weather Service Office at the Greater Cincinnati/Northern Kentucky International Airport.

The FEMP meteorological system was installed to collect site-specific data for wind speed and direction, ambient air temperature, lapse rate, dew point, temperature, relative humidity, barometric pressure, and precipitation, and was used by the National Oceanic and Atmospheric Administration (NOAA) to examine the complexity of the local wind field at the Fernald site. The NOAA study showed that two major features affect the site, the Great Miami River Valley and the ridges surrounding the site. A study by International Technology Corporation (IT) (1986) showed that the wind flow data from the Greater Cincinnati/Northern Kentucky International Airport were sufficiently representative of local conditions to serve as a database for the years prior to the installation of the on-property meteorological system.

Figure 3-1 shows the yearly wind patterns at the FEMP recorded from a 33-foot (10-meter) aboveground surface sampling station during 1992. Data from 1987 to 1990 were presented in the CERCLA/RCRA Background Soil Study (DOE 1993). Prevailing winds are generally from the southwest and west-southwest. The annual frequency distribution and stability class distribution are



STABILITY CLASS DISTRIBUTION

A - 9 %
B - 4 %
C - 4 %
D - 33 %
E - 27 %
F - 22 %

NOTES:

1. DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE - WIND IS BLOWING FROM THE NORTH 4.8 PERCENT OF THE TIME.

2. RECORDED AT FEMP FROM A 33-FEET (10 METERS) TOWER DURING 1992.

LEGEND

0-3	4-6	7-10	11-16	17-21	22-99
(57 %)	(32 %)	(10 %)	(0 %)	(0 %)	(0 %)

WIND SPEED SCALE (KNOTS)
(1 KNOT EQUALS 1.15 MPH)

fig0301.dgn

FIGURE 3-1
WIND ROSE FOR THE FEMP SITE
YEAR 1992

also shown on Figure 3-1. The stability class distribution is a parameter that is used in air dispersion modeling. Atmospheric stability is a measure of the potential for vertical mixing, both mechanical and thermal. It is classified from A through F based on the wind speed, net solar radiation, and atmospheric turbulence. Class A is the most stable, and F is the most unstable.

The most frequent adverse weather conditions in the region occur from severe thunderstorms and tornados. As part of the probabilistic risk assessment performed for the FEMP (DOE 1990), an annual probability was assessed for a tornado occurring per square mile within Ohio. Based on data accumulated for Ohio during the years 1978 through 1990, the annual probability was calculated to be 1.25 in 10,000.

The average annual precipitation for the Greater Cincinnati area for the period of 1960 through 1989 was 40.56 inches and ranged from 27.99 inches in 1963 to 52.76 inches in 1979. The highest precipitation occurs during the spring and early summer. The maximum 24-hour rainfall event on record occurred in March 1964 when 5.21 inches fell. Precipitation is typically lowest in late summer and fall. A histogram summarizing monthly precipitation recorded at the Greater Cincinnati/Northern Kentucky International Airport from 1988 to 1993 is shown in Figure 3-2. Data from daily on-property precipitation measurements from March 1993 to September 1993 are shown in Figure 3-3. The greater detail of daily rainfall amounts in Figure 3-3 provides a more precise comparison of rainfall events to groundwater elevation changes.

The average annual snowfall for the 1960 to 1989 period was 23.5 inches, with the heaviest snowfall usually occurring in January. The maximum monthly snowfall of 31.5 inches occurred in January 1978. The maximum recorded snowfall over a 24-hour period occurred in March 1968 when 9.8 inches was recorded at the Greater Cincinnati/Northern Kentucky International Airport.

The regional climate is defined as continental, with temperatures ranging from a monthly average of 29.2° F in January to 75.7° F in July. The highest temperature recorded from 1960 through 1989 was 103° F in July 1988, and the lowest was -25° F in January 1977. Average ambient air temperatures measured at the FEMP meteorological system for the period of 1987 through 1992 are shown in Table 3-1. The average number of days per year with a minimum temperature of 32° F or less is 109 days, and the average number of days per year with a maximum temperature of 90° F or greater is 20 days. Frost depth ranges from 30 to 36 inches.

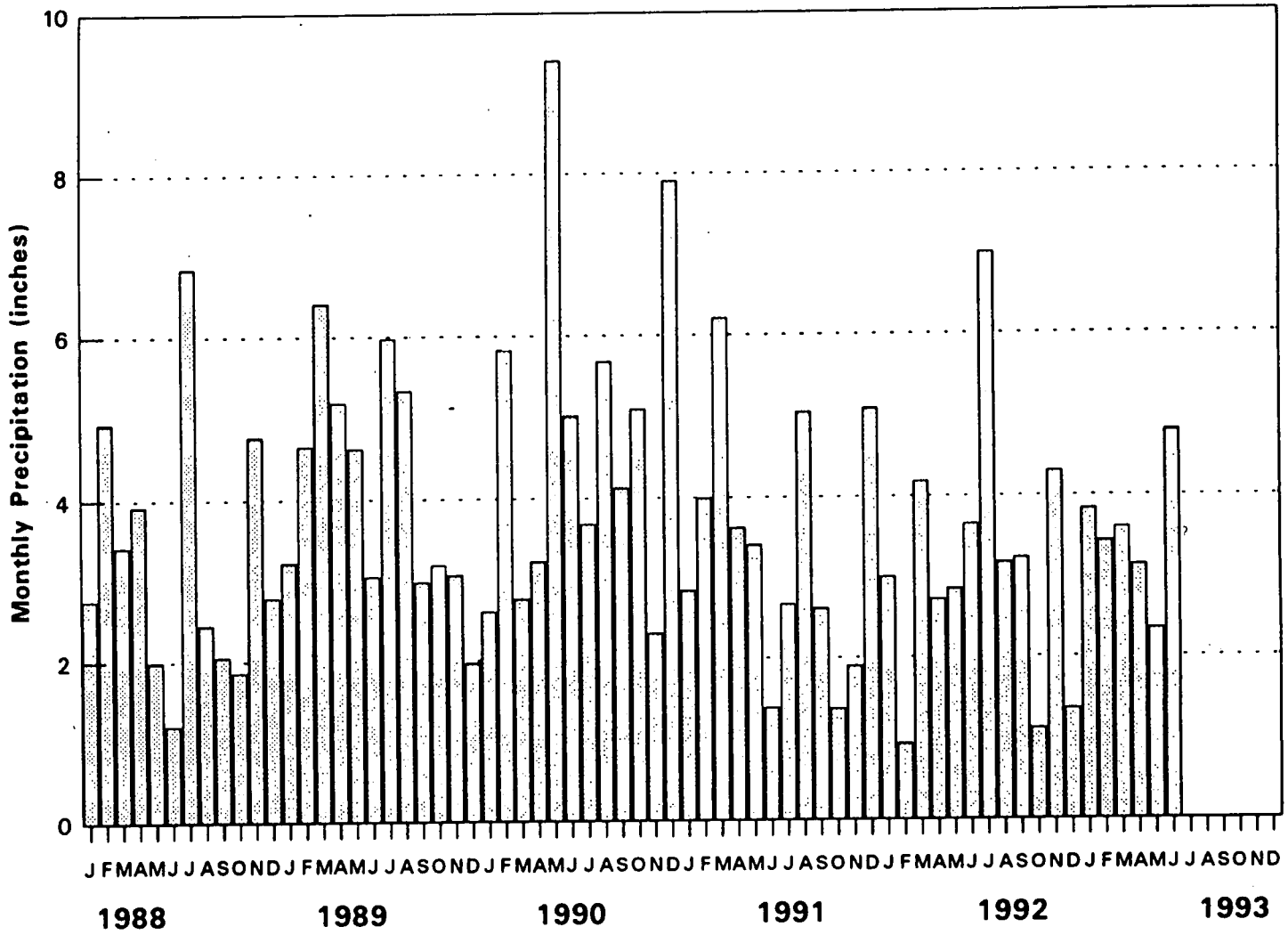


FIGURE 3-2
MONTHLY PRECIPITATION HISTOGRAM FOR BOONE COUNTY, KY. AIRPORT

H:\CRU2\RI\SECTION3\FIG3-02

000198

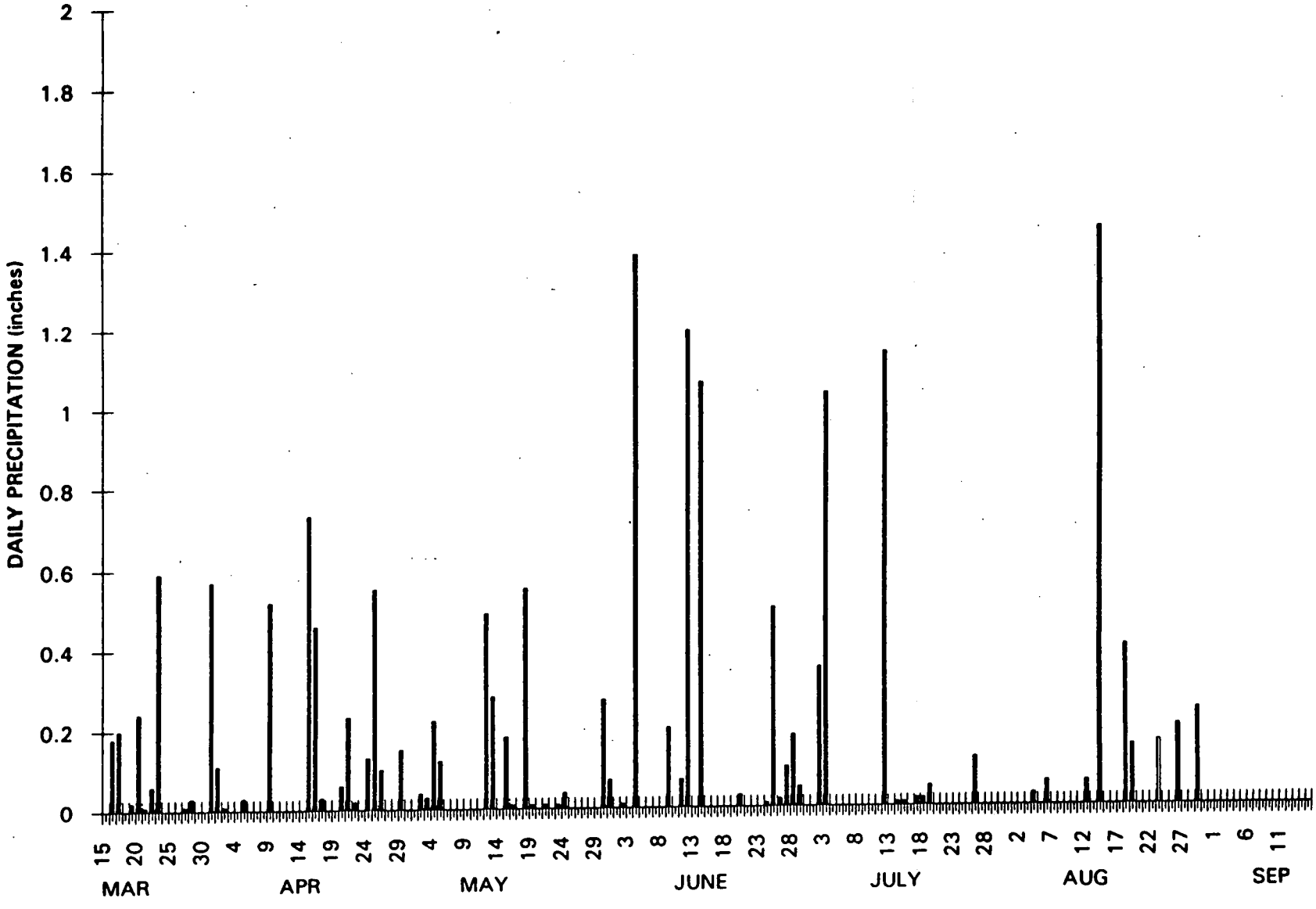


FIGURE 3-3
PRECIPITATION HISTOGRAM FOR ON-SITE DATA

000199

TABLE 3-1

AMBIENT AIR TEMPERATURE MEASURED BY THE FEMP METEOROLOGICAL SYSTEM

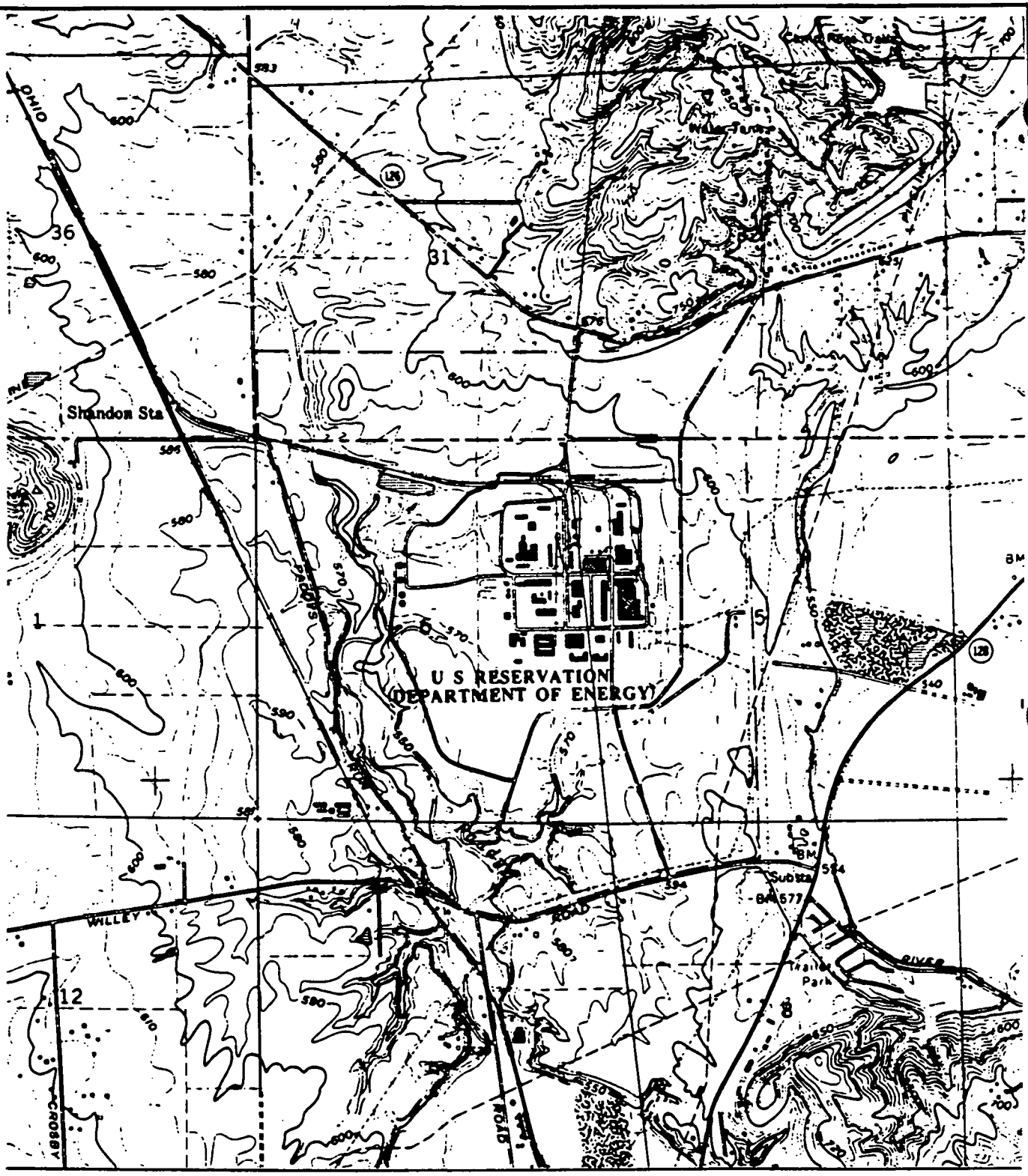
Year	Average Annual Temperature (°F)	Average Annual Daily Minimum Temperature (°F)	Average Annual Daily Maximum Temperature (°F)
1987	50.7	41.0	61.5
1988	52.3	41.9	63.7
1989	52.2	44.1	62.8
1990	52.5	43.2	62.4
1991	55.4	46.8	65.1
1992	52.0	43.3	61.7

3.1.2 Topography and Surface Water Hydrology

The topographic features of the FEMP were evaluated using data from aerial photogrammetry. Maximum elevation along the northern boundary of the FEMP property is a little more than 700 feet above mean sea level (MSL) (Figure 3-4). The former Production Area and Waste Storage Area rest on a relatively level plain at about 580 feet above MSL. The plain slopes from 600 feet above MSL along the eastern boundary of the FEMP to approximately 575 feet above MSL at the west edge of Waste Pit 3, and then drops off toward Paddys Run at an elevation of 550 feet above MSL. Surface water drainage on the FEMP is generally from east to west toward Paddys Run, with the exception of the extreme northeast corner, which drains east toward the Great Miami River (Figure 3-5). The storm water drainage from the former Production Area and Waste Storage Area is now controlled and discharged to the Great Miami River.

Data concerning surface water hydrology has been derived from site studies and from data provided by the USGS, Federal Emergency Management Agency (FEMA), and the Miami Conservancy District. The Fernald site is located within the Great Miami River Basin drainage, and parts of the site are within the Paddys Run 100-year floodplain. The Great Miami River flows within 0.75 miles of the facility's eastern boundary and discharges into the Ohio River approximately 24.1 river miles (RM) from the FEMP effluent line. Tributaries to the Great Miami River in the FEMP region include Banklick Creek at RM 28; Indian Creek at RM 27, just east of Ross, Ohio; Owl Creek at RM 22; and Blue Rock Creek, which enters the river at RM 21. Paddys Run flows along the FEMP's western boundary and joins the Great Miami River at approximately RM 19.5. Taylor Creek enters the river at approximately RM 14.4. The Whitewater River discharges into the Great Miami River at RM 6.

Rivers and intermittent streams on or adjacent to the FEMP are the Storm Sewer Outfall Ditch, Paddys Run, and the Great Miami River and are shown in Figure 3-6. No lakes occur near the Fernald site. The Storm Sewer Outfall Ditch originates within the FEMP and flows toward the southwest where it enters Paddys Run, which flows southward along the western boundary of the facility. Paddys Run, in turn, is a tributary of the Great Miami River. The Great Miami River flows generally toward the southwest. In the vicinity of the FEMP, however, it flows to the east and south. The drainage that feeds the Storm Sewer Outfall Ditch originates east of the former Production Area and is channeled within a culvert under the parking lot south of the former Production Area where it enters the Storm Sewer Outfall Ditch. The Storm Sewer Outfall Ditch then flows southwest across



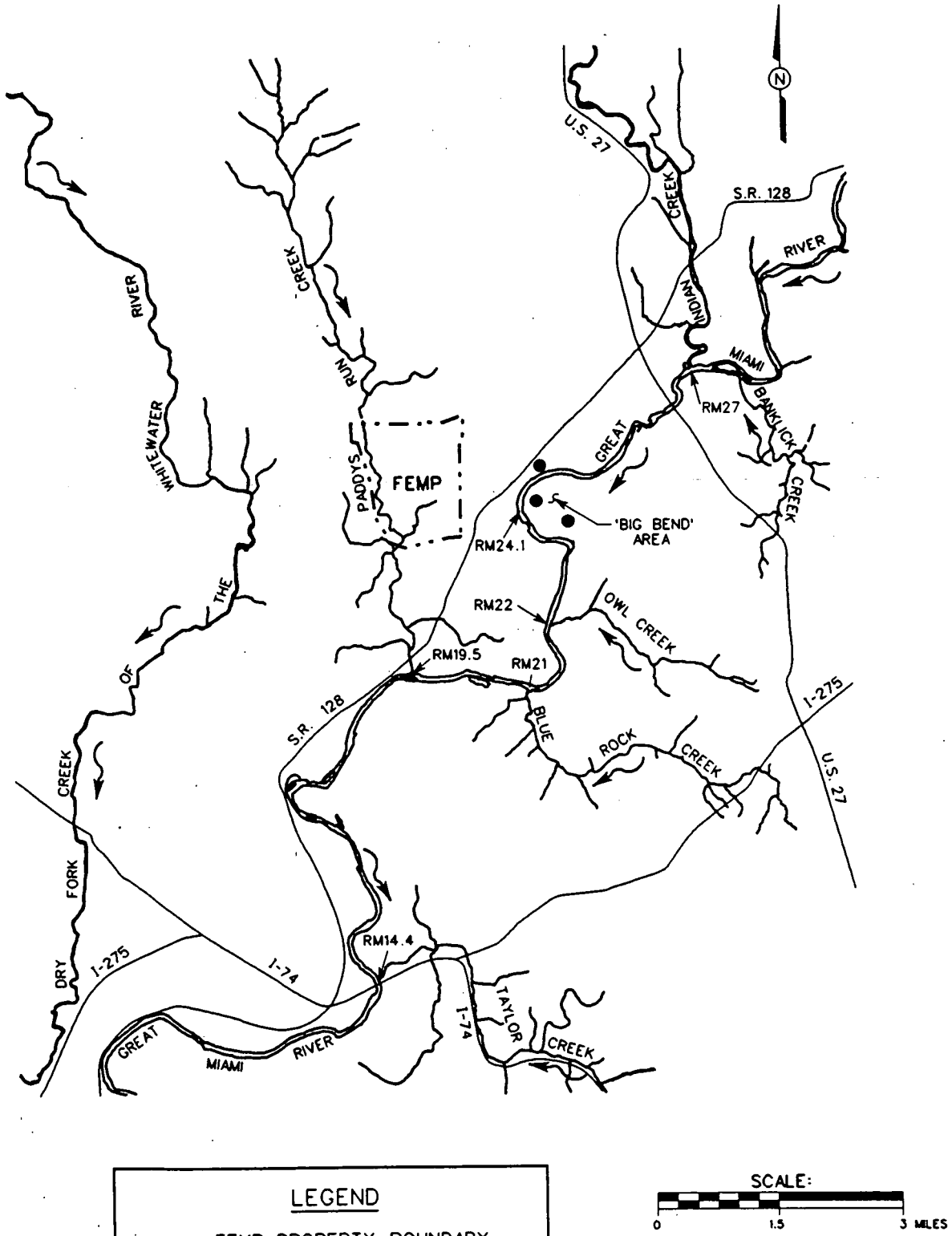
SOURCE: USGS 7.5 MINUTE QUADRANGLE, SHANDON, OHIO (1981)

FIGURE 3-4

TOPOGRAPHIC MAP OF THE FEMP

fig0304.dgn

000202



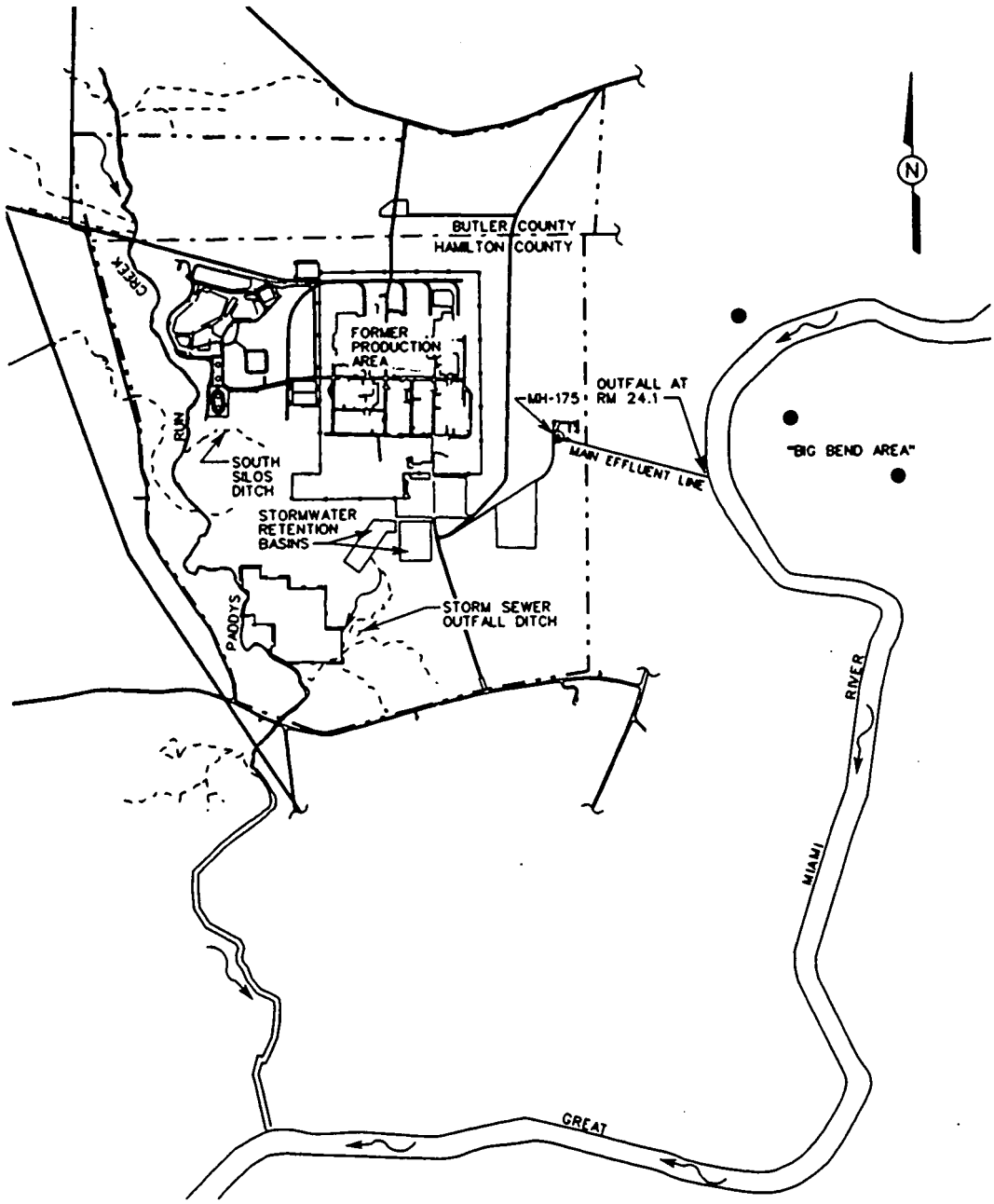
LEGEND

- FEMP PROPERTY BOUNDARY
- SOUTHWESTERN OHIO WATER COMPANY WELL FIELD
- RM22 RIVER MILE ALONG THE OHIO RIVER
- DIRECTION OF FLOW
- ROADWAYS

SCALE: 0 1.5 3 MILES

FIGURE 3-5
SURFACE WATER FEATURES AND DRAINAGE PATTERNS

fig0306.dgn



LEGEND

RM24.1 RIVER MILE FROM THE OHIO RIVER

- - - - DRAINAGE WAY

CSX RAIL LINE

DIRECTION OF FLOW

FEMP PROPERTY BOUNDARY

● SOUTHWESTERN OHIO WATER COMPANY WELL FIELD

NOT TO SCALE

NOTE:

1. SOURCE-RI/FS OU1 REPORT, 2-93, FIGURE 3-4.

FIGURE 3-6
SURFACE WATER BODIES ON AND ADJACENT TO THE FEMP

fig0305.dgn

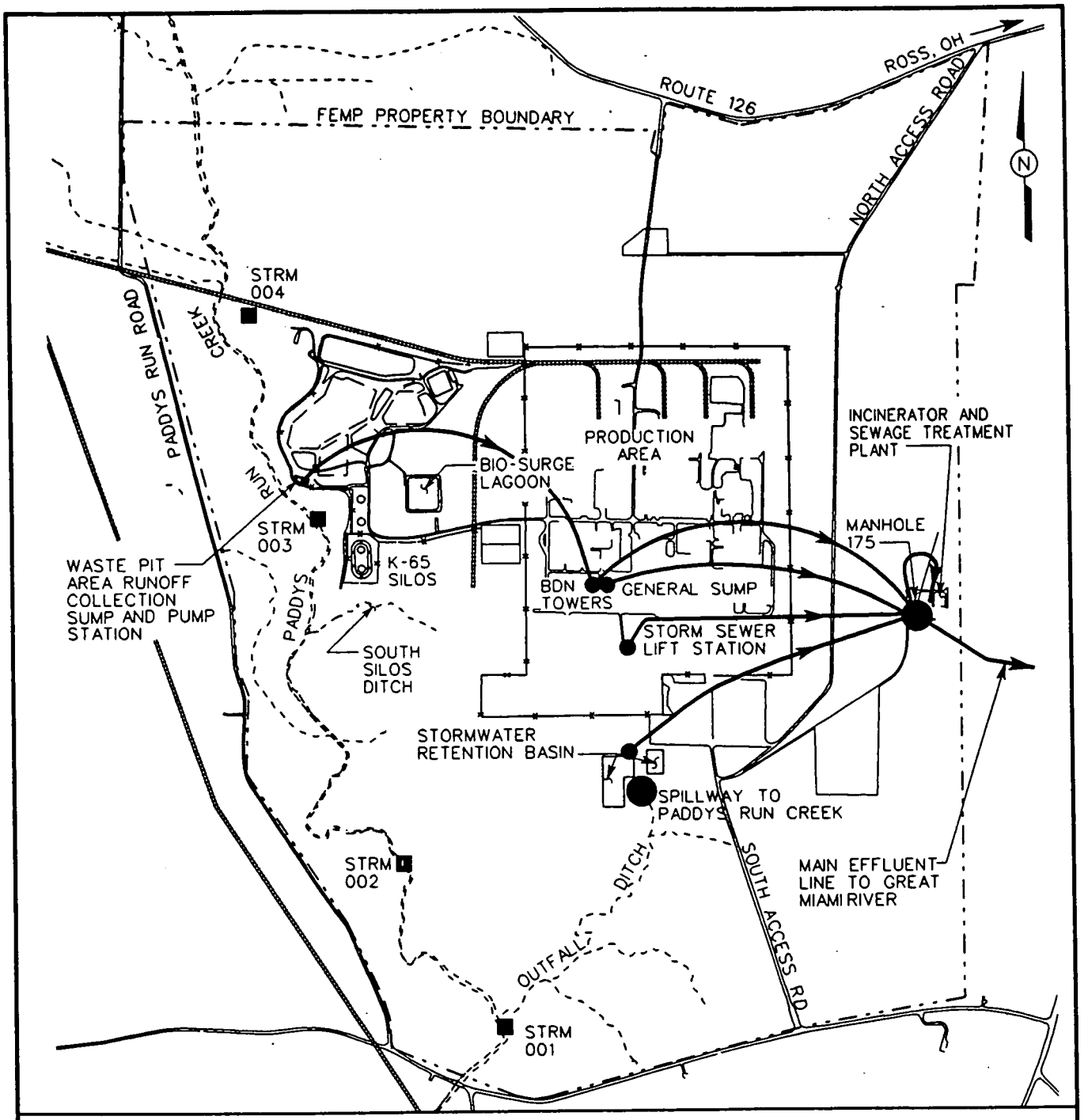
000204

the southern portion of the site and enters Paddys Run near the southwest corner of the property. The Storm Sewer Outfall Ditch has cut a gully more than 30 feet deep through the clay-rich surface deposits of the Fernald site. This erosion has occurred since the last glaciation (Wisconsin) over a period of approximately 20,000 years. Much of the stream bottom of this drainage is composed of sand and gravel and may be highly permeable. Loss of flow to the underlying Great Miami Aquifer may be significant. Throughout the year, this drainage course is generally dry, with flows occurring only during and immediately after precipitation.

The Storm Sewer Outfall Ditch historically has conveyed surface water runoff from the former Production Area directly into Paddys Run during periods of heavy precipitation when the pumping capacity of the FEMP storm sewer lift station was exceeded. The storm sewer lift station transfers former Production Area storm water runoff through an effluent line to the Great Miami River. A two-chamber storm water retention basin was constructed to collect storm water runoff at the discharge point on the Storm Sewer Outfall Ditch (Figure 3-7). The first chamber was constructed in October 1986 and the second in December 1989. Storm water runoff from the former Production Area is now conveyed to the Storm Water Retention Basin. After a minimum retention period of 24 hours to allow for settling of suspended solids, the water is pumped out of the basin into the Great Miami River through the main effluent line of the FEMP. 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 former Production Area enter the Storm Sewer Outfall Ditch.

Paddys Run originates north of the Fernald site, intermittently flows southward along the western boundary of the facility, and enters the Great Miami River approximately 1.5 miles south of the southwest corner of the FEMP property. The stream is approximately 8.8 miles long and drains an area of approximately 15.8 square miles. Natural surface drainage from the FEMP is toward Paddys Run, which in post-glacial time, has eroded 30 feet or more through the glacial till deposits upon which the facility is built. Significant loss of Paddys Run flow to the regional Great Miami Aquifer begins approximately south of the Waste Pit Area. This characteristic contributes to the intermittent nature of the stream, which usually flows throughout its entire length between January and May.

Paddys Run is a steep-sided stream, and its banks erode severely during high flow periods. In 1961 and 1962, the course of the stream was altered to prevent it from eroding into the Silo and Waste Pit Areas (WMCO 1987). In 1970, a reach of the stream south of the K-65 silos was straightened to



NOTE:

1. SOURCE-FEMP ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1991, FEMP-2255.

SCALE:

0 1300 FEET

LEGEND:

- NPDES EXTERNAL DISCHARGE TO OHIO WATERS
- NPDES INTERNAL MONITORING LOCATION
- STRM 002 — NPDES STORMWATER MONITORING LOCATION
- PATH OF PUMPING
- FENCE LINE
- DRAINAGE WAY
- CSX RAIL LINE
- ROADWAY
- FEMP PROPERTY BOUNDARY

fig0307.dgn

FIGURE 3-7
STORM WATER COLLECTION SYSTEM FOR THE FEMP

prevent erosion of Paddys Run Road. The stream is ungauged, but typical flows for the January through May period range from 0.2 to 4.0 cubic feet per second (ft^3/s). Channel overflow resulting from 25-year, 100-year, and 24-hour storm events is possible, but peak flows occurring during storm events have not been measured.

The Great Miami River is the main surface water feature in the vicinity of the FEMP and receives water from the FEMP NPDES-permitted discharge. The river generally flows to the southwest and has a drainage area of approximately 3,360 square miles at the Hamilton gauge, which is located about 10 miles upstream from the FEMP discharge outfall.

The river exhibits meandering patterns that result in sharp directional changes over distances of less than 3,000 feet. Directly east of the FEMP, the river passes through a 180-degree curve known as the Big Bend (Figure 3-6). A 90-degree bend in the river also occurs near New Baltimore, Ohio, approximately two miles downstream from the FEMP point of discharge.

The average discharge of the Great Miami River at Hamilton, Ohio, based on 55 years of records, is 3,305 ft^3/s. Using drainage area scaling, the corresponding average flow at the FEMP point of discharge has been estimated at 3,460 ft^3/s. The maximum discharge recorded for the Great Miami River at Hamilton, Ohio, occurred on March 26, 1913, and was estimated at 352,000 ft^3/s. The maximum discharge since the construction of five retarding basins in 1922, located approximately seven miles upstream of Ross, Ohio, was 108,000 ft^3/s and occurred on January 21, 1959. The minimum daily discharge of 155 ft^3/s was recorded on September 27, 1941. This value is approximately half of the 7-day, 10-year low flow value of 267 ft^3/s, as computed by the USGS for the Hamilton gauge, which corresponds to 280 ft^3/s along the portion of the river shown in Figure 3-6.

3.1.3 GEOLOGY AND GROUNDWATER HYDROLOGY

This section presents a summary of the geologic history, geology, and hydrogeology, which has been developed for the FEMP and surrounding area based on published studies, with modifications and extensions resulting from data collected during the Phase I and Phase II field investigations.

3.1.3.1 Physiography

The Fernald site lies in the Till Plains section of the Central Lowland physiographic province, characterized by structural and sedimentary basins and domes. Among these features, the Cincinnati Arch is structurally significant in this region. The regional bedrock is shale and fossiliferous limestone of Middle and Late Ordovician Age (Fenneman 1916). In some areas, it is overlain by glacial deposits that range in thickness to as much as 400 feet.

The main physiographic features in the area are gently rolling uplands, steep hillsides along the major streams, and the Great Miami River Valley. This valley is a relatively broad, flat-bottomed valley flanked on either side by bluffs that rise to a maximum of 300 feet above the general level of the valley floor.

3.1.3.2 Geologic History

The geologic history of the FEMP is based on Fenneman (1916), Brockman (1988), and the ongoing field investigation for the Operable Unit 5 RI Report. A generalized stratigraphic column of the FEMP region is shown in Figure 3-8. In summary, the FEMP overlies a 2- to 3-mile-wide, buried Pleistocene valley known as the New Haven Trough. This valley was formed (eroded) by the ancestral Ohio River during the Pleistocene Age (approximately 3 million years to 8,000 years ago) and was subsequently filled with glacial outwash deposits (primarily sands and gravels). These materials were covered by glacial overburden (loess and glacial till with the inclusion of glaciofluvial and glaciolacustrine deposits) as glaciers advanced and receded across the area (Figure 3-9). The outwash deposits under the Fernald site are a part of the Great Miami Aquifer, which is a widely distributed buried valley aquifer. In addition to surface water, the valley fill aquifer system is the major source of drinking water in the southwestern Ohio area.

During the late Ordovician (approximately 450 million years ago), sediment that eventually became a predominantly flat-lying shale with thin interbedded limestone was deposited in a shallow sea. This shale is the relatively impermeable bedrock that now underlies the FEMP Study Area and forms the adjacent highlands. The advance of Nebraskan and Kansan glaciation to the north of Cincinnati created a drainage system known as the Deep Stage Drainage System (Figure 3-10). This drainage system was composed of three major rivers: the Great Miami River, the East Fork of the Little Miami River, and the Licking River. The Great Miami River followed much the same channel as the present-day Great Miami River from Middletown, Ohio to Ross, Ohio. The East Fork of the Little

6505

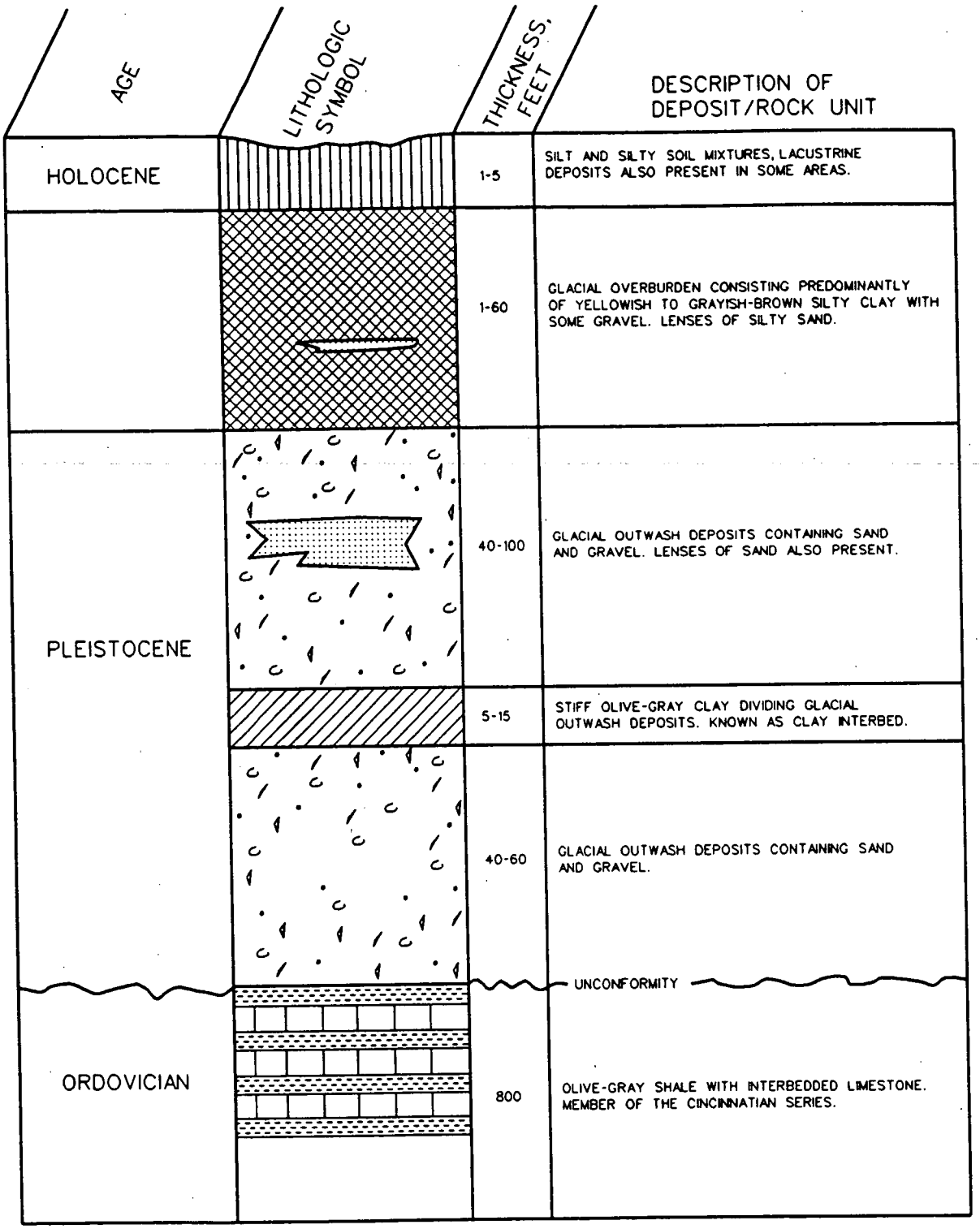
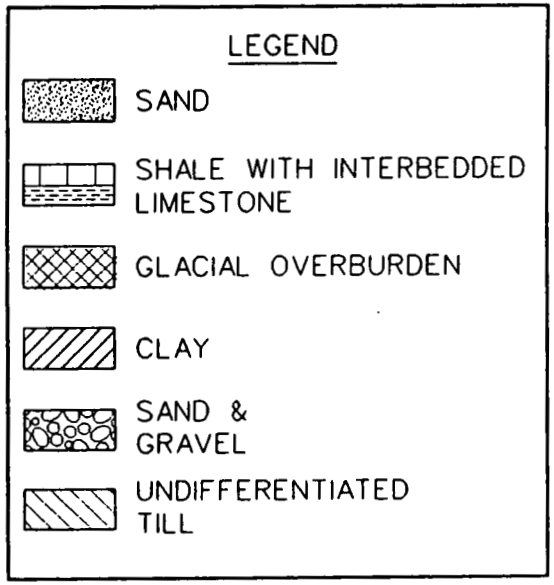


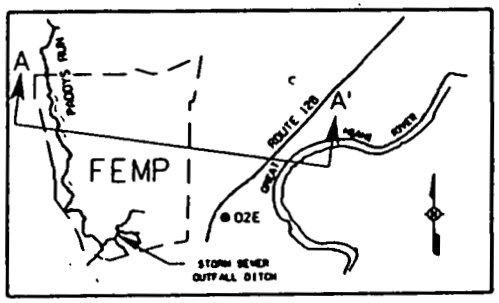
fig00308.dgn

FIGURE 3-8
GENERALIZED STRATIGRAPHIC COLUMN OF THE FEMP REGION

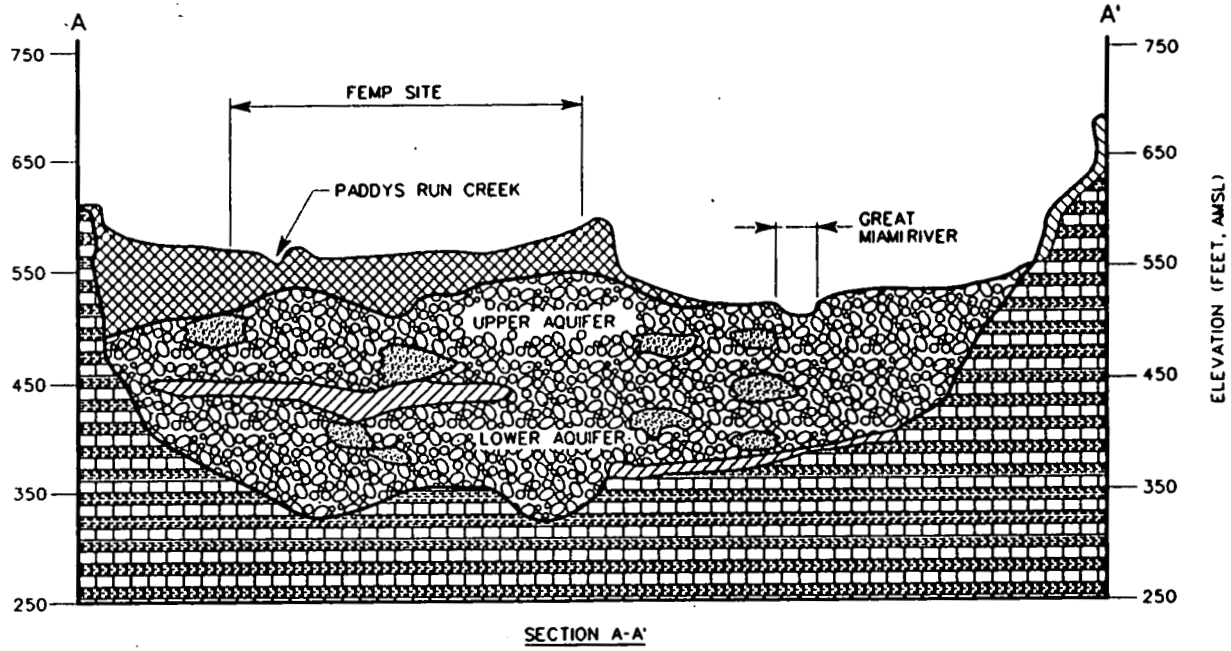
000509

fig0309.dgn





LOCATION KEY



NOTE:

1. SOURCE-1991 RCRA ANNUAL REPORT, FIGURE 2.0B.

FIGURE 3-9
SCHEMATIC CROSS SECTION OF THE FEMP AREA

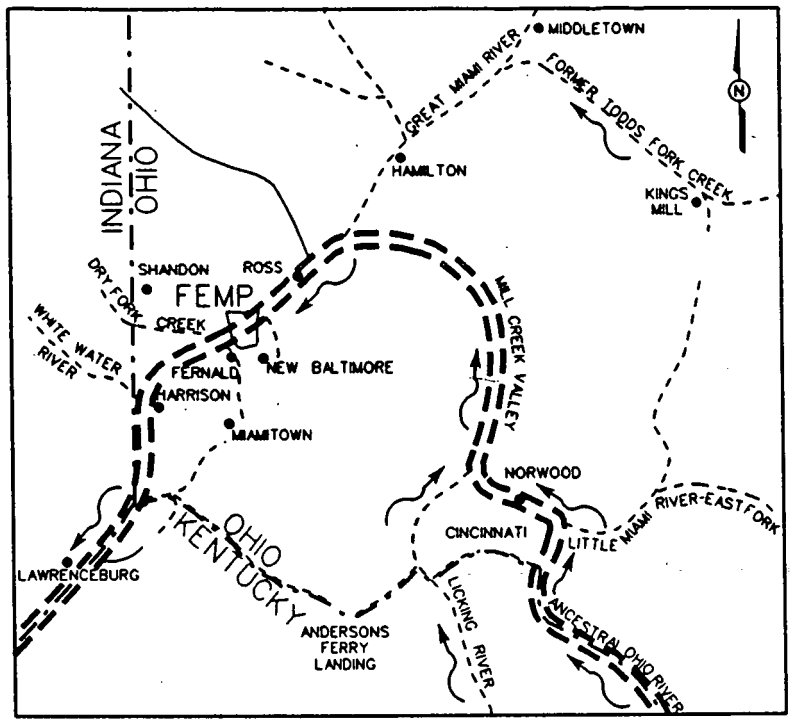


FIGURE 3-10A. DEEP STAGE (ANCESTRAL) DRAINAGE SYSTEM

LEGEND:

- DIRECTION OF FLOW
- ANCESTRAL OHIO RIVER
- STATE BOUNDARY
- STREAM

NOTE:

1. SOURCE - FENNEMAN, N.M., 1916 "THE GEOLOGY OF CINCINNATI AND VICINITY", GEOLOGICAL SURVEY OF OHIO, BULLETIN 19.

NOT TO SCALE

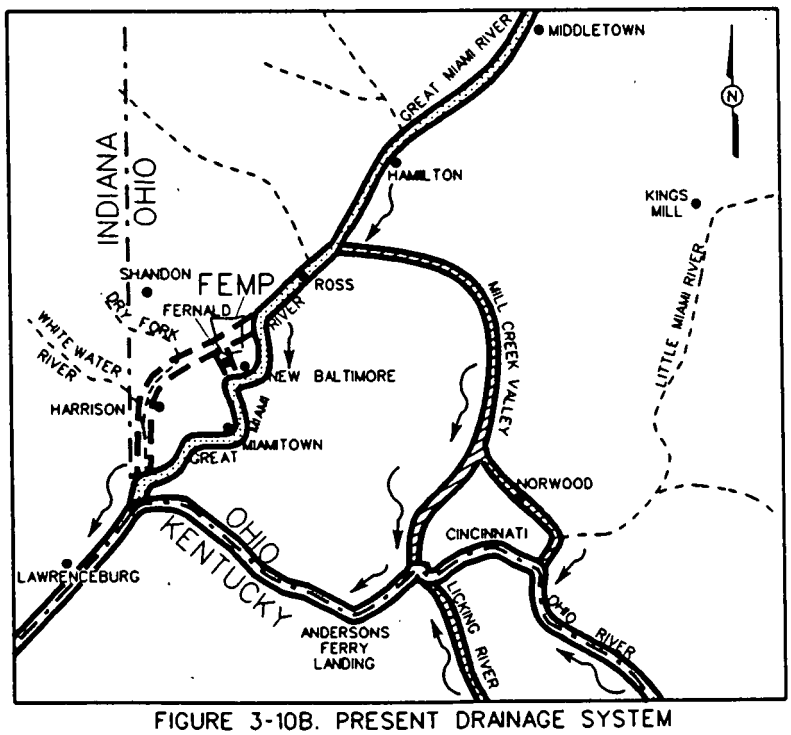


FIGURE 3-10B. PRESENT DRAINAGE SYSTEM

LEGEND:

- DIRECTION OF FLOW
- GREAT MIAMI RIVER
- PRESENT OHIO RIVER
- NEW HAVEN TROUGH
- MILL CREEK VALLEY
- STATE BOUNDARY
- STREAM

NOTE:

1. SOURCE - FENNEMAN, N.M., 1916 "THE GEOLOGY OF CINCINNATI AND VICINITY", GEOLOGICAL SURVEY OF OHIO, BULLETIN 19.

NOT TO SCALE

FIGURE 3-10
SCHEMATIC DIAGRAM OF
THE DEEP STAGE DRAINAGE
AND THE PRESENT DRAINAGE SYSTEM

fig0310.dgn

Miami River entered the area from the east. The Licking River came in from the south in essentially its present-day channel, but continued to the north of the present day Ohio River. These three rivers combined to form what is known as the ancestral Ohio River, which entered the area from the east along the present-day channel of the Ohio River, then turned northeast through the valley now occupied by the Little Miami River.

Several tributary streams of later importance entered the main stream in the vicinity of the Fernald site. Two streams originated near Miamitown, Ohio: one flowed north to join the main stream between Shandon, Ohio and Fernald, Ohio and the other flowed south following the course of the present-day Great Miami River. One other small stream originated near New Baltimore, Ohio and flowed north to the main stream. The Dry Fork of the Whitewater River, which now lies to the west of the area, formerly turned eastward to Shandon, Ohio and then flowed south through what is now the Paddys Run Valley.

During the time of Deep Stage Drainage and the early stages of Illinoisan Glaciation (300,000 to 400,000 years ago), the river valleys cut deeply into the shale bedrock to depths up to 200 feet below current land elevations. As the Illinoisan ice sheet advanced into the area, ice began to block the Great Miami River and its confluence with the ancestral Ohio River. For a time, water still flowed westward along the front of the advancing ice sheet and carved the present-day Great Miami River Valley along the tributary system near Miamitown, Ohio.

When the confluence of the Great Miami River and the ancestral Ohio River was completely blocked, ponded water in the Mill Creek Valley rose until it overflowed low divides and carved outlets at Anderson's Ferry and at what is now downtown Cincinnati. This course created the present-day channel of the Ohio River (Figure 3-10).

The Great Miami River was forced out of the Deep Stage Valley during a subsequent ice advance, carving a new narrow deep stage valley from just north of New Baltimore, Ohio to a location about one mile west of Cleves, Ohio, where it returned to the original Deep Stage Valley. Because only water from the Great Miami River and its tributaries carved this valley, it was much smaller than the ancestral Ohio Valley. This 2-mile-wide valley where the FEMP is located was termed the New Haven Trough by Fenneman (1916). As the ice retreated, the Deep Stage Valley, including the New Haven Trough, was filled with well-sorted sand and gravel outwash deposits. This formed the Great

Miami Aquifer, and the Great Miami and Ohio rivers were established in their present-day channels. During the last stage of glaciation, Wisconsin Glaciation (approximately 20,000 years ago), the ice sheet advanced only as far as the south side of the FEMP deflecting the Dry Fork of the Whitewater River to the west from its former valley (Figure 3-11). A terminal moraine was deposited at a point near the glaciers southernmost extent (Figures 3-11 and 3-12). As the ice front receded northward, till and lacustrine strata were deposited by the glacier. Within the till are deposits of debris flows and discontinuous sand bodies. The lacustrine strata are lake deposits that accumulated within a closed topographic depression (basin) on the northeast side of the Shandon Trough terminal moraine (see Figures 3-11 and 3-12). The lake deposits are debris flows, shoreline and deltaic sands, and lake clays of low energy deposition. The process of ice retreat left a second moraine, a recessional moraine, west and north of the present day former Production Area (Figure 3-12). Subsequent to the glaciers retreat, wind-blown silt and loess were deposited as a blanket over the area.

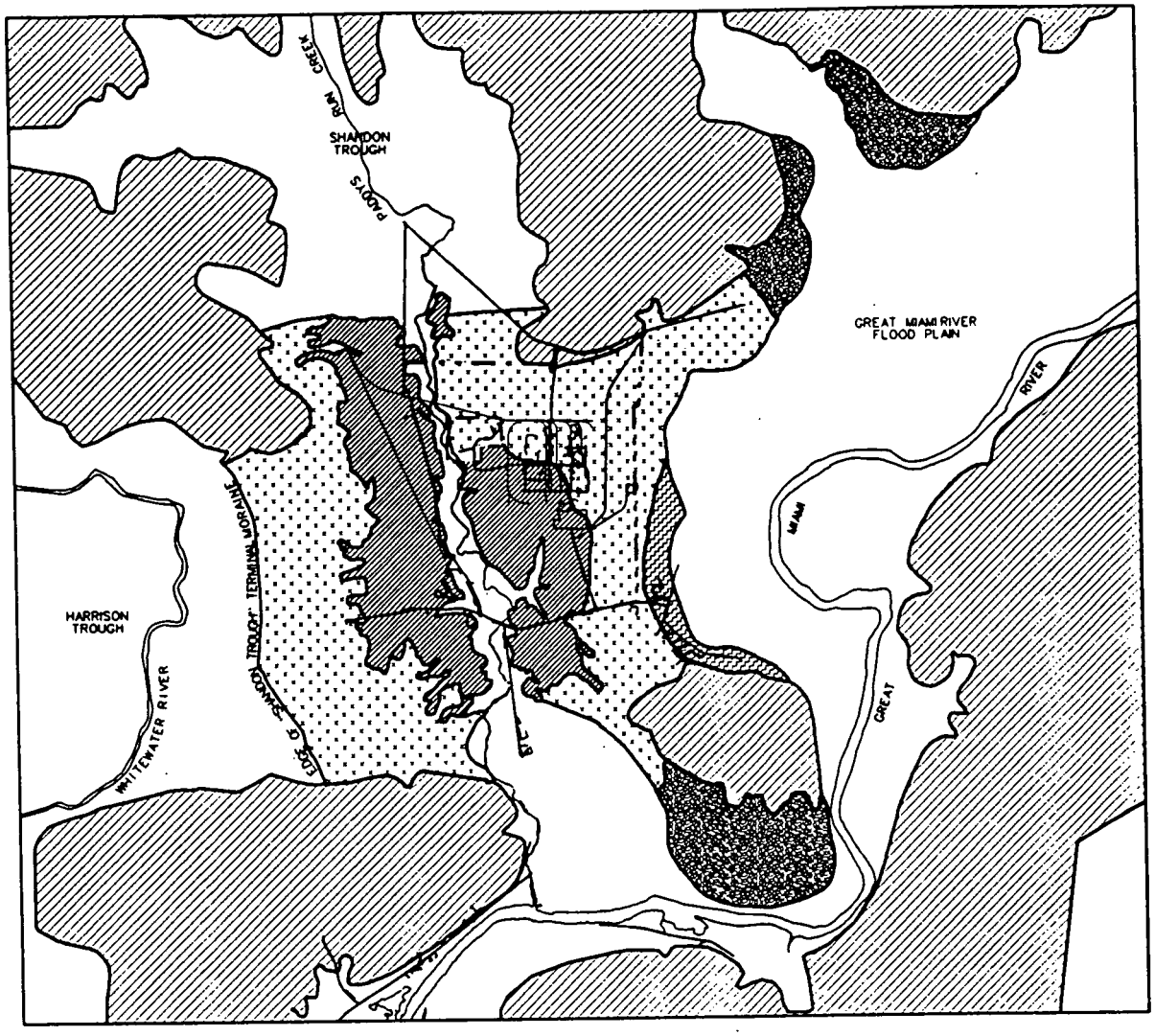
Since the last retreat of continental glaciers, the streams in the area have removed much of the glacial overburden and lacustrine strata left by the ice sheets. The Great Miami River has eroded through the glacial overburden and is now in direct contact with the glaciofluvial outwash deposits that comprise the Great Miami Aquifer. Paddys Run is also in contact with these deposits in its lower reaches. The Fernald site is located on a dissected glacial overburden plain left by the Wisconsin Glaciation.

Figures 3-11 and 3-12 show the surface geology as it would have appeared prior to site construction. The schematic cross section in Figure 3-9 and stratigraphic column in Figure 3-8 show the general subsurface geology: a valley carved into shale bedrock; filled with outwash sand and gravel; capped by a predominantly clay/silt dominated glacial overburden; and dissected by erosion along Paddys Run and the Great Miami River.

3.1.3.3 Site-Wide Hydrogeology

The stratigraphic column for the FEMP was presented as Figure 3-8. Significant hydrogeologic components of that stratigraphy include (from surface to bedrock) the glacial overburden, glacial outwash, and the Ordovician shale and limestone bedrock.

Overlying the Great Miami Aquifer throughout most of the FEMP property are a series of glacial overburden deposits. The glacial overburden is composed primarily of till: a dense, silty clay that



LEGEND

- UNDIFFERENTIATED ALLUVIUM AND GLACIAL SEDIMENTS
- WISCONSIN TILL WITH LOESS CAP
- ALLUVIAL TERRACES
- UNDIFFERENTIATED TERRACES/TILL
- WISCONSIN LACUSTRINE SEDIMENTS WITH LOESS CAP
- ORDOVICIAN LIMESTONE/SHALE WITH THIN MANTLE OF ILLINOISAN, WISCONSIN, OR RECENT SEDIMENTS
- FEMP PROPERTY BOUNDARY

N

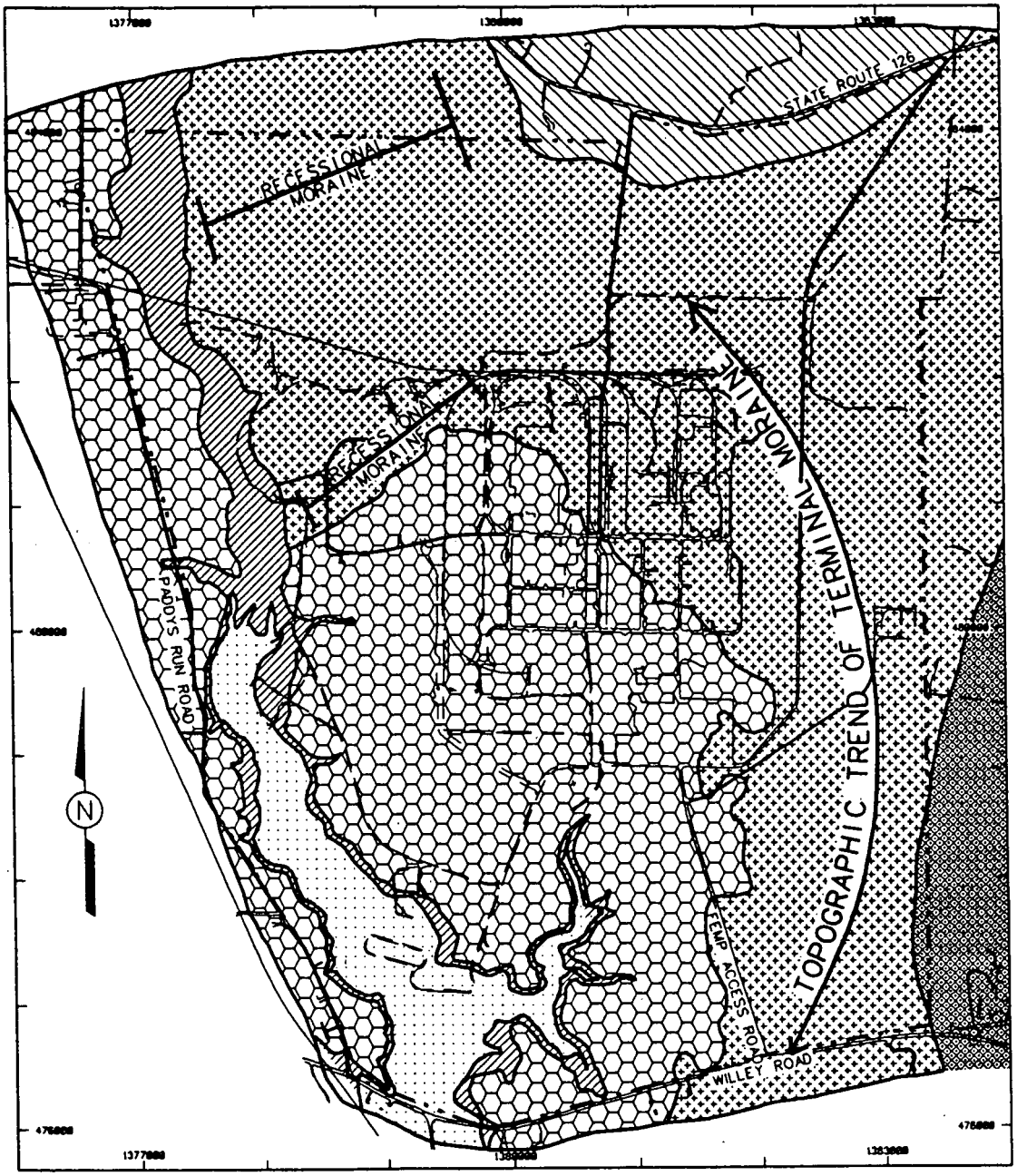
SCALE:
0 1 MILE

NOTE:
SOURCE- RI/FS OU4 REPORT, 4-93, FIGURE 3-12.

FIGURE 3-11
CONCEPTUAL MAP OF
SURFACE GEOLOGY

fig0311.dgn

000214



LEGEND:

- ALLUVIUM, FLUVIAL DEPOSITS OF RECENT (HOLOCENE)
- TILL, WISCONSIN AGE.
- FINE TO COARSE SAND.
- LACUSTRINE DEPOSITS OF LATE WISCONSIN (?) AGE.
- TILL, WISCONSIN AGE (SHELBYVILLE TILL).
- ORDOVICIAN AGE BEDROCK (ALTERNATING LAYERS OF LIMESTONE AND SHALE)
- CONTACT OF MAP UNITS
- FEMP PROPERTY BOUNDARY
- LOCATION OF RECESSIONAL MORAINES. BARS INDICATE WIDTH OF TOPOGRAPHIC EXPRESSION OF MORAINE.

NOTE:

1. SOURCE-RI/FS OU4 REPORT FIGURE 3-13.

500' 0' 1000'

SCALE: 1" = 1000'-0"
NAD27

FIGURE 3-12
GENERALIZED MAP OF
PRE-SITE CONSTRUCTION
SURFACE GEOLOGY

fig0312.dgn

contains lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt. The saturation of the clay in the till is variable, from saturated to unsaturated. This is evident by the moisture content observed from samples collected within the till, which ranged from approximately 6 percent to 28 percent. Undisturbed glacial till exposed at the surface has relatively low permeability, so most of the precipitation that falls on it is lost to evaporation and surface water runoff. Limited infiltration occurs along the upper weathered portion of the overburden, where occasionally small fracture zones of approximately one-foot thick were observed, and in isolated areas where more permeable deposits of silt, sand, and gravel are the primary overburden constituents. Lacustrine deposits lie upon till in places. The lacustrine deposits incorporate laterally extensive permeable sand/silt strata.

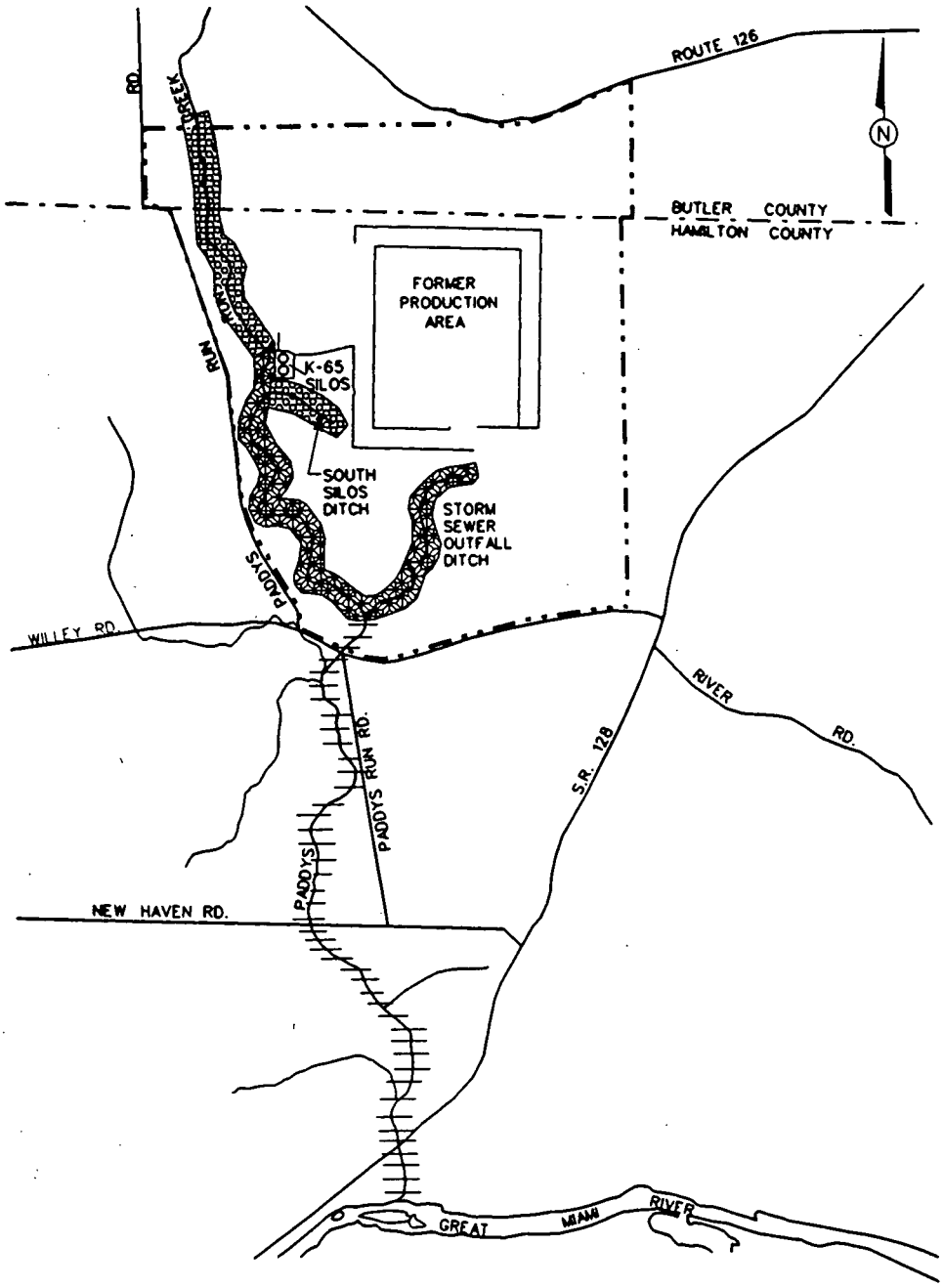
The thickness of the glacial overburden ranges from 0 to 50 feet within the FEMP Study Area, but most commonly averages between 20 and 30 feet. Except for some scattered deposits, this overburden does not exist along the floodplain of the Great Miami River to the east and south of the FEMP. Streams in this area are in direct contact with the upper Great Miami Aquifer along their reaches, allowing surface water leakage directly to the Great Miami Aquifer. Areas of inferred surface water infiltration to the aquifer along Paddys Run and the Storm Sewer Outfall Ditch are shown in Figure 3-13.

Erratically distributed pockets of sand and gravel within the glacial overburden contain zones of perched groundwater. Perched groundwater is separated from the underlying aquifer by the relatively impermeable clays and silts of the glacial overburden. These low-permeability clay and silt units behave as an aquitard that can store groundwater but transmit it slowly downward from one more porous saturated zone to another.

Depth to perched groundwater at the FEMP ranges from 1 to 15 feet below ground surface. This measurement can fluctuate seasonally by up to 10 feet at a single location, with the highest water levels occurring during the early spring and the lowest during the late fall.

Perched groundwater underlying the FEMP property is believed to flow laterally down topographic gradients or toward surface drains as well as vertically downward. There is uncertainty, however, regarding the rate of horizontal and vertical movement of perched groundwater. Perched zones may not be interconnected across the property, and layered materials comprising the overburden vary

6505



LEGEND:

- FEMP PROPERTY BOUNDARY
- COUNTY LINE
- GLACIAL OVERBURDEN PRESENT: MINIMUM STREAM INFILTRATION EXPECTED
- PERENNIAL WATER INFILTRATION
- SEASONAL SURFACE WATER INFILTRATION

SCALE: 0 — 2000 FEET

NOTES:

1. AREAS OF SURFACE WATER INFILTRATION ARE APPROXIMATE.
2. SOURCE - RI/FS OUI REPORT, 2-93, FIGURE 3-8.

FIGURE 3-13
AREAS OF INFERRED SURFACE WATER INFILTRATION TO THE GREAT MIAMI AQUIFER ALONG PADDYS RUN AND THE STORM SEWER OUTFALL DITCH

fig0313.dgn

000217

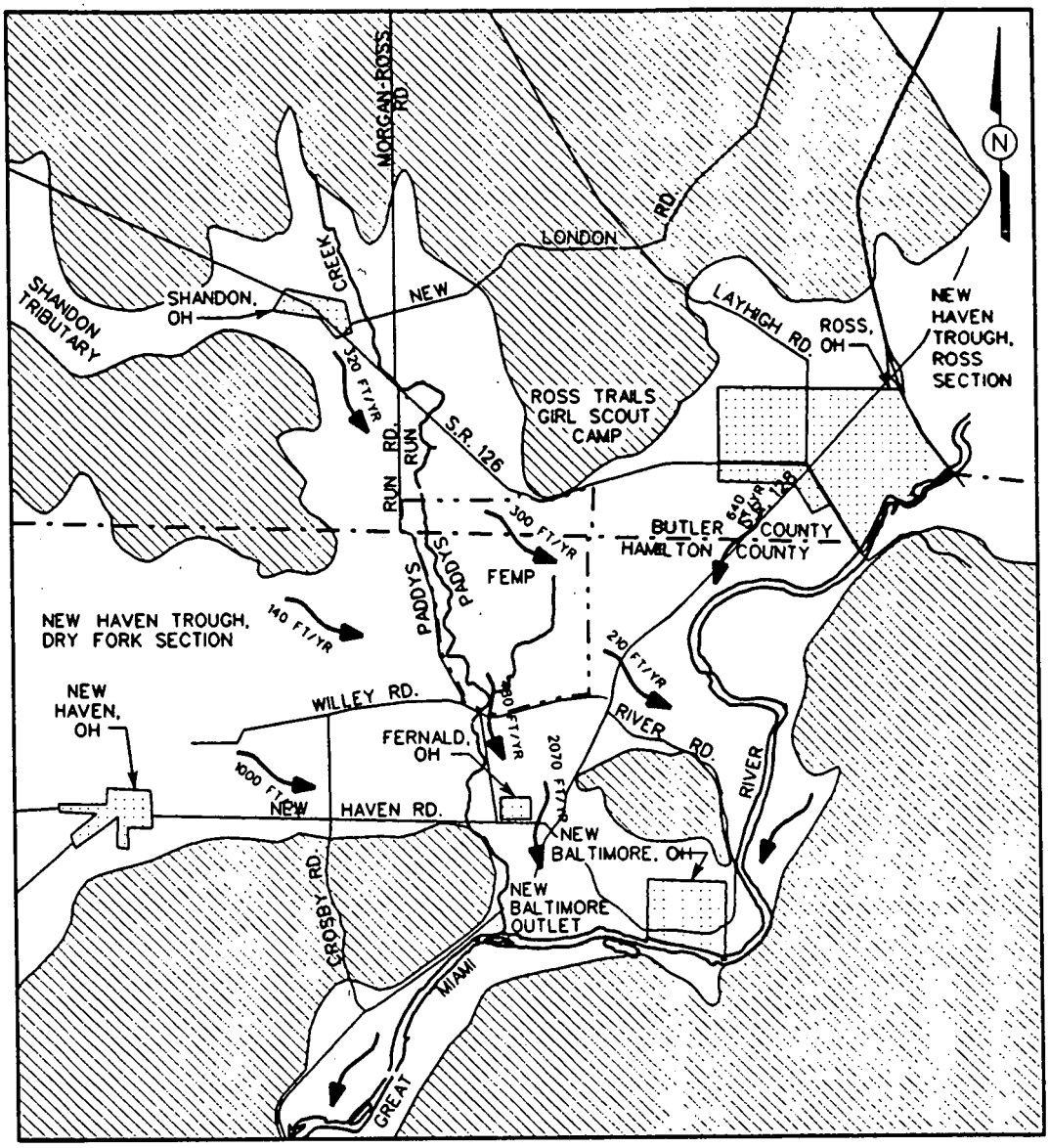
considerably in their ability to confine or transport water. Other influences on flow patterns within perched zones may include seasonal variations in rainfall and recharge and the presence of features such as storm sewers and agricultural drain tiles that were installed before the construction of the FEMP.

Core permeability tests on undisturbed soil samples have been performed on 28 samples from soil borings drilled during the site-wide investigation. Materials in these cores were described as clay-rich till and lacustrine deposits collected from depths of 1.0 to 33.0 feet. The permeability values measured for these cores ranged from 3.9×10^{-9} to 7.2×10^{-7} centimeters per second (cm/s), suggesting that clay-rich tills have very low hydraulic permeabilities.

Hydraulic conductivity measurements from 18 slug tests are shown in Table 3-2. Slug tests were performed in wells or piezometers completed in glacial overburden materials that included at least a few feet of glaciofluvial sand or sandy silt; conductivities ranged from 4.1×10^{-6} to 4.7×10^{-3} cm/s (Appendix H of this RI report), suggesting high conductivity for these sands. No attempt was made to correlate sand unit thickness and the hydraulic conductivity measured by slug tests. Slug test measurements are controlled by sand grain texture and so the gradational sand unit thickness is believed to be as important as sorting. The sand unit was correlated across several of the Operable Unit 2 waste units and was called the perched ground water within each subunit. The relationship of this sand layer to Site-Wide hydrogeological system will be investigated by Operable Unit 5.

The uppermost saturated zone within the glacial outwash deposits underlying the glacial overburden is unconfined and is known as the Great Miami Aquifer. Out wash deposits of the Great Miami Aquifer are regionally extensive and act as a conduit for groundwater that flows south and east beneath the site from off site. The regional generalized groundwater flow pattern in the Great Miami Aquifer is shown in Figure 3-14.

Groundwater enters the FEMP area from three directions. In the northeast, groundwater moves southwest from the Ross area into the portion of the New Haven Trough now occupied by the Great Miami River. The second source of groundwater is the Shandon Tributary to the northwest of the FEMP, which contains a tributary of the New Haven Trough under the town of Shandon, Ohio. The third source of groundwater flows east from the Dry Fork of the Whitewater River, located about two miles west of the FEMP. Groundwater from this source flows into the FEMP area, turns, and flows



LEGEND

- COUNTY LINE
- FEMP PROPERTY BOUNDARY
- 340 FT/YR — GENERALIZED GROUNDWATER FLOW DIRECTION, & ESTIMATED HORIZONTAL FLOW VELOCITYAT THE 2000-SERIES LEVEL.
- BEDROCK OUTSIDE GREAT MIAMI AQUIFER
- TOWNS AND VILLAGES

SCALE:
0 — 5000 FEET

NOTES:
1. DIRECTION OF GROUNDWATER FLOW BASED ON APRIL 1986 WATER LEVEL CONTOURS AND GROUNDWATER MODELING OUTPUT (3DPART07.OUT).
2. ESTIMATED VELOCITIES CALCULATED FROM GRADIENTS ON SEVERAL POTENTIOMETRIC MAPS, USING HYDRAULIC CONDUCTIVITY EQUAL TO 450 FT/DAY AND EFFECTIVE POROSITY EQUAL TO 0.23.

FIGURE 3-14
GREAT MIAMI AQUIFER UNDERLYING THE FEMP AND VICINITY

fig0314.dgn

TABLE 3-2

SLUG TEST RESULTS FOR MONITOR WELLS COMPLETED IN WATER BEARING LENSES OF THE GLACIAL OVERBURDEN

Unit	Well No.	USCS[b] Soil Type	Hydraulic Conductivity[a] (cm/sec) Falling Head Test	Hydraulic Conductivity[a] (cm/sec) Rising Head Test
Active Flyash Pile	1048	SM-GM-ML	1.8×10^{-4}	2.0×10^{-4}
South Field	1046	SM	6.4×10^{-4}	5.2×10^{-4}
	1433	FILL/CL-GM	Not Done	$1.1. \times 10^{-4}$
	1941	SC	Not Done	1.2×10^{-4}
	1942	SM	6.3×10^{-5}	5.5×10^{-5}
	1954	SM	1.5×10^{-4}	1.3×10^{-4}
	11085	SW	5.6×10^{-4}	5.4×10^{-4}
Solid Waste Landfill	1035	GW	1.2×10^{-4}	5.4×10^{-5}
	1038	SM	1.0×10^{-4}	4.2×10^{-5}
	1947	CL (weathered)	1.4×10^{-4}	1.5×10^{-4}
	1950	ML-SP	7.3×10^{-6}	4.1×10^{-6}
	1952	CL	2.4×10^{-5}	2.4×10^{-5}
Lime Sludge Ponds	1039	SW-GC	4.2×10^{-3}	4.7×10^{-3}
	1041	CL	5.1×10^{-4}	4.9×10^{-4}
	1042	SM-SW-SP	4.4×10^{-3}	4.1×10^{-3}
	1934	CL	2.9×10^{-5}	2.9×10^{-5}
	1937	SM-ML (Dense Packing)	5.0×10^{-5}	2.0×10^{-5}

[a]Hydraulic tests conducted during June and July 1993.

[b]Unified Soils Classification System:

GW - well-graded gravel
GM - silty gravel
GC - clayey gravel
SW - well-graded sand
SP - poorly graded sand
SM - silty sand
SC - clayey sand
CL - lean clay
ML - silt

southward to the Great Miami River under the southern part of Paddys Run, termed the Paddys Run Outlet. A portion of the groundwater from the Shandon Tributary also reaches the Great Miami River via Paddys Run Outlet. Although these general flow patterns dominate the regional flow system, local and short-term variations do occur. For example, pumping of production wells near the Great Miami River may influence local groundwater movement due to the groundwater depression around these production wells in the Big Bend area shown in Figure 3-15. The pumping may affect a more easterly component to the groundwater flow direction at the FEMP. Only localized effects (<500 feet) have been observed in the lower Great Miami Aquifer from the pumping of the FEMP production wells.

Aquifer water table elevations in the FEMP area display a broad cyclic trend on a yearly basis, as typified by elevation changes in Well No. 02E shown in Figure 3-16. Maximum water table elevations usually occur during the spring and early summer months corresponding to peak rainfall months. Minimum water table elevations generally occur during the late fall and early winter months. These low groundwater elevations occur at the end of southern Ohio's dry season, which usually starts in late summer or early fall and runs to late fall. During most years, the water table fluctuates on the order of four to five feet. Hydrographs of paired wells that are completed on opposing sides of the clay interbed are shown for the Inactive Flyash Pile (Figure 3-17) and for the area west of the Solid Waste Landfill (Figure 3-18). The hydrograph trend for the nested wells appears to be similar; namely, the water elevations in wells completed above and below the clay interbed respond alike. This suggests that the upper (2000- and 3000-series wells) and lower (4000-series wells) aquifers are not hydraulically isolated from each other by the clay interbed in these areas.

Regional groundwater elevations corresponding to relatively low (December 1989) and high (May 1989) groundwater elevations are presented in Figures 3-19 and 3-20, respectively. During a dry season, as shown by the December contours in Figure 3-19, groundwater in the Great Miami Aquifer appears to flow in a generally south-east to east direction. During a wet season, as shown by the May contours in Figure 3-20, groundwater in the Great Miami Aquifer appears to flow in a generally east direction.

3.1.3.4 Seismology

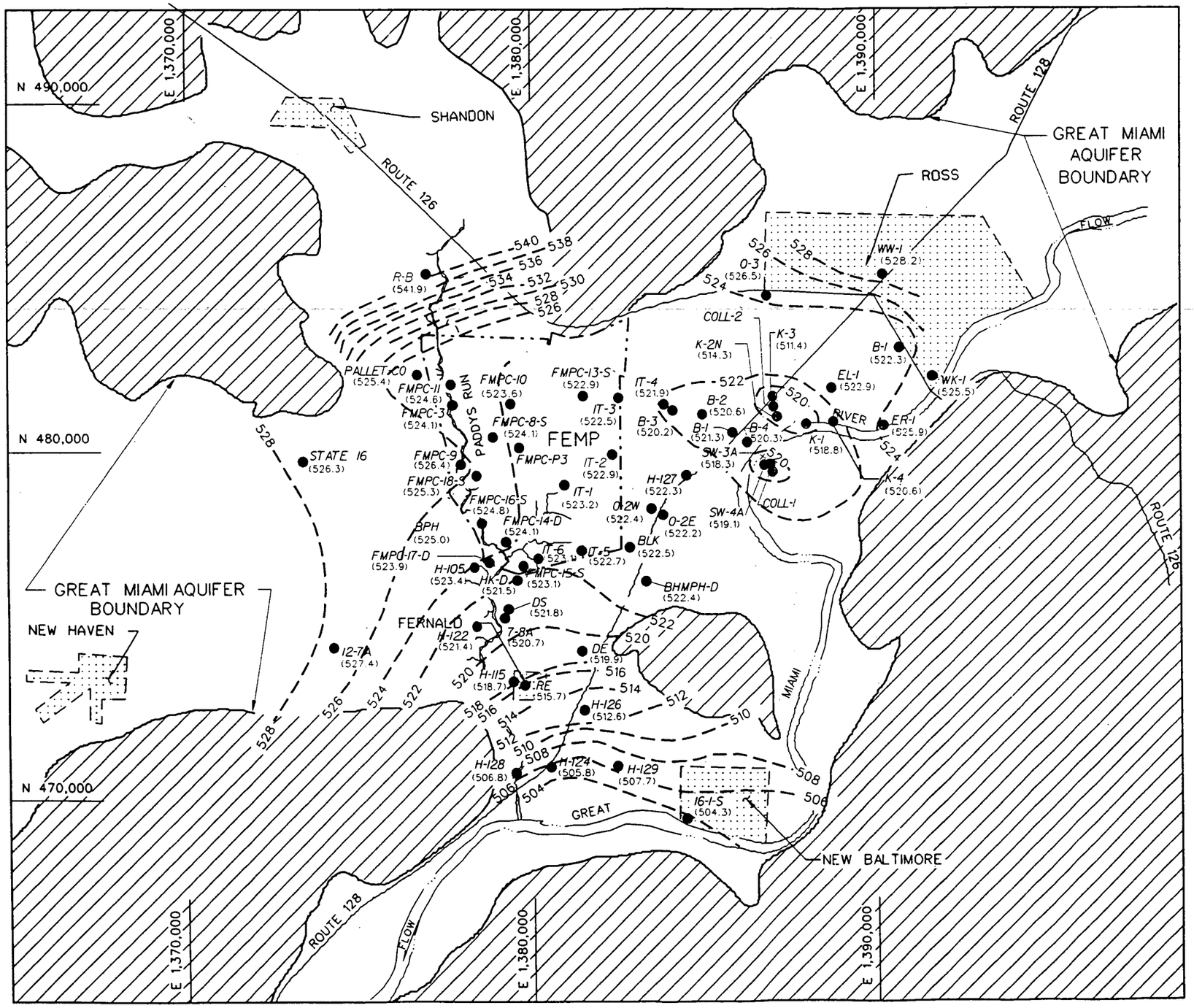
A seismic risk zone of two on a measurement of earthquake intensity on a scale of less-than-one to four has been assigned to the FEMP region. An earthquake in the FEMP region could damage facilities and cause release of contaminants into the environment. Local geologic structures and historical seismicity are used to analyze the potential for seismic events and structural damage.

Based on published regional geologic maps of southwestern Ohio, there are no major faults, active or inactive, in the vicinity of the FEMP. However, the presence of minor faults cannot be dismissed because bedrock in the region is largely covered by Pleistocene sediments. Pre-Pleistocene fault traces could potentially be obscured; however, the historical record of seismicity and the absence of post-Wisconsin faults indicate that significant local earthquakes are unlikely. Nine earthquakes caused minor damage at locations between 71 and 199 miles from the Fernald site. Most of these earthquakes were clustered in the Anna, Ohio (Bowling Green Fault) seismic zone. One earthquake caused moderate damage at Anna, Ohio, which is located 81 miles north of the FEMP. The Anna, Ohio earthquake had a reported intensity of VIII on a scale of I to XII, according to the Modified Mercalli Intensity (MMI) scale (IT 1993). The equivalent Richter Scale magnitude for the Anna, Ohio earthquake is estimated to be 5 to 6 (Nuttli 1979).

3.1.3.4.1 Historical Earthquakes Affecting the FEMP Area

The National Geophysical Data Center in Boulder, Colorado maintains the earthquake database for the NOAA. The earthquake database contains information on more than 500,000 earthquakes and can provide data on the seismicity of a selected region, prepare an edited list of earthquakes chronologically, geographically, or by radial distance from a center point.

The origins of earthquakes in the Central Stable physiographic region, as with earthquakes throughout the eastern United States, are not thoroughly understood at this time. The earthquakes in this region appear to be associated with ancient zones of weakness in the earth's crust that formed during continental collision and mountain-building events that took place about a billion years ago. These zones are characterized by deeply buried and poorly known faults, some of which serve as the sites for periodic release of strain that is constantly building up in the North American continental plate due to continuous movement of the plates. The following discussion reviews the historical earthquake activity in Ohio and the surrounding regions.



LEGEND:

- ● H-122 (521.4) — WELL NAME AND LOCATION. VALUE IN PARENTHESIS INDICATES MEASURED GROUNDWATER LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (MSL).
- —524— GROUNDWATER CONTOUR (FEET-MSL). DASHED INDICATES AREA OF UNCERTAINTY
- — - - — FEMP PROPERTY BOUNDARY
- BEDROCK OUTSIDE GREAT MIAMI AQUIFER
- TOWNS AND VILLAGES

NOTES:

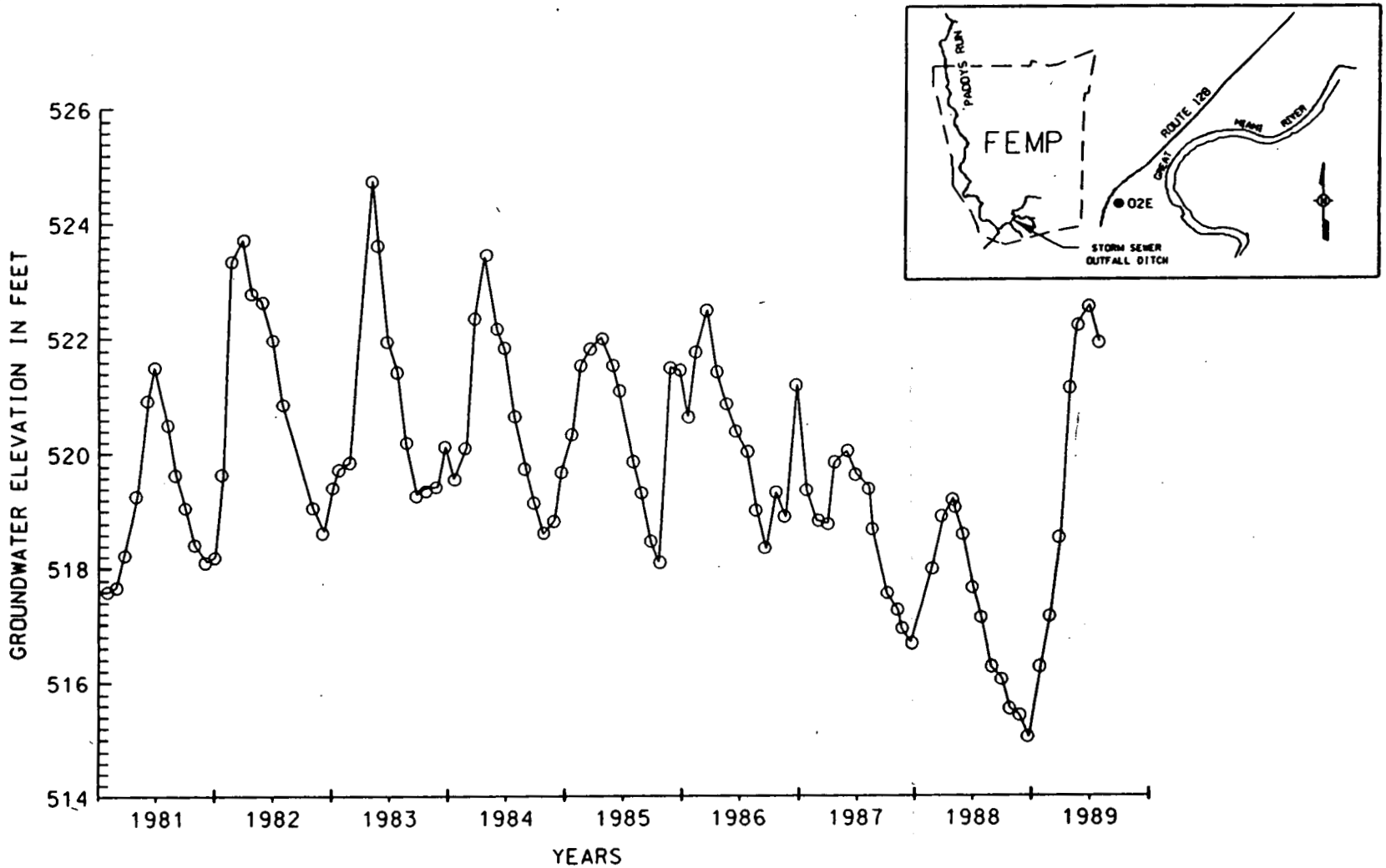
1. GROUNDWATER ELEVATIONS WERE MEASURED DURING THE PERIOD MARCH 27 THROUGH APRIL 11, 1986.
2. GROUNDWATER ELEVATIONS AT PUMPING WELLS FMPC-P3, COLL-1, AND COLL-2 WERE NOT USED FOR CONSTRUCTION OF THIS MAP.

SCALE: 0 — 4000 FEET

FIGURE 3-15
REGIONAL GROUNDWATER ELEVATIONS, APRIL 1986

fig0315.dgn

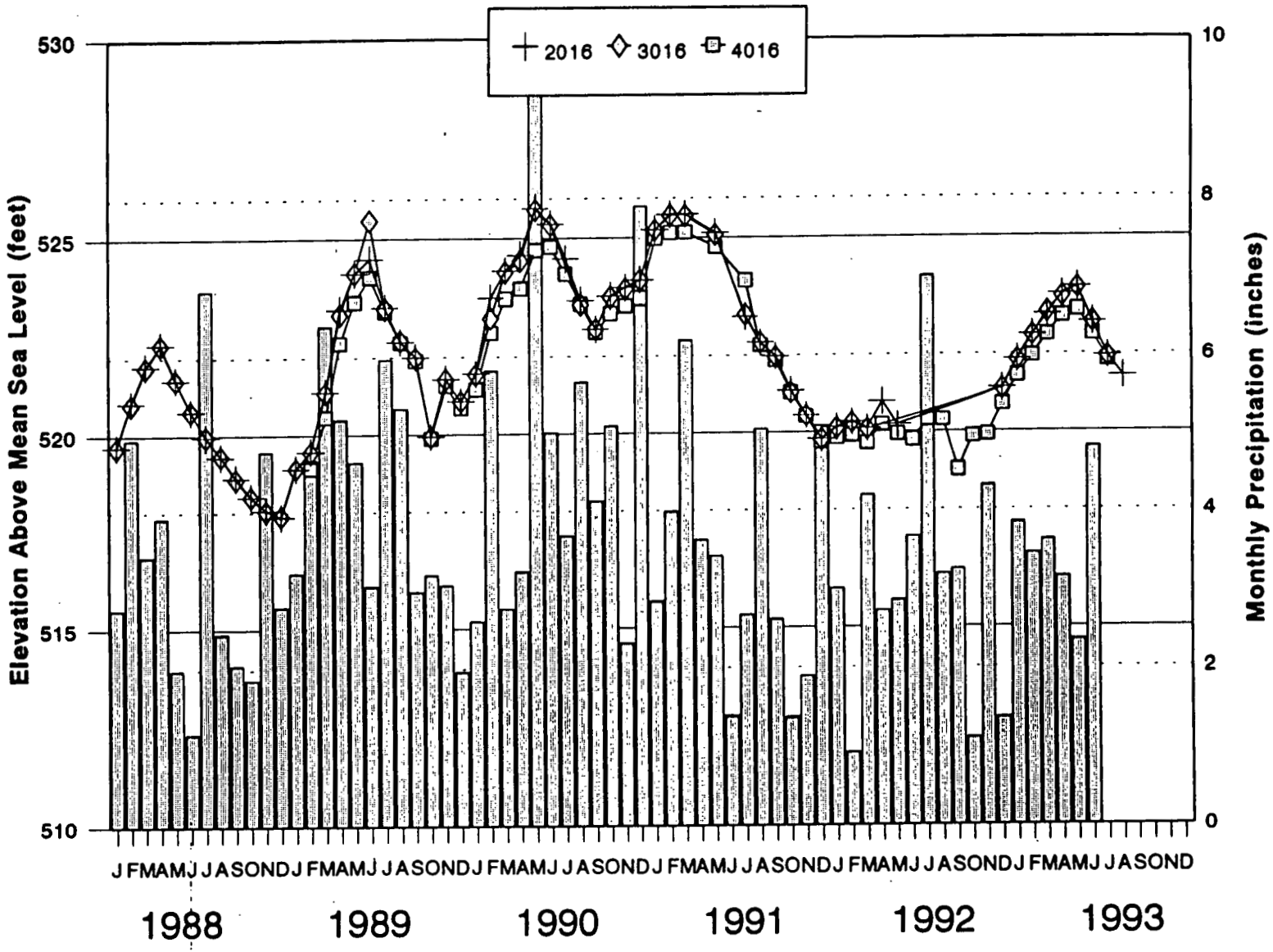
fig0316.dgn



NOTES:

LEVELS SHOWN WERE RECORDED AT WELL O2E
(SEE INSET FOR LOCATION)

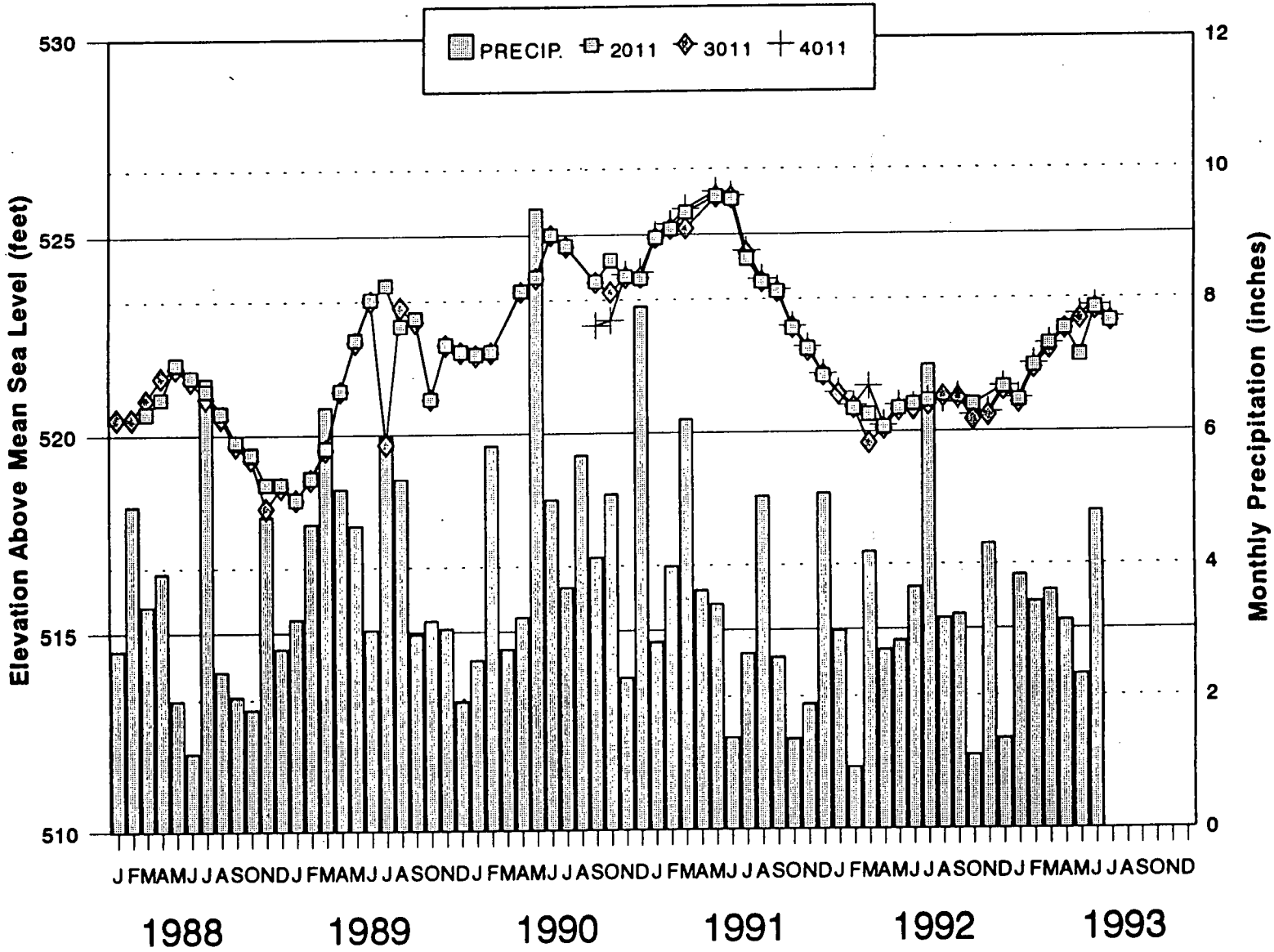
FIGURE 3-16
GROUNDWATER ELEVATION FOR WELL O2E BETWEEN JANUARY 1981 AND DECEMBER 1989



NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-17

HYDROGRAPHS FOR MONITORING WELLS 2016, 3016, AND 4016, INACTIVE FLYASH PILE



NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-18

HYDROGRAPHS FOR MONITORING WELLS 2011, 3011, AND 4011, WEST OF SOLID WASTE LANDFILL

F:\RIREPORT\FIGURES\FIG3-18

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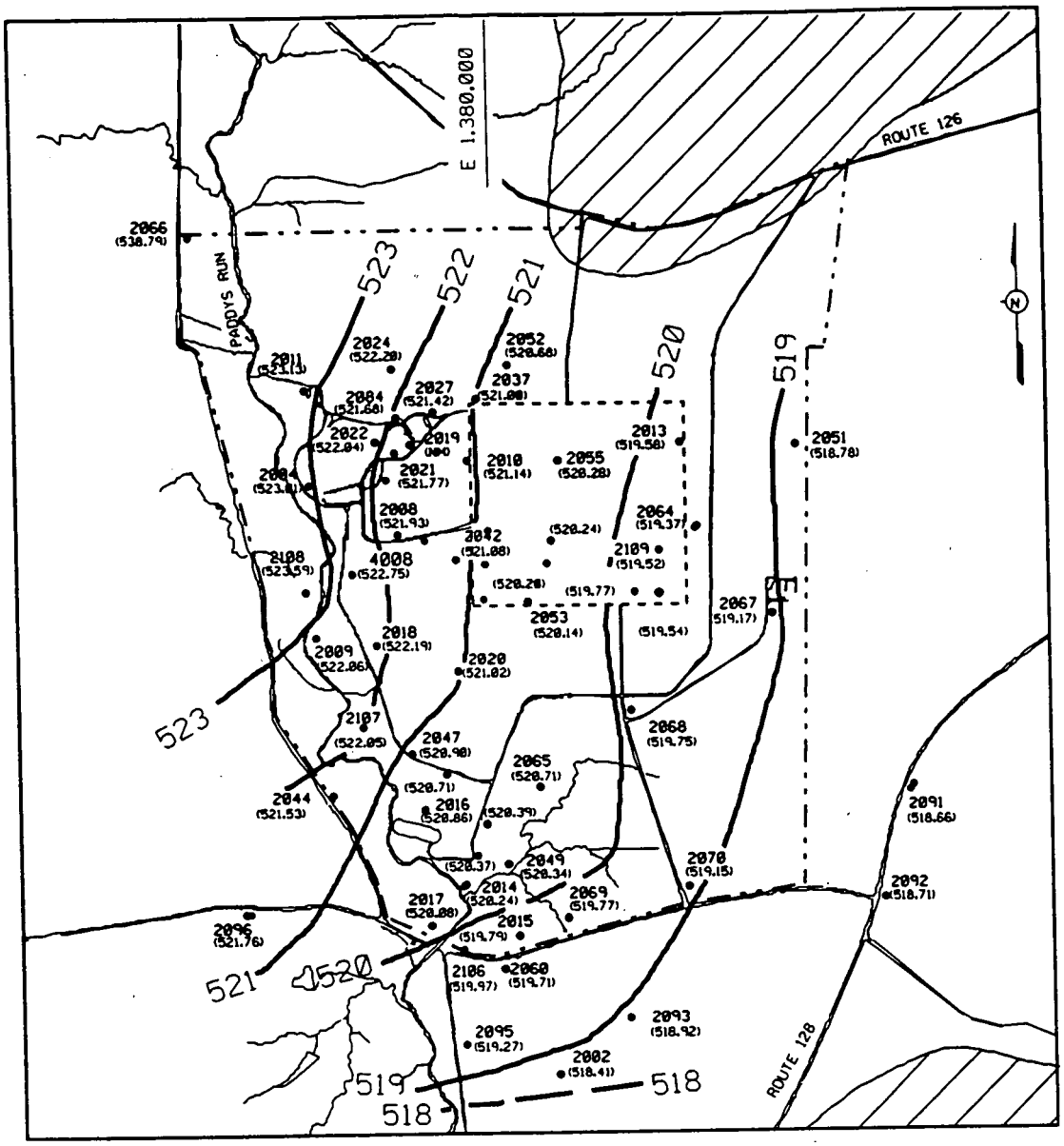
1 - 6505



LEGEND

2013 (519.58)	MONITORING WELL LOCATION. VALUE IN PARENTHESES INDICATES GROUNDWATER LEVEL IN FEET ABOVE MEAN SEA LEVEL (MSL)
2129 (000)	WATER LEVEL NOT MEASURED
518	GROUNDWATER ELEVATION CONTOUR. UNITS ARE FEET ABOVE MSL. DASHED WHERE INFERRED.
— · · —	FEMP RESERVATION BOUNDARY
- - - - - -	FORMER PRODUCTION AREA BOUNDARY
▨	BEDROCK OUTSIDE GREAT MIAMI AQUIFER

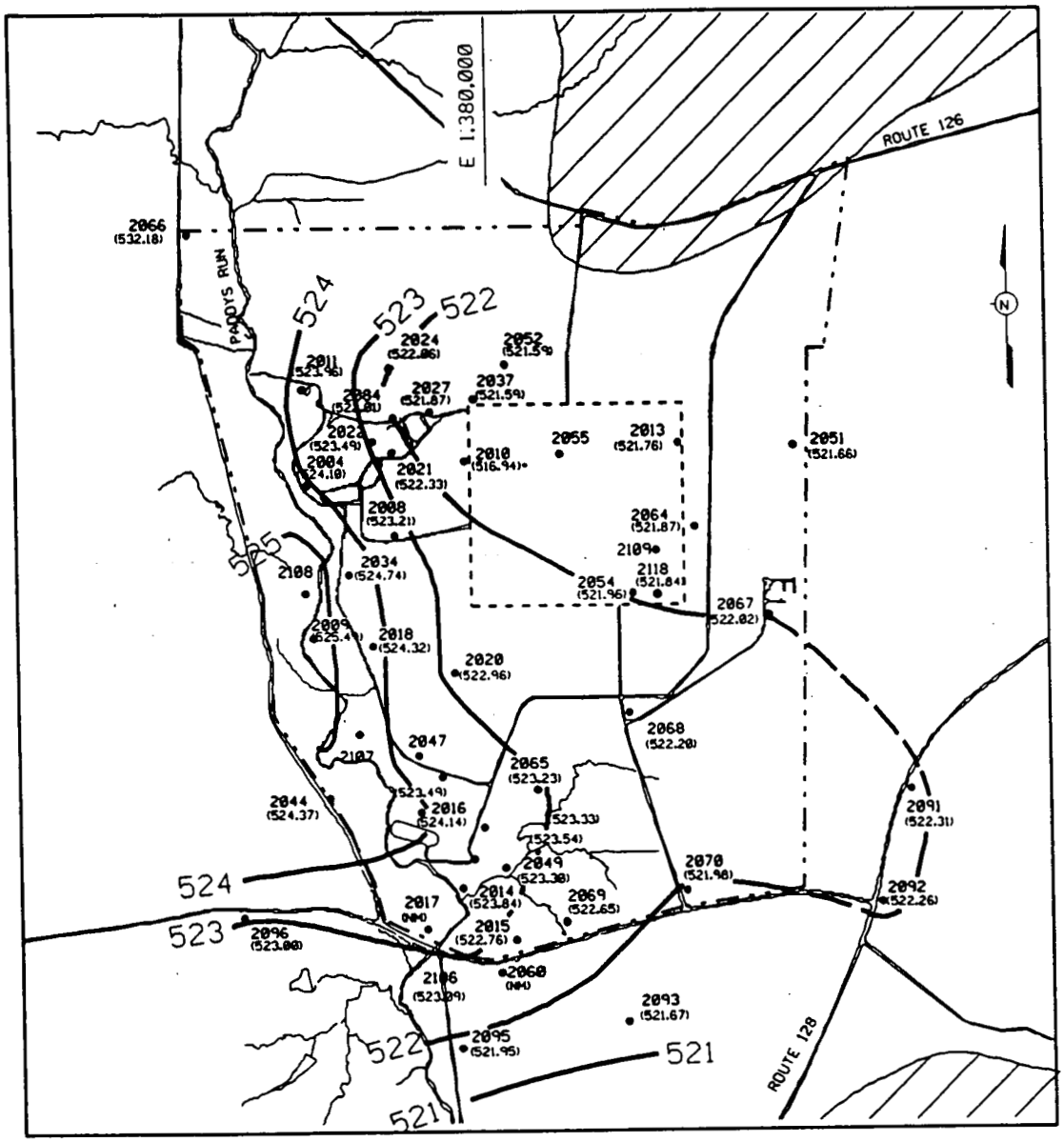
SCALE (IN FEET)

0 2000 4000

FIGURE 3-19
GROUNDWATER ELEVATIONS
2000-SERIES WELLS
DECEMBER 1989

fig0319.dgn

000227



LEGEND

2013 (519.58)	MONITORING WELL LOCATION. VALUE IN PARENTHESES INDICATES GROUNDWATER LEVEL IN FEET ABOVE MEAN SEA LEVEL (MSL)
2129 (NM)	WATER LEVEL NOT MEASURED
2010 (516.94)*	NONREPRESENTATIVE DATA
518	GROUNDWATER ELEVATION CONTOUR. UNITS ARE FEET ABOVE MSL. DASHED WHERE INFERRED.
— · · —	FEMP RESERVATION BOUNDARY
- - - - - -	FORMER PRODUCTION AREA BOUNDARY
▨	BEDROCK OUTSIDE GREAT MIAMI AQUIFER

SCALE (IN FEET)

0 2000 4000

FIGURE 3-20
GROUNDWATER ELEVATIONS
2000-SERIES WELLS
MAY 1989

fig0320.dgn

3.1.3.4.2 Historical Earthquake Activity in Ohio

Three areas of Ohio appear to have susceptibility to seismic activity. Shelby County and surrounding counties in western Ohio have experienced more earthquakes than any other area of the state. The most frequent and damaging earthquakes in Ohio have originated near the Bowling Green fault zone and the Findlay Arch in the vicinity of the western Ohio town of Anna, Shelby County. This area has often been referred to as the "Anna, Ohio," seismic source zone. During the last 100 years, the Anna area has experienced more than 30 earthquakes; the decade of the 1930s was the seismically most active period. During this time, 23 earthquakes were recorded, including the most severe shock ever reported from Ohio. This earthquake, which occurred on March 9, 1937, had a reported intensity of VIII on the MMI scale and was felt in an area of 150,000 square miles. A shock of intensity VII preceded the March 9 earthquake by seven days. Considerable damage including breaking of dishes and windows, cracking of plaster on ceilings and walls, and extensive cracking of masonry in several large buildings, including the school, the firehouse, and two churches, was done to buildings in Anna and nearby communities by these quakes. Since the considerable activity of the 1930s, only three minor earthquakes have been centered in the Anna area.

The Anna earthquakes occurred approximately 93 miles from the Fernald site. Assuming an attenuation of one MMI per 40 miles, the site MMI would have been IV to V at Fernald. Zimmer (1970) states an estimated MMI of III at the site of the Zimmer Nuclear Power Plant. There have been four earthquakes in the Anna, Ohio, area having MMIs of VII. These occurred on June 18, 1875; September 30, 1930; September 20, 1931; and March 2, 1937 and would have probably have resulted in intensities of IV to V at Fernald. The March 2, 1937 earthquake may have been a foreshock to the March 9, 1937 earthquake; however, their epicentral locations have been listed as being five miles apart (Beavers et al. 1982).

Northeastern Ohio has experienced at least 20 felt earthquakes since 1836 (Hansen 1988). Most of these events were small and caused little or no damage. However, an earthquake on January 31, 1986 strongly shook Ohio and was felt in 10 other states and southern Canada. This event had a Richter magnitude of 5.0 (MMI VI to VII) and caused minor to moderate damage, including broken windows and cracked plaster, in the epicentral area of Lake and Geauga Counties.

Southeastern Ohio has been the site of at least 10 felt earthquakes with epicenters in the state since 1776. The 1776 event, recorded by a Moravian missionary, has a very uncertain location.

Earthquakes in 1901 near Portsmouth, in 1926 near Pomeroy, and in 1952 near Crooksville caused minor to moderate damage (Hansen 1988).

The precise cause or causes of earthquakes in Ohio have not been thoroughly characterized. Data from recent tremors indicate focal depths of 12 to 18 miles or less (Hansen 1988). These shallow-focus earthquakes suggest minor crustal adjustments like those which occur continuously in many parts of the world. The specific nature of these adjustments in Ohio is unknown. One factor partially responsible for the lack of precise data on the location of active faults or other bedrock structures responsible for Ohio's earthquakes is the relative infrequency of significant seismic activity within the state. Collection of definitive data on these bedrock structures is partially dependent upon the occurrence of earthquakes that are strong enough to be recorded simultaneously by a number of standardized seismograph stations. However, no earthquakes of sufficient magnitude have occurred within the state since an adequate distribution of standardized seismographs became available in the late 1960s. Future research is expected to provide data from which more precise conclusions can be drawn as to the cause of Ohio's earthquakes.

3.1.3.4.3 Historical Earthquake Activity in Surrounding Areas

Based on historical seismic activity, the New Madrid seismic zone and the Appalachian seismic zone can be greater threats to the Fernald sites than the Anna, Ohio, seismic zone. The New Madrid seismic zone is located in an area of southeastern Missouri and was the site of the largest earthquake to occur in historical times in the continental United States. Four great earthquakes were part of a series at New Madrid in 1811 and 1812. The distance to the December 16, 1911 earthquake epicenter from Fernald was 320 miles. These events were felt throughout the eastern United States and were of sufficient intensity to topple chimneys in Cincinnati (Hansen 1988). Some estimates suggest that these earthquakes were in the range of 8.0 on the Richter scale. The estimate MMIs for the 1811 and 1812 series ranged between VII and VIII (Sterns and Wilson 1972). These earthquakes resulted in higher intensities in the Fernald sites than earthquakes occurring at other locations in Ohio.

The Appalachian seismic zone has also been an area of recorded seismic activity, although the intensities are lower than those observed for the New Madrid seismic zone. An earthquake with a Richter magnitude of 5.3 centered at Sharpsburg, Kentucky, on July 27, 1980 was strongly felt throughout Ohio and caused minor to moderate damage in communities near the Ohio River and southwestern Ohio (Reinbold et al. 1981). This earthquake was felt as far north as Cleveland, and

into Canada, and as far south as Atlanta, Georgia. The epicentral intensity has been estimated as an MMI of VII. The earthquake epicenter was approximately 60 miles from the Fernald site. Although isoseismal maps for this earthquake had not been completed prior to the report by Beavers et al. (1982), they estimated that the intensities at both sites were probably in the range of MMIs of V to VI. They also pointed out that this earthquake occurred in a very low seismicity area and should be considered and isolated event with an approximately recurrence interval in the 1000- to 2000-year range (Reinbold et al. 1981).

Another major historical earthquake from the Appalachian seismic zone that may have had some impact on the FEMP area took place in Giles County, Virginia on May 31, 1897. This earthquake has been estimated to have an epicentral MMI from VII to VIII. However, according to Bollinger (1981), the impact in the FEMP vicinity was probably insignificant since the estimated intensity ranged from an MMI of II to IV. It has been proposed that the Giles County area has a potential of producing an earthquake of epicentral MMI of IX (Bollinger 1981); however, the resulting intensity of this event in the Fernald area would be an MMI of less than VI (Beavers et al. 1982).

3.1.4 Soils

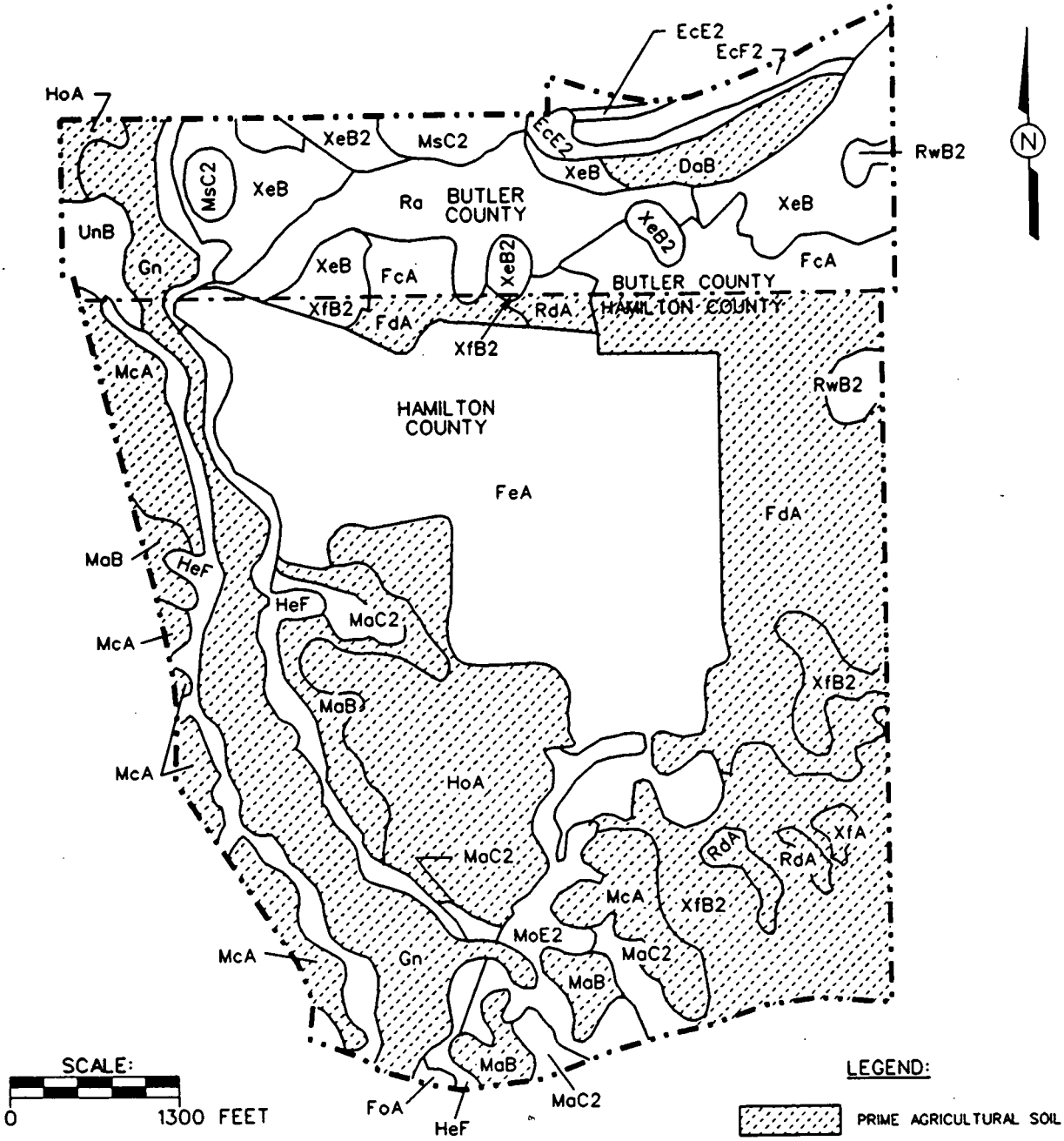
Soil characteristics affect the suitability of a site for agriculture or construction, the likelihood of erosion during remedial actions, and the kinds of habitat, such as wetlands, which can develop on a site. As a result, soil types may be important to consider during the FS phase of remediation at the FEMP. Soils in the region of the FEMP were formed from materials deposited by the Wisconsin and Illinoisan glaciers. These parent materials consist mainly of glacial till and include sand, gravel, glacial lake clays, and silt clays. Glacial tills are typically a composite of materials carried forward or pushed to an advancing glacier. These materials may be locally derived or transported long distances, in some cases hundreds of miles. A portion of the till appears to be derived from the local bedrock; however, it is not known which portion is derived from the possible sources. Three major soil associations, that is, groups of soils which typically occur together, exist in the vicinity of the FEMP: Russell-Xenia-Wynn, Fincastle-Xenia-Wynn, and Fox-Genesee (U.S. Department of Agriculture 1980, 1982). These soils are usually light colored, acidic, and poorly- to moderately-well drained. Many of them have developed on windblown material (loess), except along river basins where the Fox-Genesee soils are of glacial till origin. The soils are moderately high in productivity and are frequently used for growing cash crops and producing livestock.

The Butler County and Hamilton County Soil Surveys have 15 specific soil series or types mapped within FEMP boundaries as described in Table 3-3 and shown on Figure 3-21 (U.S. Department of Agriculture 1980, 1982). The major soil series, which cover large areas west of the FEMP, are Fincastle-Xenia silt loams. These soils are light colored, medium acidic, and moderately high in productivity when properly managed. Moisture-supplying capacity is moderate, as is fertility and organic content. The Fincastle Series consists of deep, nearly level, poorly-drained soils on broad flats. Permeability is low, and the available water capacity is high. The seasonal high water table is commonly found between one and three feet below the ground surface from January to April. In areas where these soils are predominant, artificial drainage is required for moderate crop productivity. These soils are associated with the former Production Area and the pastures to the east and west. The Xenia soil series is a deep, nearly level, moderately well-drained soil located on till plains. Permeability is moderately low, available water capacity is high, and the runoff hazard is low. The seasonal high water table is usually within two to six feet of the surface from March to April. These soils are located within the pine plantation in the northern portion of the site and in the pastures to the east of this area.

The remaining soil series occurring within the FEMP are Dana, Eden, Fox, Genesee, Hennepin, Henshaw, Markland, Martinsville, Miamian, Ragsdale, Raub, Russell, and Uniontown. Table 3-3 summarizes the soil drainage classifications within the FEMP boundaries.

One soil mapped within FEMP boundaries is considered hydric, that is, periodically depleted of oxygen due to water saturation (U.S. Department of Agriculture 1987a and 1987b). This very poorly-drained soil, Ragsdale silty clay loam, is mapped for approximately 53 acres (five percent of the area of the FEMP) in the northern portion of the FEMP. The Ragsdale soil series is nearly level, deep, and very poorly drained. It is usually located in long, narrow depressions or in shallow basins. The permeation rate is slow, available water capacity high, and the seasonal high water table is near the surface from December through May. These soils are associated with a jurisdictional wetland in the northern end of the FEMP.

Three soil series at the FEMP, represented by four map units, are classified as somewhat poorly-drained soils. These series include the Fincastle Series described above, the Henshaw Series, and the Raub Series. Somewhat poorly-drained soils occupy approximately 364 acres (35 percent) at the FEMP, excluding the highly-developed portions of the Fincastle-Urban Land Complex. Henshaw



SOIL SYMBOL BY COUNTY:

SOIL NAME	BUTLER COUNTY	HAMILTON COUNTY
DANA	DaB	N/A
EDEN	EcE2, EcF2	N/A
FINCASTLE	FcA	FdA, FeA
FOX	N/A	FoA
GENESEE	Gn	Gn
HENNEPIN	N/A	HeF
HENSHAW	HoA	HoA
MARKLAND	N/A	MaB, MaC2
MARTINSVILLE	N/A	McA
MIAMIAN-HENNEPIN	N/A	MoE2
MIAMIAN-RUSSEL	MsC2	N/A
RAGSDALE	Ra	N/A
RAUB	N/A	RdA
RUSSELL	RwB2	RwB2
UNIONTOWN	UnB	N/A
XENIA	XeB, XeB2	XfA, XfB2

NOTES:

1. SEE TABLE 4-3 AND 4-4 FOR SOIL CLASSIFICATIONS.
2. SOURCE - OHIO DEPARTMENT OF NATURAL RESOURCES.

FIGURE 3-21
SOIL CLASSIFICATIONS AND PRIME AGRICULTURAL SOIL AT THE FEMP

fig0321.dgn

TABLE 3-3

SOIL CONSERVATION SERVICE SOILS DRAINAGE CLASSIFICATIONS AT THE FEMP

Symbol	Name	Slopes (%)	Drainage Classification
DaB	Dana silt loam	2-6	Moderately well drained
EcE2	Eden silty clay loam	15-25	Well drained
EcF2	Eden silty clay loam	25-50	Well drained
FcA and FdA	Fincastle silt loam	0-2	Somewhat poorly drained
FeA	Fincastle-Urban land complex	0-2	Somewhat poorly drained
FoA	Fox loam	0-2	Well drained
Gn	Genesee loam	0-2	Well drained
HeF	Hennepin silt loam	35-60	Well drained
HoA	Henshaw silt loam	0-2	Somewhat poorly drained
MaB	Markland silty clay loam	2-6	Moderately well drained
MaC2	Markland silty clay loam	6-12	Moderately well drained
McA	Martinsville silt loam	0-2	Well drained
MnC2	Miamian silt loam	8-15, eroded	Well drained
MoE2	Miamian-Hennepin silt loams	25-35, eroded	Well drained
MsC2	Miamiam-Russell silt loams	2-6	Well drained
MsD2	Miamiam-Russell silt loams	12-18, moderately eroded	Well drained
Ra	Ragsdale silty clay loam	level	Very poorly drained
RdA	Raub silt loam	0-2	Somewhat poorly drained
RvB	Russell-Miamian silt loams	2-6	Well drained
RwB2	Russell silt loam	3-8, eroded	Well drained
UnA	Uniontown silt loam	0-2	Well drained
UnB	Uniontown silt loam	2-6	Well drained
XeB	Xenia silt loam	2-6	Moderately well drained
XeB2	Xenia silt loam	2-6	Moderately well drained
XfA	Xenia silt loam	0-2	Moderately well drained
XfB2	Xenia silt loam	0-2, eroded	Moderately well drained

SOURCES: USDA (1980, 1982)

soils are deep, nearly level, somewhat poorly-drained soils on flats and low stream terraces and in basins.

Permeability is moderately low, available water capacity is high, and runoff is slow. The seasonal high water table is usually within 2 feet of the ground surface between November and March. These soils exists along the western property line adjacent to Paddys Run Road and south of the former Production Area.

Raub soils are deep, nearly level, somewhat poorly drained, dark soils located on glacial till plains. These soils have slow permeation rates and high available water capacity. The seasonal high water table is between 1 and 3 feet during January through April. These soils are located on upland terraces in the southeast portion of the FEMP and immediately north of the former Production Area.

The remaining 10 soil series mapped within FEMP boundaries are moderately well-drained and well-drained upland soils. The Dana Series consists of deep, gently sloping, moderately well-drained soils on slopes or in gently sloping basins on till plains and moraines. This series has moderate permeability, and the available water capacity is high. The water table is usually perched at a depth of 3 to 6 feet between March and April. These soils occupy the upper third of the northern pine plantation.

The Eden Series is moderately deep, steep, well-drained soil on valley walls and hillsides. This series has a low permeability and the available water capacity is low. The water table is usually found at a depth greater than 6 feet. This series is located between the northern pine plantation and State Route 126.

Soils along Paddys Run are categorized as Fox-Genesee loams. Fox soils are deep, gently sloping, well-drained soils on slight rises and stream terraces. Erosion has removed the majority of the original surface layer, and permeability is moderate in the upper horizons and very rapid in the lower horizons. The seasonal high water table is normally more than 6 feet below the surface. A small area of Fox soils exists along the southern property line of the FEMP on the upland terrace immediately east of Paddys Run. Genesee soils are deep, nearly level, well-drained soils located on terraces adjacent to floodplains. The areas that they occupy are subject to occasional brief flooding. The permeability is moderate, and the available water capacity is very high. Normally, the seasonal

high water table is deeper than 6 feet below the surface. These soils are associated with the steep banks of Paddys Run, on either of the Genesee soils. Hennepin soils also occur in association with Miamian soils along the Storm Sewer Outfall Ditch.

The Markland series consists of deep, gently sloping, moderately well-drained soils, permeability of this soil is low, the available water capacity is moderate, and the runoff hazard is medium. The seasonal high water table is usually perched between 3 and 6 feet below the surface from March to April. These soils are located adjacent to the Hennepin soils, just outside the woodlands bordering Paddys Run, the Storm Sewer Outfall Ditch, and other drainings on the property.

Martinsville soils are deep, nearly level, well-drained soils on stream terraces and outwash plains. The permeability is moderate, the available water capacity is high, and the runoff hazard is low. The seasonal high water table is more than six feet below the surface. Martinsville soils are found on a level terrace in the southern end of the FEMP, adjacent to a tributary to Paddys Run.

Miamian soils are deep, steeply sloping, well-drained soils located on dissected plains. Erosion has removed portions of the original surface layer and the subsoil has been filled into the existing surface layer. Permeability is moderately low, and the available water capacity is moderate. The seasonal high water table is usually greater than six feet below the surface. Miamian soils exist along the northern property line of the FEMP and, associated with Hennepin soils, along the Storm Sewer Outfall Ditch and one of its tributary drainages running from Willey Road to the northwest. Russell silt loams are gently sloping, deep, well-drained soils on slight rises and knolls of till plains. Russell soils have moderate permeability in the lower horizons, and surface runoff is medium. The seasonal high water table is perched and commonly found between 3 to 6 feet below the surface from March to April. Russell soils are mapped east of the former Production Area.

Uniontown soils are deep, gently sloping, well-drained soils formed in deposits on stream terraces. These soils have moderate permeability with a very high available water capacity. The seasonal high water table is between 2.5 and 6 feet below the surface from November to May. Uniontown soils are mapped in the northwest corner of the FEMP on a terrace above Paddys Run.

Neither the former Production Area or Waste Storage Area have undisturbed soils. In almost every area, natural soil profiles were destroyed or modified during construction and regrading. These soils are described as Fincastle Urban Land Complex.

3.1.5 Population and Land Use

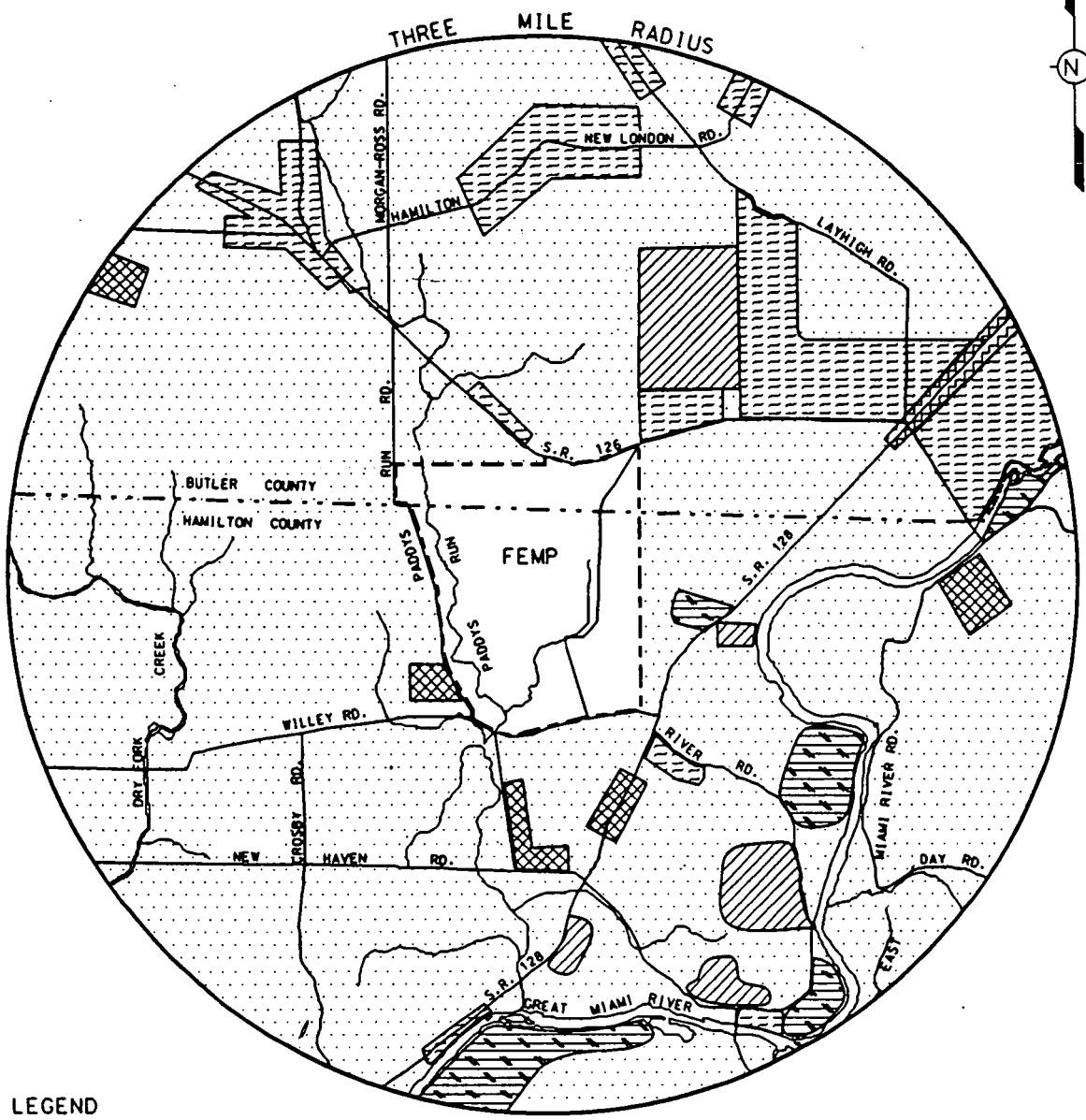
This section provides a summary of population data from the FEMP regional area and information regarding land use for the FEMP Study Area. Additionally, a summary of available archaeological and historical resource data is presented for the FEMP Study Area.

The FEMP is located approximately 29 km (17 mi) northwest of Cincinnati, the focal point of a regional market encompassing thirteen counties in Ohio, Kentucky, and Indiana. Referred to as the Consolidated Metropolitan Statistical Area (CMSA), the 13 county region consists of: Brown, Butler, Clermont, Hamilton, and Warren counties in Ohio; Boone, Campbell, Gallatin, Grant, Kenton, and Pendleton counties in Kentucky; and Dearborn and Ohio counties in Indiana. Population within the thirteen counties was 1.8 million in 1991, and within the 8 km (5 mi) radius of the FEMP site there were an estimated 22,927 residents in 1990 (SWCR 1993). Population density throughout the CMSA varies from 796 residents/km^2 (2062 residents/mi^2) in Hamilton County to 17 residents/km^2 (44 residents/mi^2) in Pendleton County. Excluding the heavily urbanized area in Hamilton County (Cincinnati), the average population density in the thirteen county region is 108 residents/km^2 (278 residents/mi^2). Population density within the 8 km (5 mi) radius of the site is 352 residents/km^2 (917 residents/mi^2). The labor force in the multicounty area was 951,987 with unemployment at approximately 8.7 percent in March 1992.

There are no residential structures within the FEMP boundaries. The 2000 on-property worker population includes employees of the DOE, the prime contractor, and other subcontractors. Most of the 2000 employees reside on site approximately 8 hours per day, 5 days per week. Only a fraction of those reside on site throughout the evening and night shifts.

The land adjacent to the FEMP is primarily devoted to open land use such as agriculture and recreation (Figure 3-22). Commercial activity is generally restricted to the village of Venice (Ross), approximately 4.8 km (3 mi) northeast of the facility, and along State Route (SR) 128 between Willey Road and New Haven Road. Residential units are situated immediately north of the FEMP, in Ross, and directly east in a trailer park adjacent to the intersection of Willey Road and SR 128. Other

- 6505



LEGEND

— · · — COUNTY LINE

— — — FEMP PROPERTY BOUNDARY

RESIDENTIAL

MINING

INDUSTRIAL

MIXED USE

RECREATION

AGRICULTURE/OPEN LAND

SCALE

0 1 2 MILES

fig0322.dgn

FIGURE 3-22
LAND USE ADJACENT TO THE FEMP 000238

residents located around the site are generally associated with farmsteads. Several of these farmsteads are located off Paddys Run Road, approximately one-half mile south of the FEMP property boundary. These residents are in the vicinity of the South Plume, a portion of the Great Miami Aquifer that contains a plume of uranium contamination extending south of the FEMP property, approximately three-quarters of a mile. There are no areas within the FEMP site boundaries considered to be Prime Farmlands under the Farmland Protection Act of 1981 (7 CFR 658). Pine plantations are located to the northeast and southwest of the former Production Area. Approximately 172 hectare (425 acres) of the open land on the FEMP are leased to a nearby dairy farmer who grazes livestock on the property. Because the area had been intensively used for agriculture purposes prior to the establishment of the FEMP site, there is no land on or in the vicinity of the FEMP site where a predevelopment natural environment remains intact. The land closest to the description is the recreated prairie lands on the Miami Whitewater Forest property, located several miles south of the FEMP site.

Current subpopulations of potential concern within five miles of the FEMP are identified below and listed by the categories suggested by the EPA (1989a). The information presented on sensitive subpopulations includes an area extending between three and four miles beyond the leading edge of the South Plume. Population descriptions within this area are based on 1990 census data.

- Schools: No schools are located within one mile of the FEMP. The Northwest, Ross, and Southwest school districts provide public education from kindergarten through high school for children living within five miles of the FEMP. The 1989-90 total enrollment is 3,316 in the six schools from these districts.

- Daycare Centers: No daycare facilities are located within one mile of the FEMP. Two daycare centers operate within the FEMP Study Area: (1) Ross County Day Nursery, with an average enrollment of 126 students per day and a total weekly enrollment of 180, is located north of the intersection of State Route 128 (SR 128) and US 27 about two and a half miles northeast of the center of the FEMP; (2) Venice Presbyterian Preschool, with an average daily enrollment of 30 and a total weekly enrollment of 110, is located in the village of Ross, approximately two miles northeast of the center of the FEMP.

- Hospitals, Nursing Homes, and Retirement Communities: No care facilities of these types operate within five miles of the FEMP.

- Residential Areas - In 1990, approximately 87 residents, occupying 30 homesteads, resided within a 1.6 km (1 mi.) radius around the FEMP site. Most of the residents are scattered within the five-mile radius reflecting the agricultural history of the area. Population concentrations include Ross, Harrison, Shandon, New Haven, New Baltimore, and one large trailer park near the FEMP.

- Commercial and Recreational Fisheries: No commercial fisheries operate within one mile of the center of the FEMP. Recreational fishing occurs on Whitewash Lake of the Miami Whitewater Forest. This heavily stocked lake lies completely within five miles of the FEMP. The Great Miami River supports no commercial fisheries in the vicinity of the FEMP, and a recreational fishing advisory for PCBs in bottom-feeding fish was issued in 1989, based on data collected by OEPA.

  The source(s) of these PCBs in the Great Miami River are unknown. Records indicate that PCB usage at the FEMP was limited to Aroclor 1254 (used as hydraulic fluid), electric capacitors, transformers, and fluorescent light ballasts. PCBs may have been introduced into the Great Miami River by leakage from the heavy equipment used in maintenance activities or by direct deposit into the waste pits without proper documentation; however, no records have been located which describe how the PCB oils from any source(s) were deposited prior to this time.

- Major Industries Using Chemicals: No industrial facilities are located within one mile of the center of the FEMP. Three companies located within two miles of the FEMP store and handle chemicals: Ruetgers-Nease Chemical Company and Albright & Wilson, Co (collectively known as the Paddys Run Road Site). These facilities are classified as CERCLA sites and listed on the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). The Paddys Run Road Site is undergoing a state-led RI/FS and Chemical Leahman, Inc. has undergone a Screening Site Inspection by EPA.

The area surrounding the FEMP has a large and diverse archaeological and historical resource base. According to records kept by the Miami Purchase Association for Historic Preservation, an unusually high percentage of the existing 19th century buildings in the area are historically important. Within the vicinity of the FEMP (a two-mile radius from the boundary), there are three properties listed in the National Register of Historic Places (NRHP) and a number of additional structures that have been judged eligible for inclusion in the listing. Six major archaeological sites lie within five miles of the FEMP; five of these are included in the NRHP.

3.1.6 Ecology

The FEMP and surrounding areas lie in a transition zone between two distinct sections of the Eastern Deciduous Forest Province as described by Bailey (1978): the Oak-Hickory and the Beech-Maple (Figure 3-23). The region is characterized by the presence of a mosaic of these forest types. The Oak-Hickory and Beech-Maple forest sections share many characteristics, including similar fauna and the presence of white oak as a common species. The Beech-Maple section covers northern Ohio, Indiana, and lower Michigan. It is bordered by Oak-Hickory to the southwest, Mixed Mesophytic to the southeast, and Appalachian Oak to the east. Beech-Maple forests are typically dominated by

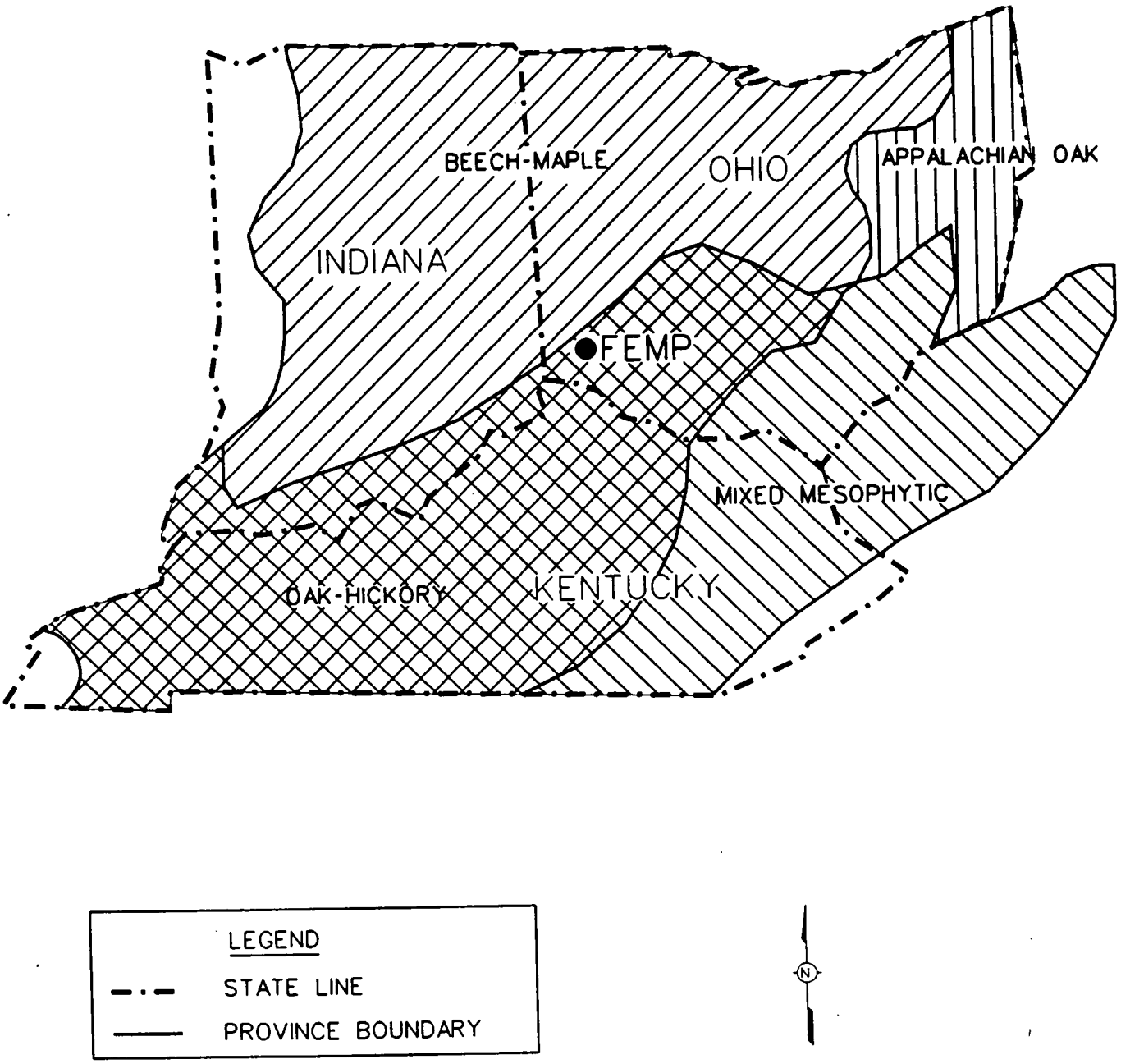


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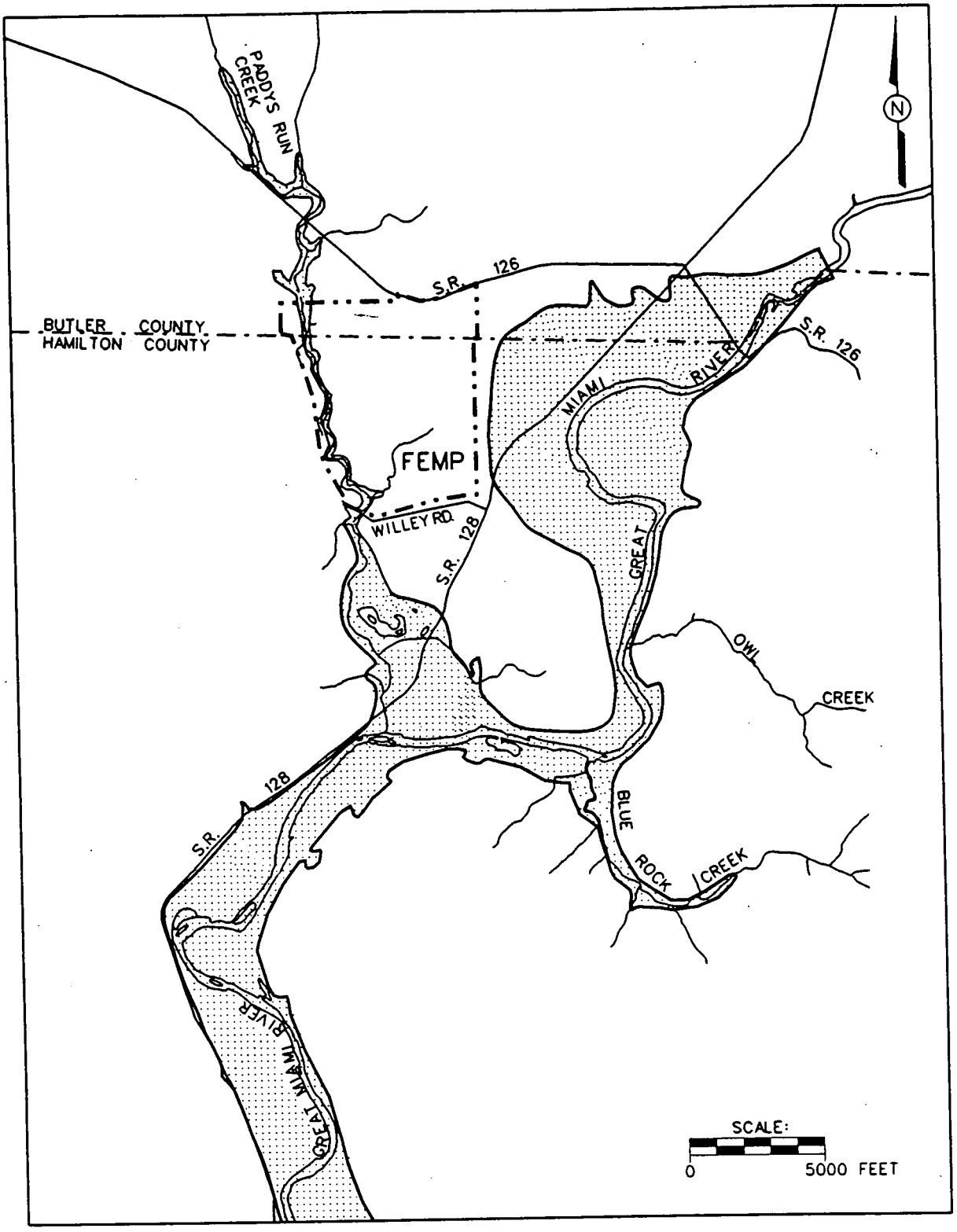
FIGURE 3-23
SECTIONS OF THE EASTERN DECIDIOUS FOREST PROVINCE
IN THE REGION OF THE FEMP

000241

beech trees in the canopy, the uppermost layer of the forest, with sugar maples dominant in the understory, below the canopy. The Oak-Hickory section covers southwest Ohio, western Kentucky and Tennessee, and parts of Indiana, Illinois, Missouri, and Arkansas. The dominant species are oaks, with an abundance of hickories. The fauna vary little between the two forest sections and include white-tailed deer, gray fox, gray squirrel, white-footed mouse, and short-tailed shrew; the cardinal, woodthrush, summer tanager, red-eyed vireo, and the hooded warbler; and the box turtle, common garter snake, and timber rattlesnake (Bailey 1978; Shelford 1963).

Floodplains within the FEMP property are related to the north-south corridor containing Paddys Run (Figure 3-24). Within the limits of the FEMP, the 100-year floodplain for Paddys Run has been defined in a study by Parsons (1993). The 100-year flood affects the western-most portion of Operable Unit 2. In the vicinity of the Inactive Flyash Pile and South Field, the 100-year flood plain is predicted to range between 544 and 546 feet MSL. At that elevation, the flood waters will cover the lower portions of the western slope of the Inactive Flyash Pile and just reach the toe of the slope along the southwestern boundary of the South Field. Outside the boundaries of the FEMP, the 100-year floodplain of the Great Miami River extends west of Big Bend, nearly to the eastern boundary of the facility. The 100-year floodplain of the river also extends northward along Paddys Run from the confluence of the two streams to a point about 600 feet from the southern boundary of the FEMP. This area overlaps the South Plume, a zone of uranium-contaminated groundwater that is a component of Operable Unit 5.

A site-wide wetlands delineation was conducted in February 1993, in accordance with the 1987 Army Corps of Engineers Wetlands Delineation Manual and in compliance with 10 CFR 1022 [the month of February was determined to be acceptable based on coordination efforts with the Army Corps of Engineers (COE)]. The purpose of the delineation was to determine the extent of jurisdictional wetlands and waters of the United States and to avoid or minimize impacts to these resources during future activities at the FEMP. A jurisdictional determination has been requested from the COE to verify the wetland boundaries and waters of the United States. Results from the site-wide delineation indicate a total of 35.9 acres of wetlands on the FEMP site. Delineated wetlands included 26.58 acres of palustrine forested wetlands, 6.95 acres of drainage ditches/swales, and 2.37 acres of isolated emergent and emergent-scrub/shrub wetlands. Figure 3-25 shows the results of the site-wide wetlands delineation including wetland areas in close proximity to the Solid Waste Landfill subunit of Operable Unit 2.



LEGEND:

- FEMP PROPERTY BOUNDARY
- COUNTY LINE
- 100-YEAR FLOODPLAIN

NOTE:

1. SOURCE - THE RALPH M. PARSONS CO. 1993

fig0325.dgn

FIGURE 3-24
GREAT MIAMI RIVER AND PADDYS RUN CREEK
100-YEAR FLOODPLAIN

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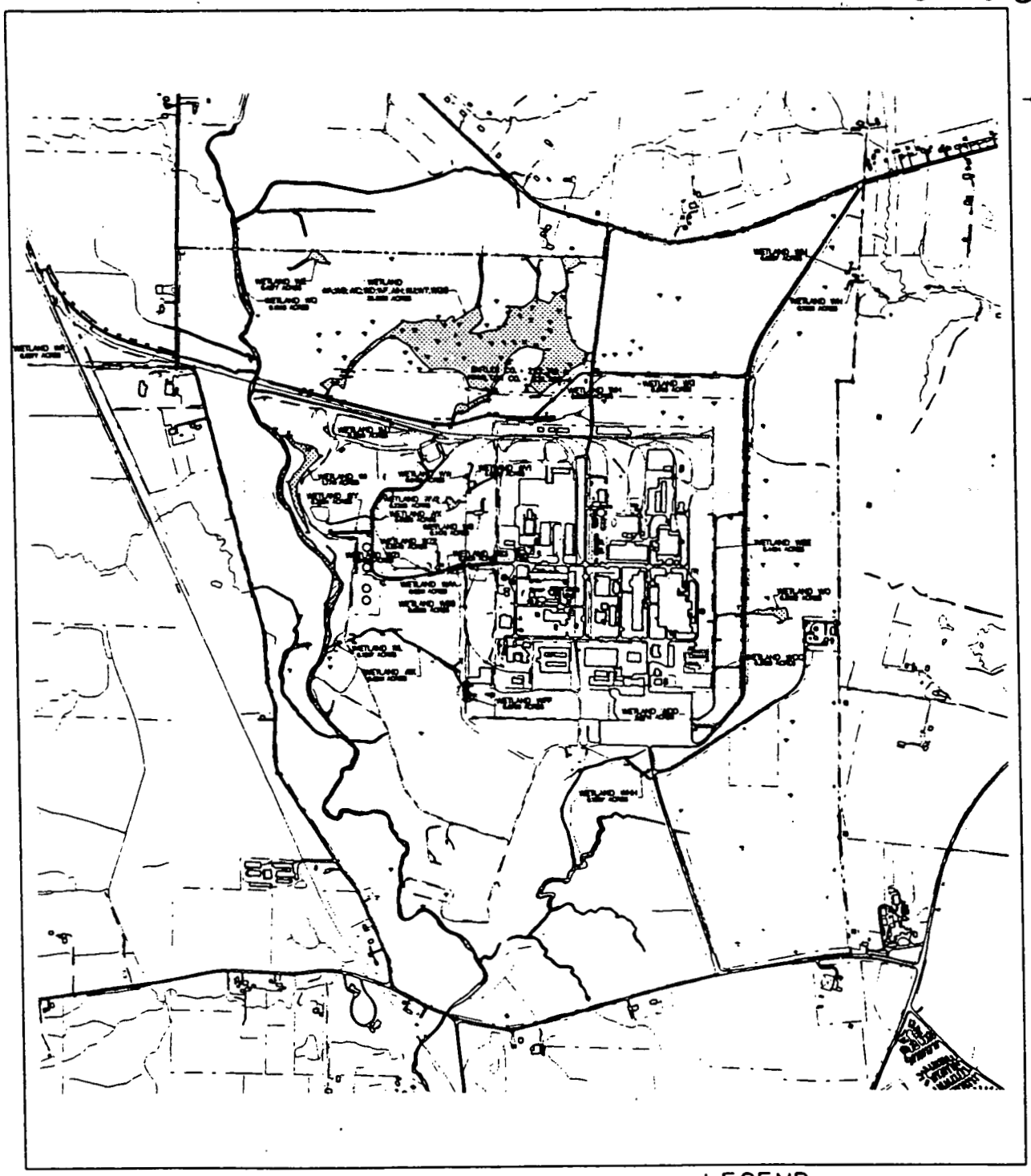

LEGEND

- WETLAND AREA
- WATERS OF THE U.S.
- SITE BOUNDRY
- COUNTY LINE
- PHOTO LOCATION
- DREDGED OR FILLED, NO LONGER MEETS WETLAND CRITERIA

SCALE

0 1550 3100 FEET

SCALE

0 225 950 METERS

RES2236 8x11 fig1-1.dgn cru2 GES 3-16-94

FIGURE 3-25 1993 JURISDICTIONAL WETLANDS & WATERS OF THE U.S. FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

The largest of the four palustrine forested wetland areas is located north of the former Production Area. The remaining three areas are located: (1) along the east bank of Paddys Run near the northern site border, (2) in the northeast corner of the site, and (3) southwest of the K-65 silos. Drainage ditches and swales constituting wetlands are located in four sections throughout the site: (1) north of the former Production Area traversing west into Paddys Run, (2) drainage of the Waste Pit Area, (3) drainage of the area south of the K-65 silos, and (4) adjacent to the eastern boundary of the former Production Area, draining higher elevations of the site to the east.

Two of the four isolated scrub/shrub and/or emergent wetlands are located in the northern part of the FEMP: one near the eastern corner and the other just east of Paddys Run near the western corner of the FEMP. The remaining two are located in the vicinity of the Waste Pit Area, one to the east, and one to the west. On-site waters of the site are confined to Paddys Run and its unnamed tributary and total approximately 8.9 acres.

Ecological communities on the FEMP consist of grazed and ungrazed pastures, two pine plantations, deciduous woodlands, riparian woodlands, and the "reclaimed flyash pile area" (Figure 3-26). The reclaimed flyash area coincides approximately with the South Field and the Inactive Flyash Pile, and was considered a distinct habitat by Facemire et al. (1990) due to the unique plant and animal species composition. 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 inhabit the FEMP.

Typical grasses found on the Fernald site 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 are white and Austrian pine, with Norway spruce occurring occasionally. Common trees in the deciduous woodlands are white ash, American elm, shagbark hickory, and slippery elm. Dominant tree species in the riparian woodlands are eastern cottonwood, hackberry, American elm, and box elder. The reclaimed flyash pile is dominated by American elm, eastern cottonwood, and black locust.

Mammal species observed on the FEMP include white-tailed deer, coyote, red fox, opossum, raccoon, groundhog, eastern cottontail, fox squirrel, and several species of bats. Common small

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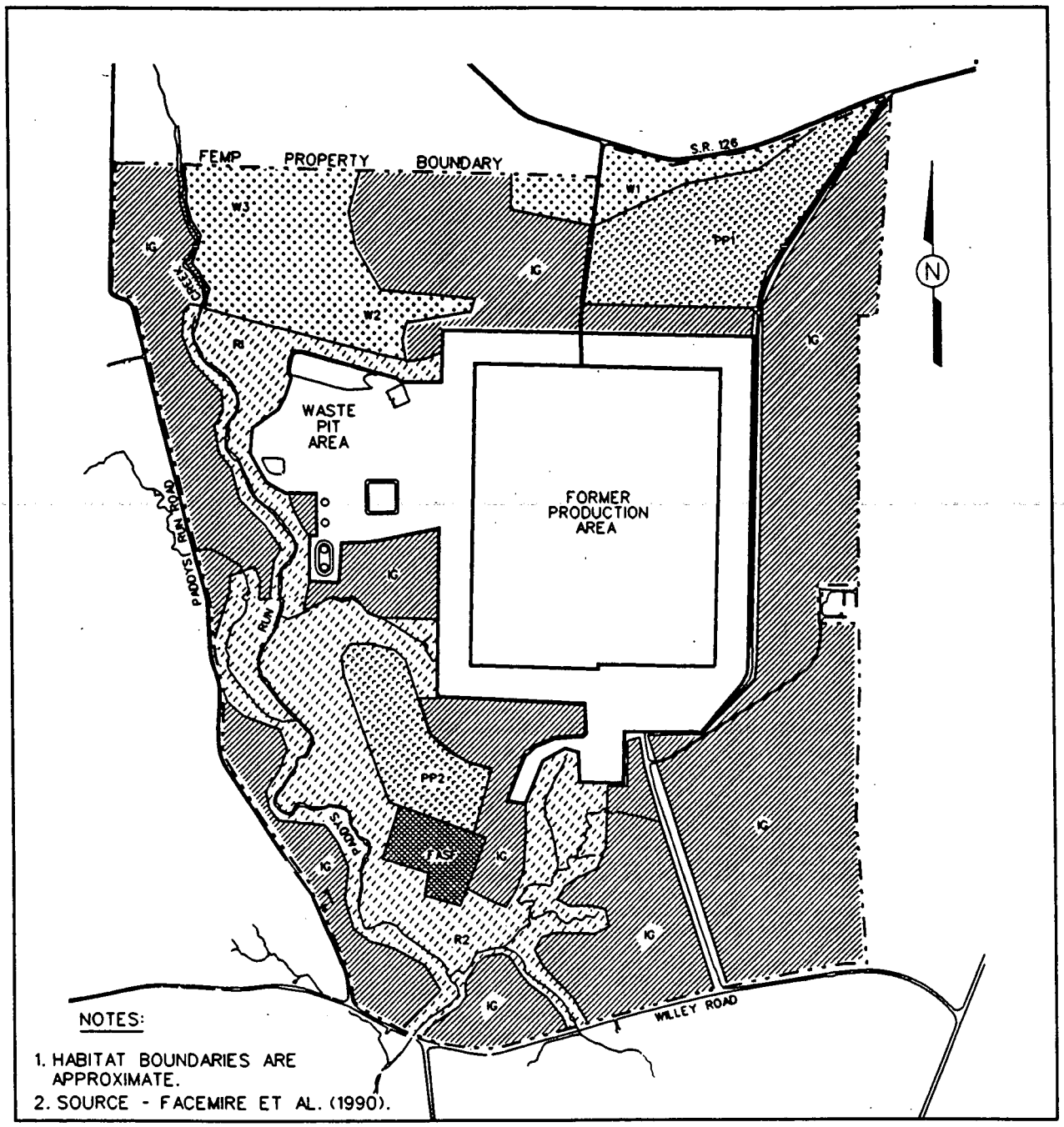


LEGEND:

- FEMP PROPERTY BOUNDARY
- INTRODUCED GRASSLAND (IG)
- FLYASH/SOUTH FIELD (FASF)
- PLANTED PINE PP1, PP2
- WOODLANDS W1 - INTERMEDIATE, W2 - YOUNG, W3 - MATURE
- RIPARIAN R1, R2
- DISTURBED

SCALE: 0 — 1200 FEET

FIGURE 3-26
HABITAT TYPES
PRESENT ON THE FEMP

fig0324.dgn

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 have been observed in the vicinity of the FEMP.

Amphibians and reptiles that occur on the FEMP 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 FEMP 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.

A baseline ecological risk assessment was performed as part of the Site-Wide Characterization Report (DOE 1993) to estimate potential, present, and future baseline risks that FEMP contaminants may present to ecological receptors. This risk assessment was based on data available as of December 1991. Ecological receptors considered included all organisms, exclusive of humans and domestic animals. Pursuant to the Amended Consent Agreement, an ecological risk assessment for FEMP will be completed as part of the Operable Unit 5 RI/FS process.

To comply with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, that requires federal agencies, "in consultation with and with the assistance of [the Secretaries of the Interior and Commerce, to ensure that their actions are] not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the critical habitat of such species...," Miami University performed an Ecological Characterization Study of the FEMP in 1989. The following discussion concerning threatened and endangered species with potential habitats in the vicinity of the FEMP were drawn from conclusions of the study and supplemental investigations conducted as part of the Operable Unit 4 RI.

Indiana Bat (*Myotis sodalis*)

The Indiana bat is listed as both a federal and state endangered species and occurs in Butler and Hamilton counties. Surveys were conducted at the FEMP to determine the distribution and presence of the Indiana bat and to identify potential habitat on the FEMP and in the immediate vicinity. The Indiana bat has not been identified at the FEMP; however, during the summer of 1988, a population was identified approximately 5 km (3 miles) east of the FEMP (DOE 1993). Potential habitat for the Indiana bat occurs in portions of the riparian woodland associated with Paddys Run. Figure 3-27 classifies the habitat locations from excellent to poor. Very little habitat was considered excellent due to a general lack of dead trees suitable for colonies. Habitat along the banks of Paddys Run was somewhat better than habitat along the banks of Great Miami River. Within the FEMP, the majority of good habitat was located in the northern portion of the site. There were some questions over the accuracy of the methodology used in these surveys. Therefore, a follow-up survey will be performed in the summer of 1994, and updated information will be provided in future RI/FS documents.

Running buffalo clover (Trifolium stoloniferum)

Known populations exist at Miami Whitewater Forest, approximately 2.5 km southwest of the property. The FEMP has areas of similar habitat where this species might occur. In 1992, a limited survey of habitats suitable for this species failed to find any populations on property. A comprehensive survey for this species will be conducted in early summer 1994.

Cave Salamander (*Eurycea lucifuga*)

After an initial survey by ASI in 1988 (DOE 1993), a follow-up was completed in October 1993 (Davis 1994). Preliminary results show suitable habitat was found in a ravine in the north woodlot, as well as in a limestone-lined well at an old homestead, east of the east access road (Figure 3-28). It also appears that salamanders may utilize another well south of the FEMP property. However, because of severe drought conditions in the summer and fall of 1993, the survey only found two individuals (at the Girl Scout control site). It may be necessary to perform a brief survey in the spring 1994 to verify these assumptions.

Other Species

The northern water thrush (*Seiurus noveboracensis*), a state listed endangered species, was reported as a spring migrant along Paddys Run during the spring of 1987 by Facemire et al. (1990).

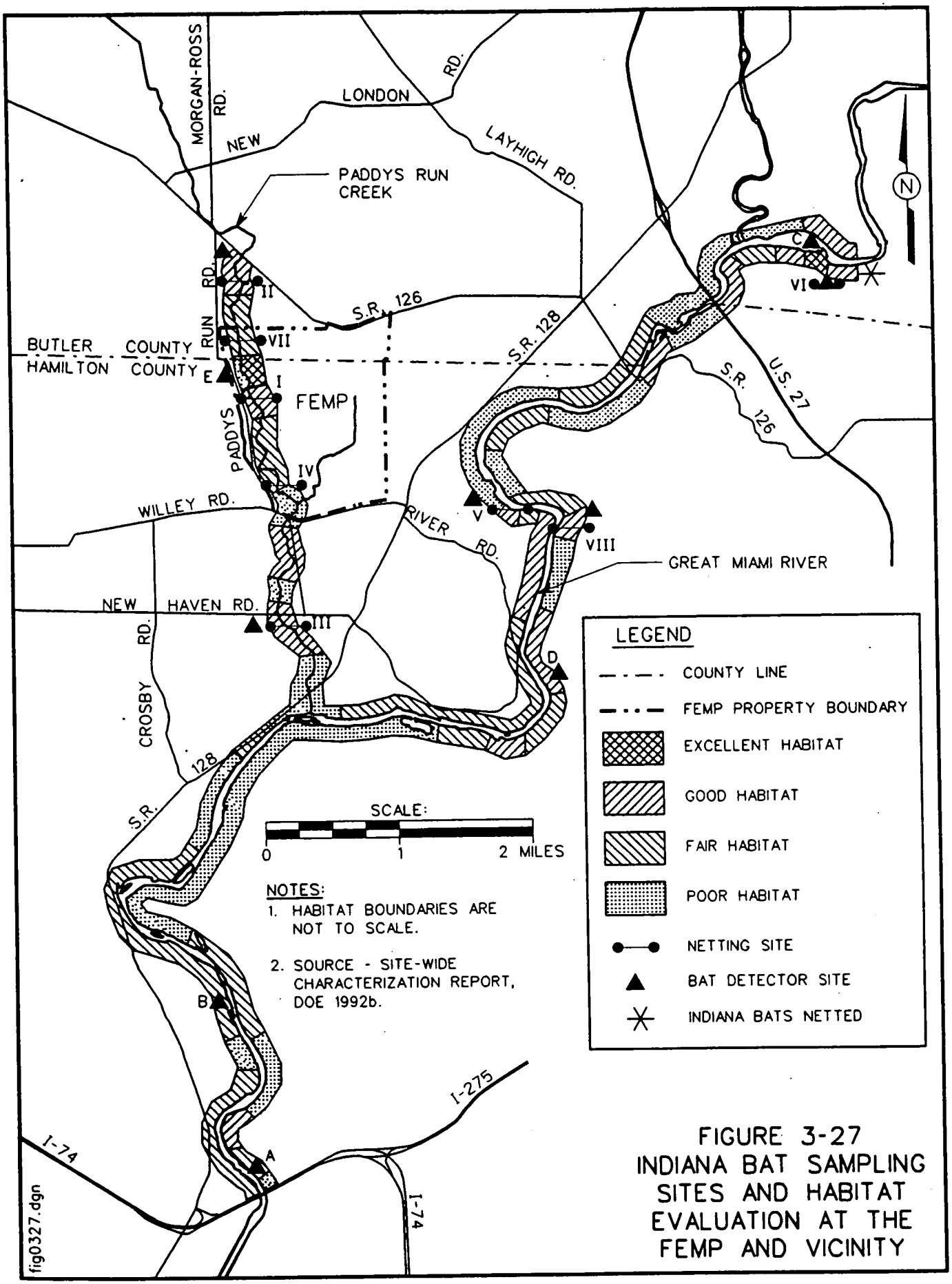
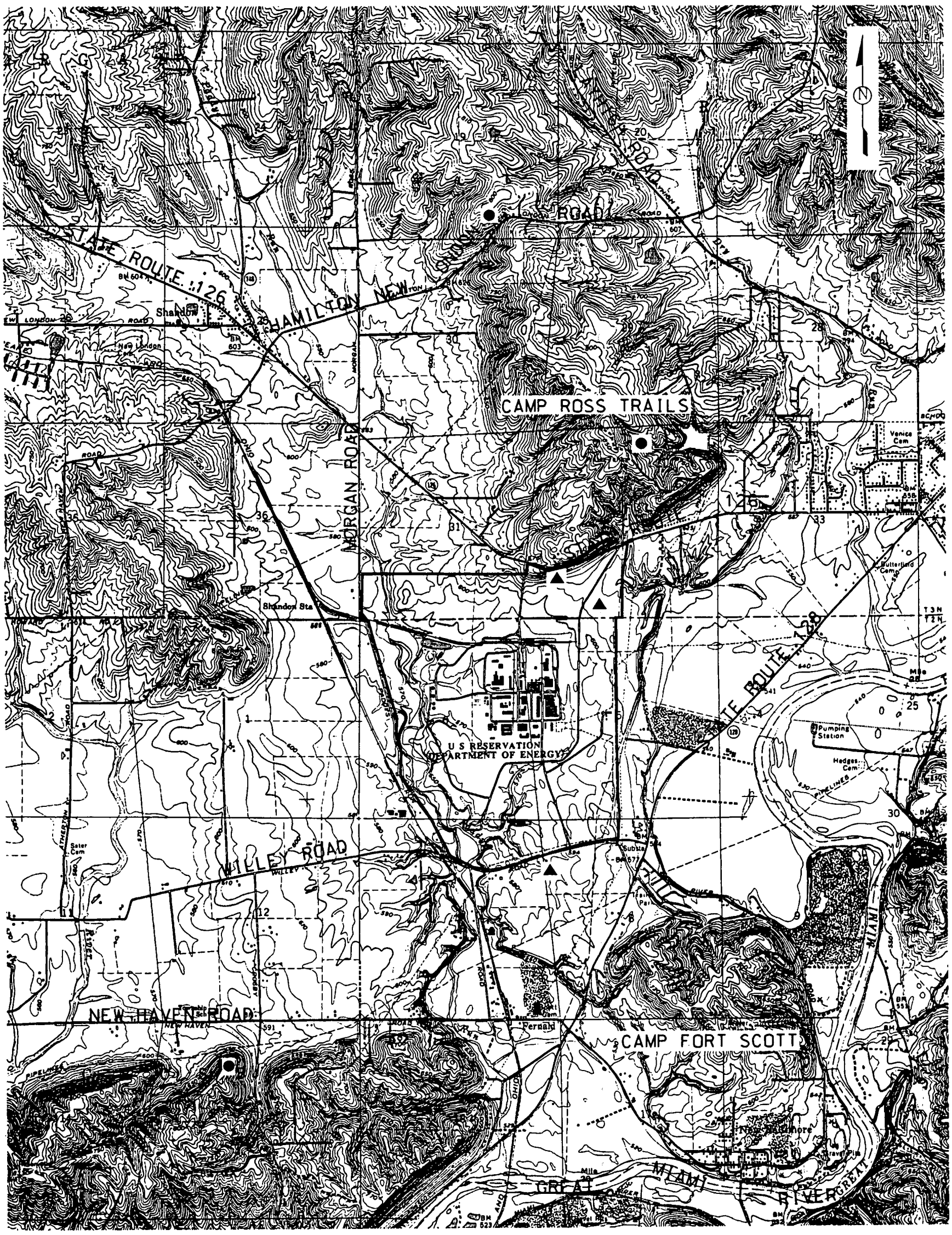


FIGURE 3-27
INDIANA BAT SAMPLING SITES AND HABITAT EVALUATION AT THE FEMP AND VICINITY



LEGEND:

POTENTIAL HABITAT

▲ ADULT CAVE SALAMANDERS ARE NORMALLY FOUND IN LIMESTONE SEEPS, WELLS, SPRINGHOUSES, AND UNDER ROCKS IN SPRING-FED STREAMS.

● KNOWN HABITAT

ADULT CAVE SALAMANDERS HAVE BEEN OBSERVED IN THESE AREAS.

SCALE

½ 0 1 MILE

FIGURE 3-28. KNOWN AND POTENTIAL HABITATS OF CAVE SALAMANDERS

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The northern harrier (*Circus Caneus*), a state listed endangered species, and the red-shouldered hawk (*Buteo lineatus*), a state listed threatened species, were observed flying over the FEMP by Facemire et al. (1990) on two separate occasions. Neither species has been reported to nest at the FEMP. The dark-eyed junco (*Junco ayemalis*), a state listed endangered species, was observed throughout the FEMP during the winter of 1986 and 1987 by Facemire et al. (1990).

Slender fingergrass (*Digitaria filiformis*) was listed in Facemire et al. (1990) as rare in the riparian area along Paddys Run. A survey will be conducted in the summer of 1994 to verify the presence of this species on the FEMP property. The mountain bindweed (*Polygonum cilinode*) also listed in the Facemire study, is reported by the Ohio Department of Natural Resources (ODNR) that the only other population have been reported from three counties near Lake Erie (ODNR 1992). A survey to verify this information will be conducted in the summer of 1994.

Spring coralroot (Corallorhiza wisteriana) is found locally at Miami Whitewater Forest in swampy woods. Although it was not found during the Facemire survey, northern areas of the FEMP appear to be appropriate habitat for this species. a survey will be conducted in the early spring of 1994.

Sloan's crayfish (*Orconectes sloanii*), also known as the Cincinnati crayfish, is a state listed threatened species reported from Paddys Run by Facemire et al. (1990). This crayfish is found in streams of Ohio and Indiana. One individual of this genus, not identified to species, was recorded in Paddys Run during RI/FS sampling (DOE 1993). A survey was completed in October 1993 (St. John 1993). Despite the fact that Paddys run was completely dry for most of the section on FEMP property, this species resided in pools in the north section of the property and downstream off property. It is uncertain if the population is large enough to repopulate the entire stream when water flows. An additional abbreviated survey may be performed in the spring of 1994 to define this species' range within Paddys Run during regular water flow.

The cobblestone tiger beetle (*Cicendela margipennis*), which is under review by the U.S. Fish and Wildlife Service for possible consideration as a threatened or endangered species, was found on a gravel bar in the Great Miami River two miles west southwest of the bridge at New Baltimore, Ohio. It is listed as a federal category two species, as well as a special interest species for the state of Ohio. Category two species are considered appropriate for federal listing as threatened or endangered;

however, this data is insufficient to support their protection under the Endangered Species Act. Additional field investigations will be done in 1994 to verify the status and distribution of this species.

3.2 SOLID WASTE LANDFILL CHARACTERISTICS

The Solid Waste Landfill occupies an approximate area of 1.5 acres and is located northwest of the former Production Area near the center of the FEMP property. The present elevation of land surface ranges from 585 to 590 feet MSL, which is about 5 to 10 feet above the 1950 surveyed elevation for the area. This suggests that there are at least 5 to 10 feet of fill in the landfill. The Solid Waste Landfill was capped with soil and currently has a grassy vegetation cover. A detailed assessment of topography, surface water, geology, and hydrogeology was performed around this unit to define specific pathways and potential impacts from the Solid Waste Landfill to the environment.

3.2.1 Topography and Surface Water

Surface drainage at the Solid Waste Landfill has been controlled by grading the area toward a drainage channel that flows westward along the northern portion of the landfill (Figure 3-29). The drainage channel discharges into Paddys Run. A drainage pond, seen in aerial photographs from 1973 to 1986, was located along the western boundary of the landfill and was apparently designed to receive storm water runoff from the landfill. The pond contents would then evaporate, percolate into the soil, or overflow via a spillway into the drainage channel. A railroad bed to the south of the landfill serves as a berm to divert any surface water runoff from the landfill into the aforementioned drainage channel. Surface drainage south of the railroad bed and outside the landfill limits has been altered by recontouring the area to allow westwardly flow toward Paddys Run.

The highest point in the landfill, with an elevation of 593 feet above MSL, is situated in its north central portion (Figure 3-29). The landfill's lowest point, excluding the drainage channel, is approximately 584.5 feet above MSL and is located at the culvert crossing near the northwest boundary of the landfill. The access road on the east side of the landfill is at an elevation of approximately 590 feet above MSL. Surface water drainage off of the site was observed to be inefficient, with ponding of water visible on the surface after rain events. Percolation is also slow since the ponded water was observed for up to several weeks after rain events.

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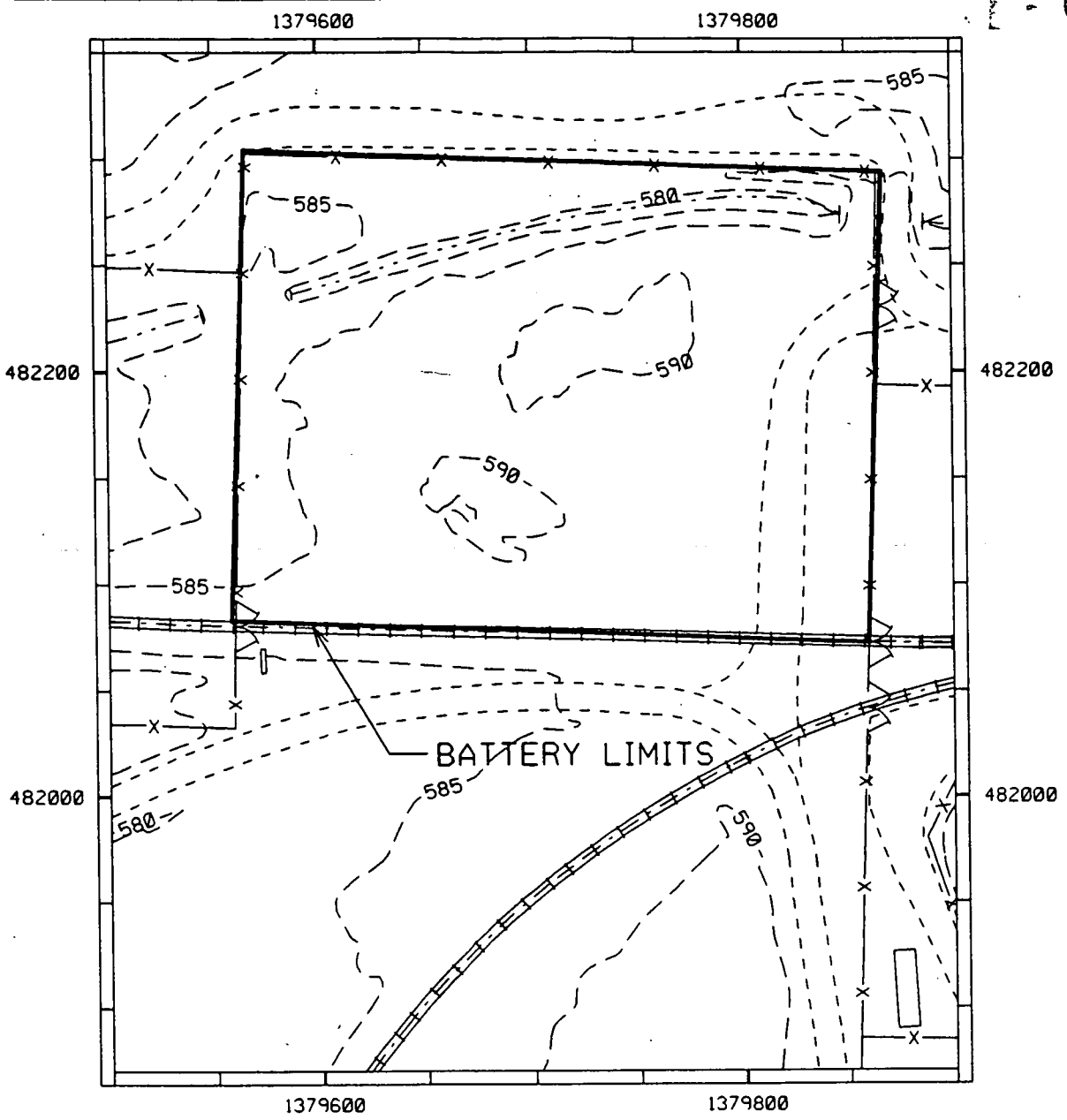

LEGEND

575 ELEVATION CONTOURS
ROADS
DRAINAGE
FENCE
RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 40 80 160

fig0329.dgn

FIGURE 3-29
TOPOGRAPHY OF THE SOLID WASTE LANDFILL

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3.2.2 Geology and Groundwater Hydrology

Soil samples from subsurface borings were examined to define the lithology of the subsurface strata. Groundwater monitoring wells were installed to determine concentrations of various chemical constituents in groundwater and to determine groundwater elevations. Based on the lithologic descriptions presented in the boring logs (Appendix C), a general description of the strata below the landfill was determined.

Two geological cross sections are presented for the Solid Waste Landfill. The geologic cross sections represent the interpreted geology along the actual cross-section traces shown on the map insets. In order to generate the geologic cross-section, a three-dimensional model of the geologic strata was developed using Intergraph Corporation's MGE suite of software products. The MGE Geologic Analyst (MGLA) was used to associate boring log information with the modeled geologic strata. Some interpretation was added to augment the information from the borings. For example, aerial photographs from 1950 indicated two pre-existing drainages in the South Field area which were not apparent from the soil boring data. These features were manually added to the model. The MGE Terrain Modeler (MSM module) was then used to create the surface model of each of the geologic surfaces. Triangulated surfaces were created based upon XYZ points from soil borings and the digitized (interpreted) contours. The MSM software also provides for the generation of sections through the terrain models. This feature was applied to each of the six geologic layers and combined to form the sections shown. Figure 3-30 shows the location of cross sections. The Solid Waste Landfill study area consists of approximately 40 feet of glacial overburden overlying the Great Miami Aquifer. The glacial overburden consists of interbedded layers of hard and stiff clay and silt with varying amounts of sand and gravel. At several locations, vertical fractures with iron staining were also noted. The clay and silt appear as yellowish-brown layers that grade downward into a stiff gray clay. This color transition is thought to be a function of the weathering, which has oxidized the upper layers from a gray to a yellowish-brown color.

The gray clay layer beneath the oxidized layer varies in shading from olive-gray to dark gray and consists of a very soft to very dense hard clay with some sands and gravels. The thickness of this layer ranges from greater than 15.0 feet at Boring No. 1038 to 24 feet at Boring No. 3037. Within this gray clay layer, there appear to be discontinuous lenses of wet gray sand varying in thickness between 2.5 feet at Boring No. 2027 and 6 feet at Boring No. 1038. The sand lenses were not

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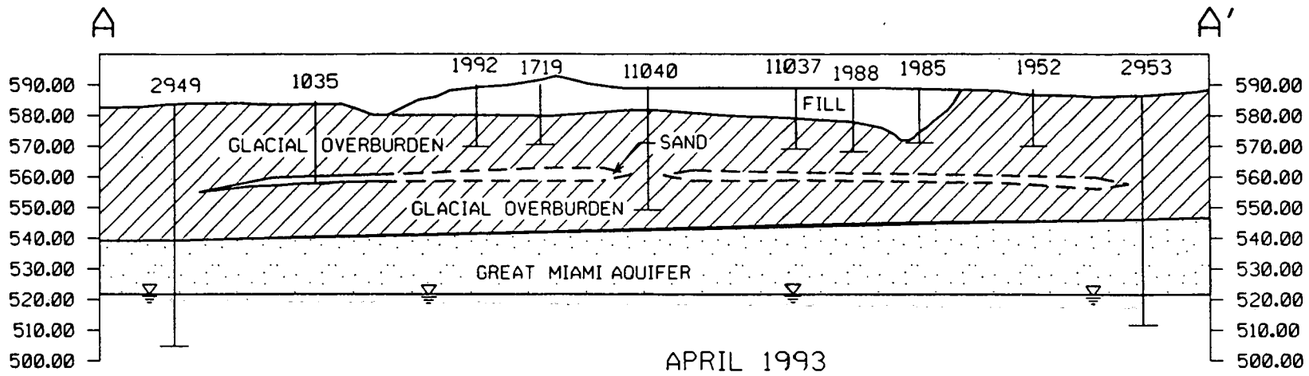
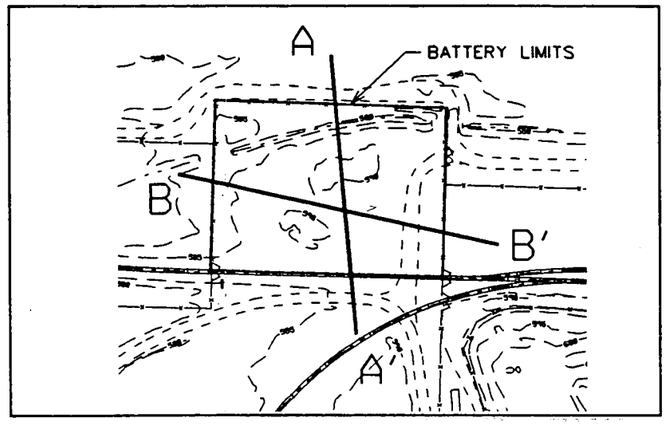
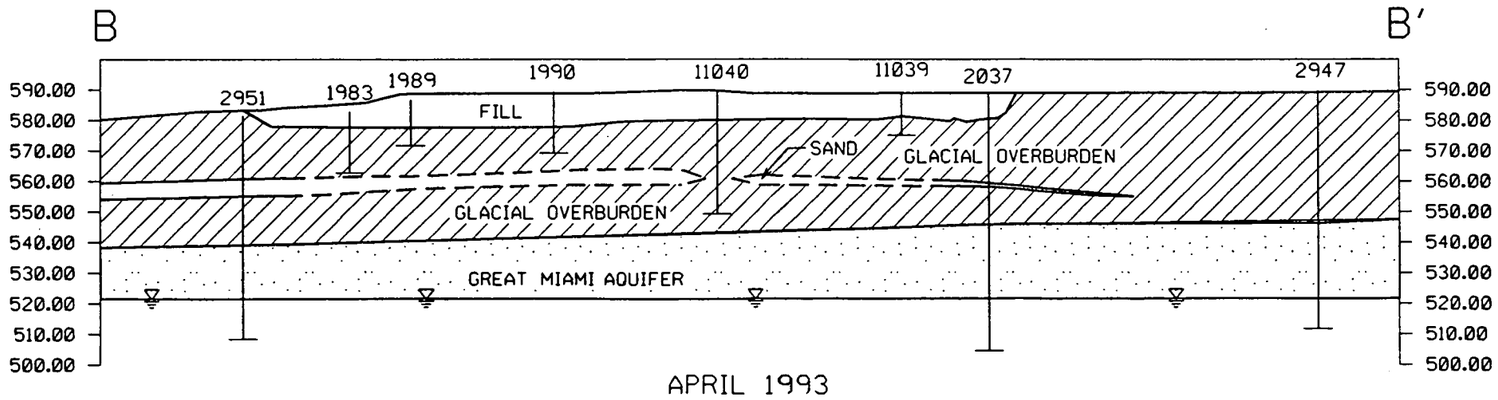
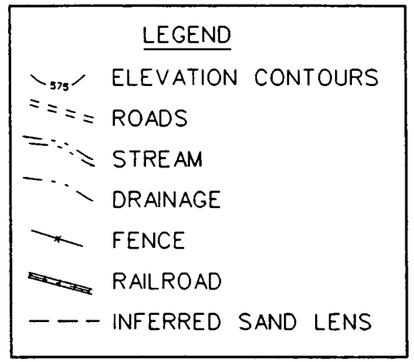
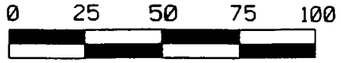




CROSS-SECTION LOCATION KEY (1"=200')







SCALE, SECTIONS (FT)
Vertical Exaggeration = 2 to 1

FIGURE 3-30
GEOLOGIC CROSS-SECTIONS
OF THE SOLID WASTE LANDFILL

fig0330.dgn

apparent in Boring No. 3037. This gray sand is described as a medium dense to very dense, well-graded sand of olive-gray to dark gray color with varying degrees of gravel.

A sand and gravel unit, approximately 90.0 feet thick at Boring No. 3037, underlies the gray clay layer. This unit, described in the boring logs as being very dense, dark, yellowish-brown sand and gravel layer, is the Upper Great Miami Aquifer. The Great Miami Aquifer is separated into the Upper and Lower Great Miami Aquifers by a blue clay aquitard (clay interbed). The deepest boring in the area, Boring No. 3037, terminated at a depth of approximately 135 feet in a dark gray clay, which, based on drilling activities across the site, is interpreted to be the blue clay aquitard.

Groundwater was encountered at shallow depths in two boreholes while drilling during April 1993, which was an unseasonably wet period. Otherwise, samples of till appeared to be unsaturated to dry during drilling with the exception of a thin (less than 1-inch thick) sand lens. However, all monitoring wells completed in the till eventually filled with groundwater. The groundwater elevation surface map for the glacial overburden is provided in Figure 3-31. Groundwater elevations within the glacial overburden ranged from approximately 550 to 580 feet above MSL, which is about 10 to 40 feet below land surface. Groundwater appears to flow toward the southwest, which parallels the trend in local topography, with an apparent discharge area in the vicinity of Paddys Run.

Hydrographs for the glacial overburden groundwater monitoring wells are presented in Figure 3-32 along with a rainfall histogram from March to September 1993. Groundwater elevation changes in the wells show poor correlation to rainfall events. This trend suggests that direct precipitation recharge at the Solid Waste Landfill is slow, which is consistent with the low permeability expected in the thick clay at the site. A summary of slug tests conducted in wells completed in the glacial overburden was shown on Table 3-2. Calculated hydraulic conductivities range from 4.1×10^{-6} cm/s to 4.7×10^{-3} cms (Appendix H). Soil samples of silty sand collected from the interval beneath the glacial till and above the Great Miami Aquifer water table were partially saturated to saturated. This suggests that the upper groundwater system and the Great Miami Aquifer are not in hydraulic contact beneath the Solid Waste Landfill; therefore, the upper groundwater system is defined as a perched groundwater system.

Geotechnical samples were collected during the Operable Unit 2 RI (Phase II), the Solid Waste Landfill Pre-Design Study, and the On-Site Disposal Cell Pre-Design Study. Thirty-three

geotechnical samples were collected from twenty-six locations during the Phase II sampling activity for the RI, thirty-one samples from seventeen locations for the Solid Waste Landfill Pre-Design Study, and forty-six samples from ten locations during the On-Site Disposal Cell Pre-Design Study (see Table 3-3a). These samples were collected from various depths within fill material, the till, and the upper portion of the Great Miami Aquifer. For the purpose of this discussion, only those collected from the till will be discussed.

The soil classification for the till included loams, silt loams, silty clay loams, silty clays, and clays. The classification was determined from the grain size distribution (Table 3-3a), which ranged from 0 to 40 percent for gravel, 2 to 51 percent for sand, 2 to 53 percent for silt, and 5 to 56 percent for clay. The grain size distribution varied throughout the samples and was independent of depth and color (i.e., yellowish brown, brown, grayish brown, or gray).

The specific gravity ranged from 2.6 to 2.84 and the moisture content ranged from 7 to 25.1 percent by weight (Table 3-3a). The percent saturation for the till ranges from 54.6 percent to 128.7 percent (see Table 3-3a). The percent saturation was calculated by using the water content, specific gravity, and the bulk density (total unit weight). The formula for saturation, taken from Capper and Cassie (1976), and Lambe and Whitman (1969), is as follows:

$$S = \omega G_s \rho / G_s(1+\omega)-\rho$$

where:

S is the saturation,
ω is the water content,
G_s is the specific gravity,
ρ is the bulk density.

The water content is determined by taking the unit weight of water (the difference between the total unit weight and the dry unit weight) and dividing by the dry unit weight. The specific gravity was determined during geotechnical analysis; however, where this determination was not made the value of 2.7 was used, which is the average value. The bulk density (when the soil is in its natural state) was taken as the total unit weight and converted into megagrams per meter cubed (Mg/m^3). The

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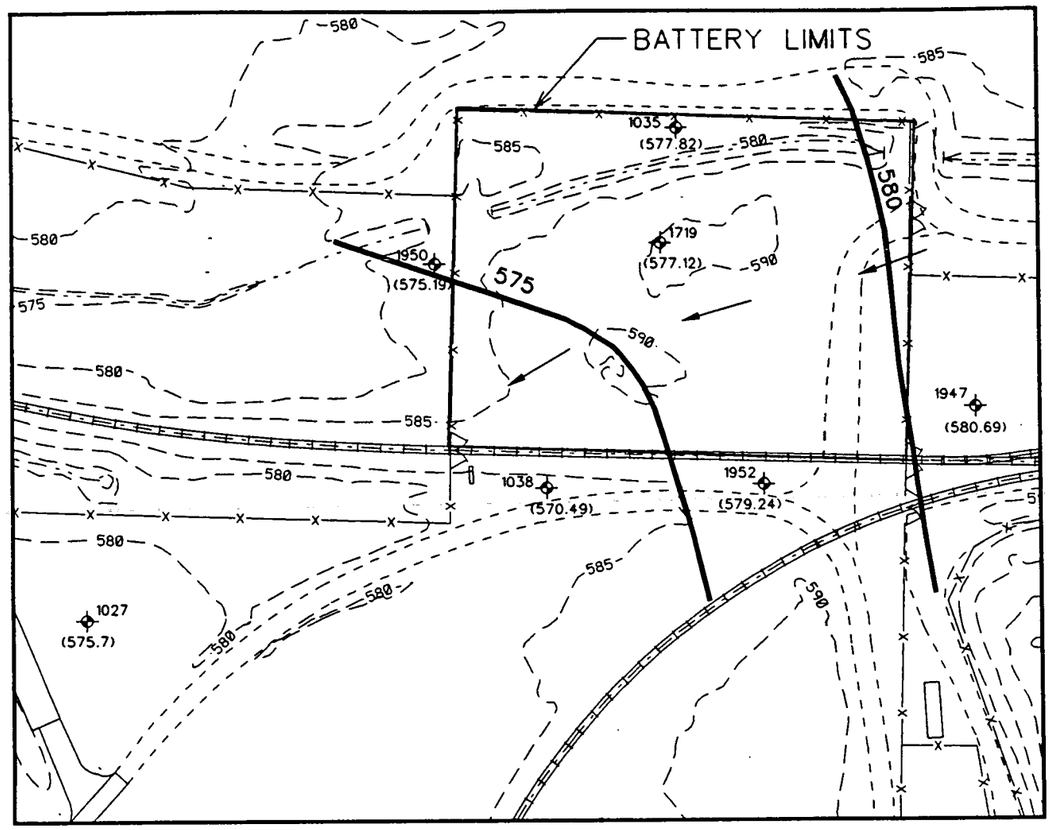
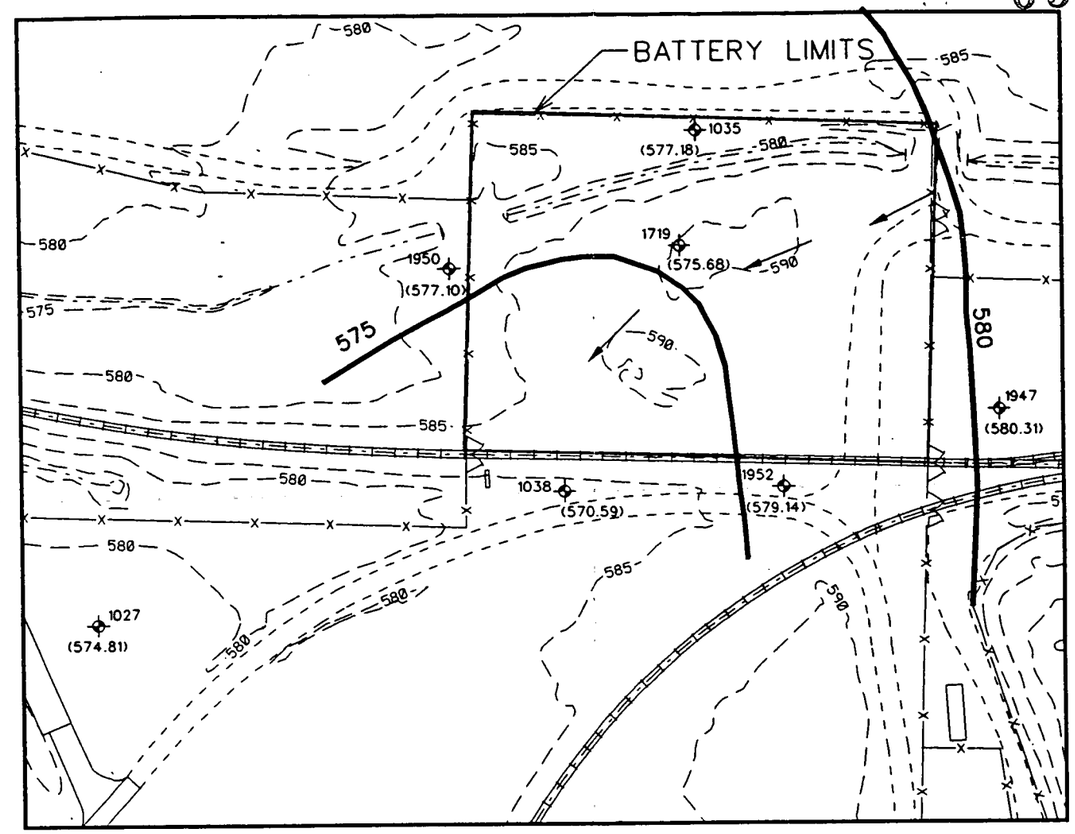


JUNE 21, 1993



JULY 19, 1993

LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- 1038 — 1000 MONITORING WELLS
- (570.49) — GROUNDWATER ELEVATIONS
- 575 — GROUNDWATER CONTOURS
- INFERRED DIRECTION OF PERCHED GROUNDWATER ZONE

N

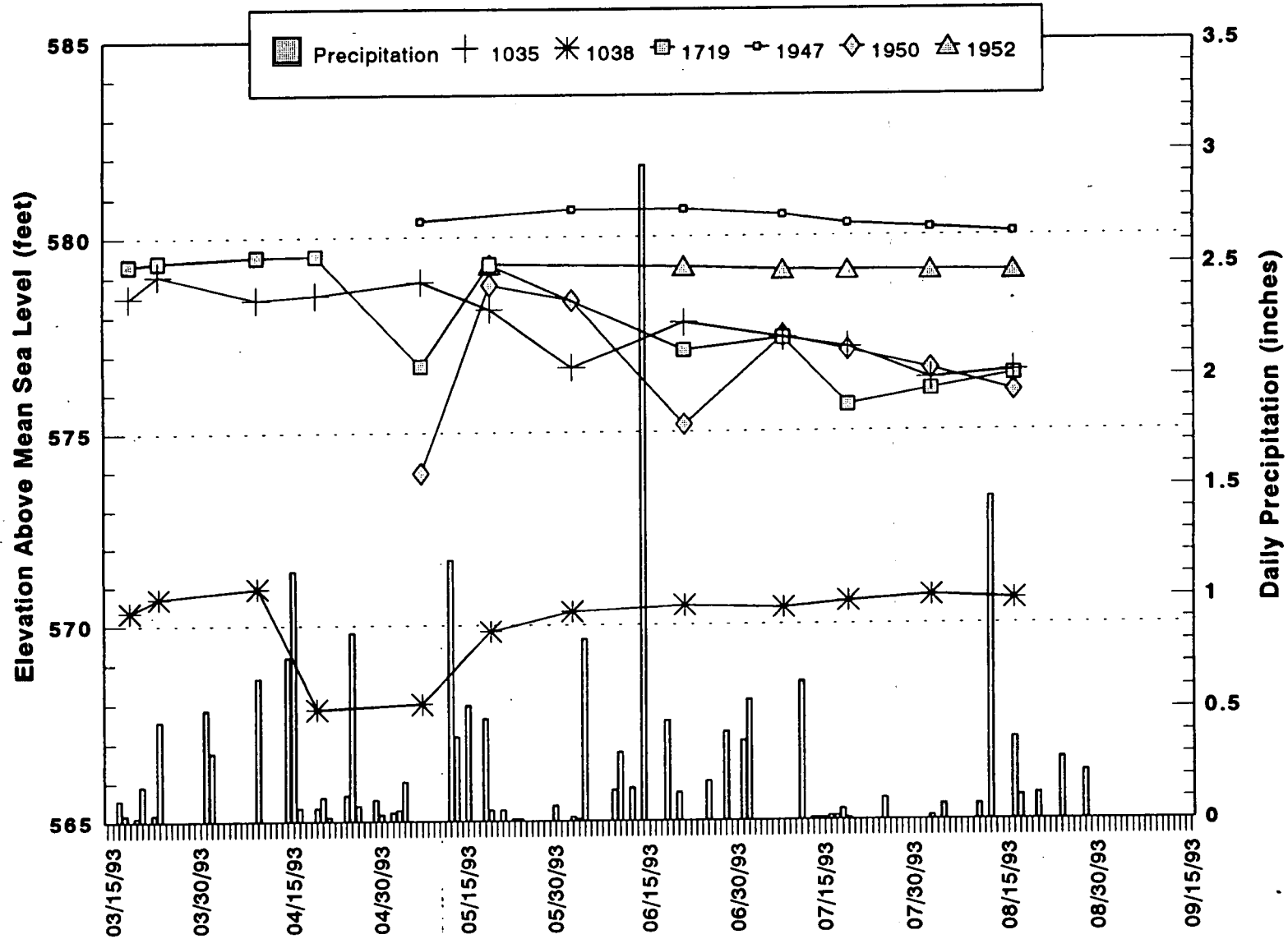
NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)

0 50 100 150

FIGURE 3-31
GROUNDWATER ELEVATIONS FOR 1000-SERIES WELLS, SOLID WASTE LANDFILL, JUNE 21, 1993 AND JULY 19, 1993

fig0332.dgn



NOTE: SURFACE ELEVATIONS IN SOLID WASTE LANDFILL RANGE FROM APPROXIMATELY 593 TO 584.

PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-32

HYDROGRAPHS FOR 1000-SERIES WELLS, SOLID WASTE LANDFILL

F:\RIREPORT\FIGURES\FIG3-32

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TABLE 3-3A

SUMMARY OF GEOTECHNICAL RESULTS

BORING	DEPTH	DESCRIPTION	MOISTURE CONTENT (%)	(%) GRAVEL	(%) SAND	(%) SILT	(%) CLAY	SPECIFIC GRAVITY	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SATURATION %
G2-104	-15	YELLOWISH BROWN FAT SILTY CLAY	10	6	14	44	36	2.74	138	125	75.3777916059
G2-105	-23.5	GRAY LEAN SILTY CLAY LOAM	14	6	20	39	35	2.72	141	123	102.112082749
G2-107	-3.5	YELLOWISH BROWN LEAN LOAM	16	3	23	41	33	2.77	134	115	89.17327514
G2-111	-6	GRAY BROWNLEAN CLAY LOAM	17	2	20	42	36	2.65	137	117	109.113668251
G2-115	-16	YELLOWISH BROWN LEAN CLAY	21			53	47	2.74	133	110	103.444936785
G2-201	-3	YELLOWISH BROWN CLAY	19		3	49	48	2.7	124	104	83.0586562414
G2-201	-8.5	YELLOWISH BROWN CLAY	16	2	10	46	42	2.73	137	118	98.5816343767
G2-201	-23.5	GRAY LEAN CLAY	13	8	29	39	24	2.75	143	127	100.239214445
G2-202	-8.5	YELLOWISH BROWN LOAM	14	10	25	38	27	2.81	141	124	94.0358326613
G2-203	-18.5	YELLOWISH BROWN	17	7	31	32	30	2.74	139	119	105.902864256
G2-203	-23.5	GRAY SILT LOAM	14	7	28	40	25	2.75	139	122	94.3538973118
G2-204	-8.5	YELLOWISH BROWN LOAM	14	6	26	39	29	2.74	139	122	95.2054476991
G2-204	-13.5	GRAY LEAN LOAM	13	4	25	44	27	2.76	144	128	101.895722475
G2-204	-23.5	GRAY LEAN SILT LOAM	12	7	29	38	26	2.78	144	129	95.3496236964

TABLE 3-3A
(Continued)

BORING	DEPTH	DESCRIPTION	MOISTURE CONTENT (%)	(%) GRAVEL	(%) SAND	(%) SILT	(%) CLAY	SPECIFIC GRAVITY	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SATURATION %
G2-205	-3.5	YELLOWISH BROWN LEAN SILTY CLAY LOAM	11	1	12	51	36	2.68	138	124	85.2593277126
G2-205	-18.5	GRAY LEAN LOAM	13	16	27	37	20	2.77	144	128	100.861652734
G2-206	-3.5	YELLOWISH BROWN CLAY LOAM	11	5	19	41	35	2.76	123	110	54.7068437313
G2-206	-8.5	YELLOWISH BROWN CLAY LOAM	14	9	23	38	30	2.75	139	122	94.3538973118
G2-208	-3.5	YELLOWISH BROWN CLAY	23		2	63	35	2.76	122	99	86.1113547373
G2-208	-8.5	YELLOWISH BROWN CLAY LOAM	17	1	30	42	27	2.76	137	117	99.5080327118
1947	-7	YELLOWISH BROWN CLAY	21.2	7	7	7	7	2.7	125	103.4	90.2324843522
1950	-3	OLIVE BROWN CLAY	20.6	7	7	7	7	2.7	127	105.3	92.5981593795
1950	-9	OLIVE BROWN CLAY	18.2	7	7	7	7	2.7	141	118.9	118.972106614
1986	-16	OLIVE BROWN CLAY	18.4	7	7	7	7	2.7	144	121.5	128.724399871
1988	-21	GRAY CLAY	12	7	7	7	7	2.7	134	119.6	79.2441883891
1989	-11	OLIVE BROWN CLAY	15.4	7	7	7	7	2.7	140	121.7	106.774438439
1990	-21	OLIVE BROWN CLAY	14.1	7	7	7	7	2.7	141	123.7	104.581021332
1934	-3	OLIVE BROWN CLAY	25.1	7	7	7	7	2.7	124	99	96.7373612904

TABLE 3-3A
(Continued)

BORING	DEPTH	DESCRIPTION	MOISTURE CONTENT (%)	(%) GRAVEL	(%) SAND	(%) SILT	(%) CLAY	SPECIFIC GRAVITY	TOTAL UNIT WEIGHT (pcf)	DRY UNIT WEIGHT (pcf)	SATURATION %
1940	-3	OLIVE BROWN CLAY	20.1	7	7	7	7	2.7	127	105.7	91.3599984939
2936	-3	OLIVE BROWN CLAY	12	7	7	7	7	2.7	134	119.6	79.2441883891
1994	-29	YELLOW BROWN CLAY	17.2	7	7	7	7	2.2	133	113.9	179.939797592
1998	-17	GRAY CLAY	14.3	7	7	7	7	2.7	142	124.5	108.214227645
1965	-25.5	YELLOW BROWN CLAY	7	7	7	7	7	2.7	134	124.9	54.6294672147
1966	-14	OLIVE BROWN CLAY	19	7	7	7	7	2.7	130	109.6	94.4793678029
1969	-13	GRAY CLAY	12.1	7	7	7	7	2.6	144	128.1	119.349390666
1970	-8	BROWN CLAY	21.3	7	7	7	7	2.7	123	101.6	86.8328782284
1975	-6	BROWN CLAY	26.1	7	7	7	7	2.7	122	96.9	94.9409254438
1977	-4	OLIVE BROWN CLAY	13.1	7	7	7	7	2.7	139	122.9	95.2025702915
1977	-15.5	OLIVE BROWN CLAY	17.6	7	7	7	7	2.7	135	114.9	101.462991202

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results from the equation were multiplied by 100 to obtain the percentage value (Table 3-3a). The percentage value was plotted against the depth using a scatter plot (Figure 3-32a).

Soils are considered saturated when they reach 100 percent or greater saturation, and are considered partially saturated below this value. As indicated by Figure 3-32a the level of saturation is independent from the depth. However, the till has an apparent tendency to be partially saturated at depths less than 10 feet, and a greater tendency for saturation at depths greater than 10 feet.

Gray soils, which are considered to be unoxidized, are found at depths from 12 to approximately 23 feet, and their saturation levels varied independently from depth (Figure 3-32b), but there were more samples saturated than partially saturated. The yellow/brown soils, the oxidized soils, were found at depths ranging from approximately 3 feet to approximately 25 feet, and with a tendency to be partially saturated at shallower depths (Figure 3-32c). Operable Unit 2 agrees to the precept that there is a degree of saturation throughout the till (from partial to total saturation); however, it must be kept in mind that wells have been installed in the till and screened at particular intervals and these wells have water levels. These water levels indicate a water table, which is "the upper surface of a zone of saturation" above which exists the vadose zone. As a whole, 39 percent of the samples were saturated and 51 percent partially saturated.

Groundwater elevation data from 2000-series monitoring wells completed within the upper Great Miami Aquifer indicate that the regional aquifer is essentially flat beneath the Solid Waste Landfill, displaying an southeasterly potential flow direction with a gradient of 0.001 on June 21, 1993 (Figure 3-33). Groundwater elevations for monitoring wells screened within the aquifer are approximately 520 to 525 feet above MSL as shown on the hydrograph in Figure 3-34, which is about 60 feet below ground surface. The wells were screened in the saturated sands of the Upper Great Miami Aquifer (see Boring Log 3037, Appendix C-22; and well installation diagram for 2037, Appendix C-23). Groundwater elevation hydrographs from the Great Miami Aquifer in Well No. 2037 (Figure 3-34) above and Well No. 3037 at the blue clay aquitard are approximately the same (locations are shown on Figure 2-2). This suggests that there is very little vertical gradient in this area, a condition that does not favor deep recharge to the Great Miami Aquifer.

3.3 LIME SLUDGE PONDS CHARACTERISTICS

The Lime Sludge Ponds are located immediately west of the former Production Area. A north-south railway is located along the western boundary of this waste area (Figure 3-35). Access roads lie to the north and east of the waste area. A portion of the K-65 Slurry pipeline (part of Operable Unit 3) lies in a covered, concrete trench and forms the southern boundary.

The Lime Sludge Ponds were constructed at the beginning of the production activity, although the exact method of construction is not known.

The South Lime Sludge Pond has been inactive for approximately 25 years and is currently covered by grass and weeds. The North Lime Sludge Pond is still active and has only sparse vegetation on the lime sludge surface. A portion of the North Lime Sludge Pond contains standing water whose depth varies depending on site processes. The standing water ranges from three feet deep at the west edge to several inches deep approximately 20 feet to the east.

3.3.1 Topography and Surface Water

Topography in the vicinity of the Lime Sludge Ponds slopes gently to the west. The topography was recontoured to the west of this waste area during construction of the ponds and again during recent alterations of the Waste Pit Area drainage. The ponds are bermed and unlined. A central east-west oriented berm is common to both ponds. The berms of the south pond exhibit elevations from a low of 580.6 feet above MSL to a high of 583.5 feet above MSL (the highest surveyed point within the Lime Sludge Ponds area). The maximum surveyed elevation of the north pond is located on the east berm and is 579.5 feet above MSL. This means that the surface of the south pond is approximately three feet higher than the north pond. Precipitation is intercepted by the Lime Sludge Ponds and retained within them due to the surrounding berms. Outside the berms, surface water to the east, north, and west collects in a drainage ditch on the north side of the North Lime Sludge Pond, drains toward the west, and eventually drains into the drainage ditch located south of the K-65 silos. The drainage discharges to Paddys Run. Surface water to the south generally flows to the southwest as sheet flow.

3.3.2 Geology and Groundwater Hydrology

Soil samples from subsurface borings were examined to define the lithology of the subsurface strata. Groundwater monitoring wells were constructed to determine concentrations of various chemical

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FIGURE 3-32.a
TILL SATURATION
Vs
DEPTH

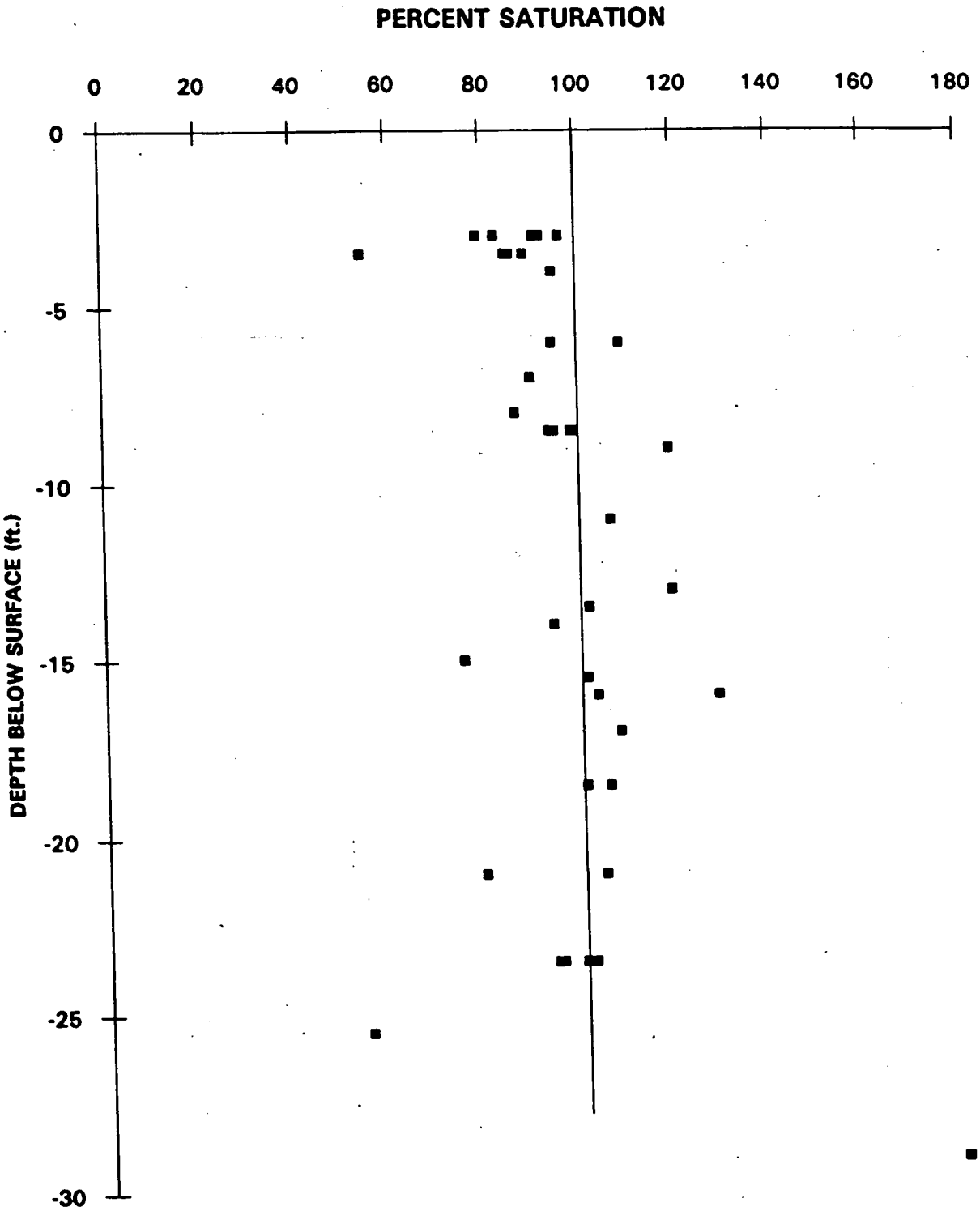
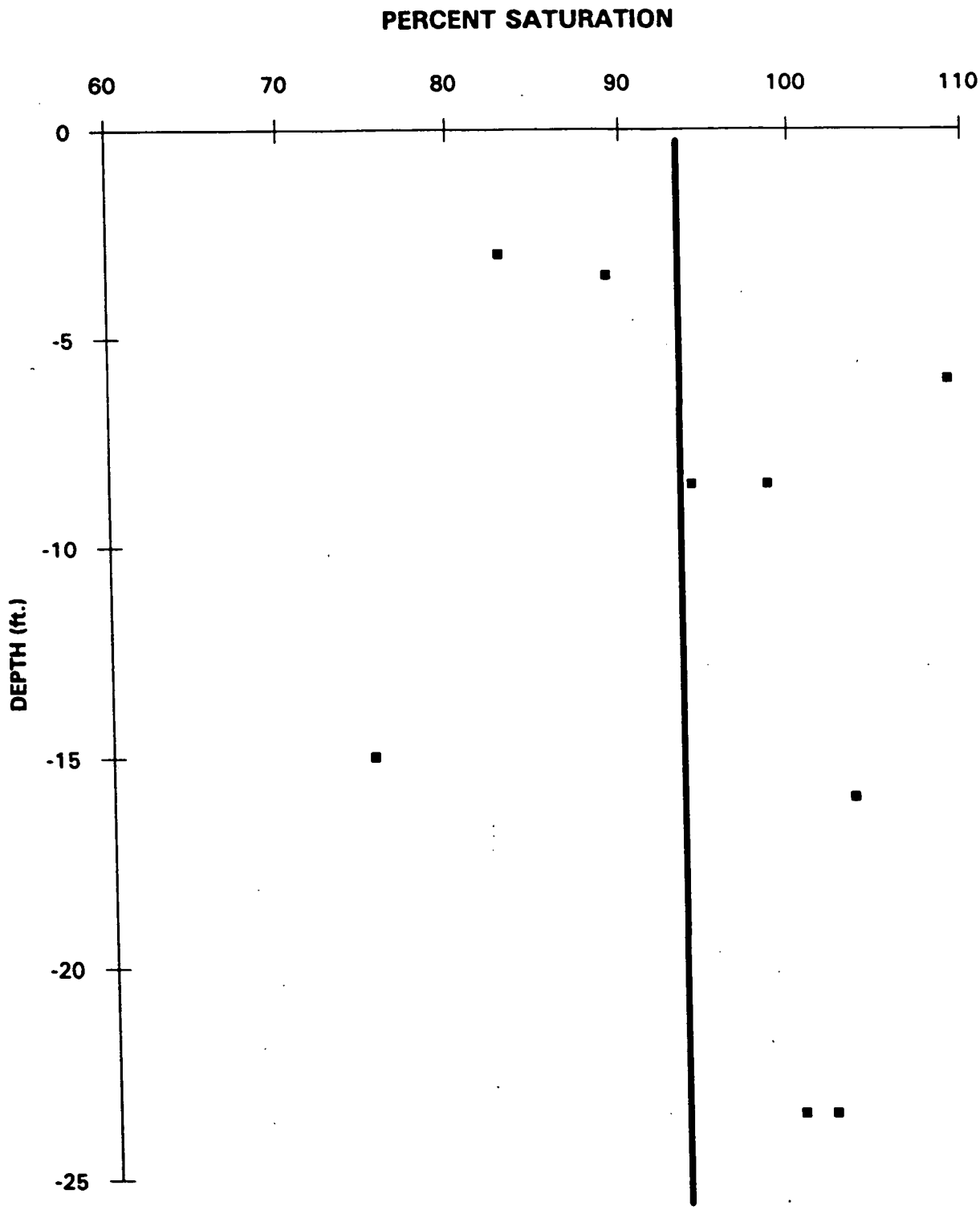


FIGURE 3-32.b
GRAY TILL SATURATION
Vs
DEPTH



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SAT_3.XLC/5/31/94/2:26 PM

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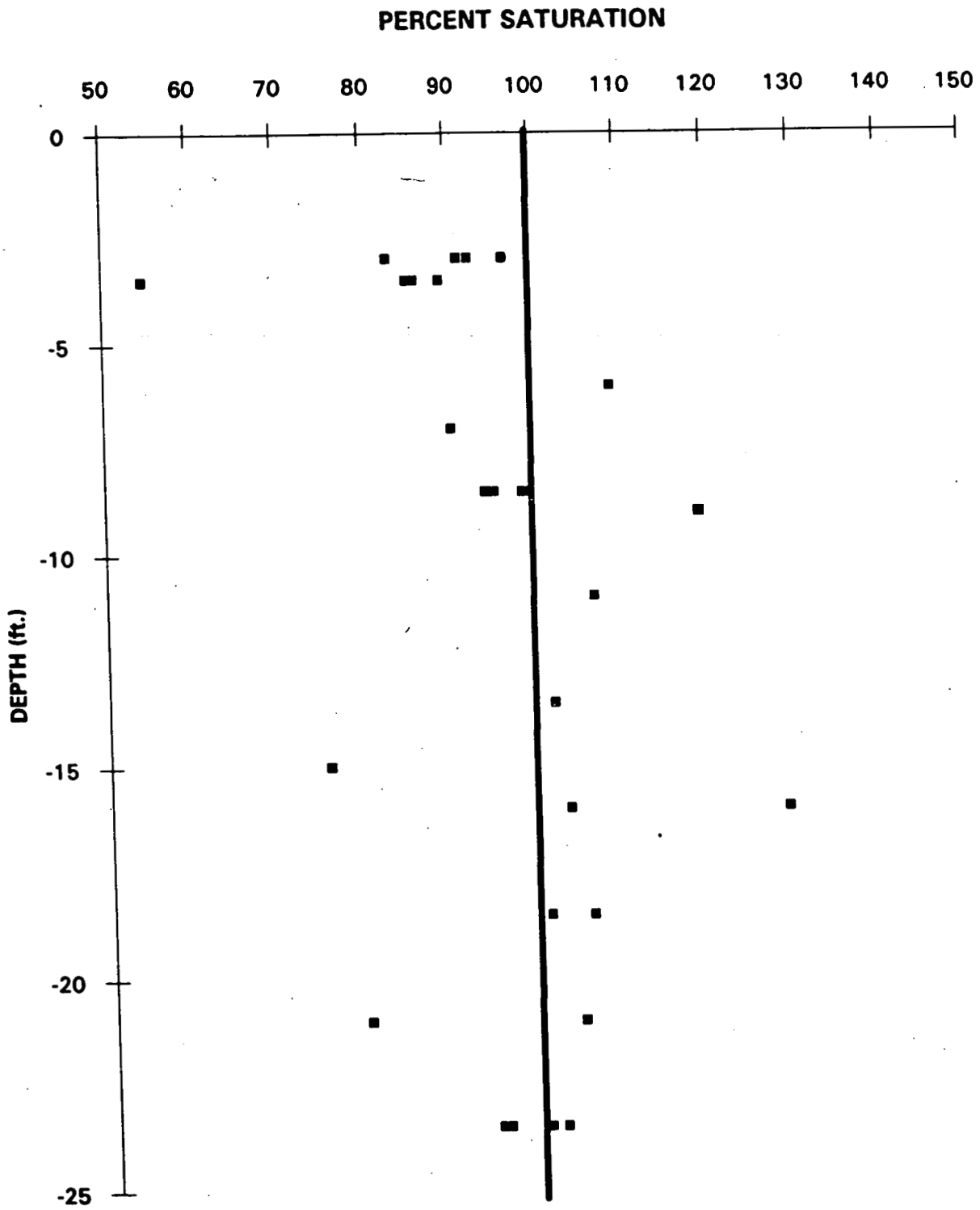
FIGURE 3.32.c
YELLOW/BROWN TILL SATURATION
Vs
DEPTH



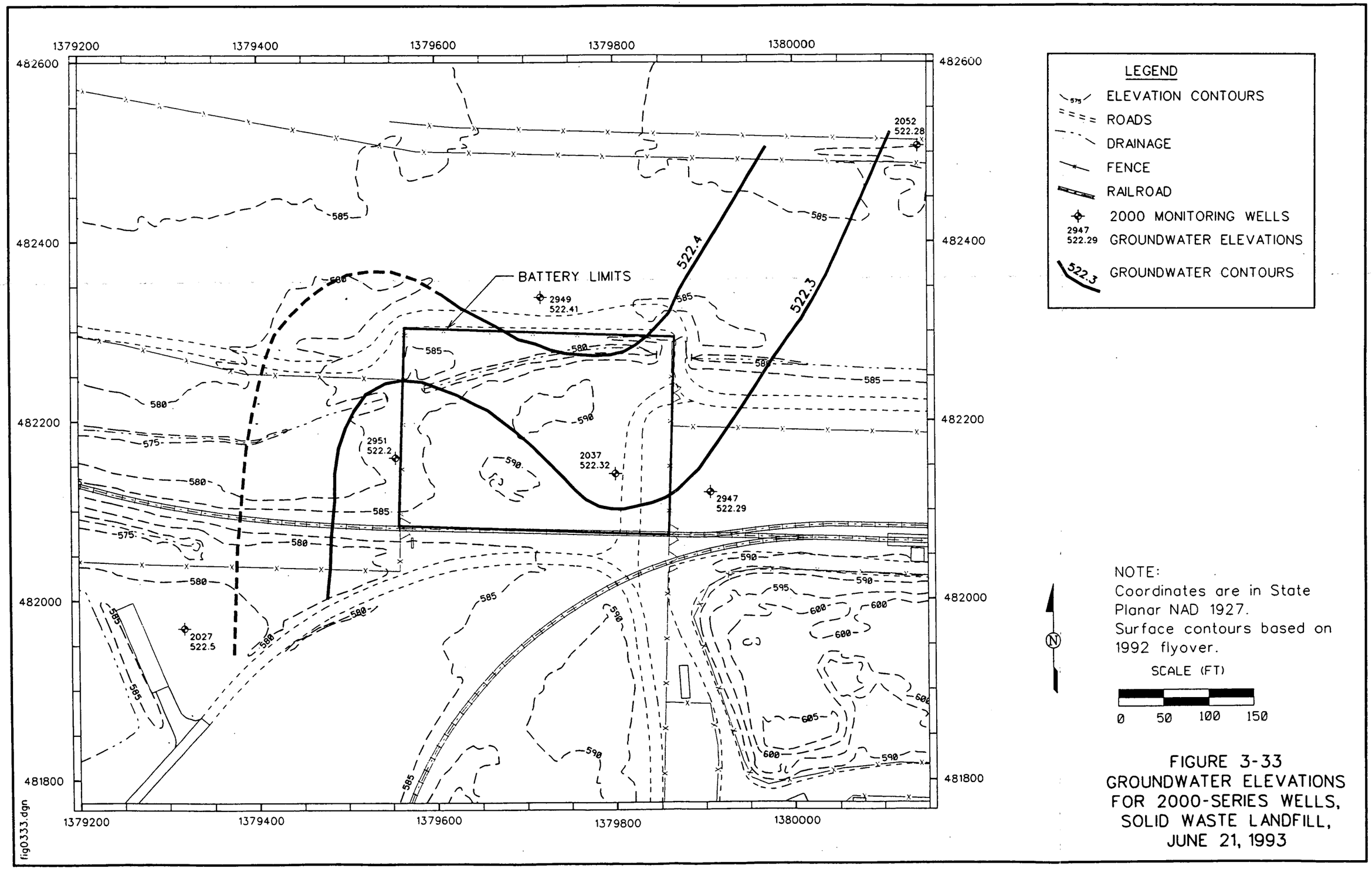


FIGURE 3-33
GROUNDWATER ELEVATIONS FOR 2000-SERIES WELLS, SOLID WASTE LANDFILL, JUNE 21, 1993

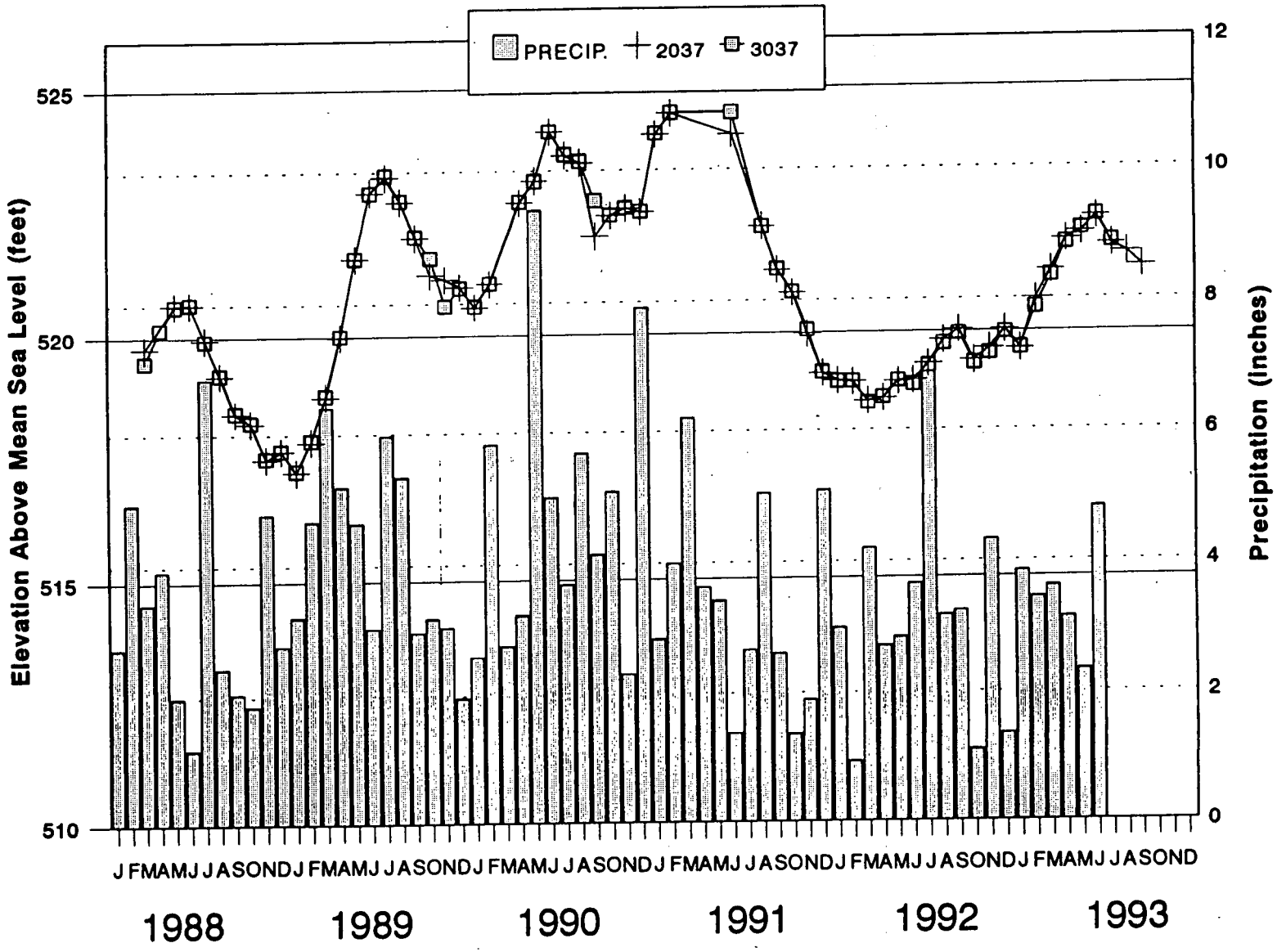


FIGURE 3-34
HYDROGRAPHS FOR MONITORING WELLS 2037 AND 3037, SOLID WASTE LANDFILL

F:\RIREPORT\FIGURES\FIG3-34B

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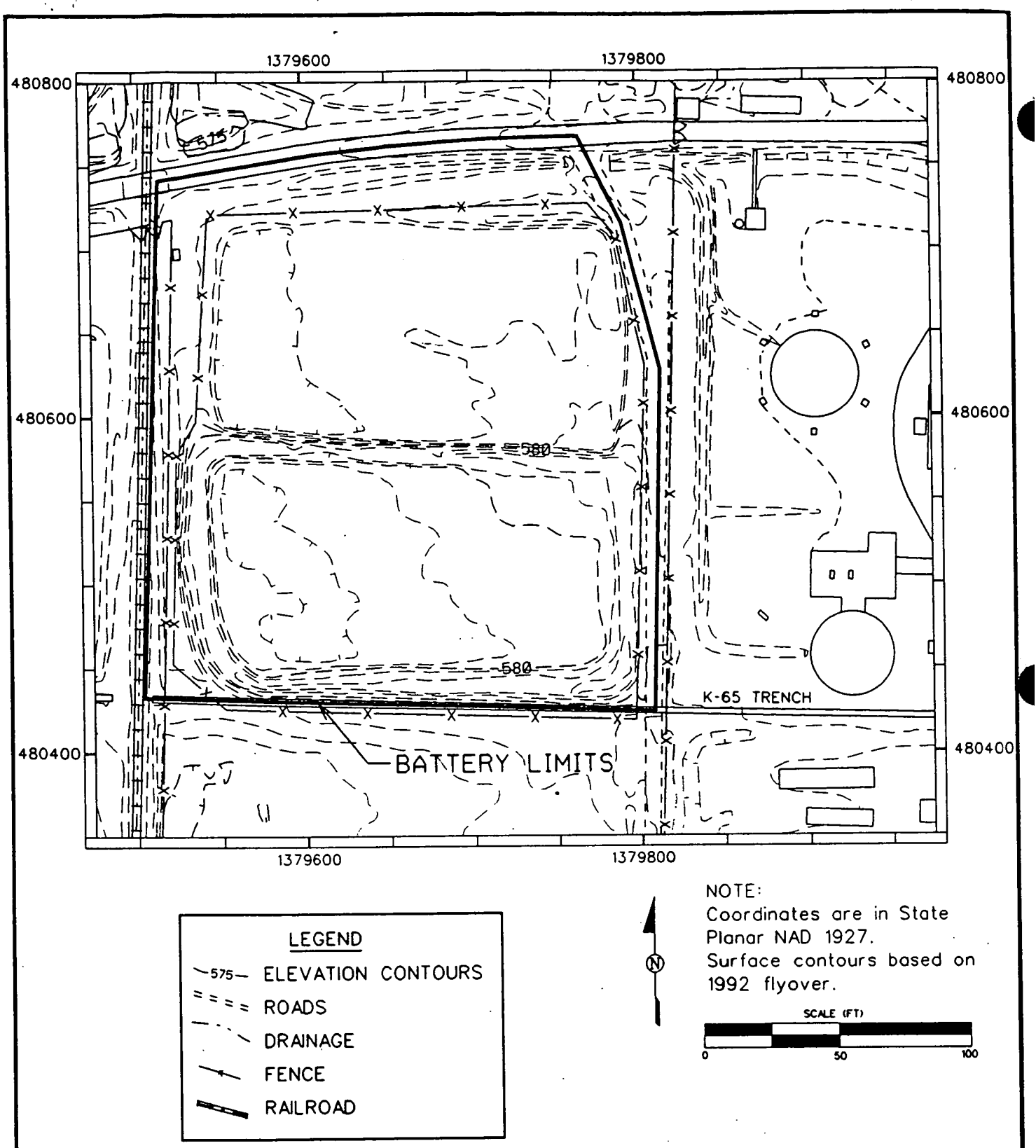

fig0334.dgn

FIGURE 3-35
TOPOGRAPHY OF THE LIME SLUDGE PONDS

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constituents in groundwater and to determine groundwater elevations. Based on the lithologic descriptions presented in the boring logs (Appendix D), a general description of the strata below the Lime Sludge Ponds was determined.

Fill material in the Lime Sludge Ponds consists of residue that has settled out of the sludge. The depth of this lime sludge residue, based on boring logs, was found to vary from 3.5 to 11.5 feet. Geological cross sections were prepared for the Lime Sludge Ponds (Figure 3-36). The geologic cross sections represent the interpreted geology along the actual cross-section traces shown on the map insets. See Section 3.2.2 for a description of the three-dimensional computer model that was used to develop the geological cross-sections. The Lime Sludge Ponds Study Area consists of a 30- to 40-foot thick layer of glacial overburden overlying the Great Miami Aquifer. The glacial overburden consists primarily of clay containing some sand and gravel. The clay appears as a stiff yellowish-brown clay that grades downward into a stiff gray clay, a transition thought to be a function of the weathering of the clay that is closer to the ground surface. The depth at which this transition occurs is approximately seven feet at Borings Nos. 1039 and 2042.

A lens of sand, detected in the glacial overburden at Borings Nos. 1039 and 2042, may extend continuously beneath the Lime Sludge Ponds. The sand lens occurs at a depth of 19 feet at Boring No. 1039 and at approximately 16.5 feet at Boring No. 2042. This zone is approximately five feet thick and appears to be continuous from northeast and southwest beneath the entire north pond and through the western portion of the south pond. The sand lens is approximately two feet below the deepest point of the Lime Sludge Ponds.

Groundwater elevations for wells completed in the glacial overburden in the Lime Sludge Ponds Study Area are shown in Figure 3-37. Groundwater in the perched system flowed toward the southwest in July and August 1993 and presumably discharged in the vicinity of Paddys Run. The gradient of the perched groundwater surface appeared to be consistent in July 8, 1993 (a gradient of 0.006) and August 16, 1993 (a gradient of 0.010).

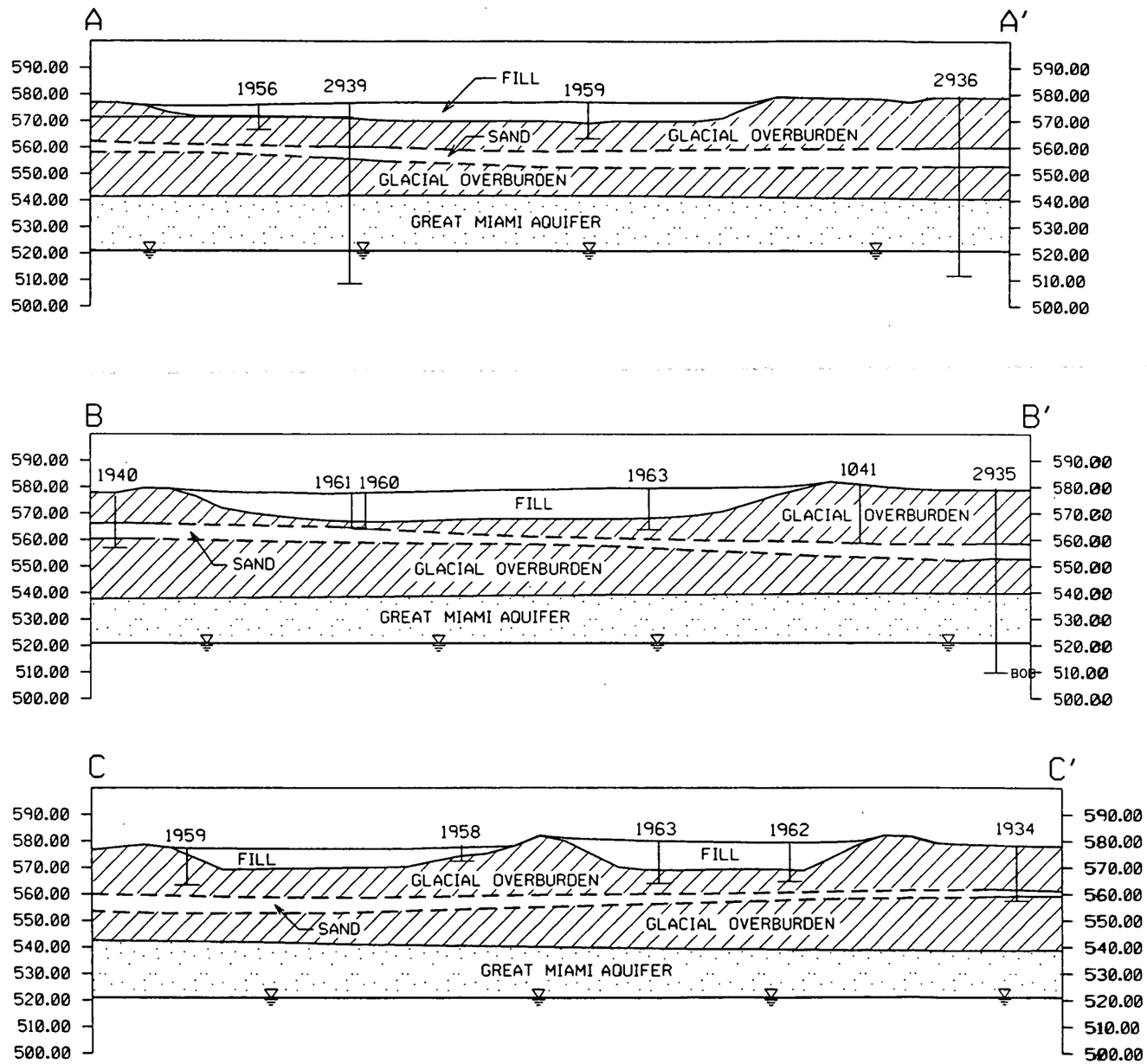
The potentiometric surface of the perched groundwater intersects the ponds, indicating possible hydraulic connection of the perched groundwater with the impounded materials. The south pond does not have a free water surface, even after heavy precipitation events. This indicates that water can percolate vertically to drain the upper zone of the south pond and that the drainage may recharge the

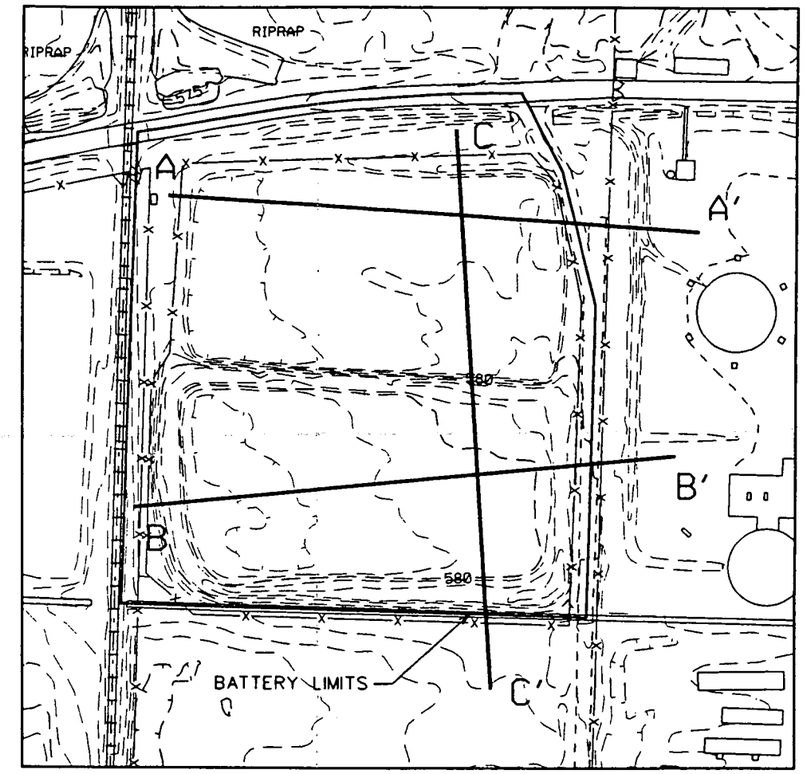
perched zone groundwater system. Groundwater in the glacial overburden is located approximately two to four feet below ground surface, and an annual fluctuation of about five feet between 1988 and 1993 has been observed, which is shown in Figure 3-38. Hydrograph measurements during 1993 in 1000-series wells, completed in the glacial overburden, are presented in Figure 3-39 and Figure 3-40. A comparison of precipitation and groundwater elevation data indicate that groundwater elevation in the vicinity of the sludge ponds responds rapidly to precipitation events, with the greatest response observed in the wells located closest to the ponds. For example, groundwater elevations increased over three feet in Well No. 1039, which is approximately 15 feet north the North Pond, in response to a rain event of 2.9 inches on June 15, 1993. In contrast, water levels in 1000-series wells (1210, 1229, and 1934) located further away from the ponds did not show an elevation response to the June 15, 1993 rain event (Figure 3-40). Well 1210 is approximately 100 feet east of the South Pond, 1229 is approximately 180 feet south of the South Pond, and 1934 is approximately 50 feet south of the South Pond.

The Great Miami Aquifer, which consists of glacial outwash deposits containing sand and gravel, underlies the glacial overburden approximately 40 feet below the surface. The Great Miami Aquifer is divided into an upper and a lower unit; however, only the upper unit was penetrated by wells in the Lime Sludge Ponds Study Area. The deepest boring in the area, Boring No. 2042, terminated at a depth of 68.0 feet in the upper unit. In the vicinity of the Lime Sludge Ponds, shown in Figure 3-41, the groundwater elevation of the Great Miami Aquifer averages approximately 521 to 522 feet above MSL (about 60 feet below ground surface). The groundwater flow direction was to the southeast at a gradient of 0.0006 in August 1993.

3.4 INACTIVE FLYASH PILE AND SOUTH FIELD

The Inactive Flyash Pile was constructed by dumping material off the previously existing steep embankment adjacent to Paddys Run. Additional dumping occurred along a haul road constructed along a south facing embankment; thus, the Inactive Flyash Pile also has a south facing slope. The Inactive Flyash Pile is bounded on the west by a drainage ditch and a portion of Paddys Run, on the north by an access road, on the east by a drainage ditch (which separates it from the South Field), and on the south by the running track/firing range facility (Figure 3-42). Once disposal activities were completed, portions of the southern part of the Inactive Flyash Pile were covered with soil/fill. A covering of trees and dense brush have grown over the Inactive Flyash Pile.



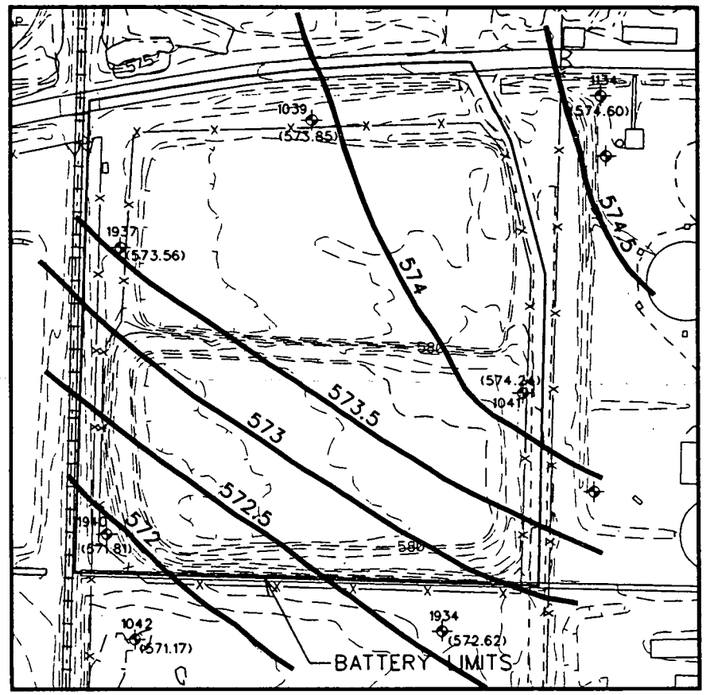


CROSS-SECTION LOCATION KEY (1"=100')

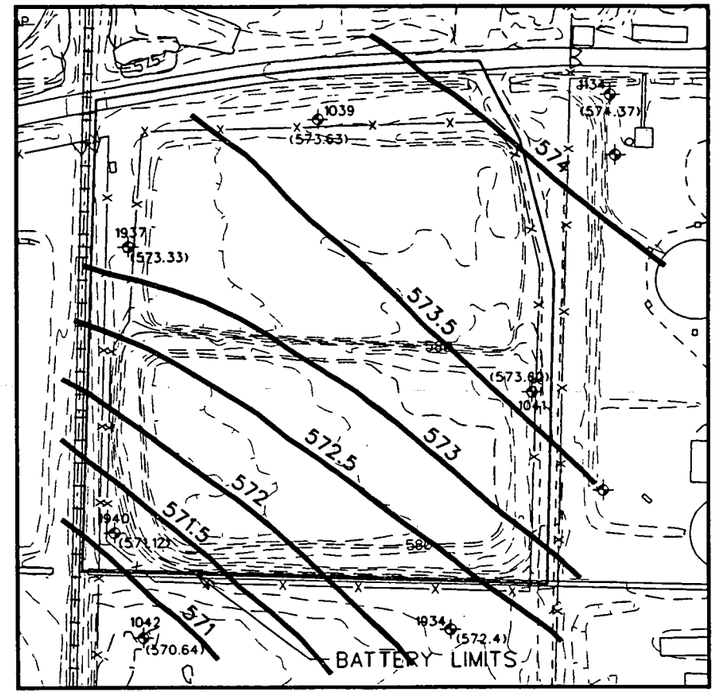
LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD

FIGURE 3-36
GEOLOGIC CROSS SECTIONS,
LIME SLUDGE PONDS



JULY 8, 1993



AUGUST 16, 1993

LEGEND

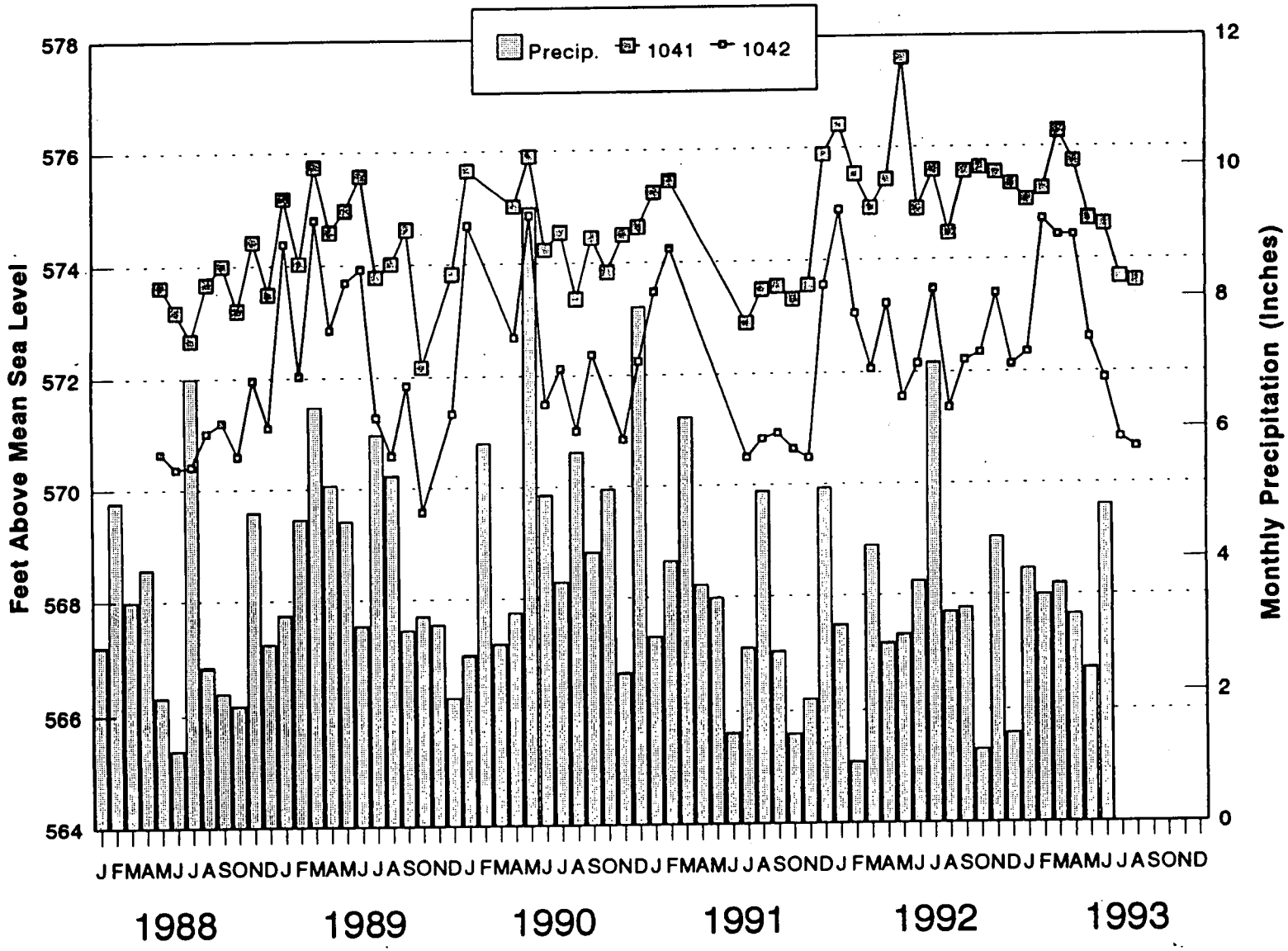
- ELEVATION CONTOURS
- ROADS
- FENCE
- RAILROAD
- 1000 MONITORING WELLS
- (573.60) WATER LEVEL ELEVATIONS
- WATER LEVEL CONTOURS

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100 200

FIGURE 3-37
GROUNDWATER ELEVATIONS FOR 1000-SERIES WELLS, LIME SLUDGE POND, JULY 8, 1993 AND AUGUST 16, 1993

fig0336.dgn



NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

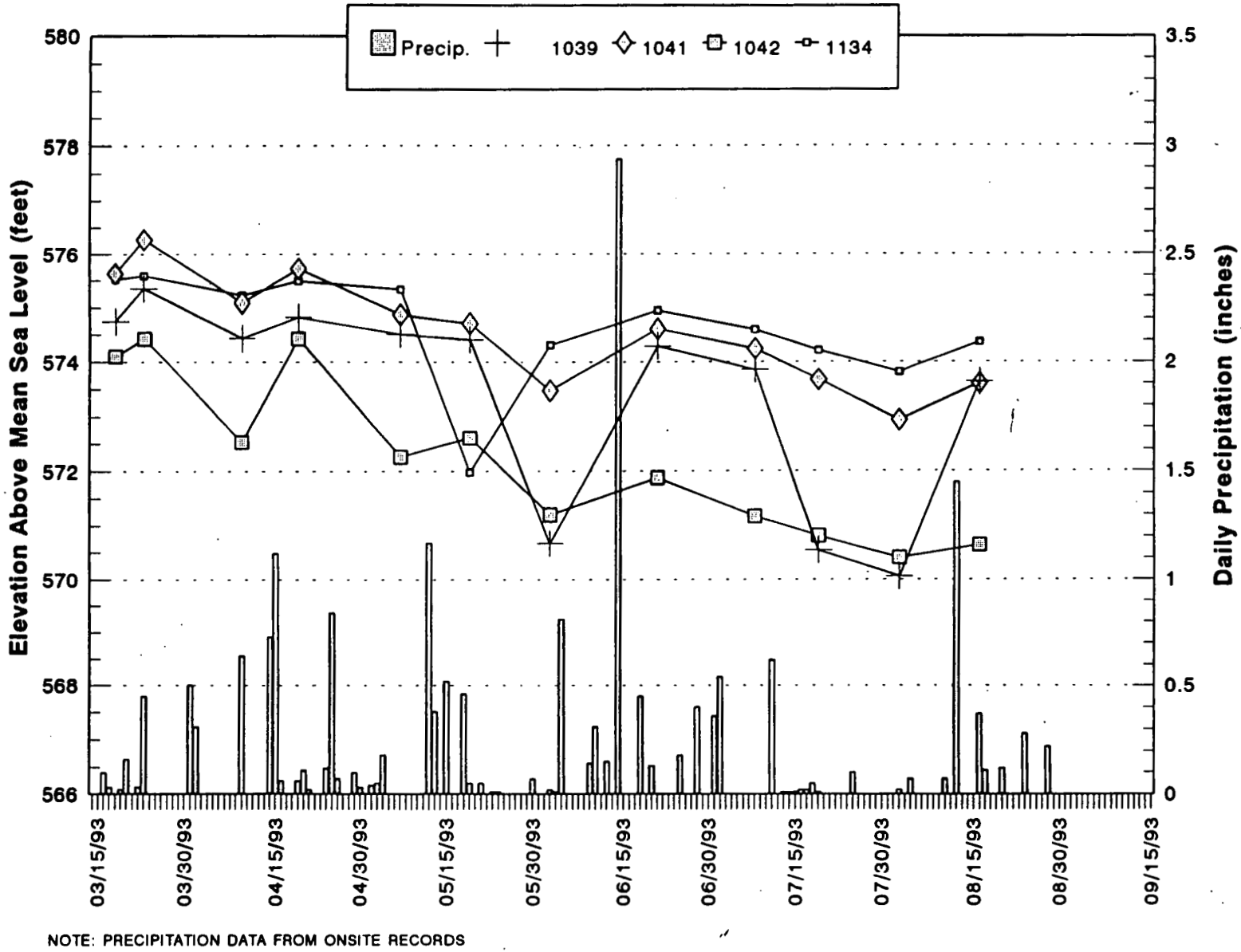
FIGURE 3-38
HYDROGRAPHS FOR MONITORING WELLS 1041 AND 1042, LIME SLUDGE PONDS

F:\RIREPORT\FIGURES\FIG3-38

000275

HEMP-00026 FINAL
January 21, 1995

6505

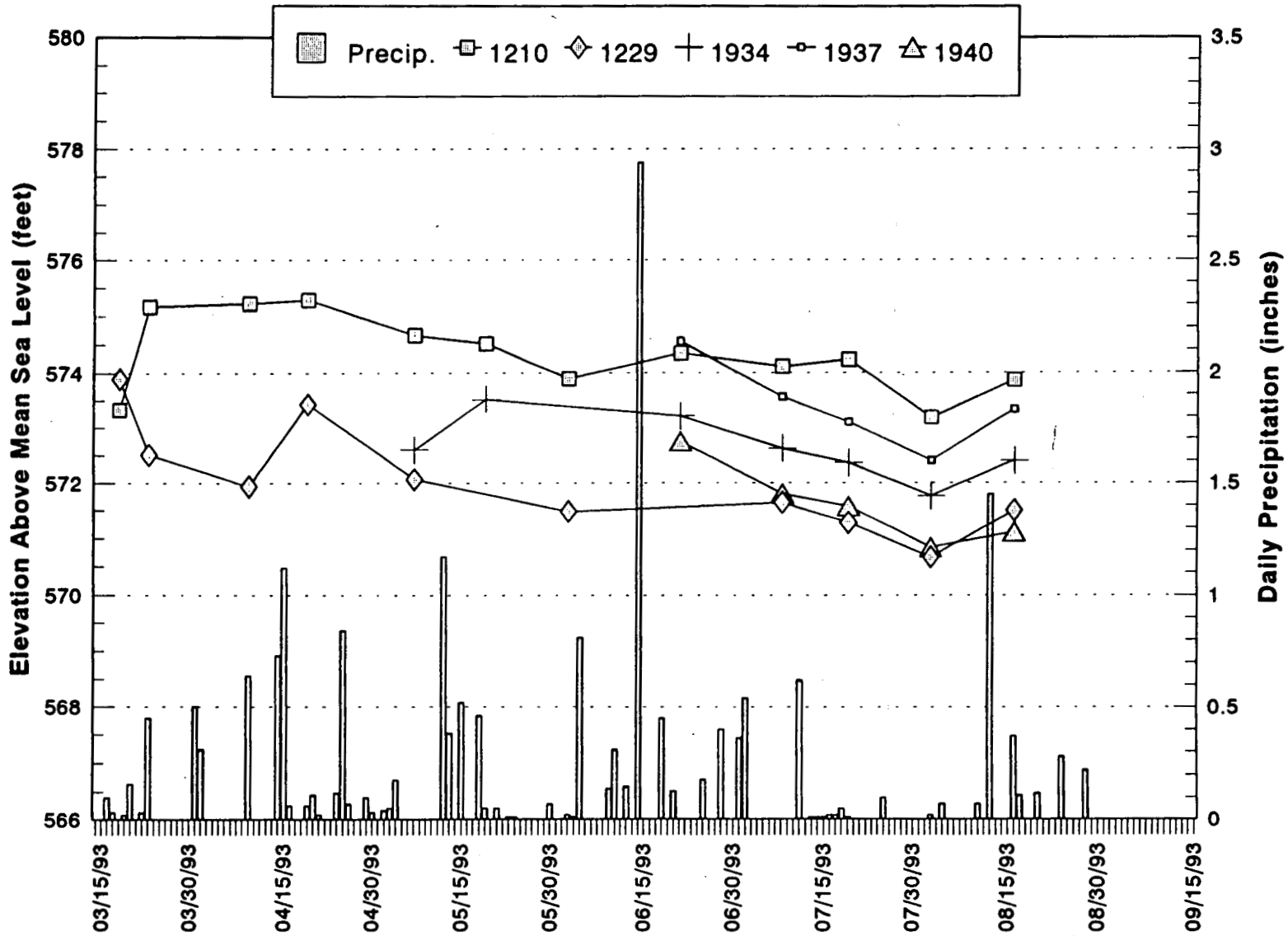


NOTE: PRECIPITATION DATA FROM ONSITE RECORDS

FIGURE 3-39
HYDROGRAPHS FOR 1000-SERIES WELLS, LIME SLUDGE PONDS

F:\RIREPORT\ ES\FIG3-39

002276



NOTE: PRECIPITATION DATA FROM ONSITE RECORDS

FIGURE 3-40

HYDROGRAPHS FOR ADDITIONAL 1000-SERIES MONITORING WELLS, LIME SLUDGE POND

F:\RIREPORT\FIGURES\FIG3-40

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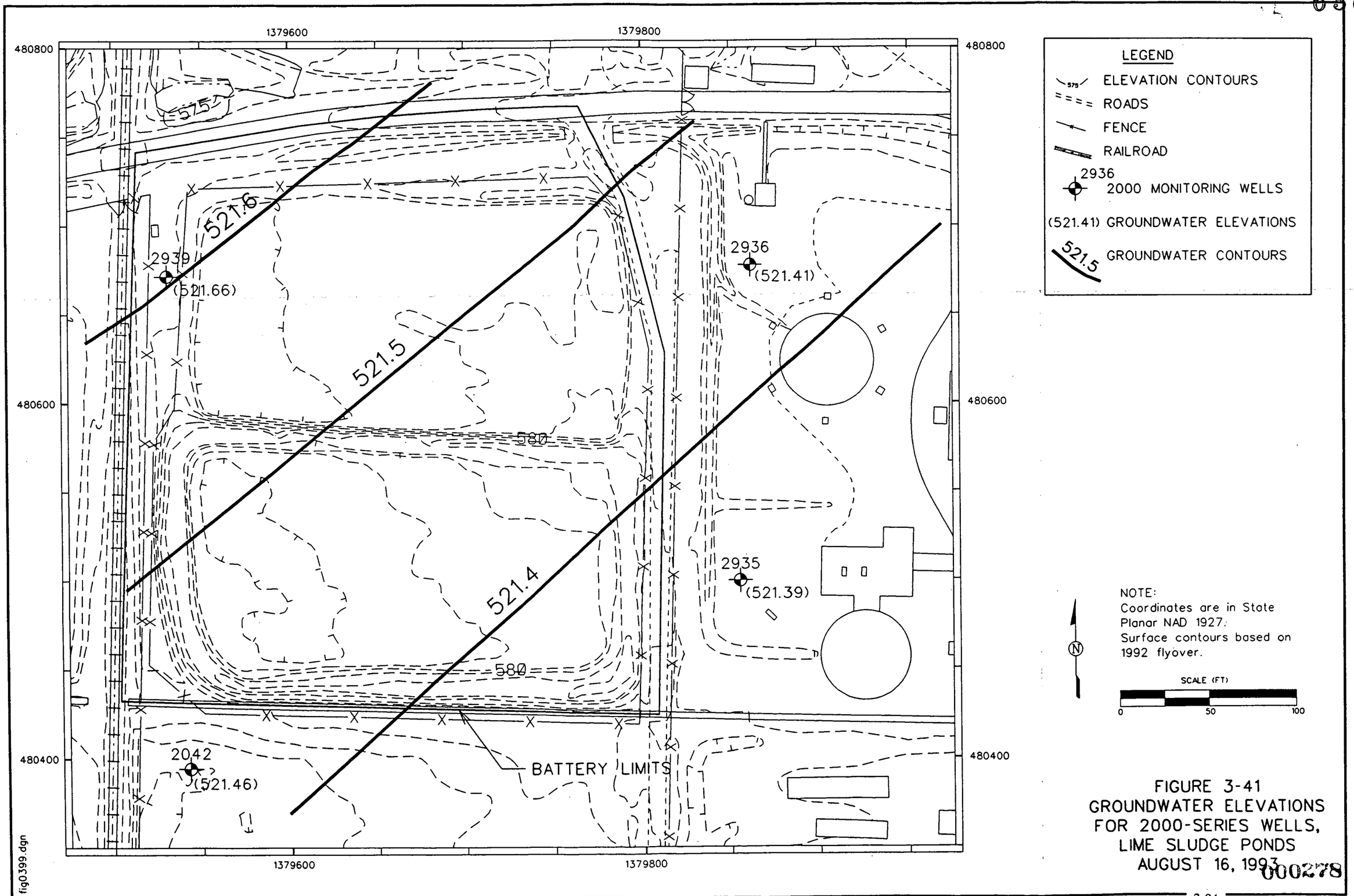


FIGURE 3-41
GROUNDWATER ELEVATIONS FOR 2000-SERIES WELLS, LIME SLUDGE PONDS
AUGUST 16, 1993

000278

6505

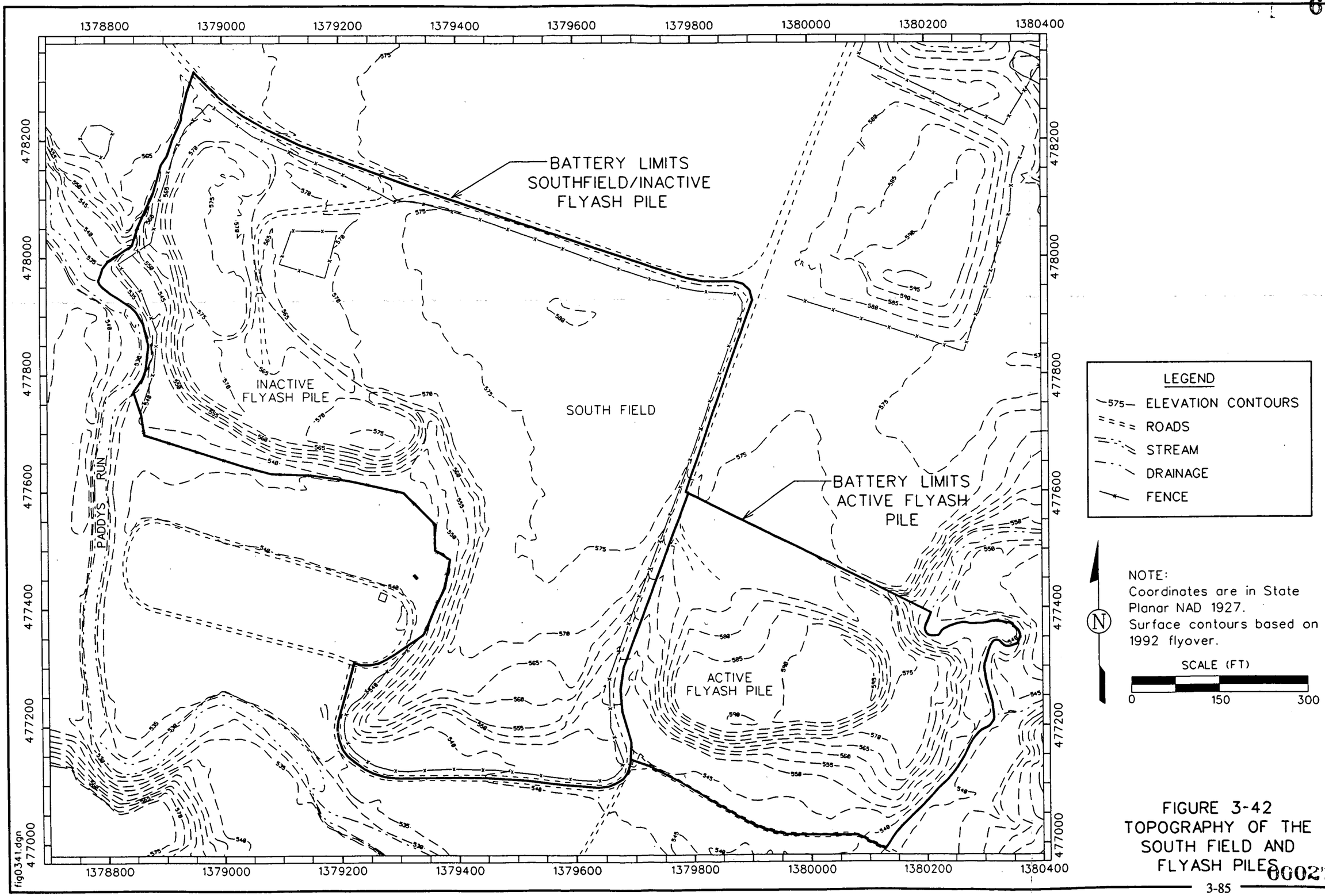


FIGURE 3-42
TOPOGRAPHY OF THE
SOUTH FIELD AND
FLYASH PILES

000279

The South Field is located south of the former Production Area and is between the Inactive Flyash Pile on the west and the Active Flyash Pile on the east. An east-west oriented access road borders the northern extent of the South Field. A north-south oriented access road (which turns east and leads to the running track/shooting range facility), borders the eastern and southern extent of the South Field. The western edge of the South Field is bordered by a drainage ditch which divides the Inactive Flyash Disposal Area from the South Field. The South Field was used to dispose of construction rubble and fill excavated from the Production Area. The South Field was graded with a covering of clay fill and is now overgrown with grass, brush and, less abundantly, trees.

3.4.1 Topography and Surface Water

The topography of the Inactive Flyash Pile is shown in Figure 3-42. Elevations range from approximately 540 to 580 feet above MSL across the Inactive Flyash Pile from north to south. The western edge of the area slopes steeply toward Paddys Run, and the southern edge of the area slopes steeply toward the running track in the south. Both the south facing slope and the west facing slope are covered with dense vegetation including stands of trees. An eroded drainage channel is located at the approximate center of the west facing slope and directs flow to Paddys Run. The remainder of this waste area slopes more gently toward a drainage ditch that borders the South Field to the east. The north edge of the unit is bordered by a drainage ditch and an access road.

Surface water drains in a radial pattern from the center of the Inactive Flyash Pile; however, the pile is covered with dense shrubs, trees, and grass, so sheet flow runoff east toward the South Field has not been observed. Shallow interflow at the north edge of the pile was seen to fill a drainage ditch that is parallel to the north boundary, and this runoff joins drainage crossing under the road from the north before flowing southwest to Paddys Run. Surface water from the south facing slope joins shallow drainage from the former running track area in a drainage ditch at the toe of the pile. The combined drainage flows west to Paddys Run. Drainage from the west facing slope either infiltrates into the flyash before reaching the toe of the pile or flows in the drainage observed at the center of the pile to Paddys Run.

Topography in the vicinity of the South Field slopes from the northeast at 580 feet above MSL to the west at 560 feet above MSL and to the south at 540 feet MSL (Figure 3-42). The natural topography of the South Field has been recontoured as fill was introduced. Drainage from the South Field appears to be shallow interflow originating near to the boundaries of the unit that is intercepted by

engineered channels. Drainage channels are adjacent to the north boundary road, the east boundary road, and the running track. Sheet flow caused by average precipitation events would most likely infiltrate or pool on the South Field surface since it is covered by dense shrubs and grass and has mature trees. Drainage is directed to the west along the north boundary, where it joins drainage from the off-site wooded area north of the boundary road and discharges to Paddys Run. Drainage in the east channel flows south and pools at the southern edge of the South Field. Flow in both channels was observed to continue for several days after heavy rain events. Drainage that flows south toward the running track is intercepted by a channel that flows west to Paddys Run.

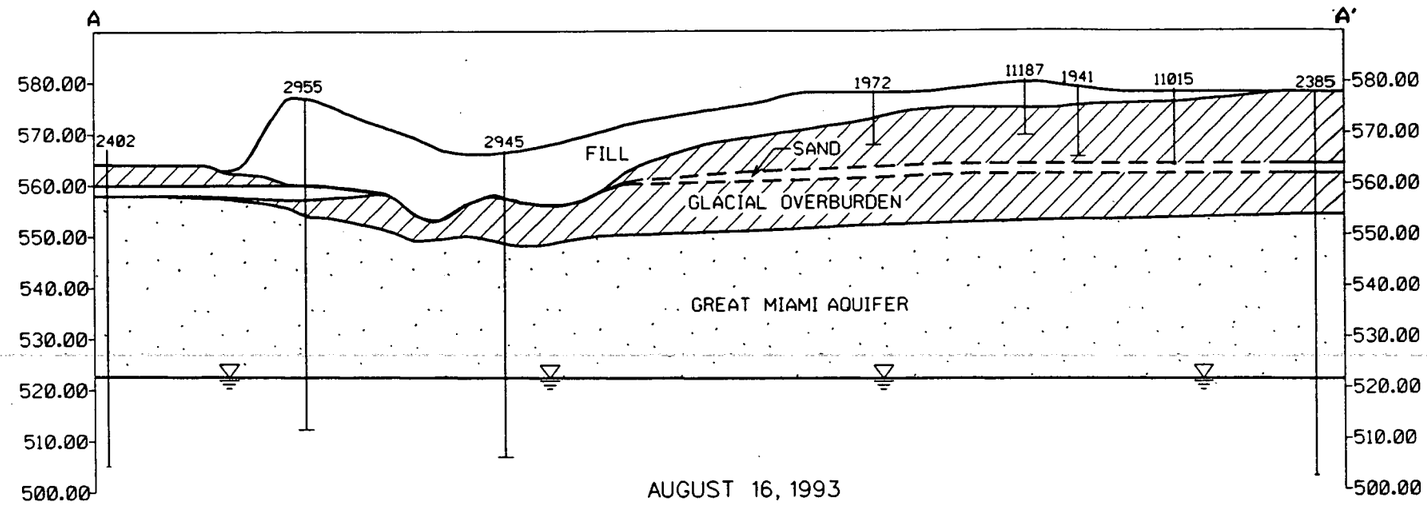
3.4.2 Geology and Groundwater Hydrology

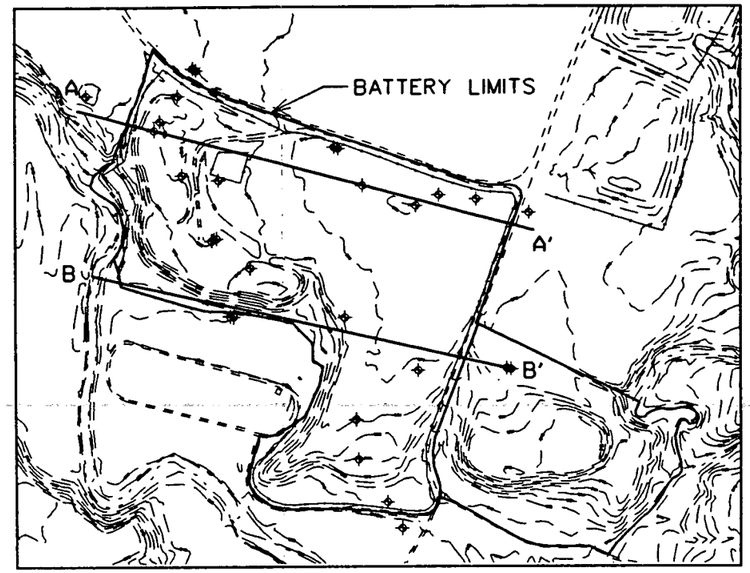
The Inactive Flyash Pile was used to dispose of flyash and bottom ash from the coal-fired boiler plant. Soil samples from borings indicate that the fill consists primarily of flyash, but building rubble (such as concrete, gravel, asphalt, masonry, and steel rebar) is also present. Cross sections of the South Field/Inactive Flyash Pile are shown in Figure 3-43 and Figure 3-44.

The Inactive Flyash Pile is predominately flyash, with up to six feet of silt and clay at the surface in the southern half of the unit that appears to be a cap. The flyash overlies the till surface existing in 1951; therefore, the topography of the flyash fill/till interface is characterized by erosional channels that were cut into the pre-existing till surface prior to 1951. Cross sections of these features are presented in Figures 3-43 and 3-44.

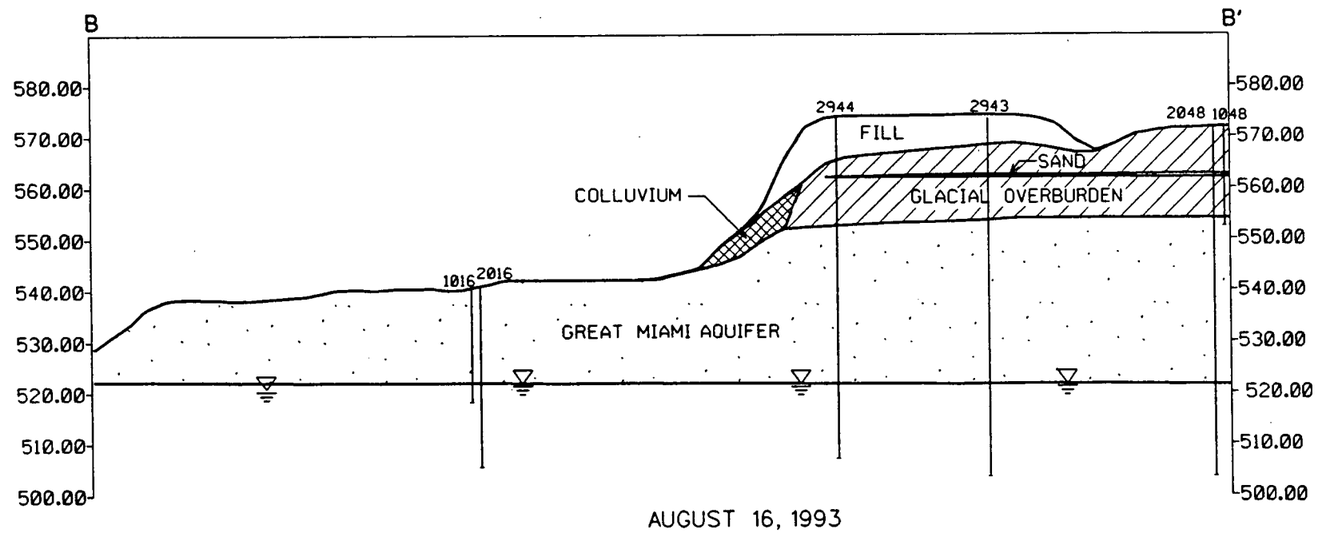
Glacial till overburden is present beneath most of the Inactive Flyash Pile and becomes thinner toward the west and south boundaries of the unit. There was no till encountered beneath the most southern portion of the flyash in Borings Nos. 1994 and 1996 (see cross section C-C' on Figure 3-44). The geologic cross sections represent the interpreted geology along the actual cross-section traces shown on the map insets. See Section 3.2.2 for a description of the three-dimensional computer model that was used to develop the geological cross-sections.

Soil samples were examined from subsurface borings in the South Field to define lithology of the subsurface strata. Chemical analyses of soil samples and groundwater samples from monitoring wells were used to determine concentrations of various chemical constituents in soil, waste material, and groundwater. Groundwater elevations were measured to determine the potential groundwater flow direction. Based on the lithologic descriptions presented in the boring logs (Appendices F and G for





CROSS-SECTION LOCATION KEY (1"=400')



LEGEND

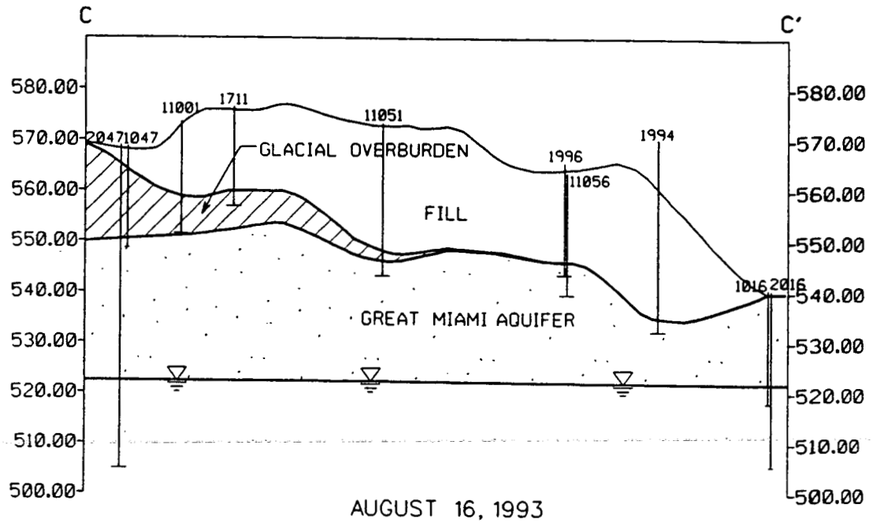
- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- MONITORING WELL

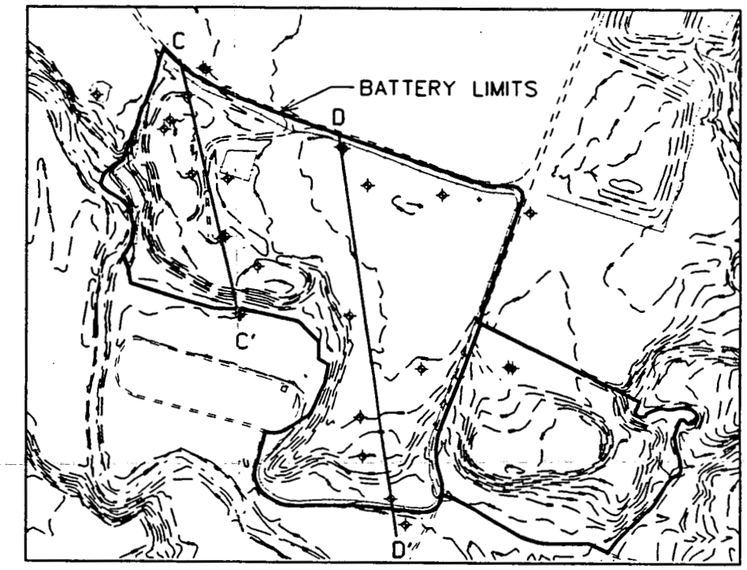
0 50 100 200
SCALE, SECTIONS (FT)
Vertical Exaggeration = 2 to 1

fig0342.dgn

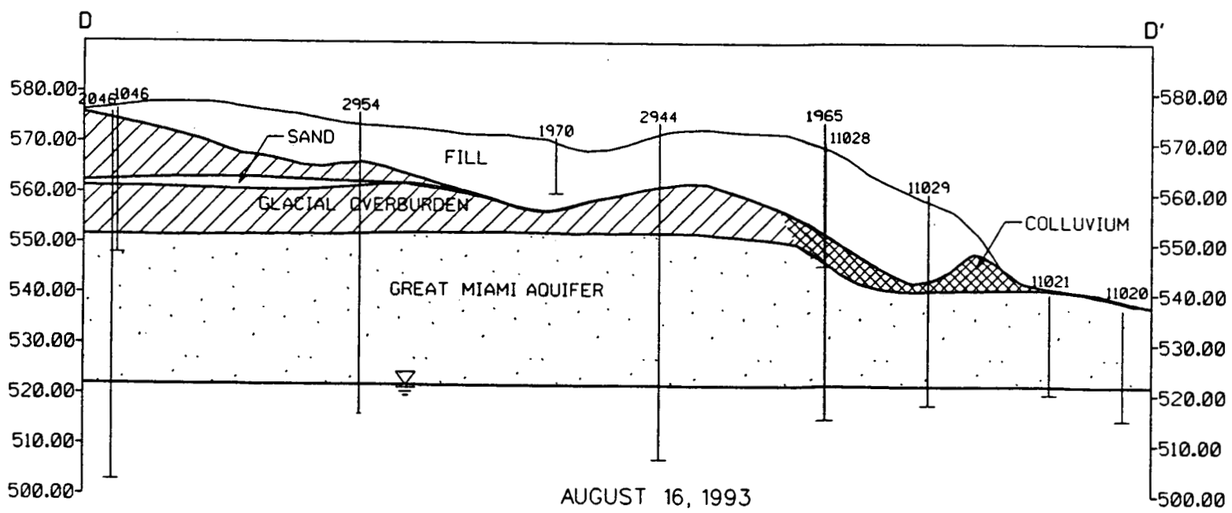
FIGURE 3-43
GEOLOGIC CROSS SECTIONS
WEST TO EAST
SOUTH FIELD/INACTIVE
FLYASH PILE

6505





CROSS-SECTION LOCATION KEY (1"=400')



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- DRAINAGE
- FENCE
- 1000 MONITORING WELLS

0 50 100 200
SCALE, SECTIONS (FT)
Vertical Exaggeration = 2 to 1

fig0343.dgn

FIGURE 3-44
GEOLOGIC CROSS SECTIONS
NORTH TO SOUTH
SOUTH FIELD/INACTIVE
FLYASH PILE

the Inactive Flyash Pile and South Field, respectively), a general description of the strata below the South Field area was determined.

Geologic cross sections derived from boring data were prepared for the South Field area and are shown in Figures 3-43 and 3-44. Cross-section traces are shown on insets in the upper right-hand corner of the figures. Boring log data indicate that the glacial overburden is overlain by deposits of fill material of unknown origin and variable thickness. Beneath this fill, a series of glacial overburden deposits underlie the South Field/Inactive Flyash Pile Area. The Great Miami Aquifer, consisting of glacial outwash deposits containing sand and gravel, underlies these glacial overburden deposits.

The glacial overburden is composed predominantly of silty clay interbedded with lenses of clay and silt, sandy clay, silty sand, and sand and gravel. These lithologies are potentially discontinuous and often cannot be correlated laterally between borings. One sand layer was correlated in soil borings drilled throughout the site and is shown in the cross sections presented in Figures 3-43 and 3-44. The color of the overburden generally grades downward from a yellowish-brown to brown, silty clay into a gray to gray-brown clay. This color transition may be related to oxidation during weathering. The depth at which this transition occurs below the surface is variable, ranging from 27.0 feet in Boring No. 2047 to 0.0 feet in Boring No. 1045. The thickness of the glacial overburden in the South Field/Inactive Flyash Pile Area ranges from approximately five feet at Boring No. 2049 (south of the Active Flyash Pile) to approximately 27 feet at Boring No. 1046 (located on the north side of the Inactive Flyash Pile). Overall, in the South Field/Inactive Flyash Pile Area, the glacial overburden averages between 20 and 30 feet thick.

Data collected from Hydropunch™ and soil borings are summarized in Table 3-4. Groundwater was detected in sand and silt lenses within the glacial till overburden underlying the east edge of the flyash pile. The flyash was reported to directly overlie the Great Miami Aquifer at the southern tip of the Inactive Flyash Pile, and there was no perched groundwater system encountered. Groundwater conditions in the flyash/till are monitored by Well 1711, which was completed at the north end of the Inactive Flyash Pile in May 1991. Eight groundwater elevation measurements in Well 1711 from July 1991 to March 1994 differed by 0.01 feet, while from March 1992 to August 1993, the elevation increased 2.5 feet (Figure 3-45). Examination of the boring log (Appendix E) indicated that Well 1711 is completed at the interface between the flyash and a sand and gravel zone within the till. The

TABLE 3-4

SUMMARY OF DATA RELATED TO SATURATED GROUNDWATER CONDITIONS INACTIVE FLYASH PILE

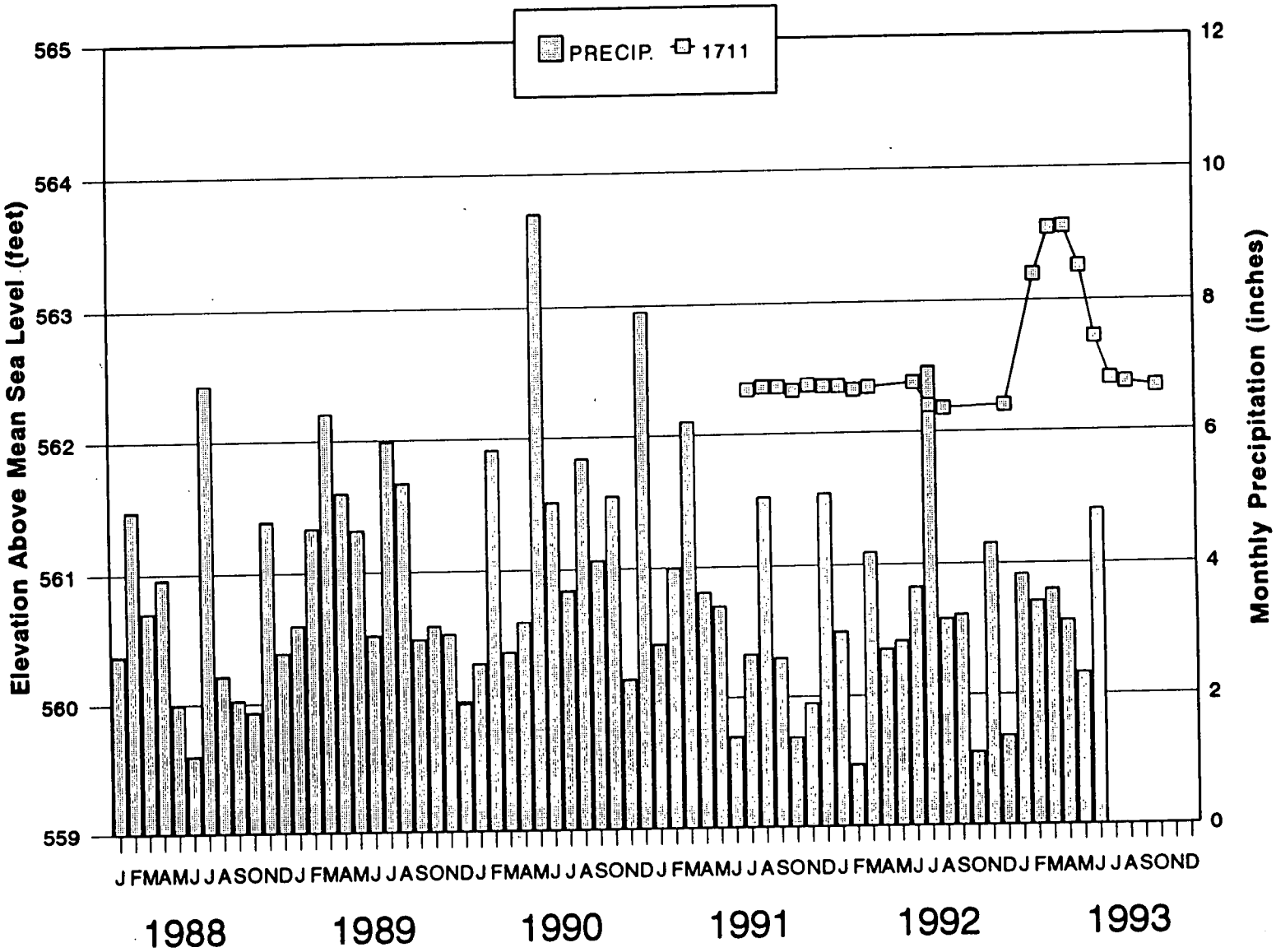
Boring No.	Depth of Flyash (Ft. Below Surface)	Depth of First Water (Ft. Below Surface)	Water Bearing Unit	Comment
1994	25	NA	NA*	Located at south end of Inactive Flyash Pile. Flyash rests directly on Great Miami Aquifer.
1995	26	NA	NA	Located at south end of Inactive Flyash Pile in center of pile. Layers of clay/silt cap to 8 feet deep; Great Miami Aquifer at 31.5 below ground surface.
1996	17	NA	NA	Located at east edge of Inactive Flyash Pile. Waste material at surface. Tough drilling. Flyash from surface to depth. Great Miami Aquifer directly under flyash.
1997	28.5	NA	NA	Located at west edge of Inactive Flyash Pile. Great Miami Aquifer at 39 feet below surface. Clay/silt to 5 feet deep.
1998	9	9	Interface of flyash and till	Located at east edge of Inactive Flyash Pile at north end. Saturation occurs at flyash/till interface. Very stiff clay beneath flyash reported to be dry.
		12	Gravelly sand in till	Second saturated unit. A third sand lens at 16 feet deep reported to be dry.
1999	4	8	Well graded sand lens in till	Located at east side of Inactive Flyash Pile.
11000	8	12.5	Silty sand lens	Located at east side of Inactive Flyash Pile.
11001	8.5	13	Gray silty sand in till	Second wet sand lens at 20 feet deep. Location at north end of Active Flyash Pile.
11002	3.5	12.5	Gravelly clay in till	Located at northwest corner Active Flyash Pile.
11003	16.5-18	18-23	Silty clay in till	Located at north end of Active Flyash Pile, near center.
11004	15.5	22.5	Silty sand lens in till	Located at center of Active Flyash Pile in east/west direction near to north 1/3.

See footnote at end of page

TABLE 3-4
(Continued)

Boring No.	Depth of Flyash (Ft. Below Surface)	Depth of First Water (Ft. Below Surface)	Water Bearing Unit	Comment
11005	8.5	NA	NA	Located at east edge of Active Flyash Pile. Poor recovery, moist samples otherwise.
11006	12.5	13.5	Gray sand lens	Located at east edge of Inactive Flyash Pile. Flyash rests directly upon Great Miami Aquifer. Poor recovery due to concrete.
11007	15	19.5	Brown sand lens	Located at center of Inactive Flyash Pile.
11008	17.5	NA	NA	Located at west edge of Inactive Flyash Pile. Sand lens at 21.5 feet deep was dry.
11047	0	8.5	Light brown sand in till	Located outside of Inactive Flyash Pile to north.
11048	11.5	21.5	Silty sand lens in till	Saturated zone in till approximately 2 feet above top of Great Miami Aquifer. Location is at the north center part of the Inactive Flyash Pile.
11049	0	4.5	Clay/sand lens in till	Located at north end of Inactive Flyash Pile.
11050	6.5	10-13	Silty sand in till	Very moist conditions. Not noted as saturated.
11051	19	19	NA	Drilled south of 11005 to obtain sample. Waste materials encountered.
11053	NA	NA	NA	Located south and east of 11005. Drilled to obtain sample since one was not collected from dry 11005. There is no perched water at this location.

* N/A - Not applicable since no saturated interval was identified.



NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-45
HYDROGRAPH FOR MONITORING WELL 1711, INACTIVE FLYASH PILE

000287

elevation data suggest that groundwater flow may be in the sand/gravel zone until increased precipitation (as encountered during early 1993) raises the perched water table into the flyash.

Saturated groundwater conditions in the South Field were encountered in the glacial overburden within sand and silt lenses. One sand/silt lens was correlated across the site at approximately 8 to 12 feet below ground surface. The extent of groundwater appears to be directly related to the geometry and existence of this sand layer. Slug tests (Table 3-2) were conducted in several 1000-series wells in the South Field and indicate an average hydraulic conductivity for the sands in the glacial overburden of 3.8×10^{-4} cm/s (falling head tests) to 3.41×10^{-4} cm/s (rising head test). The elevation of perched groundwater was contoured and is shown on Figure 3-46. Data indicate that flow in the perched system follow topography and is toward the southwest in the South Field area. The gradient was 0.021 on August 16, 1993. Flow direction east of the Solid Waste Landfill is to the east/southeast and parallels the local topographic trend. The potentiometric surface indicates a groundwater divide in the perched water, extending north/northwest from the northeast corner of the South Field. This divide is reflective of the local topography of the area.

Groundwater elevations from January 1988 to November 1992 in two perched zone monitor wells are plotted as hydrographs in Figures 3-47 and 3-48. Groundwater elevations within the glacial overburden vary from approximately 555 to 575 feet above MSL (approximately 5 to 20 feet below the surface) in the South Field. Wells 1046 and 1047, located north of the South Field, displayed over 10 feet of elevation variation, and there appears to be a good correlation between the two wells and precipitation events (Figure 3-47). No defined groundwater recharge zone was discovered during the field study, but groundwater elevations response to precipitation measured in Wells 1046 and 1047 may indicate the location of a possible recharge area. Groundwater elevations in Well 1046 displayed a 10.8 foot range from May 1988 to March 1992. Well 1047 displayed a 13.8 foot range from January 1988 to February 1992. The highest groundwater levels are within two feet of ground surface. Since wide groundwater elevation fluctuations are characteristic of groundwater recharge zones, it is possible that the north section of the South Field is a groundwater recharge zone for perched groundwater. Hydrographs for downgradient 1000-series wells (Well 1942 and Well 1954) are shown in Figure 3-48. These wells show no response to significant precipitations events on June 15 and August 12, 1993, suggesting that direct recharge at these locations is limited.

Data from soil borings have been evaluated to determine the thickness of till materials beneath the South Field/Inactive Flyash Pile Area. Thickness of till isopachs are presented in Figure 3-49. Contours presented in Figure 3-49 indicate that the southern portion of the South Field and the Inactive Flyash Pile overlie till that ranges in thickness from 0 to 2 feet. This means that fill materials at the southern end of the Inactive Flyash Pile and the South Field lie directly upon the sand and gravel of the Great Miami Aquifer, with a few feet of colluvial material separating them. This is also shown on the cross sections in Figures 3-43 and 3-44.

Several borings were drilled through the glacial overburden into the top of the Great Miami Aquifer. The lithology of the Great Miami Aquifer consists principally of sand and gravel with scattered lenses of clay or fine-grained material. It is not believed that clay materials are of a sufficient thickness and areal extent to act as semi-confining layers or to otherwise affect groundwater movement.

Groundwater elevations within the Upper Great Miami Aquifer are approximately 520 to 525 feet above MSL or about 30-50 feet below the surface. Contours of this potentiometric surface from elevations measured in 2000-series wells on August 16, 1993 are shown in Figure 3-50. Groundwater flows east to southeast in the Great Miami Aquifer beneath the South Field/Inactive Flyash Pile Area with a gradient of 0.001. Local groundwater mounding appears to occur near monitoring Wells 2401 and 2065. These wells occur near areas where the glacial overburden is projected to be absent due to erosion; therefore, recharge from the perched water may be occurring.

Groundwater elevation data for the 3000- and 4000-series wells (completed at the base of the Upper and Lower Great Miami Aquifer, respectively) are also approximately 520 to 525 feet above MSL (Figures 3-51 and 3-52). Groundwater elevations in these wells display approximately eight feet of change, and there is an excellent correlation between the nested wells. This indicates that there is hydraulic communication between the upper and lower aquifer above and below the clay layer, and that there is no significant vertical gradient during recharge events. Water levels in the 2000- and 3000-series wells appear to be the same, while the elevation of groundwater in Well 4016, shown in Figure 3-52, appears to lag behind the 2000- and 3000-series wells during recharge events, as exemplified by the period from November 1992 to April 1993. This suggests that there may be an impediment to vertical flow between the aquifer zones divided by the clay layer.

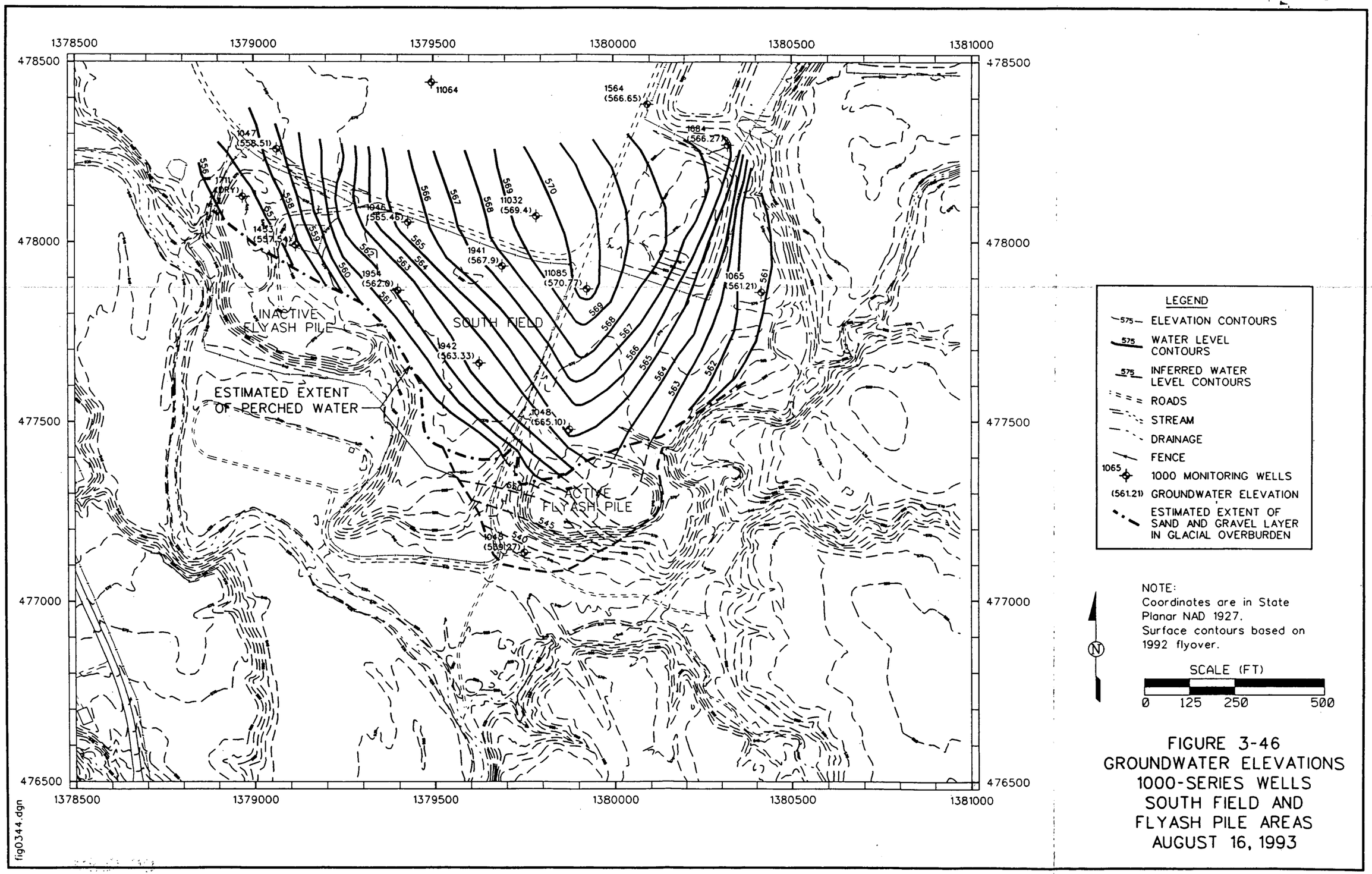
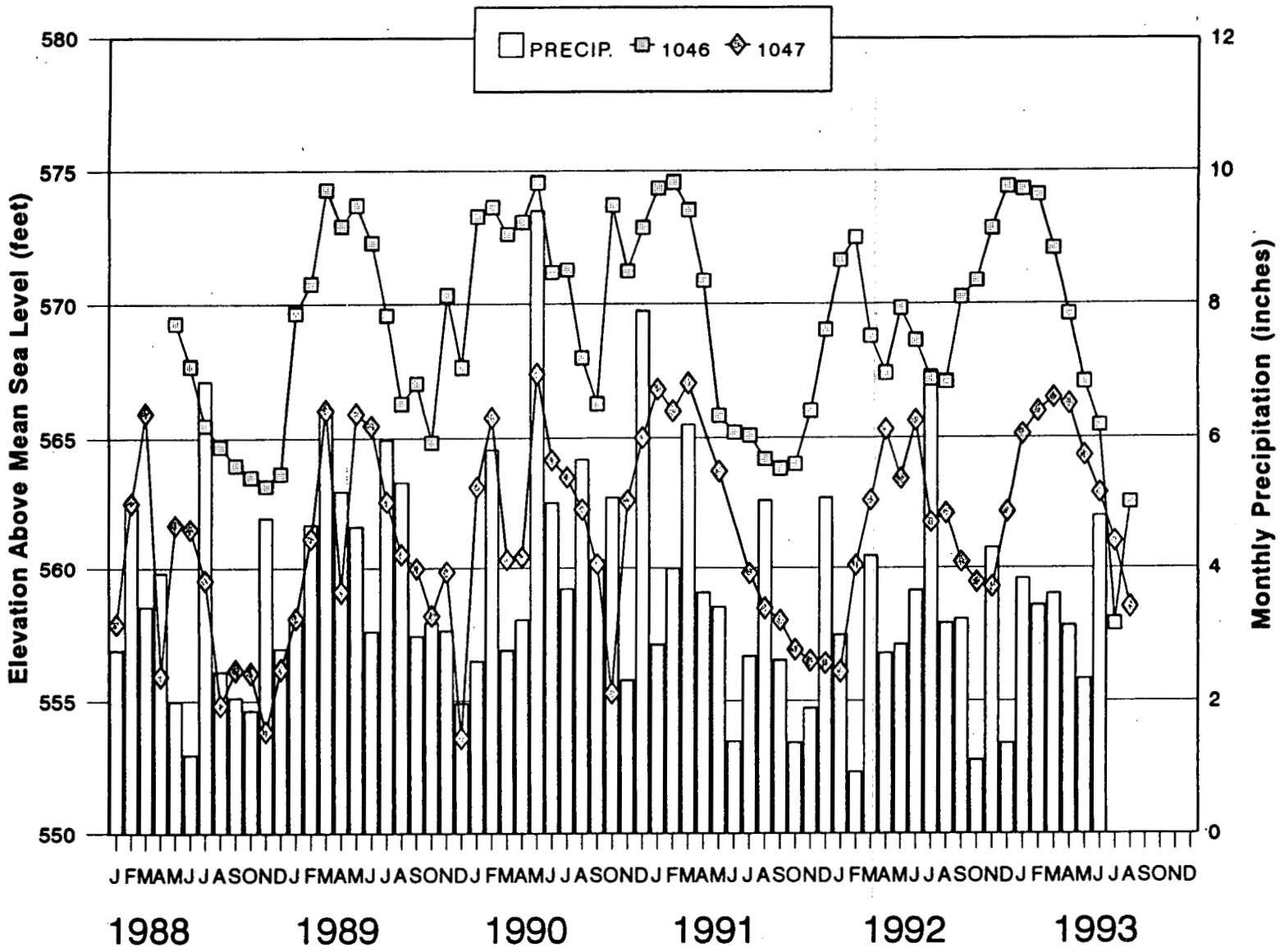


FIGURE 3-46
GROUNDWATER ELEVATIONS
1000-SERIES WELLS
SOUTH FIELD AND
FLYASH PILE AREAS
AUGUST 16, 1993



NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-47

HYDROGRAPHS FOR MONITORING WELLS 1046 AND 1047, SOUTH FIELD/INACTIVE FLYASH PILE

F:\RIREPORT\FIGURES\FIG3-47

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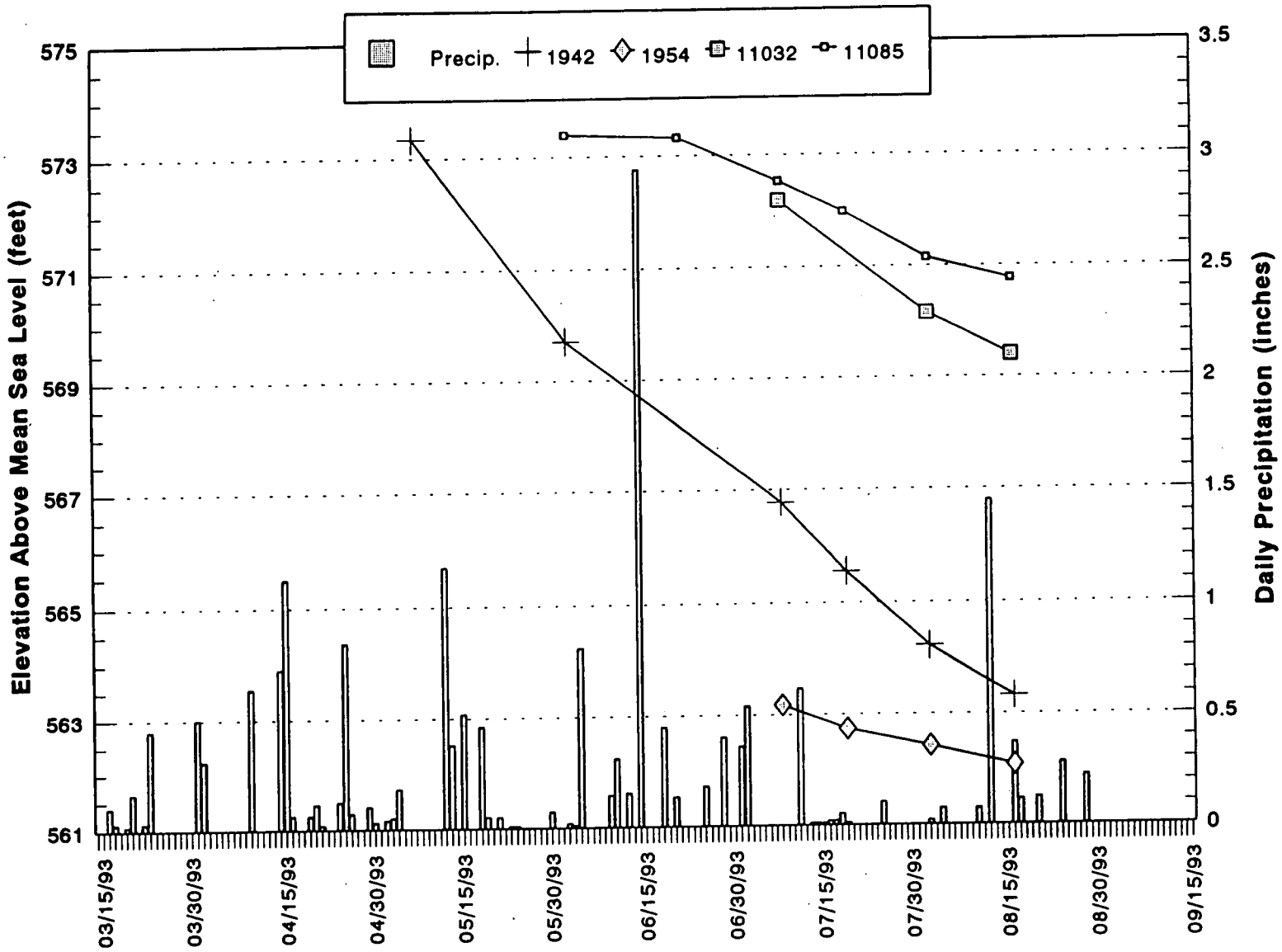

NOTE: PRECIPITATION DATA FROM ONSITE RECORDS

FIGURE 3-48

HYDROGRAPHS FOR MONITORING WELLS 1942, 1954, 11032 AND 11085, SOUTH FIELD

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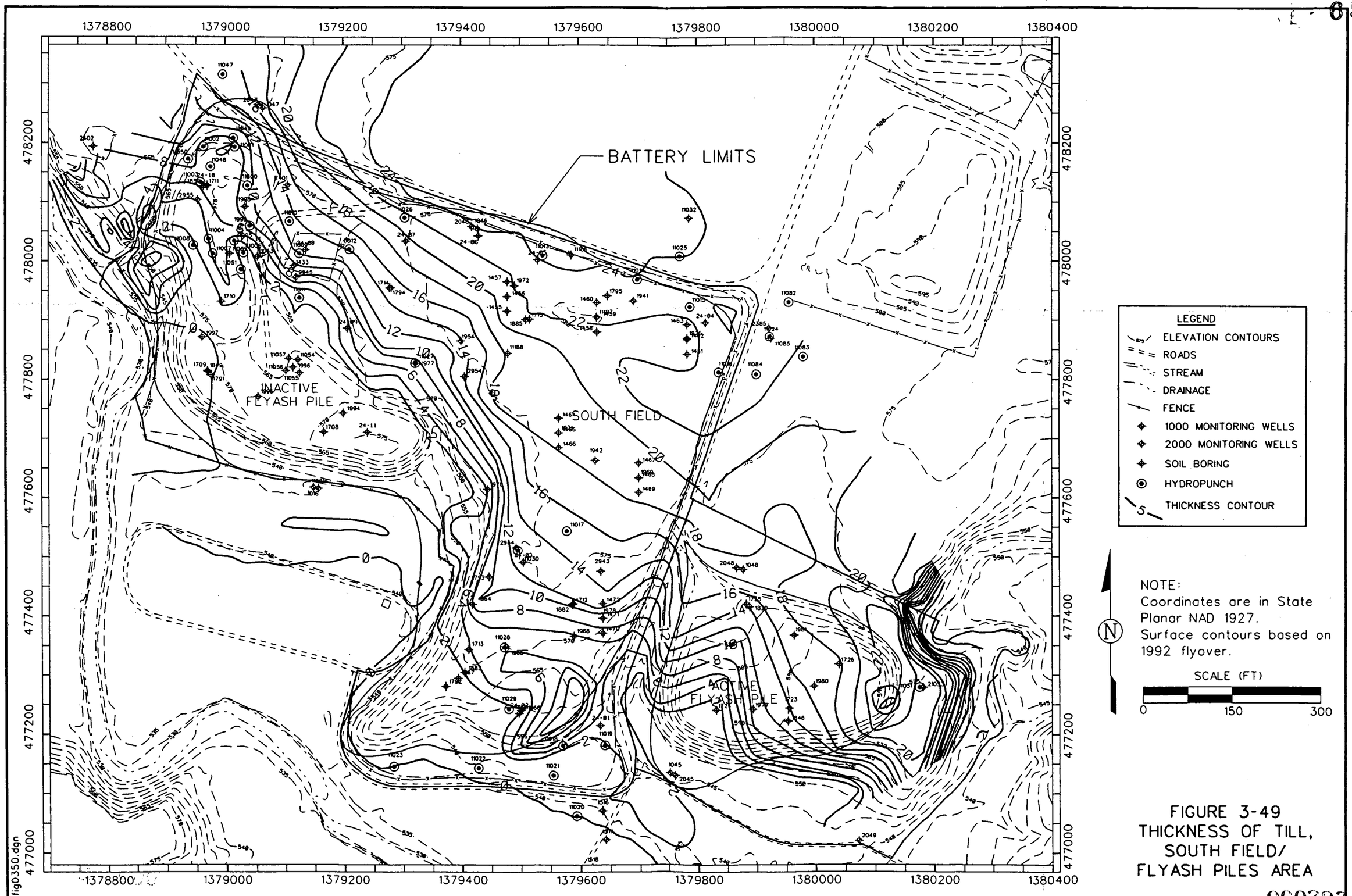


FIGURE 3-49
THICKNESS OF TILL,
SOUTH FIELD/
FLYASH PILES AREA

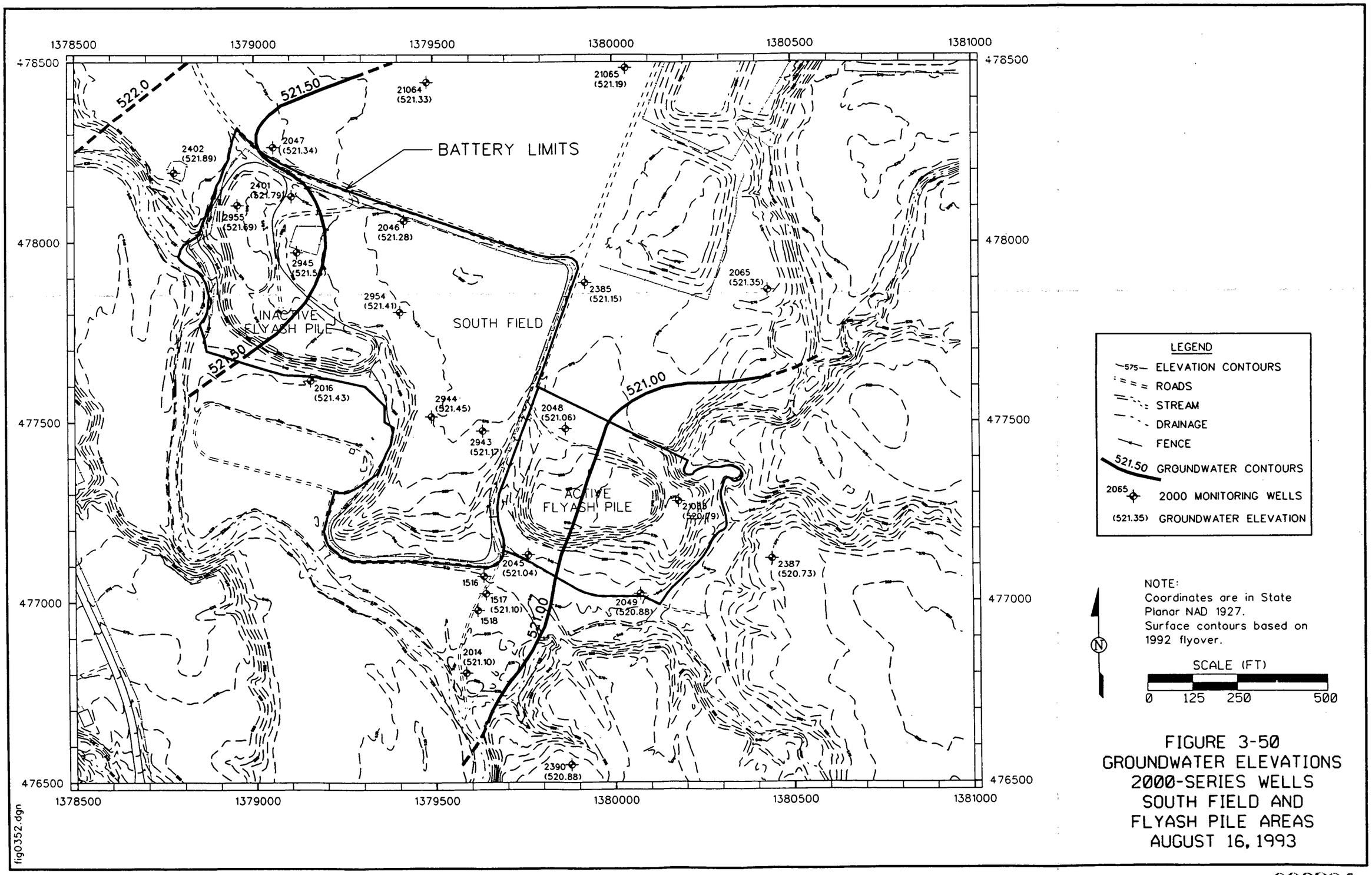
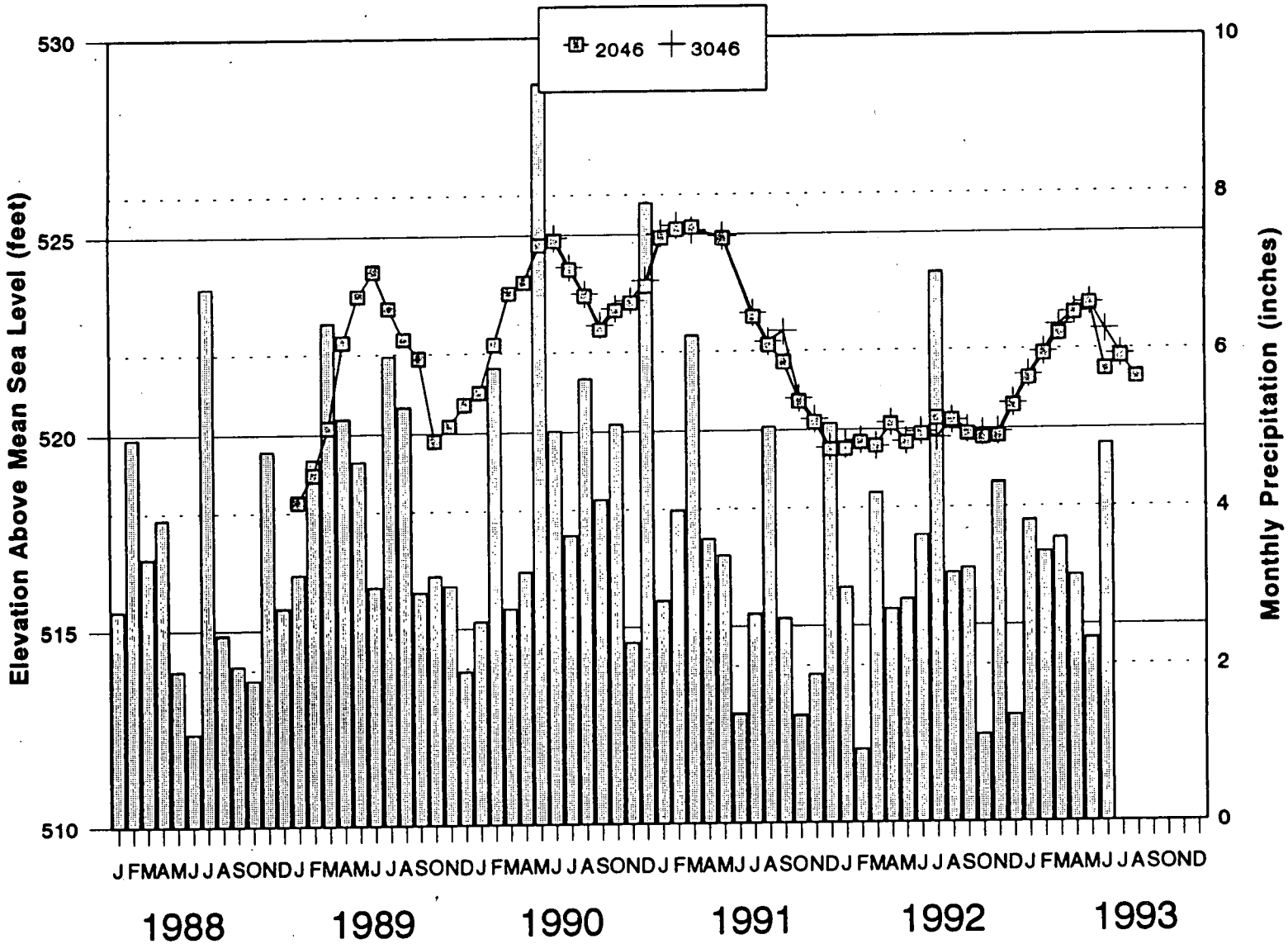


FIGURE 3-50
GROUNDWATER ELEVATIONS
2000-SERIES WELLS
SOUTH FIELD AND
FLYASH PILE AREAS
AUGUST 16, 1993



NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-51
HYDROGRAPHS FOR MONITORING WELLS 2046 AND 3046, INACTIVE FLYASH PILE

F:\RIREPORT\FIGURES\FIG3-51

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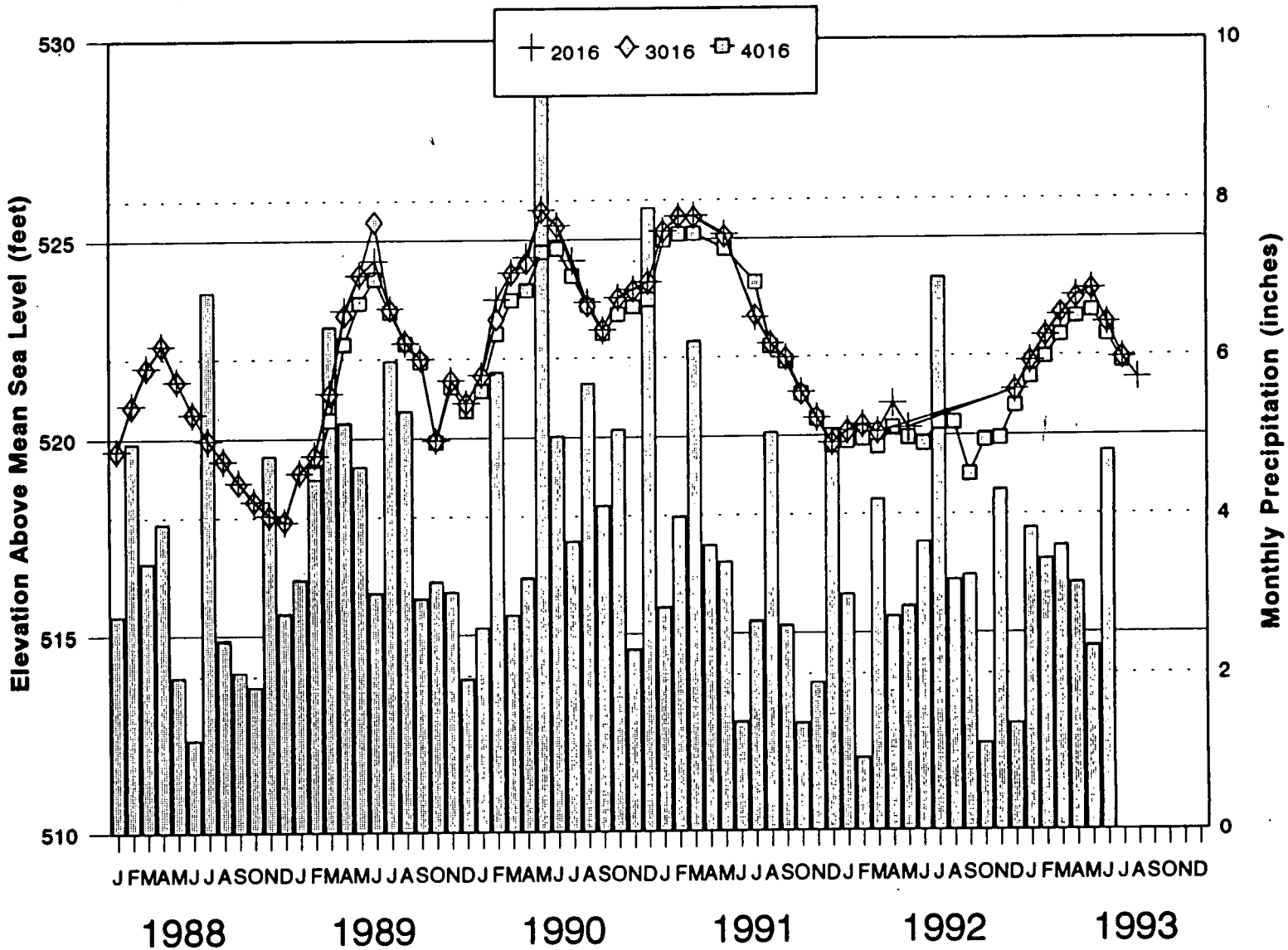

NOTE: PRECIPITATION DATA FROM BOONE CO. KY AIRPORT

FIGURE 3-52

HYDROGRAPHS FOR MONITORING WELLS 2016, 3016, AND 4016, INACTIVE FLYASH PILE

F:\RIREPORT[redacted]RE8\FIG3-52

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3.5 ACTIVE FLYASH PILE

The Active Flyash Pile is a steep-sided pile of flyash that was built up over the years by truck-hauled loads of flyash that were dumped and compacted. The Active Flyash Pile is bounded on the west by a gravel access road that separates it from the South Field (Figure 3-42). A gravel lined ditch runs between the waste area and this road. To the north, east, and south, the Active Flyash Pile is bounded by an area that slopes downward toward the Storm Sewer Outfall Ditch. The Active Flyash Pile is uncovered, but wind barriers and a crusting agent have been applied to reduce wind erosion; silt barriers have been installed to control surface water erosion. The Active Flyash Pile is surrounded on the east, south, and west by dense trees and brush and on the north by a grass field.

3.5.1 Topography and Surface Water

The top of the Active Flyash Pile, at an elevation of approximately 597 feet above MSL, is presently a relatively flat surface that slopes towards the northwest. Steep slopes around the flyash pile drain surface water radially off the pile. The topography of the Active Flyash Pile is shown in Figure 3-42. Observations have indicated that surface water runoff is rapid for the top and side slopes of the Active Flyash Pile, which may indicate a lower permeability. Drainage from the top surface is downslope to the northwest, collected at the northwest corner, and directed along the west toe of the pile into an engineered drainage channel. Drainage from the north side slope is directed toward a drainage, shown in Figure 3-42, that channels flow east to the Storm Sewer Outfall Ditch. Drainage from the west and south slopes flows south and west along the toe of the pile and joins the engineered drainage channel to discharge at a silt trap located at the southwest corner of the pile. A small quantity of flow from the west slope drains east through a wooded area toward the Storm Sewer Outfall Ditch and infiltrates along the west bank of the Storm Sewer Outfall Ditch.

Runoff from the pile is rapid, and there is little to no residual drainage visible after a rain event is complete. Drainage through the silt trap is also rapid with little to no standing water visible after precipitation ceases. Flow from the silt trap is south by sheet flow toward the Storm Sewer Outfall Ditch.

3.5.2 Geology and Groundwater Hydrology

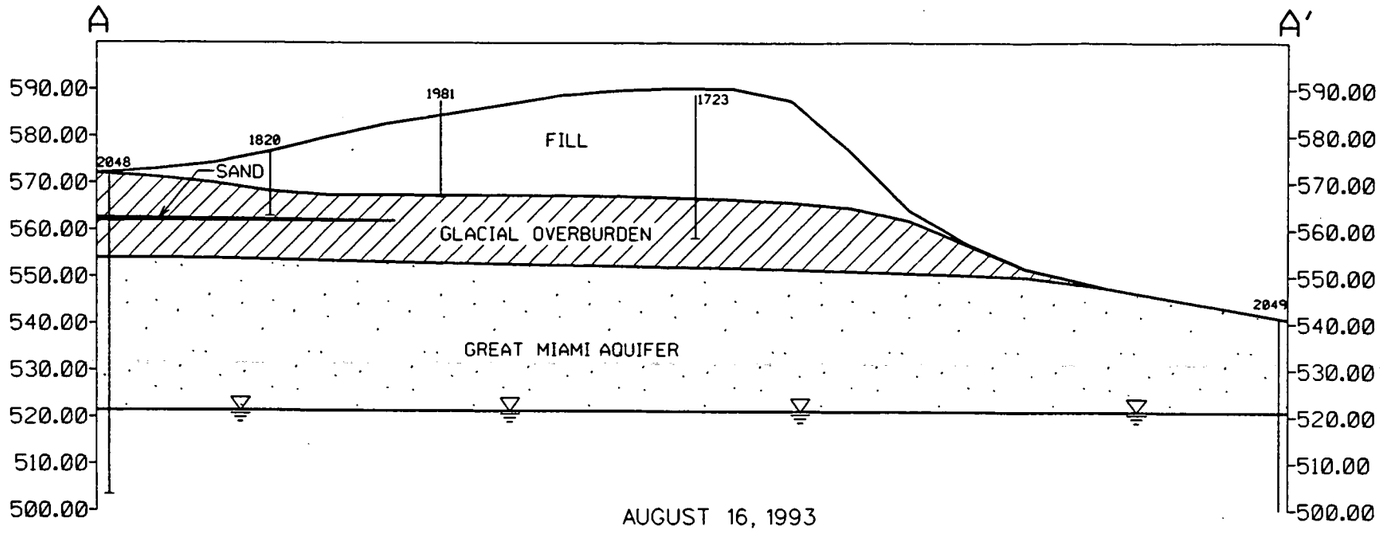
The Active Flyash Pile has been used to dispose of flyash and bottom ash from the coal-fired boiler plant. Soil samples collected from borings in the Active Flyash Pile were used to define its structure. Groundwater monitoring wells were installed to define groundwater conditions. Two geologic cross

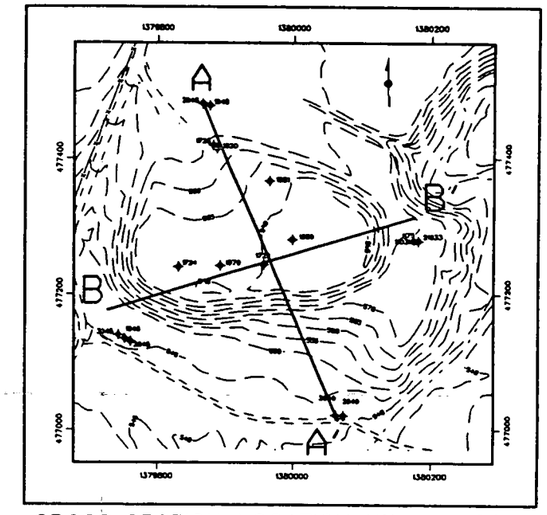
sections are shown in Figure 3-53. The geologic cross sections represent the interpreted geology along the actual cross-section traces shown on the map insets. See Section 3.2.2 for a description of the three-dimensional computer model that was used to develop the geological cross-sections. The cross sections indicate that the flyash pile was constructed on glacial overburden materials that range from less than 2 feet thick south of the pile (Well 1045) to 16 feet thick north of the pile (Well 1048). Approximately 19 feet of glacial overburden was encountered in a boring advanced on the east side of the pile (Well 21033). Contours of the thickness of glacial overburden are presented on Figure 3-49.

Groundwater within the glacial overburden ranges from 3 feet to 7 feet below the surface. Hydrographs from wells in the glacial overburden (Wells 1045 and 1048) are presented in Figure 3-54 and Figure 3-55. Trends in elevation changes indicate that the two wells are monitoring a common hydrogeologic unit, and water levels in the glacial overburden fluctuate about five to seven feet per year.

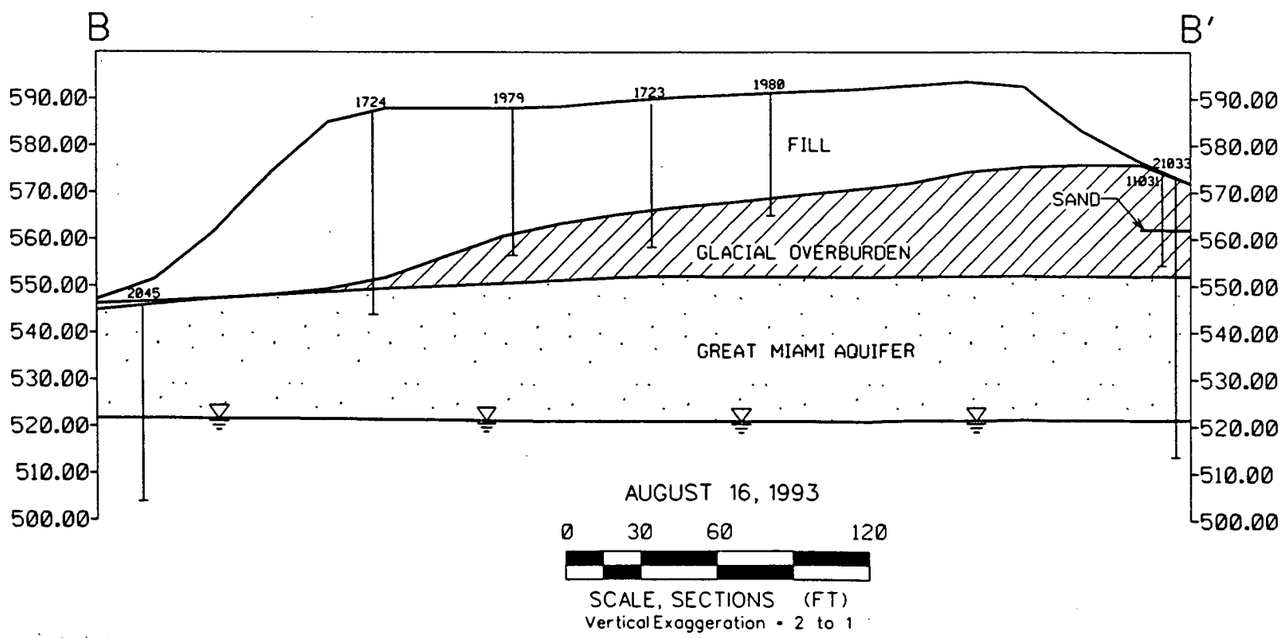
Groundwater elevations in the perched groundwater aquifer were presented in Figure 3-46. Groundwater flows toward the southwest and southeast due to an apparent groundwater divide that exists north of the flyash pile (see Section 3.4.2 for detailed discussion). The calculated gradient, 0.019, was based on inferred equipotentials on August 16, 1993, in till underlying the pile that does not contain sand layers.

Saturated groundwater conditions were detected within sand and silt in Well 1048 and within a sandy clay unit in Well 1045. Water levels in these wells fluctuated 7.7 feet in Well 1048 (upgradient) and 4.8 feet in Well 1045 (downgradient) from January 1988 to March 1992. The groundwater levels in Well 1045 typically rose to within two feet of the surface during the January to March wet period, suggesting that the upgradient well at the north edge of the Active Flyash Pile is monitoring a potential recharge zone. No groundwater was encountered at the east edge of the Active Flyash Pile; however, the boreholes in the area were not left open long enough to observe groundwater recovery.





CROSS-SECTION LOCATION KEY (1"=200')

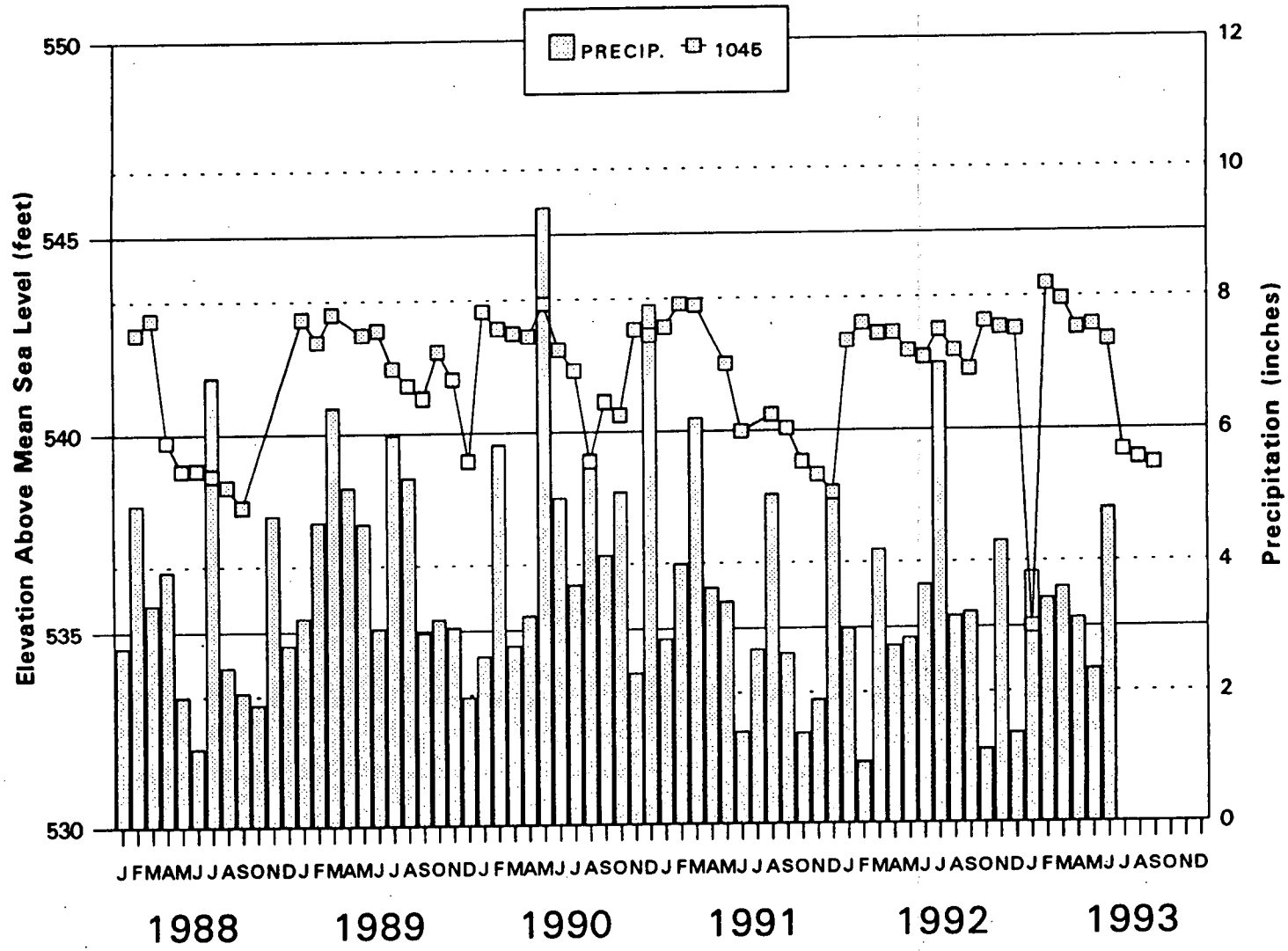


LEGEND

- ROADS
- ELEVATION CONTOURS
- DRAINAGE
- 1000 MONITORING WELLS
- 2000 MONITORING WELLS
- 3000 MONITORING WELLS
- SOIL BORING
- HYDROPUNCH

fig0337.dgn

FIGURE 3-53
GEOLOGIC CROSS SECTIONS,
ACTIVE FLYASH PILE



NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-54
HYDROGRAPH FOR MONITORING WELL 1045, ACTIVE FLYASH PILE

F:\RIREPORT\FIGURES\FIG3-54

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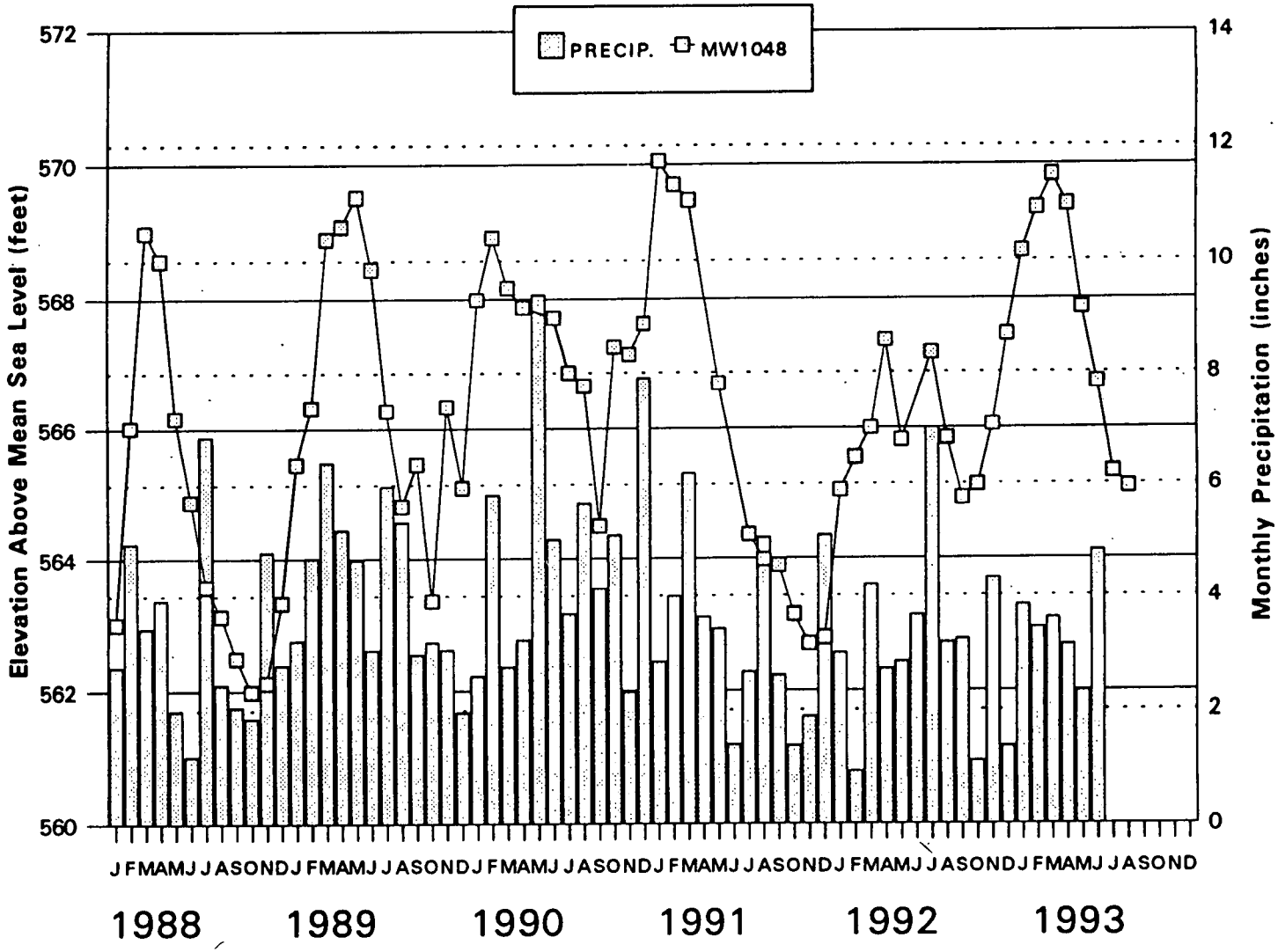

NOTE: PRECIPITATION DATA FROM BOONE CO., KY AIRPORT

FIGURE 3-55
HYDROGRAPH FOR MONITORING WELL 1048, ACTIVE FLYASH PILE

F:\RIREPORT\FIGURES\FIG3-55

4.0 NATURE AND EXTENT OF CONTAMINATION

Section 4.0 provides a detailed discussion of nature and extent of constituents that were determined to be contaminants of concern (COCs), which are defined in Section 6.0 of this RI report and summarized on Table 4-0. Based on the 1991 Amended Consent Agreement, the definition of Operable Unit 2 is waste materials, berms, and soils within the operable unit boundary. All other media (e.g., surface water, groundwater) is defined under another operable unit. Accordingly, the COCs in Operable Unit 2 RI/FS documents have been categorized as surface soil for the direct exposure to contaminated material/surface soil and cross-media for other media that would be impacted by contaminated material/soil in Operable Unit 2. This section also addresses radionuclides detected above background in ground water, surface water, sediment, and soils in Operable Unit 2. This allows for a more focused approach for discussing the nature and extent of constituents that comprise the greatest risk to human health. The summary tables in Section 4.0 (i.e., Table 4-3) list all of the constituents analyzed, summarize the number of occurrences where constituents were detected above background, and provide the ranges of concentrations for each constituent. For comparison purposes in Section 4.0, both filtered and nonfiltered Operable Unit 2 metal samples were compared to filtered background metal samples. This was considered to be a conservative assumption (more hits above background). All other Operable Unit 2 samples shown in Section 4.0 (radionuclides, organics, and general chemistry) were compared to like (unfiltered) background samples. Detailed tables used to formulate the Section 4.0 summary tables and tables listing all sampling results are provided in the appendices C through G. The discussion of nature and extent in this section concentrates on areas within the battery limits of the Operable Unit 2 subunits. Also included are data used to define background concentrations for comparison purposes.

The figures in this section provide a summary of the COCs detected above background and radionuclides detected above background (note: When the figure titles state "of concern" the title is referring to COCs; i.e., Metals of Concern are metals that are COCs).

The nature and extent of radiological and chemical constituents within Operable Unit 2 are based upon data collected during the Phase I and II field investigations and, to a limited extent, on field investigations conducted prior to Phase I (e.g., CIS and ES).

TABLE 4-0

OPERABLE UNIT 2 CONTAMINANTS OF CONCERN

Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
SURFACE SOIL				
neptunium-237 radium-226 radium-228 thorium-228 thorium-230 thorium-232 plutonium-238 uranium-234 uranium-235/236 uranium-238 antimony arsenic beryllium benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene dibenzo(a,h)anthracene indeno(1,2,3-cd)pyrene	cesium-137 radium-226 radium-228 thorium-228 thorium-230 thorium-232 uranium-238 uranium-total	radium-226 radium-228 thorium-228 thorium-232 arsenic dibenzo(a,h)anthracene	cesium-137 neptunium-237 radium-226 radium-228 thorium-228 thorium-230 thorium-232 uranium-234 uranium-235/236 uranium-238 uranium-total arsenic beryllium Aroclor-1254 Aroclor-1260 benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene benzo(k)fluoranthene dibenzo(a,h)anthracene dieldrin indeno(1,2,3-cd)pyrene	cesium-137 neptunium-237 radium-226 radium-228 thorium-228 thorium-232 arsenic beryllium
CROSS-MEDIA IMPACT ON SURFACE WATER				
uranium-total arsenic	no COCs	no COCs	uranium-total arsenic dieldrin	no COCs
CROSS-MEDIA IMPACT ON SEDIMENT				
uranium-total	no COCs	no COCs	radium-226	radium-226 arsenic
CROSS-MEDIA IMPACT ON GROUNDWATER				
no COCs	no COCs	uranium-234 uranium-235/236 uranium-238 uranium-total	uranium-234 uranium-235/236 uranium-238 uranium-total	uranium-234 uranium-238 uranium-total

TABLE 4-0
(Continued)

Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
CROSS-MEDIA IMPACT ON PERCHED GROUNDWATER				
technetium-99 carbazole	neptunium-237 strontium-90 technetium-99	no COCs	no COCs	no COCs
CROSS-MEDIA IMPACT ON AIR				
radon-222	no COCs	radon-222	radon-222	radon-222
CROSS-MEDIA IMPACT FROM DUST ON BEEF/MILK AND HOMEGROWN PRODUCE				
neptunium-237 radium-226 strontium-90 uranium-234 uranium-238 arsenic beryllium benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene dibenzo(a,h)anthracene indeno(1,2,3-cd)pyrene	no COCs	dibenzo(a,h)anthracene	cesium-137 radium-226 radium-228 strontium-90 technetium-99 uranium-238 arsenic beryllium Aroclor-1254 Aroclor-1260 benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene benzo(k)fluoranthene dibenzo(a,h)anthracene dieldrin indeno(1,2,3-cd)pyrene	arsenic
CROSS-MEDIA IMPACT FROM GROUNDWATER ON BEEF/MILK AND HOMEGROWN PRODUCE				
no COCs	no COCs	uranium-234 uranium-235/236 uranium-238 uranium-total	uranium-234 uranium-235/236 uranium-238 uranium-total	radium-226 strontium-90 uranium-235/236 uranium-total
GREAT MIAMI RIVER SURFACE WATER CROSS-MEDIA IMPACT				
no COCs	no COCs	no COCs	radium-226 technetium-99	no COCs

The range of chemical and radionuclide constituents that are present in Operable Unit 2 reflect the various uranium production and thorium operations conducted in the past at the FEMP. The radiological constituents include uranium and thorium isotopes and their progenies. It should be noted that plutonium-239/240 and plutonium-238 had lower detection limits for Phase II (from 0.6 to 0.02 pCi/g); consequently, the frequency of detection increased for Phase II. Because the FEMP also processed recycled uranium from the Hanford facility during the 1970s, Operable Unit 2 could also be contaminated with uranium fission products. Other chemical constituents likely to be encountered at the FEMP based upon process knowledge include: tributyl phosphate, a mobilizing agent used in the extraction of uranium; PCBs; polynuclear aromatic Hydrocarbons (PAHs) from flyash or fuel oils; common organics such as acetone, 2-butanone (MEK), and methylene chloride; chlorinated phenoxy acid herbicides (used for weed control) and their degradation products; chlorinated organics used as degreasers or paint thinner; and various inorganic species (such as calcium, magnesium, fluoride, and heavy metals).

4.1 BACKGROUND DATA

This section summarizes background data used to define the nature and extent of contamination in Operable Unit 2. The full range of statistical tests, which includes a comparison to background, applied to identify CPC are presented in Section 6.0. A summary of the processes that generated the waste stored in Operable Unit 2 and the nature of the materials that are known. The results of environmental media background studies performed in the vicinity of the FEMP are discussed in this section. In addition, baseline concentrations of constituents in flyash are presented to support the evaluation of the Active Flyash Pile.

The background values presented for surface and subsurface soil were based on direct analysis of regional soils at three depths (0 to 6 inches, 36 to 42 inches, and 48 to 54 inches). Background concentrations calculated for surface soil includes the 0- to 6-inch sample set; subsurface soil include the combined 36- to 42-inch and 48- to 54-inch sample sets, as presented in the CERCLA/RCRA Background Soil Study (DOE 1993b). The values presented for perched groundwater and the Great Miami Aquifer were calculated from datasets developed for the Characterization of Background Water Quality for Streams and Groundwater (DOE 1993a). Samples collected for metals in the groundwater background study were filtered through a 0.45 micrometer (μm) membrane filter; therefore, the background metal concentrations represent dissolved levels. Background radiological samples were not filtered; all radiological background concentrations and activities represent total levels.

4.1.1 Operable Unit 2 Process Data

In general, waste materials in Operable Unit 2 subunits consist of conventional industrial wastes associated with any large industrial facility such as boiler plant ash, water treatment sludge, construction rubble, and nonprocess trash. The wastes placed in Operable Unit 2 are not direct byproducts of the chemical and metallurgical processes used for uranium production. These process wastes were included in the three major waste streams (general sump sludge, neutralized raffinate, and magnesium fluoride) that were disposed on site in the Waste Pit Area (Operable Unit 1). Therefore, radionuclide contamination in Operable Unit 2 is apparently due to contamination resulting from past waste management practices.

The understanding of processes that generated the waste contained in Operable Unit 2 varies with each subunit. Operations that generated wastes contained in the Lime Sludge Ponds and the Active Flyash Pile are well known, whereas operations which contributed waste to the Solid Waste Landfill and the South Field are poorly documented.

The Lime Sludge Ponds received waste consisting of water treatment sludge, coal pile runoff, and boiler blowdown. The largest component, sludge, was generated by the addition of lime and aluminum sulfate to treat the site water supply for hardness. Elevated levels of certain inorganic constituents including aluminum, calcium, and magnesium would be expected.

Ash from the coal-fired boiler plant was transported by truck and placed on the Inactive Flyash Pile from 1952 until the mid-1960s; after the mid-1960s, most flyash was sent to the Active Flyash Pile. Ash material placed at the Inactive Flyash Pile consists of bottom ash and flyash and includes ash collected from precipitators installed to control emissions from the boiler plant operation. Some unburned coal and rock are found in both piles, while soils and construction debris such as transite, reinforced concrete, and asphalt have also been disposed of at the Inactive Flyash Pile. To support evaluation of analytical results for the flyash pile samples, a literature search produced comparison data for normal constituents of ash. The findings are presented in Section 4.1.4.

No documentation of the types of wastes dumped at the Solid Waste Landfill has been discovered, although documents from the NLO engineering files indicate that the facility was intended as a sanitary landfill for nonburnable trash. A construction drawing, dated May 23, 1974, depicts five waste cells planned for the facility, but historical photographs and field investigations defined only

one disposal cell and an evaporation pond. According to visual observation made during Phase I field investigation trenching at the landfill, the contents are mostly nonburnable. Trenching revealed that a variety of nonprocess solid wastes were placed in the landfill in addition to bagged trash, including bagged and loose asbestos materials, ceramic tiles, glass acid bottles, rubber hoses and tubing, medical wastes, fire hoses, steel cables, full and empty paint cans, asphalt roofing materials, respirator cartridges, and copper tubing. The trenching also uncovered very localized areas of higher radioactivity that could be process samples or media contaminated by process activities.

The least information is available on the activities that generated wastes disposed in the South Field, the largest of the Operable Unit 2 subunits. Field investigation confirm reports that this area was used for disposal of on-site construction/demolition rubble and soil with low levels of radioactivity. This material appears to have been placed within excavated pits by trucks and covered with native soils.

4.1.2 Statistical Evaluation of Background Data

Data collected from Operable Unit 2 environmental media were compared with the 95th percentile of the validated background concentration datasets to identify constituent concentrations that exceeded naturally occurring or other non-site related levels of radiological or chemical constituents. Table 4-1A presents the calculated 95th percentile background concentrations for radiological and inorganic constituents in surface soil, subsurface soil, perched groundwater, and Great Miami Aquifer groundwater. Organic compounds in the soil and groundwater were considered to be waste-related regardless of their concentration. Background data for surface water in Paddys Run is not available because data have not been validated (DOE 1993a). Individual samples whose constituent concentrations exceed the respective 95th percentile background concentrations are identified as being not consistent with background data (Note: 95th percentile background concentrations are used in Section 4.0, to address nature and extent. The 95% UCL of the mean is used to determine the source terms for fate and transport modeling (Section 5.0) and the risk assessment (Section 6.0). The 95th percentile is used in this section because individual constituent concentrations are being compared to the population of background concentrations). The initial step in calculating a 95th percentile background concentration is to determine the distribution of the data. This procedure was used in Sections 4.0, 5.0, and 6.0, and is discussed in Appendix B. The 95th percentile background concentration is determined based on one of the following three methods dependent upon the distribution assumed to best fit the data.

TABLE 4-1A

BACKGROUND CONCENTRATIONS FOR SOILS AND GROUNDWATER OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Background Concentration[a]			
	Soils		Groundwater	
Analyte	Surface (0-6 inches)	Subsurface (36-42 and 48-54 inches combined)	Perched	Great Miami Aquifer
Radionuclides	(pCi/g)	(pCi/g)	(pCi/L)	(pCi/L)
Actinium-227	0.090[b]	0.06	0.0[e]	0.0[e]
Cesium-137[d]	0.71	0.0[e]	0.0[e]	0.0[e]
Lead-210	1.30	0.81	0.0[e]	0.0[e]
Neptunium-237	0.0[e]	0.0[e]	0.0[c]	0.0[c]
Plutonium-238	0.0[e]	0.0[e]	0.0[c]	0.0[c]
Plutonium-239	0.0[e]	0.0[e]	0.0[c]	0.0[c]
Plutonium-240	0.0[e]	0.0[e]	0.0[c]	0.0[c]
Potassium-40	19.71	27.76	0.0[e]	0.0[e]
Protactinium-231	0.0[e]	0.0[c]	0.0[e]	0.0[e]
Radium-224	0.900	1.01	0.0[e]	0.0[e]
Radium-226	1.42	1.47	1.0[b]	1.20
Radium-228	1.25	1.31	5.2	4.0
Ruthenium-106[d]	0.0[c]	0.0[c]	0.0[e]	0.0[c]
Strontium-90[d]	0.0[c]	0.56[b]	0.0[c]	0.0[c]
Technetium-99[d]	0.0[c]	0.0[c]	0.0[c]	36.0[b]
Thorium-228	1.43	1.33	1.04[b]	1.4
Thorium-230	1.97	1.88	2.0[b]	1.7
Thorium-232	1.36	1.26	0.0[c]	0.0[c]
Total Thorium	10.70μg/g	9.470μg/g	3.0μg/L[b]	2.0μg/L[b]
Uranium-234	1.24	1.04	1.9	1.2[b]
Uranium-235/236	0.15	0.15	0.0[c]	0.0[c]
Uranium-238	1.22	1.12	1.07[b]	0.90[b]
Total Uranium	3.7mg/kg[g]	3.4mg/kg[g]	4.0μg/L	2.0μg/L

See footnotes at end of table

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TABLE 4-1A
(Continued)

Analyte	Background Concentration[a]			
	Soils		Groundwater	
	Surface (0-6 inches)	Subsurface (36-42 and 48-54 inches combined)	Perched	Great Miami Aquifer
Metals	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)
Aluminum	11880.19	16063.97	0.123	0.180
Antimony	0.0[c]	0.0[c]	0.0[c]	0.006
Arsenic	8.20	9.57	0.05[h]	0.05[h]
Barium	94.10	119.17	0.450	0.436
Beryllium	0.60[b]	0.62	0.002	0.0023
Boron	25.10	42.95	not analyzed	not analyzed
Cadmium	0.87	0.91	0.005[h]	0.005[h]
Calcium	4339.17	150000.00	123.837	134.783
Chromium	15.50	20.68	0.035	0.041
Cobalt	14.16	15.75	0.0[c]	0.0[c]
Copper	14.07	20.03	0.03	0.120
Cyanide	0.27	0.13[b]	0.0[e]	0.0[c]
Iron	21728.17	30700.00	3.44	4.0
Lead	26.4	15.58	0.015[h]	0.015[h]
Magnesium	2776.97	42648.21	48.546	37.961
Manganese	1348.04	1300.00	0.05[h]	0.05[h]
Mercury	0.12[b]	0.29[b]	0.0004[b]	0.0005
Molybdenum	0.0[c]	2.7[b]	0.025	0.025
Nickel	20.87	34.35	0.026	0.024
Potassium	1231.34	1979.99	26.976	3.077
Selenium	0.72[b]	0.0[c]	0.0[c]	0.004
Silicon	1797.03	1593.08	not analyzed	6.14
Silver	0.0[c]	0.0[c]	0.04	0.014
Sodium	51.10	285.00	47.982	51.267
Thallium	0.58[b]	0.49[b]	not analyzed	0.0[c]
Tin	not analyzed	not analyzed	not analyzed	0.0[c]

See footnotes at end of table

TABLE 4-1A
(Continued)

Analyte	Background Concentration[a] Soils: Surface (0-6 inches)	Soils: Subsurface (36-42 and 48-54 inches combined)	Groundwater: Perched	Groundwater: Great Miami Aquifer
Metals (Continued)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)
Vanadium	30.37	37.80	0.020	0.025
Zinc	59.61	72.58	0.032	0.095
All Organic Compounds	0.0	0.0	0.0	0.0
General Water Chemistry			(mg/L)	(mg/L)
Ammonia	NA	NA	4.34	3.24
Chloride	NA	NA	46.10	120.0
Fluoride	NA	NA	1.298	0.929
Nitrate	NA	NA	0.462	10.0[h]
Total Phosphorus	NA	NA	0.206	0.679
Sulfate	NA	NA	138.192	352.992

[a]Source: DOE1993a (Soils), DOE1993d (Groundwater.) Value presented represents 95 percentile from site specific data except as noted. Metal background values for groundwater based on filtered samples; all other compounds are based on unfiltred samples.

[b]Value presented represents minimum detected value since 95th percentile UCL would be a nondetect.

[c]All values in the data set are nondetects; value assumed to be zero.

[d]This radionuclide is a fission product, and its presence in the environment may be due to atmospheric releases of radiation (e.g., weapons testing) and or reprocessing activities. This radionuclide is not naturally occurring and is only expected to be present at or near detectable activities in the surface soil.

[e]Not analyzed; value assumed to be zero.

[f]NA = Not Applicable.

[g]Individual activity concentrations of the three isotopes for uranium and thorium were converted to mass concentrations. The three isotope mass concentrations were added to obtain the total thorium or uranium mass concentrations.

[h]Background value has been set to the MCL.

Normal Distribution

If the background data distribution is assumed to be normal, the equation used to calculate the 95th percentile is:

$$95\text{th Percentile} = \bar{x} + Z_{(.95)} \times S$$

where:

n = number of samples
$\bar{x}$ = sample mean concentration
$Z_{(.95)}$ = percentage point from the Normal distribution
s = sample standard deviation

$$= \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

Lognormal Distribution

If the background data distribution is assumed to be lognormal, the equation used to calculate the 95th percentile is:

$$95\text{th Percentile} = e^{\bar{y} + Z_{(.95)} \times S_y}$$

where:

n = number of samples
$\bar{y}$ = sample mean of the log-transformed data
$Z_{(.95)}$ = percentage points from the Normal distribution
S_y = sample standard deviation of the log-transformed data

$$= \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (y_i - \bar{y})^2}$$

Undetermined Distribution

If the distribution of the background data could not be adequately determined, a non-parametric method was used to estimate the 95th percentile concentration. The initial step in this procedure is to order the data such that

$$x_1 \leq x_2 \leq \ldots \leq x_i$$

where:

$x_{j,\ (j=1\ to\ i)}$ = sample concentrations
i = the number of background samples

The 95th percentile concentration is then determined to be

$$x_k$$

such that

$$k \geq i \times 0.95 \text{ (i = number of samples)}$$

4.1.3 Flyash Baseline Concentrations

Typical flyash concentrations of trace elements, radionuclides, and organics were obtained from a literature search for comparison with data collected from the Active Flyash Pile to support evaluation of the nature and extent of contamination in the Active Flyash Pile. These values are presented in Table 4-1B. To develop a baseline with a greater degree of statistical confidence, particularly for the metals and radionuclides, numerous sources were utilized. The criteria for obtaining applicable values were as follows:

- Data resulting from the combustion/conversion of coal only were used. All flyash data resulting from oil-fired boiler systems were excluded.
- The types of coal used in the systems were generally bituminous and sub-bituminous, although a few of the studies included lignite coal-fired units. This is considered applicable since a search of the historical coal delivery records was unable to define a single type of source coal.
- Data included in the baseline mean were obtained only from flyash piles and electrostatic precipitator hopper ash (or similar dry ash technology). All data obtained from wet ash control technologies were excluded.
- All data were analyzed in accordance with comparable methods for the determination of total metals (e.g., ICAP, GFAA, X-ray diffraction, etc.).
- Data were reported in units of ppm [milligrams per kilogram (mg/kg)] or percentages convertible to ppm and pCi/g for radionuclides.

TABLE 4-1B

ELEMENTS COMPOSITION OF FLYASH (ppm)
TOTAL METALS

	Al	As	Sb	Ba	Be		Cd	Ca	Cr	Co	Cu	Fe	Pb
	14000	3.2	1	896	13		0.39	770	169	105	313	12250	96
	100000	74	1.5	3600	5.2		1.4	115000	5.6	127	43	21500	6.4
	140000	56.6	2.5	700	7.5		5.3	15900	3.6	15	113	109400	17
	13660	61	4.4	750	13.1		4.2	31270	28	5	59	28240	27
	132000	137	2.1	800	5.2		3.5	6220	8.9	7	238	7680	4
	110000	3.3	1	1000	2.3		7.3	24000	48	30	72	90000	85
	92700	20	10	1000	3.2		2	142000	0.114	10	105	36000	15
	100,000	100	15	500	0.5		8	38000	62	72	30	48000	200
	140000	100	10	3000	1.5		10	9100	218		200	43000	150
	130000	30		1487	1.5		15	8200			300	39000	100
	130000	39		4920	10		2	7100			200	89000	70
	136000	24		1003	4.4	<	0.5	11200			115	37200	45
	119000	150		2770			1.6	21800			159	108000	114
	114000							34300			185	22500	118
	84000							150000			220	46000	210
	132000							10400			510	70900	
	110000							9800				47000	
	120000							20000				69000	
	129000							39500				24000	
	92000							28000				120000	
	135000							12300				56000	
	136000							6700				88900	
	79200							24700				107000	
	100000							97200				28000	
COUNT:	24	13	9	13	12		13	24	9	8	16	24	15
MEAN:	108273.33	61.39	5.28	1725.08	5.62		4.71	35977.50	60.36	46.38	178.88	56190.42	83.83
95%	140000	141	18.4	4920	19.9		20.6	134687.5	218.0	199.4	382.2	148364.4	194.0

000213

TABLE 4-1B
(Continued)

ELEMENTS COMPOSITION OF FLYASH (ppm)
TOTAL METALS

	Mg	Mn	Ni	Se		Ag		V	Zn		Hg	B	Sn	Mo
	1432	157	263	1.7	<	1		390	195		0.126	218	75	293
	350	242	34.2	3.27		0.0008	<	50	92	<	0.01	179	85	10
	14700	273	75.1	14.7	<	1	<	100	102		0.146	274	3	40
	4200	374	108	16.4		0.7		14.7	386	<	0.01	392	10	70
	181	12	92.9	73		0.7		0.3	854		0.14	1040	10	70
	4200	1000	37	0.02		1		47	56		0.22	2.4	15	46
	6100	50	0.12	5		0.28		0.5	0.3	<	0.01	260		25
	73100	300	50	20		14		195	20	<	1	100		
	8700	200	169	20				270	800	<	1	300		
	5600	500	65	5					120	<	1	200		
	15000	290		0.28					300	<	1	400		
	5500	150		11					403		0.72	290		
	4630	1190							106			980		
	5510								254					
	9470								153					
	24000								320					
	4720													
	5200													
	5200													
	5910													
	6200													
	5000													
	4180													
	4530													
	40000													
COUNT:	25	13	10	12		8		9	16		12	13	6	7
MEAN:	10544.52	364.46	89.43	14.20		2.34		118.61	260.08		0.45	356.57	33.00	79.14
95%	40000.0	1610.7	215.6	73.0		14.0		390.0	677.3		0.72	1040.0	85.0	269.6

000314

6505

TABLE 4-1B
(Continued)

RADIONUCLIDE COMPOSITION OF FLYASH

	Th-232 (pCi/g)	U-238 (pCi/g)	Ra-226 (pCi/g)	Pb-210 (pCi/g)	Po-210 (pCi/g)	Escaping Rn-222 (pCi/L)	Total U (ug/g)	Total Th (ug/g)
	1.56	2.31	2.22	2.07	0.86	0.039	19	150
	2.35	3.09	3.2	5	2.6	0.018		16
	2.3	3.2	3.44	4.6	1.9	0.079		330
	4.12	6.46	5.65	9.28	5.32	0.011		
	2.25	3.45	4.06	6.3	5	0.025		
	2.41	3.78	3.72	4.4	3.1			
	0.87	2.42	3	3.12	2.06			
	0.73	1.2	1.37	12.7	10.6			
	1.41	2.23	2.27	2.53	0.94			
COUNT:	9	9	9	9	9	5	1	3
MEAN:	2.000	3.127	3.214	5.556	3.598	0.0344	19	165.333
95%	4.3	6.1	5.3	12.5	10.3	0.1	19.0	330.0

000215

The background ash 95th percentile concentrations were developed in accordance with the procedures described in section 4.1.2 and presented in Table 4-1A. A few of the reference studies reported data as a mean developed from multiple data points; these data were considered to be a single data point for the purpose of calculating the 95th percentile. Multiple data points presented within a single reference were considered in the calculations as discreet data points. Not all studies contained data for each parameter of concern.

Metals

The majority of the data obtained for trace constituents of flyash from the combustion of coal were metals. Many studies have been conducted to determine the amount and type of metals in flyash due to the environmental concerns regarding the potential for the leaching of metals. Three data points were eliminated from the final dataset of trace element composition because these concentrations were two orders of magnitude greater than all other data points for that analyte. By removing these three data points, the dataset is more conservative (e.g., biased low rather than high). It should also be noted that one study presented Extraction Procedure Toxicity test data to indicate the leaching potential of metals from typical flyash. The following summary provides the results of the extraction test using the Extraction Procedure Toxicity test for metals:

Extraction Procedure Toxicity Metals	Concentration
Arsenic	< 0.2 μg/L
Barium	2.8 μg/L*
Cadmium	< 0.1 μg/L
Chromium	< 0.5 μg/L
Lead	< 0.5 μg/L
Selenium	< 0.2 μg/L
Silver	< 0.1 μg/L
Mercury	< 0.0005 μg/L

*Note that seven total data points were collected. The result listed for barium was the only detectable result reported.
Source: Kilkelly Environmental Associates, 1991

Radionuclides

Only two studies were found that met the data acceptance criteria presented (see references; Garcez and Titlebaum, 1984; and Labuz, 1986). Few values were found for the parameters of total uranium and total thorium. The limited data for these two parameters (only one data point in the case of total uranium), is presented in Table 4-1B.

4.2 SOLID WASTE LANDFILL

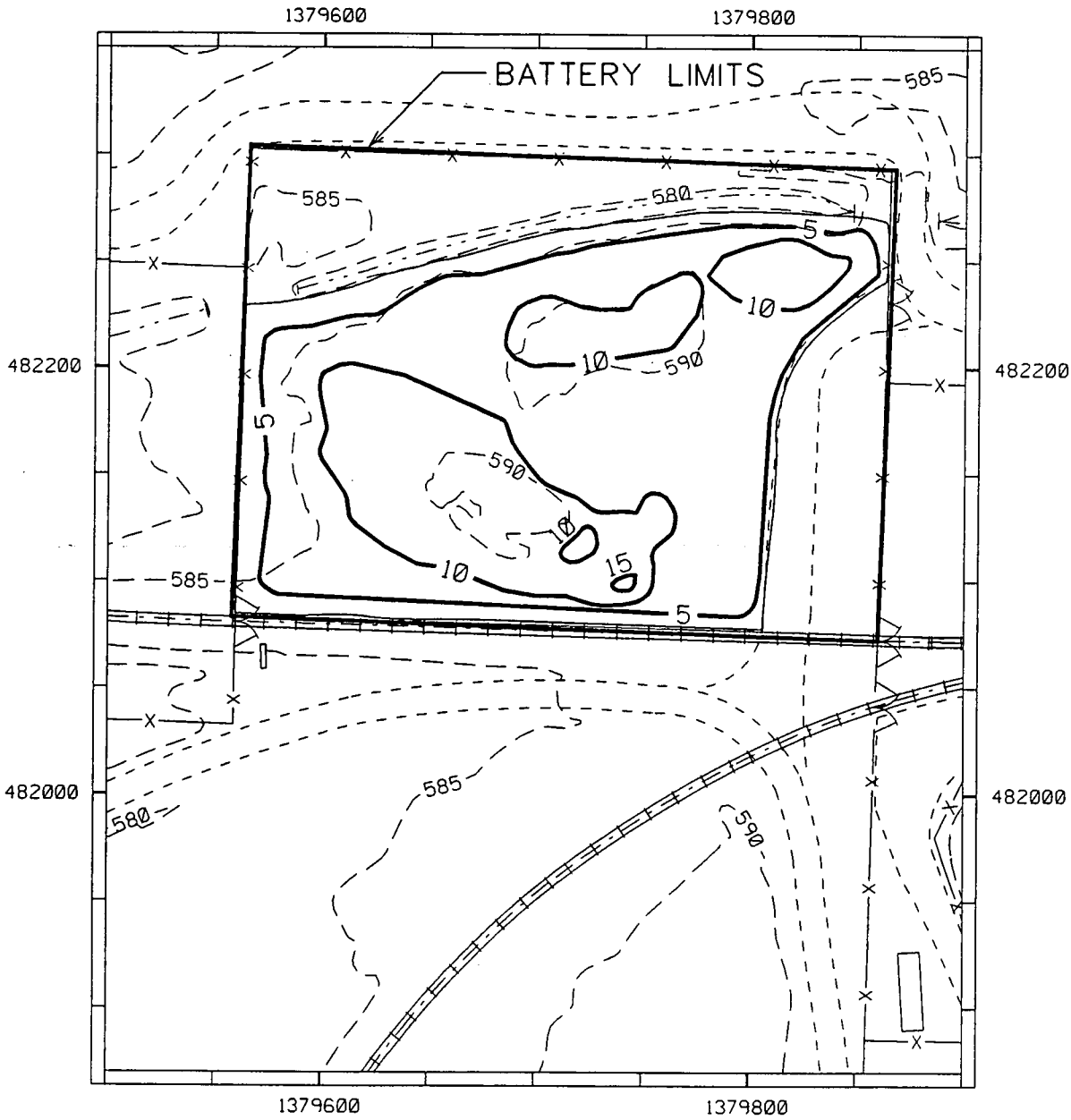
Analytical results for samples collected from the Solid Waste Landfill are presented in Appendix C. The nature and extent of COCs for the Solid Waste Landfill and radionuclides detected above background will be discussed in this section. Geology and hydrogeology of the Solid Waste Landfill referred to in this section are discussed in more detail in Section 3.0.

4.2.1 Volume and Physical Characteristics

The volume of waste material at the Solid Waste Landfill was estimated by means of digitized topographic maps, boring log data, and interpolation using Intergraph Corporation Microstation PC software. Volume calculations are summarized in Figure 4-1. The volume of waste material is calculated to be approximately 14,425 cubic yards.

A plan for an extension to the Solid Waste Landfill prepared by the National Lead Company in May 1974 showed five waste disposal cells and an evaporation pond. However, construction of four of the five waste cells could not be confirmed through interviews with employees or by examining historical aerial photographs; therefore, the location/date column on Table 4-2A notes these as "possible waste cells". A 1976 aerial photograph of the landfill shows the presence of the evaporation pond at the west edge of the landfill and Cell 1, located parallel to the south boundary of the landfill. Soil gas sample collection and trenching were used to determine the extent of waste disposal. Soil gas data from samples analyzed in the field indicate areas of elevated methane and VOC in the southeast corner and the east side of the landfill. These results are consistent with the existence of one waste cell and the evaporation pond and were shown in Figure 2-3. Aerial photographs also indicate that there may have been some randomly placed pits, which may have been deeper than ten feet to accommodate waste disposal.

Visual identification of waste materials encountered in three trenches excavated in July 1992, and borings completed in 1993 are summarized in Table 4-2A. These data were used to improve the



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- DRAINAGE
- 5 THICKNESS OF FILL
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 40 80 160

TOTAL FILL VOLUME = 15,200 Cu. Yds.

FIGURE 4-1
VOLUME OF
WASTE MATERIAL,
SOLID WASTE LANDFILL

fig0401.dgn

TABLE 4-2A

SUMMARY OF WASTE CHARACTERISTICS AND ANALYTICAL RESULTS FROM TRENCHING ACTIVITIES AND SOIL BORINGS IN THE SOLID WASTE LANDFILL

Location/Date	Materials encountered, samples and field observations	Analytical Results	
Trench 1. Located perpendicular to possible waste Cell 5 and 4. 7/7/92	South end: medical vials and bagged asbestos at shallow depths (<3' deep). Construction debris, found as deep as 10 feet. Leachate sample collected. North end: (at edge of landfill where drainage cuts through) plastic bags, glass bottles and trash found to 10' deep.	Leachate[a] from the south end (Sample 039151): U-238 = 151 pCi/L Total U = 375 μg/L Total Th = 1.36 μg/L	No organics detected
Trench 2. Located perpendicular to possible Cell 2 and North edge of Cell 1. 7/16/92	South end: Trash found at less than 1 foot deep Leachate sample collected (rads) Center: Medical waste material and plastic bags found to 5' deep. No sample collected. North end: Roofing materials and wood found to 5' deep. Leachate sample collected (rad and organic)	Leachate from south end (039160): U-238 = 311 pCi/L Total U = 776 μg/L Total Th = 2.38 μg/L Leachate from North end (039163): U-238 = 532 pCi/L Total U = 1530 μg/L Total Th = 1.69 μg/L	Organics from north end (039163) Fluoride = 1.9 mg/L Phenols = 558 μg/L Benzoic Acid = 290 μg/L Acenapthene = 89 μg/L Phenanthrene =: 89 μg/L Fluorene = 68 μg/L 2-methylnephthalene = 70 μg/L 2-methylphenol = 48 μg/L Anthracene = 25 μg/L Pyrene = 11 μg/L

See notes at end of table

000519

TABLE 4-2A
(Continued)

Location/Date	Materials encountered, samples and field observations	Analytical Results	
Trench 3. Located perpendicular to Cell 1, approximately midway in Cell 1 7/13/92	South end: Trash at surface, assorted medical and production waste from 3 to 7 feet deep. One report of copper tubing at 10-12' deep. Leachate sample collected (rad and organic) Center: A yellow colored material registering a reported 50,000 cpm detected at 6' deep. No sample collected. North end: Paint cans at 2-3' deep. Trench terminated at 3' deep here. No sample collected.	Leachate from South end (039155): U-238: 868 pCi/L Total U : 1610 μg/L Total Th : <0.5 μg/L	No organics detected
Boring 11036 Located at possible west end of Cell 1 completed 5/17/93	No waste observed up to 4.5' deep. Silty clay had 3500-4000 cpm at 5' deep. Sample 115381 (2.5'-5.0' deep)	U-238 = 557 pCi/g Total U = 1770 μg/g Ra-228 = 6.65 pCi/g Total Th = 75.6 μg/g Tc99 = 5.13 pCi/g	20 organic compounds including: Benzopyrene = 230 μg/kg Crysene = 350 μg/kg Fluoranthene = 630 μg/kg Total Xylenes = 54 μg/kg Ethylbenzene = 15 μg/kg
	Sample 115380 (17'-19'deep) collected to define clean conditions beneath waste.	U-238 = 1.08 pCi/g Total U = 3.1 μg/g Ra228 = 0.86 pCi/g Total Th = 6.5 pCi/g	bis(2-Ethylhexyl) phthalate = 1600 μg/kg Toluene = 13 μg/kg 1,1-Dichloroethene = 1 μg/kg
Boring 11037 Located at North end of Trench 3, in area of possible waste disposal Cell 2. 5/15/93	Sample 115374 collected from leachate at 21-22' deep	Leachate analyzed on site: Total U = 1000 μg/L	
	Plastic cup lids, assorted kitchen waste, glass Sample 115371 (5'-7' deep)	U-238 = 1.19 pCi/g Total U = 5.01 μg/g Ra228 = 1.16 pCi/g Total Th = 9.12 μg/g	Fluoranthene = 89 μg/kg Benzo(a)anthrene = 48 μg/kg Crysene = 48 μg/kg Benzo(b)fluoranthene = 67 μg/kg

See notes at end of table

000520

6505

TABLE 4-2A
(Continued)

Location/Date	Materials encountered, samples and field observations	Analytical Results	
Boring 11037 Located at North end of Trench 3, in area of possible waste disposal Cell 2. 5/15/93 (Continued)	Native till beneath waste material Sample 115372 (17.5'-20' deep)	U-238 = 1.56 pCi/g Total U - 5.5 μg/g Ra228 = 0.81 Total Th = 7.19	Di-n-octylphthalate = 55 μg/kg 4-Methyl-2-pentanone = 30 μg/kg 2-Hexanone = 2 μg/kg
Boring 11038 Located within possible waste Cell 1. 5/16/93	Yellow material detected at 2.5' deep that had 28,000 cpm (approximate location of center of Trench 3) Sample 115376 (0'-2.5' deep)	U-238 = 78.4 pCi/g Total U = 230 μg/g Ra228 = 1.45 Total Th = 8.546 mg/kg**	12 organic compounds including: Fluoranthene = 780 μg/kg Phenanthrene - 400 μg/kg Pyrene = 630 μg/kg Crysene = 400 μg/kg
	Sample 115377 (12.5'-15' deep) Collected to define clean conditions beneath waste	U-238 = 0.82 pCi/g Total U = 5.32 pCi/g Ra228 = 0.88 pCi/g Total Th = 6.85 μg/g	Toluene = 5 μg/kg
Boring 11039 Located adjacent to North end of Trench 2, in area of possible waste disposal Cell 2 5/19/93	Sample 115388 of Leachate collected from 8-10' deep (water detected between 6-7' deep	Leachate analyzed on site: 650 μg/L Total U	
	Sample 115384 (2.5-5' deep) Black roofing shingles, tar observed in soil	U-238 = 119 pCi/g Total U = 375 μg/g Ra228 = 1.06 pCi/g Total Th = 6.9 pCi/g	over 21 organics detected including: Acenapthene = 140,000 μg/kg Benzo(K)fluoranthene = 140,000 μg/kg Fluorene = 180,000 μg/kg Pyrene = 610,000 μg/kg
	115385 (12-14' deep) Collected to detect clean conditions below waste	U-238 = 1.18 pCi/g Total U = 6.08 μg/g Ra228 = 0.759 pCi/g Total Th = 47 pCi/g	19 organics detected including: Acenapthene = 370 μg/kg Benzo(k)fluoranthene = 740 μg/kg Fluorene = 430 μg/kg Pyrene = 1900 μg/kg

See notes at end of table

000321

TABLE 4-2A
(Continued)

Location/Date	Materials encountered, samples and field observations	Analytical Results	
Boring 11040 5/20/93	Sample 115398 of leachate collected from 25-30' deep	Leachate analyzed on site: 50 μg/L Total U	
	Sample 115392 (2.5-5' deep) pieces of plastic and wood detected	U-238 = 1.84 pCi/g U-Total = 8.49 μg/g Ra228 = 1.13 pCi/g Total Th = ND*	14 organics detected including: Fluoranthene = 770 mg/kg Benzo(K)Fluoranthene = 290 mg/kg Pyrene = 640 μg/kg
	Sample 115393 (12.5-15' deep) Sample collected to detect clean conditions beneath waste	U-238 = 0.9 pCi/g Total U = 2.49 μg/g Ra228= 0.9 pCi/g Total Th = ND	No organics detected
Boring 1985 Located adjacent to South boundary of waste Cell 1 4/27/93	No waste material detected in borehole no change from background cpm Sample 111441 (2-4' deep)	U-238 = 19.77 pCi/g Total U = 62.3 μg/g Ra228 = 1.19 pCi/g Total Th = 6.03 μg/g	20 organic compounds including: Fluoranthene = 1700 μg/kg Benzo(k)fluoranthene = 700 μg/kg Crysene = 940 μg/kg Phenanthrene = 970 μg/kg Pyrene = 1500 μg/kg
	Sample 111448 (15'-17' deep) Sample collected to detect clean conditions beneath possible waste disposal zone	U-238 = 1.52 pCi/g Total U = 5.91 μg/g Ra228 = 0.98 pCi/g Total Th = 8.52 μg/g	bis(2-ethylhexyl) Phthalate = 1700 μg/kg
Boring 1986 Located adjacent to center of trench 2, possibly in Waste Cell 1 4/30/93	Yellow material detected at 4.5' deep had 10,000 cpm, green material observed to 10' deep. (170 cpm) Sample 111450 (2.5-5' deep)	Total U = 1280 μg/g Total Th = 15.5 μg/g	18 organic compounds including: Pyrene = 1100 μg/kg Phenanthrene = 1100 μg/kg Benzo(a)anthracene = 490 μg/kg Fluoranthene = 1300 μg/kg

See notes at end of table

TABLE 4-2A
(Continued)

Location/Date	Materials encountered, samples and field observations	Analytical Results	
Boring 1986 Located adjacent to center of trench 2, possibly in Waste Cell 1 4/30/93 (Continued)	Sample 111458 (12.5-15' deep) Clayey sand sample collected to detect clean conditions beneath waste	U238 = 0.83 pCi/g Total U = 11.4 μg/g Ra228 = 0.92 pCi/g Total Th - 7.35 μg/g	Acetone = 9 μg/kg bis(2-ethylhexyl) Phthalate = 950 μg/kg
Boring 1988 Located South end of Trench 2, possibly in waste disposal Cell 1 or 2 5/12/93	Waste material seen in soil samples collected to 4.5-5' deep including plastic burned materials and mica (vermiculite?). 300 cpm detected at 4' deep. Sample 115351 (2.5-5' deep)	U-238 = 37.8 pCi/g U-Total = 109 μg/g Ra228 = 2.56 pCi/g Total Th = 17.8 μg/g	7 organic compounds including Fluoranthene = 160 μg/kg Total xylenes = 260 μg/kg Phenanthrene = 82 μg/kg Pyrene = 100 μg/kg
	Sample 115351 (17.5-20' deep) Collected to detect clean conditions beneath waste	U-238 = 0.961 pCi/g U Total = 3.62 μg/g Ra228 = 1 pCi/g Total Th = 7.58 μg/g	Total xylenes = 1 μg/kg bis(2-ethylhexyl)phthate = 410 μg/kg

[a]All leachate samples are unfiltered.

*ND = Not detected

**This value was calculated from the isotopic analytical results.

conceptual model of the landfill construction. Visual examination of samples from excavations dug in the landfill detected waste in discrete locations at depths ranging from near surface to ten feet. The waste materials found at a depth of ten feet appear to have been dumped and buried close to the estimated original land surface in the landfill. The waste distribution appears to be consistent with face dumping practices and not waste disposal trenches. A few samples of waste were detected in soil borings deeper than 10 feet deep.

Waste materials identified in the landfill included materials possibly originating from the cafeteria (plastic cup lids), the medical lab (plastic bag containing medical waste), maintenance/construction department (wood, roofing shingles, and paint cans) and from the process sampling [(yellow material emitting estimated 50,000 counts per minute (cpm)]. A summary of detected chemicals and their possible origin at the FEMP is presented as Table 4-2B. Detected organic compounds in samples from the landfill indicate that historical sources for the detected compounds include cafeteria wastes (benzoic acid), medical laboratory wastes (phenanthrene and pyrene), manufacturing waste (2-butanone and carbon disulfide) or construction and maintenance waste (pentachlorophenol, carbazole, and 4,4-DDE).

4.2.2 Surface and Subsurface Media

To determine the presence of constituents due to DOE activities, chemical and radiological analytical results were compared to soil background concentrations. Analytes detected above background in surface soils during Phase II are presented in Table C-2A in Appendix C and summarized in Table 4-3. Twelve surface soil samples were collected from twelve locations during the Phase II field program. These samples were analyzed for the constituents listed in summary Table 4-3. Background concentrations were exceeded for seventeen metals, isotopes of six elements, and twenty three organic compounds. No surface soil samples were collected during Phase I. Beryllium and chromium were detected above background concentrations in surface soil samples as shown on Figure 4-2 (see Volume 2 Oversized Figures). Molybdenum and silver were consistently detected at concentrations that were ten times above background, suggesting that metallurgical wastes are part of the surface soil cover at the landfill. Arsenic, antimony, and beryllium were detected above background in surface soil samples. Radioisotopes detected above background surface soil concentrations are shown on Figure 4-2 (see Volume 2, Oversized Figures). Isotopes of uranium exceeded five times background in most samples and the isotopes of plutonium, cesium, and radium were detected at trace activity levels. In addition, neptunium-237, plutonium-238, thorium-228, thorium-

TABLE 4-2B

SELECTED CHEMICALS DETECTED IN SAMPLES COLLECTED FROM THE SOLID WASTE LANDFILL AND THEIR COMMON USAGE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Detected Chemical	Common Usage	Possible Historical Use at FEMP
Anthracene	associated with phenanthrene, possible biomedical research	medical lab
Acenaphthene	insecticide	maintenance
Benzoic acid	food preservative	kitchen
2-butanone (MEK)	cleaning fluid	maintenance, metallurgy
Carbon disulfide	floatation agent, solvent	metallurgy
Carbazole	pesticide	maintenance
Chrysene	organic intermediary	metallurgy
Chlorophenol	organic intermediary	metallurgy
Di-n-butyl phthalate	organic intermediary	metallurgy
Chloro-methylphenol	germicide	medical, kitchen
2 methylnaphthalene	emulsion breaker	metallurgy
Napthelene	scintillation counters	lab
Pentachlorophenol	wood preservative	construction department
Phenanthrene	biochemical research	medical lab
Pyrene	biochemical research	medical lab
1,1,1-trichloroethane	degreaser	maintenance, metallurgy

000225

TABLE 4-3

SOLID WASTE LANDFILL
SURFACE SOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	12	12	6610	18400	3
Antimony	mg/kg	.000	0	12	0	0	0
Arsenic	mg/kg	8.200	12	12	4.4	8.3	1
Barium	mg/kg	94.100	12	12	44.6	101	4
Beryllium	mg/kg	.600	12	12	.46	.97	4
Cadmium	mg/kg	.870	1	12	.85	.85	0
Calcium	mg/kg	4339.170	12	12	6970	112000	12
Chromium	mg/kg	15.500	12	12	8.2	19.9	3
Cobalt	mg/kg	14.160	12	12	2.8	10.2	0
Copper	mg/kg	14.070	12	12	8.6	57.6	11
Cyanide	mg/kg	.270	0	12	0	0	0
Iron	mg/kg	21728.170	12	12	10600	24000	3
Lead	mg/kg	26.400	12	12	3.2	33.3	1
Magnesium	mg/kg	2776.970	12	12	4330	37900	12
Manganese	mg/kg	1348.040	12	12	349	826	0
Mercury	mg/kg	.120	0	12	0	0	0
Molybdenum	mg/kg	.000	10	12	4.4	7.3	10
Nickel	mg/kg	20.870	12	12	7.7	23.1	1
Potassium	mg/kg	1231.340	12	12	924	1800	6
Selenium	mg/kg	.720	1	12	.42	.42	0
Silicon	mg/kg	1797.030	12	12	453	996	0
Silver	mg/kg	.000	12	12	3.1	7.4	12
Sodium	mg/kg	51.100	12	12	65.6	206	12
Thallium	mg/kg	.580	0	12	0	0	0
Vanadium	mg/kg	30.370	12	12	17.7	46	3
Zinc	mg/kg	59.610	12	12	28.8	83.4	2
RADIONUCLIDES							
CS-137	pCi/g	.710	5	12	.0718	.257	0
GROSS ALPHA	pCi/g	.000	12	12	17.4	95	12
GROSS BETA	pCi/g	.000	12	12	22.1	112	12
NP-237	pCi/g	.000	8	8	.0457	3.11	8
PU-238	pCi/g	.000	10	12	.0191	.9024	10
PU-239/240	pCi/g	.000	7	12	.0191	.126	7
RA-226	pCi/g	1.420	12	12	.915	2.26	2
RA-228	pCi/g	1.250	12	12	.721	2.99	5
RU-106	pCi/g	.000	0	12	0	0	0

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TABLE 4-3
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
SR-90	pCi/g	.000	8	12	.527	1.44	8
TC-99	pCi/g	.000	0	12	0	0	0
TH-228	pCi/g	1.430	9	9	.482	2.33	1
TH-230	pCi/g	1.970	9	9	.939	9.61	7
TH-232	pCi/g	1.360	9	9	.601	2.5	1
TH-TOTAL	mg/kg	10.700	9	9	5.48	22.8	2
U-234	pCi/g	1.240	12	12	1.43	48.9	12
U-235/236	pCi/g	.150	12	12	.0764	3.33	9
U-238	pCi/g	1.220	12	12	2.34	63.8	12
U-TOTAL	mg/kg	3.700	12	12	6.86	194	12
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	12	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	12	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	12	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	12	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	12	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	12	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	12	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	12	0	0	0
2-Butanone	ug/kg	.000	1	12	1	1	1
2-Hexanone	ug/kg	.000	0	12	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	12	0	0	0
Acetone	ug/kg	.000	4	12	1	5	4
Benzene	ug/kg	.000	0	12	0	0	0
Bromodichloromethane	ug/kg	.000	0	12	0	0	0
Bromoform	ug/kg	.000	0	12	0	0	0
Bromomethane	ug/kg	.000	1	12	2	2	1
Carbon Tetrachloride	ug/kg	.000	0	12	0	0	0
Carbon disulfide	ug/kg	.000	0	12	0	0	0
Chlorobenzene	ug/kg	.000	0	12	0	0	0
Chloroethane	ug/kg	.000	0	12	0	0	0
Chloroform	ug/kg	.000	0	12	0	0	0
Chloromethane	ug/kg	.000	1	12	2	2	1
Dibromochloromethane	ug/kg	.000	0	12	0	0	0
Ethylbenzene	ug/kg	.000	0	12	0	0	0
Methylene chloride	ug/kg	.000	0	12	0	0	0
Styrene	ug/kg	.000	0	12	0	0	0
Tetrachloroethene	ug/kg	.000	0	12	0	0	0
Toluene	ug/kg	.000	0	12	0	0	0
Trichloroethene	ug/kg	.000	0	12	0	0	0
Vinyl Acetate	ug/kg	.000	0	12	0	0	0
Vinyl chloride	ug/kg	.000	0	12	0	0	0
Xylenes, Total	ug/kg	.000	0	12	0	0	0

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TABLE 4-3
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
cis-1,3-Dichloropropene	ug/kg	.000	0	12	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	12	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	12	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	12	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	12	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	12	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	12	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	12	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	12	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	12	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	12	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	12	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	12	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	12	0	0	0
2-Chlorophenol	ug/kg	.000	0	12	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	12	0	0	0
2-Methylphenol	ug/kg	.000	0	12	0	0	0
2-Nitroaniline	ug/kg	.000	0	12	0	0	0
2-Nitrophenol	ug/kg	.000	0	12	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	12	0	0	0
3-Nitroaniline	ug/kg	.000	0	12	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	12	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	12	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	12	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	12	0	0	0
4-Methylphenol	ug/kg	.000	0	12	0	0	0
4-Nitroaniline	ug/kg	.000	0	12	0	0	0
4-Nitrophenol	ug/kg	.000	0	12	0	0	0
Acenaphthene	ug/kg	.000	2	12	49	120	2
Acenaphthylene	ug/kg	.000	0	12	0	0	0
Anthracene	ug/kg	.000	2	12	120	230	2
Benzo(a)anthracene	ug/kg	.000	6	12	55	880	6
Benzo(a)pyrene	ug/kg	.000	6	12	59	760	6
Benzo(b)fluoranthene	ug/kg	.000	5	12	64	710	5
Benzo(g,h,i)perylene	ug/kg	.000	4	12	82	500	4
Benzo(k)fluoranthene	ug/kg	.000	7	12	42	880	7
Benzoic acid	ug/kg	.000	0	12	0	0	0
Benzyl alcohol	ug/kg	.000	0	12	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	12	0	0	0
Carbazole	ug/kg	.000	1	12	77	77	1
Chrysene	ug/kg	.000	8	12	45	1100	8
Di-n-butyl phthalate	ug/kg	.000	1	12	55	55	1

TABLE 4-3
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Di-n-octyl phthalate	ug/kg	.000	0	12	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	2	12	56	200	2
Dibenzofuran	ug/kg	.000	1	12	56	56	1
Diethyl phthalate	ug/kg	.000	0	12	0	0	0
Dimethyl phthalate	ug/kg	.000	0	12	0	0	0
Fluoranthene	ug/kg	.000	8	12	57	1900	8
Fluorene	ug/kg	.000	2	12	56	100	2
Hexachlorobenzene	ug/kg	.000	0	12	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	12	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	12	0	0	0
Hexachloroethane	ug/kg	.000	0	12	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	5	12	46	480	5
Isophorone	ug/kg	.000	0	12	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	12	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	12	0	0	0
Naphthalene	ug/kg	.000	0	12	0	0	0
Nitrobenzene	ug/kg	.000	0	12	0	0	0
Pentachlorophenol	ug/kg	.000	0	12	0	0	0
Phenanthrene	ug/kg	.000	7	12	59	1500	7
Phenol	ug/kg	.000	0	12	0	0	0
Pyrene	ug/kg	.000	9	12	49	2100	9
bis(2-Chloroethoxy)methane	ug/kg	.000	0	12	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	12	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	12	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	4	12	40	48	4
p-Chloroaniline	ug/kg	.000	0	12	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	12	0	0	0
4,4'-DDE	ug/kg	.000	1	12	12	12	1
4,4'-DDT	ug/kg	.000	0	12	0	0	0
Aldrin	ug/kg	.000	0	12	0	0	0
Aroclor-1016	ug/kg	.000	0	12	0	0	0
Aroclor-1221	ug/kg	.000	0	12	0	0	0
Aroclor-1232	ug/kg	.000	0	12	0	0	0
Aroclor-1242	ug/kg	.000	0	12	0	0	0
Aroclor-1248	ug/kg	.000	0	12	0	0	0
Aroclor-1254	ug/kg	.000	0	12	0	0	0
Aroclor-1260	ug/kg	.000	0	12	0	0	0
Dieldrin	ug/kg	.000	0	12	0	0	0
Endosulfan II	ug/kg	.000	0	12	0	0	0
Endosulfan sulfate	ug/kg	.000	0	12	0	0	0
Endosulfan-I	ug/kg	.000	0	12	0	0	0
Endrin	ug/kg	.000	0	12	0	0	0

TABLE 4-3
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Endrin aldehyde	ug/kg	.000	0	12	0	0	0
Endrin ketone	ug/kg	.000	0	12	0	0	0
Heptachlor	ug/kg	.000	0	12	0	0	0
Heptachlor epoxide	ug/kg	.000	0	12	0	0	0
Methoxychlor	ug/kg	.000	0	12	0	0	0
Toxaphene	ug/kg	.000	0	12	0	0	0
alpha-BHC	ug/kg	.000	0	12	0	0	0
alpha-Chlordane	ug/kg	.000	0	12	0	0	0
beta-BHC	ug/kg	.000	0	12	0	0	0
delta-BHC	ug/kg	.000	0	12	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	12	0	0	0
gamma-Chlordane	ug/kg	.000	0	12	0	0	0

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230, thorium-232, and technetium-99 were detected above background. The distribution does not suggest a single hot spot source area.

Organic compounds detected in surface soil samples are shown on Figure 4-2. Four volatiles organic compounds, eighteen semivolatile organic compounds, and one pesticide were detected in 12 samples. Volatile organics were found at trace concentrations in surface soil samples and the semivolatile organics, representing the greater portion of detected organics, were generally detected at higher than trace concentrations. The distribution of organic constituents suggests that organic chemical waste from production, metallurgy, medical laboratory, construction, and maintenance are incorporated throughout the surface soil cover and that there are no defined hot spots.

A comparison of the Phase II surface soil data to the CIS and ES surface soil data, for samples collected within the battery limits of the Solid Waste Landfill in Appendix C-4 and C-5, indicates that the parameters that were detected in these preliminary studies were also detected in Phase II and within the same order of magnitude, except for uranium-238, which was one order of magnitude higher in the CIS results for location SS46362.

Analytes detected above background in subsurface soil samples are presented in Table C-2B and Table C-2C in Appendix C and summarized in Table 4-4 and Table 4-5. Radionuclides and metals detected above background in subsurface soil samples are shown on Figure 4-3 (see Volume 2, Oversized Figures) and organic compounds are shown on Figure 4-4 (see Volume 2, Oversized Figures).

During Phase I subsurface soil samples were collected from ten locations and were analyzed for the constituents listed in summary Table 4-4. Background concentrations were exceeded for twenty three metals, isotopes of five elements, and fifty one organic compounds. During Phase II, 38 subsurface soil samples were collected for radionuclide and chemical analysis from 25 locations and were analyzed for the constituents listed in summary Table 4-5. Background concentrations for these locations were exceeded for twenty two metals (the same metals in Phase I except for calcium, which was detected above background only in Phase II, Thallium, Antimony, and manganese were detected above background only in Phase I), isotopes of eight elements (neptunium-237, cesium-137, plutonium-238, plutonium-239/240, and technetium-99 were detected above background for Phase II and not detected above background during Phase I; lead-210, and radium-224 were detected above background during Phase I and not for Phase II), and forty four organic compounds. Cesium-137, strontium-

TABLE 4-4

SOLID WASTE LANDFILL
SUBSURFACE SOIL
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	15	16	748	25200	2
Antimony	mg/kg	.000	11	16	3.8	27.3	11
Arsenic	mg/kg	9.570	16	16	2.2	15.4	4
Barium	mg/kg	119.170	16	16	16.7	223	4
Beryllium	mg/kg	.620	16	16	.19	1.6	13
Boron	mg/kg	42.950	8	11	7.2	32.8	0
Cadmium	mg/kg	.910	15	16	.48	6.5	12
Calcium	mg/kg	150000.000	16	16	6330	141000	0
Chromium	mg/kg	20.680	16	16	6.3	51.8	13
Cobalt	mg/kg	15.750	16	16	2.4	26	4
Copper	mg/kg	20.030	16	16	4.2	41.5	9
Cyanide	mg/kg	.130	3	16	.14	.79	3
Iron	mg/kg	30700.000	16	16	3350	42600	4
Lead	mg/kg	15.580	16	16	6.5	147	4
Magnesium	mg/kg	42648.210	16	16	3320	31500	0
Manganese	mg/kg	1300.000	16	16	115	1690	1
Mercury	mg/kg	.290	0	16	0	0	0
Molybdenum	mg/kg	2.700	16	16	2.9	29.3	16
Nickel	mg/kg	34.350	16	16	4.4	47.1	5
Potassium	mg/kg	1979.990	16	16	830	2430	2
Selenium	mg/kg	.000	1	16	.54	.54	1
Silicon	mg/kg	1593.080	14	14	132	2620	2
Silver	mg/kg	.000	15	16	3.3	19.7	15
Sodium	mg/kg	285.000	16	16	30	342	2
Thallium	mg/kg	.490	3	16	.6	12.5	3
Tin	mg/kg	.000	0	7	0	0	0
Vanadium	mg/kg	37.800	15	16	6.7	68.8	2
Zinc	mg/kg	72.580	16	16	10.3	108	3
RADIONUCLIDES							
CS-137	pCi/g	.000	0	22	0	0	0
NP-237	pCi/g	.000	0	21	0	0	0
PB-210	pCi/g	.810	3	4	.68	1.03	1
PU-238	pCi/g	.000	0	22	0	0	0
PU-239/240	pCi/g	.000	0	22	0	0	0
RA-224	pCi/g	1.010	4	4	1.11	2.14	4

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TABLE 4-4
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RA-226	pCi/g	1.470	20	22	.38	1.55	2
RA-228	pCi/g	1.310	19	22	.6	3.15	5
RU-106	pCi/g	.000	0	22	0	0	0
SR-90	pCi/g	.560	10	20	.73	3.09	10
TC-99	pCi/g	.000	0	19	0	0	0
TH-228	pCi/g	1.330	21	22	.7	4.01	9
TH-230	pCi/g	1.880	20	22	.69	12.3	11
TH-232	pCi/g	1.260	13	19	.64	3.59	3
TH-TOTAL	mg/kg	9.470	15	15	2.65	32.4	6
U-234	pCi/g	1.040	20	23	.89	334	17
U-235/236	pCi/g	.150	10	23	.126	22.4	9
U-238	pCi/g	1.120	21	23	.9	420	18
U-TOTAL	mg/kg	3.400	18	18	3.05	940	16
VOLATILE ORGANICS							
1,1,1,2-Tetrachloroethane	ug/kg	.000	0	6	0	0	0
1,1,1-Trichloroethane	ug/kg	.000	0	16	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	16	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	16	0	0	0
1,1-Dichloroethane	ug/kg	.000	2	16	16	130	2
1,1-Dichloroethene	ug/kg	.000	0	16	0	0	0
1,2,3-Trichloropropane	ug/kg	.000	0	6	0	0	0
1,2-Dibromo-3-chloropropane	ug/kg	.000	0	6	0	0	0
1,2-Dibromoethane	ug/kg	.000	0	6	0	0	0
1,2-Dichloroethane	ug/kg	.000	1	16	16	6	1
1,2-Dichloroethene	ug/kg	.000	3	16	2	12	3
1,2-Dichloropropane	ug/kg	.000	0	16	0	0	0
1,4-Dioxane	ug/kg	.000	2	2	66	12900	2
2-Butanone	ug/kg	.000	1	15	3	3	1
2-Chloro-1,3-butadiene	ug/kg	.000	0	6	0	0	0
2-Hexanone	ug/kg	.000	1	15	1	1	1
3-Chloropropene	ug/kg	.000	0	6	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	2	15	1	1	2
Acetone	ug/kg	.000	5	15	7	39	5
Acetonitrile	ug/kg	.000	0	6	0	0	0
Acrolein	ug/kg	.000	0	5	0	0	0
Acrylonitrile	ug/kg	.000	0	5	0	0	0
Benzene	ug/kg	.000	0	16	0	0	0
Bromodichloromethane	ug/kg	.000	0	16	0	0	0
Bromoform	ug/kg	.000	0	16	0	0	0
Bromomethane	ug/kg	.000	0	16	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	16	0	0	0
Carbon disulfide	ug/kg	.000	0	16	0	0	0

TABLE 4-4
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Chlorobenzene	ug/kg	.000	2	16	2	6	2
Chloroethane	ug/kg	.000	0	16	0	0	0
Chloroform	ug/kg	.000	0	16	0	0	0
Chloromethane	ug/kg	.000	1	16	6	6	1
Dibromochloromethane	ug/kg	.000	0	16	0	0	0
Dibromomethane	ug/kg	.000	0	6	0	0	0
Dichlorodifluoromethane	ug/kg	.000	1	1	576	576	1
Ethyl cyanide	ug/kg	.000	0	6	0	0	0
Ethyl methacrylate	ug/kg	.000	0	6	0	0	0
Ethylbenzene	ug/kg	.000	1	16	18	18	1
Iodomethane	ug/kg	.000	0	6	0	0	0
Isobutyl alcohol	ug/kg	.000	0	3	0	0	0
Methacrylonitrile	ug/kg	.000	0	6	0	0	0
Methyl methacrylate	ug/kg	.000	0	6	0	0	0
Methylene chloride	ug/kg	.000	5	16	6	13	5
Pyridine	ug/kg	.000	1	3	3	3	1
Styrene	ug/kg	.000	1	16	2	2	1
Tetrachloroethene	ug/kg	.000	1	16	30	30	1
Toluene	ug/kg	.000	3	16	1	8	3
Trichloroethene	ug/kg	.000	0	16	0	0	0
Trichlorofluoromethane	ug/kg	.000	1	5	840	840	1
Vinyl Acetate	ug/kg	.000	0	16	0	0	0
Vinyl chloride	ug/kg	.000	0	16	0	0	0
Xylenes, Total	ug/kg	.000	1	16	100	100	1
cis-1,3-Dichloropropene	ug/kg	.000	0	16	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	16	0	0	0
trans-1,4-Dichloro-2-butene	ug/kg	.000	0	4	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4,5-Tetrachlorobenzene	ug/kg	.000	0	4	0	0	0
1,2,4-Trichlorobenzene	ug/kg	.000	0	13	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	13	0	0	0
1,3,5-Trinitrobenzene	ug/kg	.000	0	2	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	13	0	0	0
1,3-Dinitrobenzene	ug/kg	.000	0	3	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	13	0	0	0
1,4-Naphthoquinone	ug/kg	.000	0	4	0	0	0
1-Naphthylamine	ug/kg	.000	0	4	0	0	0
2,3,4,6-Tetrachlorophenol	ug/kg	.000	0	4	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	13	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	13	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	13	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	13	0	0	0

TABLE 4-4
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
2,4-Dinitrophenol	ug/kg	.000	0	13	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	13	0	0	0
2,6-Dichlorophenol	ug/kg	.000	0	4	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	13	0	0	0
2-Acetylaminofluorene	ug/kg	.000	0	4	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	13	0	0	0
2-Chlorophenol	ug/kg	.000	1	14	49	49	1
2-Methylnaphthalene	ug/kg	.000	1	13	93	93	1
2-Methylphenol	ug/kg	.000	0	13	0	0	0
2-Naphthylamine	ug/kg	.000	0	4	0	0	0
2-Nitroaniline	ug/kg	.000	0	13	0	0	0
2-Nitrophenol	ug/kg	.000	0	13	0	0	0
2-Picoline	ug/kg	.000	0	3	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	13	0	0	0
3,3'-Dimethylbenzidine	ug/kg	.000	0	4	0	0	0
3-Methylcholanthrene	ug/kg	.000	0	4	0	0	0
3-Methylphenol	ug/kg	.000	0	3	0	0	0
3-Nitroaniline	ug/kg	.000	0	13	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	13	0	0	0
4-Aminobiphenyl	ug/kg	.000	0	4	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	13	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	1	14	55	55	1
4-Chlorophenylphenyl ether	ug/kg	.000	0	13	0	0	0
4-Methylphenol	ug/kg	.000	0	13	0	0	0
4-Nitroaniline	ug/kg	.000	0	13	0	0	0
4-Nitrophenol	ug/kg	.000	0	13	0	0	0
4-Nitroquinoline-1-oxide	ug/kg	.000	0	2	0	0	0
5-Nitro-o-toluidine	ug/kg	.000	0	4	0	0	0
7,12-Dimethylbenz(a)anthracene	ug/kg	.000	0	4	0	0	0
Acenaphthene	ug/kg	.000	5	16	53	840	5
Acenaphthylene	ug/kg	.000	0	13	0	0	0
Acetophenone	ug/kg	.000	0	4	0	0	0
Aniline	ug/kg	.000	0	4	0	0	0
Anthracene	ug/kg	.000	5	15	130	1000	5
Aramite	ug/kg	.000	0	3	0	0	0
Benzo(a)anthracene	ug/kg	.000	8	16	43	7500	8
Benzo(a)pyrene	ug/kg	.000	6	16	69	8200	6
Benzo(b)fluoranthene	ug/kg	.000	7	16	54	15000	7
Benzo(g,h,i)perylene	ug/kg	.000	4	15	300	650	4
Benzo(k)fluoranthene	ug/kg	.000	3	15	300	1800	3
Benzoic acid	ug/kg	.000	1	12	110	110	1
Benzyl alcohol	ug/kg	.000	0	13	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	13	0	0	0
Chrysene	ug/kg	.000	9	16	47	5600	9

TABLE 4-4
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Di-n-butyl phthalate	ug/kg	.000	1	13	120	120	1
Di-n-octyl phthalate	ug/kg	.000	0	13	0	0	0
Diallate	ug/kg	.000	0	4	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	5	15	49	250	5
Dibenzofuran	ug/kg	.000	2	13	160	340	2
Diethyl phthalate	ug/kg	.000	3	16	45	750	3
Dimethyl phthalate	ug/kg	.000	0	13	0	0	0
Diphenylamine	ug/kg	.000	0	4	0	0	0
Ethyl methanesulfonate	ug/kg	.000	0	3	0	0	0
Fluoranthene	ug/kg	.000	8	16	94	12000	8
Fluorene	ug/kg	.000	4	15	88	640	4
Hexachlorobenzene	ug/kg	.000	0	13	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	13	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	13	0	0	0
Hexachloroethane	ug/kg	.000	0	13	0	0	0
Hexachlorophene	ug/kg	.000	0	4	0	0	0
Hexachloropropene	ug/kg	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	5	15	210	5500	5
Isophorone	ug/kg	.000	0	13	0	0	0
Isosafrole	ug/kg	.000	0	4	0	0	0
Methapyrilene	ug/kg	.000	0	2	0	0	0
Methyl methanesulfonate	ug/kg	.000	0	4	0	0	0
Methyl parathion	ug/kg	.000	0	16	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	13	0	0	0
N-Nitrosodi-n-butylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosodiethylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	13	0	0	0
N-Nitrosomethylethylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosomorpholine	ug/kg	.000	0	3	0	0	0
N-Nitrosopiperidine	ug/kg	.000	0	3	0	0	0
N-Nitrosopyrrolidine	ug/kg	.000	0	3	0	0	0
Naphthalene	ug/kg	.000	2	13	41	140	2
Nitrobenzene	ug/kg	.000	0	13	0	0	0
O,O,O-Triethylphosphorothioate	ug/kg	.000	0	13	0	0	0
Parathion	ug/kg	.000	0	16	0	0	0
Pentachlorobenzene	ug/kg	.000	0	4	0	0	0
Pentachloroethane	ug/kg	.000	0	4	0	0	0
Pentachloronitrobenzene	ug/kg	.000	0	4	0	0	0
Pentachlorophenol	ug/kg	.000	0	14	0	0	0
Phenacetin	ug/kg	.000	0	4	0	0	0
Phenanthrene	ug/kg	.000	9	16	53	4800	9
Phenol	ug/kg	.000	1	14	61	61	1
Pronamide	ug/kg	.000	0	4	0	0	0

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TABLE 4-4
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Pyrene	ug/kg	.000	9	16	73	12000	9
Safrole	ug/kg	.000	0	4	0	0	0
Sulfotep	ug/kg	.000	0	13	0	0	0
a,a-Dimethylphenethylamine	ug/kg	.000	0	4	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	13	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	13	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	13	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	3	13	40	1200	3
o-Toluidine	ug/kg	.000	0	4	0	0	0
p-Chloroaniline	ug/kg	.000	0	13	0	0	0
p-Dimethylaminoazobenzene	ug/kg	.000	0	4	0	0	0
p-Phenylenediamine	ug/kg	.000	0	2	0	0	0
PESTICIDES/PCBs							
2,4,5-T	ug/kg	.000	0	5	0	0	0
2,4,5-TP (Silvex)	ug/kg	.000	0	5	0	0	0
2,4-D	ug/kg	.000	0	5	0	0	0
Dinoseb	ug/kg	.000	0	5	0	0	0
4,4'-DDD	ug/kg	.000	0	16	0	0	0
4,4'-DDE	ug/kg	.000	0	16	0	0	0
4,4'-DDT	ug/kg	.000	0	16	0	0	0
Aldrin	ug/kg	.000	0	16	0	0	0
Aroclor-1016	ug/kg	.000	0	16	0	0	0
Aroclor-1221	ug/kg	.000	0	16	0	0	0
Aroclor-1232	ug/kg	.000	0	16	0	0	0
Aroclor-1242	ug/kg	.000	0	16	0	0	0
Aroclor-1248	ug/kg	.000	0	16	0	0	0
Aroclor-1254	ug/kg	.000	1	16	150	150	1
Aroclor-1260	ug/kg	.000	1	16	610	610	1
Chlorobenzilate	ug/kg	.000	0	5	0	0	0
Dieldrin	ug/kg	.000	0	16	0	0	0
Endosulfan II	ug/kg	.000	0	16	0	0	0
Endosulfan sulfate	ug/kg	.000	0	16	0	0	0
Endosulfan-I	ug/kg	.000	0	16	0	0	0
Endrin	ug/kg	.000	0	16	0	0	0
Endrin ketone	ug/kg	.000	0	16	0	0	0
Heptachlor	ug/kg	.000	0	16	0	0	0
Heptachlor epoxide	ug/kg	.000	0	16	0	0	0
Isodrin	ug/kg	.000	0	5	0	0	0
Kepone	ug/kg	.000	0	5	0	0	0
Methoxychlor	ug/kg	.000	0	16	0	0	0
Toxaphene	ug/kg	.000	0	16	0	0	0
alpha-BHC	ug/kg	.000	0	16	0	0	0
alpha-Chlordane	ug/kg	.000	0	16	0	0	0

TABLE 4-4
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
beta-BHC	ug/kg	.000	0	16	0	0	0
delta-BHC	ug/kg	.000	0	16	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	16	0	0	0
gamma-Chlordane	ug/kg	.000	0	16	0	0	0
DIOXIN/FURAN							
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ug/kg	.000	1	19	.38	.38	1
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ug/kg	.000	1	19	.073	.073	1
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	19	0	0	0
1,2,3,4,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	19	0	0	0
1,2,3,6,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	19	0	0	0
1,2,3,7,8,9-Hexachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ug/kg	.000	1	20	.067	.067	1
1,2,3,7,8-Pentachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
2,3,4,6,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
2,3,4,7,8-Pentachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
2,3,7,8-TCDD	ug/kg	.000	0	19	0	0	0
2,3,7,8-TCDF	ug/kg	.000	0	19	0	0	0
Heptachlorodibenzo-p-dioxin	ug/kg	.000	2	19	.65	.9	2
Heptachlorodibenzofuran	ug/kg	.000	1	19	.25	.25	1
Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	19	0	0	0
Hexachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
Octachlorodibenzo-p-dioxin	ug/kg	.000	18	19	.05	13.7	18
Octachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
Pentachlorodibenzo-p-dioxin	ug/kg	.000	0	19	0	0	0
Pentachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
Tetrachlorodibenzo-p-dioxin	ug/kg	.000	0	19	0	0	0
Tetrachlorodibenzofuran	ug/kg	.000	0	19	0	0	0
GENERAL CHEMISTRY							
Sulfide	mg/kg	.000	6	6	7.27	12.7	0
Total Organic Carbon	mg/kg	.000	6	6	6020	27071	6
MISCELLANEOUS							
Azinphosmethyl	ug/kg	.000	0	16	0	0	0
Benzidine	ug/kg	.000	0	1	0	0	0
Demeton	ug/kg	.000	0	16	0	0	0
Diazinon	ug/kg	.000	0	16	0	0	0
Dimethoate	ug/kg	.000	0	13	0	0	0
Disulfoton	ug/kg	.000	0	16	0	0	0
Ethion	ug/kg	.000	0	15	0	0	0

TABLE 4-4
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
MISCELLANEOUS (Continued)							
Famphur	ug/kg	.000	0	13	0	0	0
Malathion	ug/kg	.000	0	16	0	0	0
Phorate	ug/kg	.000	0	13	0	0	0
Tetraethylpyrophosphate	ug/kg	.000	0	16	0	0	0
Thionazin	ug/kg	.000	0	13	0	0	0

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TABLE 4-5

SOLID WASTE LANDFILL
SUBSURFACE SOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	37	37	2750	16900	2
Antimony	mg/kg	.000	0	32	0	0	0
Arsenic	mg/kg	9.570	37	37	3.5	13.9	3
Barium	mg/kg	119.170	37	37	26.8	251	7
Beryllium	mg/kg	.620	32	37	.37	1.8	23
Cadmium	mg/kg	.910	20	37	.7	2	14
Calcium	mg/kg	150000.000	37	37	4500	151000	1
Chromium	mg/kg	20.680	37	37	4	36.9	2
Cobalt	mg/kg	15.750	36	37	3.8	20.4	1
Copper	mg/kg	20.030	37	37	4.8	26.9	10
Cyanide	mg/kg	.130	2	27	.16	1	2
Iron	mg/kg	30700.000	37	37	5630	32500	1
Lead	mg/kg	15.580	37	37	3.1	17.3	5
Magnesium	mg/kg	42648.210	37	37	3520	63400	2
Manganese	mg/kg	1300.000	37	37	296	1130	0
Mercury	mg/kg	.290	1	37	.24	.24	0
Molybdenum	mg/kg	2.700	27	37	.86	9	14
Nickel	mg/kg	34.350	36	37	10.1	36.5	1
Potassium	mg/kg	1979.990	37	37	550	2480	5
Selenium	mg/kg	.000	1	37	.48	.48	1
Silicon	mg/kg	1593.080	37	37	392	1690	1
Silver	mg/kg	.000	14	37	.43	7.7	14
Sodium	mg/kg	285.000	37	37	70.3	338	1
Thallium	mg/kg	.490	9	37	.23	.32	0
Vanadium	mg/kg	37.800	37	37	8.4	38.4	1
Zinc	mg/kg	72.580	37	37	22.8	84.7	2
RADIONUCLIDES							
CS-137	pCi/g	.000	6	35	.091	.522	6
GROSS ALPHA	pCi/g	.000	34	35	7.63	2532	34
GROSS BETA	pCi/g	.000	35	35	16.1	1220	35
NP-237	pCi/g	.000	25	25	.047	1.67	25
PU-238	pCi/g	.000	28	35	.0148	.433	28
PU-239/240	pCi/g	.000	23	35	.0148	1.67	23
RA-226	pCi/g	1.470	35	35	.79	113	2
RA-228	pCi/g	1.310	35	35	.618	6.65	7
RU-106	pCi/g	.000	0	35	0	0	0
SR-90	pCi/g	.560	5	33	.195	1.99	3

TABLE 4-5
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
TC-99	pCi/g	.000	3	33	.754	5.13	3
TH-228	pCi/g	1.330	30	30	.584	9.36	7
TH-230	pCi/g	1.880	30	30	.792	720	11
TH-232	pCi/g	1.260	30	30	.489	8.22	7
TH-TOTAL	mg/kg	9.470	30	30	4.5	75.6	8
U-234	pCi/g	1.040	35	35	.651	553	20
U-235/236	pCi/g	.150	33	35	.015	28.9	14
U-238	pCi/g	1.120	35	35	.731	577	22
U-TOTAL	mg/kg	3.400	35	35	2.49	1770	29
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	38	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	36	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	38	0	0	0
1,1-Dichloroethane	ug/kg	.000	2	38	1	55	2
1,1-Dichloroethene	ug/kg	.000	0	38	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	38	0	0	0
1,2-Dichloroethene	ug/kg	.000	1	37	2	2	1
1,2-Dichloropropane	ug/kg	.000	0	38	0	0	0
2-Butanone	ug/kg	.000	2	33	13	110	2
2-Hexanone	ug/kg	.000	2	38	1	2	2
4-Methyl-2-pentanone	ug/kg	.000	2	38	3	20	2
Acetone	ug/kg	.000	5	30	6	88	5
Benzene	ug/kg	.000	2	38	3	4	2
Bromodichloromethane	ug/kg	.000	0	38	0	0	0
Bromoform	ug/kg	.000	0	38	0	0	0
Bromomethane	ug/kg	.000	0	38	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	38	0	0	0
Carbon disulfide	ug/kg	.000	1	38	2	2	1
Chlorobenzene	ug/kg	.000	0	38	0	0	0
Chloroethane	ug/kg	.000	0	38	0	0	0
Chloroform	ug/kg	.000	0	38	0	0	0
Chloromethane	ug/kg	.000	0	38	0	0	0
Dibromochloromethane	ug/kg	.000	0	38	0	0	0
Ethylbenzene	ug/kg	.000	4	38	2	76	4
Methylene chloride	ug/kg	.000	0	38	0	0	0
Styrene	ug/kg	.000	0	38	0	0	0
Tetrachloroethene	ug/kg	.000	2	38	1	2	2
Toluene	ug/kg	.000	16	38	1	54	16
Trichloroethene	ug/kg	.000	0	38	0	0	0
Vinyl Acetate	ug/kg	.000	0	25	0	0	0
Vinyl chloride	ug/kg	.000	1	38	2	2	1
Xylenes, Total	ug/kg	.000	4	38	1	260	4

TABLE 4-5
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
cis-1,3-Dichloropropene	ug/kg	.000	0	38	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	38	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	37	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	37	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	37	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	37	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	36	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	36	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	37	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	37	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	37	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	37	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	37	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	2	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	37	0	0	0
2-Chlorophenol	ug/kg	.000	0	37	0	0	0
2-Methylnaphthalene	ug/kg	.000	4	37	97	46000	4
2-Methylphenol	ug/kg	.000	0	37	0	0	0
2-Nitroaniline	ug/kg	.000	0	37	0	0	0
2-Nitrophenol	ug/kg	.000	0	37	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	34	0	0	0
3-Nitroaniline	ug/kg	.000	0	36	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	37	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	37	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	37	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	37	0	0	0
4-Methylphenol	ug/kg	.000	1	37	140	140	1
4-Nitroaniline	ug/kg	.000	0	34	0	0	0
4-Nitrophenol	ug/kg	.000	0	37	0	0	0
Acenaphthene	ug/kg	.000	11	37	47	140000	11
Acenaphthylene	ug/kg	.000	1	37	2500	2500	1
Anthracene	ug/kg	.000	14	37	70	250000	14
Benzo(a)anthracene	ug/kg	.000	18	37	48	310000	18
Benzo(a)pyrene	ug/kg	.000	17	37	47	260000	17
Benzo(b)fluoranthene	ug/kg	.000	17	37	49	220000	17
Benzo(g,h,i)perylene	ug/kg	.000	15	37	64	150000	15
Benzo(k)fluoranthene	ug/kg	.000	14	37	56	140000	14
Benzoic acid	ug/kg	.000	0	20	0	0	0
Benzyl alcohol	ug/kg	.000	0	18	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	37	0	0	0
Carbazole	ug/kg	.000	11	37	58	89000	11
Chrysene	ug/kg	.000	17	37	48	310000	17

TABLE 4-5
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Di-n-butyl phthalate	ug/kg	.000	2	37	71	170	2
Di-n-octyl phthalate	ug/kg	.000	1	37	55	55	1
Dibenzo(a,h)anthracene	ug/kg	.000	11	37	40	79000	11
Dibenzofuran	ug/kg	.000	9	37	38	120000	9
Diethyl phthalate	ug/kg	.000	0	37	0	0	0
Dimethyl phthalate	ug/kg	.000	0	37	0	0	0
Fluoranthene	ug/kg	.000	20	37	46	790000	20
Fluorene	ug/kg	.000	10	37	46	180000	10
Hexachlorobenzene	ug/kg	.000	0	37	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	34	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	37	0	0	0
Hexachloroethane	ug/kg	.000	0	37	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	16	37	45	150000	16
Isophorone	ug/kg	.000	0	37	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	37	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	37	0	0	0
Naphthalene	ug/kg	.000	7	37	46	96000	7
Nitrobenzene	ug/kg	.000	0	37	0	0	0
Pentachlorophenol	ug/kg	.000	0	36	0	0	0
Phenanthrene	ug/kg	.000	18	37	66	900000	18
Phenol	ug/kg	.000	0	37	0	0	0
Pyrene	ug/kg	.000	20	37	44	610000	20
Tributyl phosphate	ug/kg	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	37	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	37	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	37	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	22	37	48	3200	22
p-Chloroaniline	ug/kg	.000	0	34	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	3	36	4.3	5	3
4,4'-DDE	ug/kg	.000	0	37	0	0	0
4,4'-DDT	ug/kg	.000	0	37	0	0	0
Aldrin	ug/kg	.000	0	36	0	0	0
Aroclor-1016	ug/kg	.000	0	37	0	0	0
Aroclor-1221	ug/kg	.000	0	37	0	0	0
Aroclor-1232	ug/kg	.000	0	37	0	0	0
Aroclor-1242	ug/kg	.000	0	37	0	0	0
Aroclor-1248	ug/kg	.000	0	37	0	0	0
Aroclor-1254	ug/kg	.000	1	37	48	48	1
Aroclor-1260	ug/kg	.000	4	37	26	170	4
Dieldrin	ug/kg	.000	1	36	13	13	1
Endosulfan II	ug/kg	.000	1	37	6.2	6.2	1

TABLE 4-5
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Endosulfan sulfate	ug/kg	.000	3	37	6.2	10	3
Endosulfan-I	ug/kg	.000	0	36	0	0	0
Endrin	ug/kg	.000	0	37	0	0	0
Endrin aldehyde	ug/kg	.000	1	37	180	180	1
Endrin ketone	ug/kg	.000	2	37	5.7	7.1	2
Heptachlor	ug/kg	.000	0	37	0	0	0
Heptachlor epoxide	ug/kg	.000	0	37	0	0	0
Methoxychlor	ug/kg	.000	0	37	0	0	0
Toxaphene	ug/kg	.000	0	37	0	0	0
alpha-BHC	ug/kg	.000	0	37	0	0	0
alpha-Chlordane	ug/kg	.000	0	36	0	0	0
beta-BHC	ug/kg	.000	0	37	0	0	0
delta-BHC	ug/kg	.000	0	37	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	36	0	0	0
gamma-Chlordane	ug/kg	.000	0	37	0	0	0

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strontium-90, and technetium-99 were detected, indicating the presence of materials from reprocessing activities at the FEMP. Six dioxins/furans were detected for Phase I, except for Octochlorodibenzo-p-dioxin, which was detected in eighteen samples at concentrations ranging form 0.05 to 13.7 μg/kg, the remaining five dioxins/furans were detected once or twice at trace concentrations. Aroclor-1254 and Aroclor-1260 were detected above background in five samples. Other radionuclides and organic compounds detected in the subsurface soils lead to the assumption that waste materials are a mixture of wastes from production, metallurgy, medical laboratory, construction, and maintenance activities. Comparison of the detected organic compounds for Phase I and Phase II shows that there were a variety of compounds detected in each sampling event. The surface soil COCs detected above background in the subsurface samples include antimony, arsenic, beryllium, neptunium-237, plutonium-238, radium-226, radium-228, technetium-99, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235/236, uranium-238, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. For both the surface soil and subsurface soil in the Solid Waste Landfill the concentrations for the constituents detected were variable and distributed throughout the subunit. The highest concentration for the surface soil radionuclides is 143 ug/g for uranium-total at location SWL-SS-05, and the highest concentration for an organic constituent is 2100 ug/kg for Pyrene at location SWL-SS-01 (Figure 4-2). The highest concentration for the subsurface soil radionuclides is 1770 ug/g for uranium-total at location 11036 (Figure 4-3, south-central portion), and the highest concentration for an organic constituent is 900000 ug/kg for Phenanthrene at location 11039 (Figure 4-4, east-central portion). A review illustrates that concentrations for these same constituents, or even other constituents, are within the same order of magnitude, or one order of magnitude lower, and are distributed throughout the Solid Waste Landfill south of the north drainage ditch. Therefore, as previously stated, there is not just a single hot spot source area but several contributing to the whole.

Radionuclides and organic compounds have been detected to an approximate depth of 2 to 4 feet (approximately 566 to 568 feet above the MSL) into the glacial overburden. The approximate extent of impact is 21 to 23 feet above the Great Miami Aquifer (551 to 553 feet above the MSL) and approximately 44 to 46 feet above the average ground water elevation (522 feet above the MSL) under the Solid Waste Landfill. A review of surface soil concentrations and subsurface soil concentrations indicates that analyte concentration are variable throughout the fill material. Concentrations in the borings decrease rapidly with depth, particularly in the glacial overburden (Figures 4-3 and 4-4). However, radionuclides were detected in higher concentrations in the vicinity

of 11036; and organic constituents were detected in higher concentrations in the vicinity of 11039, and in the vicinity of 1719. Also, total thorium increased from 6.9 pCi/g to 47 pCi/g in boring 1039, at depths of 2.5 to 14 feet, respectively.

A likely scenario for waste disposal is that organic and radioactive contaminated materials were dumped and inadvertently mixed, and were exposed with no cover materials; thereby, allowing greater rainwater infiltration and increasing the potential of downward vertical migration of leachable material during the act of waste disposal. The present configuration of the Solid Waste Landfill has a soil cover, which has reduced the amount of rainwater infiltration and the potential for downward migration.

A comparison of the Phase I and Phase II subsurface soil data with the CIS and ES subsurface soil data in Appendices C-7 and C-8 indicates that the parameters detected in the preliminary studies were also detected in Phase I and Phase II, and were within the same order of magnitude.

Total uranium in leachate detected in trenches and borings is presented in Table 4-2A. A comparison of soil and leachate data shown in Table 4-2A from the south end of Trench 2 (located within former Waste Cell 1) indicates that similar isotopes and organic compounds were detected in the soil and in leachate collected from the trench. This suggests that water in contact with the buried waste material is a potential transport media for organic and radioisotope constituent migration to perched groundwater. The leachate results were used in fate and transport modeling in Section 5.

Six soil samples were collected for hazardous waste characteristic determination by TCLP analyses, and analytical data are summarized in Table 4-6. The data did not exceed the RCRA standard for determining toxic characteristic hazardous waste, although manganese was detected at trace levels in five of the six leach samples. Note; the TCLP analysis detection limits for heptachlor epoxide were above the regulatory standard (0.0083 mg/L compared to the limit of 0.008 mg/L), however, the compound was not detected by the TCLP analysis or direct analyses of samples collected from the Solid Waste Landfill.

Five Extraction Procedure Toxicity test samples were collected during the CIS and are listed in Appendix C, Table C-16. Barium was the only parameter detected and ranged from 1276.00 to 3307.00 μg/L

TABLE 4-6

SOLID WASTE LANDFILL TCLP RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	RCRA Standard (mg/L)	Location/Sample Number and Result (mg/L)					
		1983	1986	1987	1990	1991	2951
		111478	111454	115358	115334	115320	111432
Arsenic	5.0	<0.0303	rejected[a]	0.0548	<0.1	<0.048	<0.0303
Barium	100.0	1.33	1.11	1.46	<0.0016	1.32	1.14
Benzene	0.5	-[b]	<0.005	<0.005	<0.005	<0.005	<0.015
Cadmium	1.0	<0.0021	<0.0021	<0.0021	<0.005	<0.0021	<0.0021
Carbon Tetrachloride	0.5	-	<0.005	<0.005	<0.005	<0.005	<0.015
Chlordane	0.03	-	<0.0014	<0.0014	<0.0014	<0.0014	<0.015
Chlorobenzene	100.0	-	<0.005	<0.005	<0.005	<0.005	<0.015
Chloroform	6.0	-	<0.005	<0.005	<0.005	<0.005	<0.015
Chromium	5.0	<0.0031	<0.0031	<0.0031	<0.05	<0.0031	<0.0031
Copper		<0.0017	0.0098	<0.0017	<0.025	<0.0017	-
2,4-D	10.0	-	<0.12	<0.12	<0.120	<0.12	-
1,4-Dichlorobenzene	7.5	-	<0.05	<0.05	<0.05	<0.05	-
1,2-Dichloroethane	0.5	-	<0.005	<0.005	<0.005	<0.005	<0.015
1,1-Dichloroethene	0.7	-	<0.005	<0.005	<0.005	<0.005	<0.015
2,4-Dinitrotoluene	0.13	-	<0.05	<0.05	<0.05	<0.05	-
Endrin	0.02	-	<0.0006	<0.0006	<0.0006	<0.0006	-
Heptachlor	0.008	-	<0.0003	<0.0003	<0.0003	<0.0003	-
Heptachlor epoxide	0.008	-	<0.0083	<0.0083	<0.0083	<0.0083	-
Hexachlorobenzene	0.13	-	<0.05	<0.05	<0.05	<0.05	-
Hexachlorobutadiene	0.5	-	<0.05	<0.05	<0.05	<0.05	-
Hexachloroethane	3.0	-	<0.05	<0.05	<0.05	<0.05	-

See footnotes at end of table

TABLE 4-6
(Continued)

Parameter	RCRA Standard (mg/L)	Location/Sample Number and Result (mg/L)					
		1983	1986	1987	1990	1991	2951
		111478	111454	115358	115334	115320	111432
Iron		<0.0158	0.0636	<0.0254	<0.1	<0.046	-
Lead	5.0	<0.0155	<0.125	<0.0155	<0.05	0.0657	<0.0155
Lindane	0.4	-	<0.0004	<0.0004	<0.0004	<0.0004	-
Manganese		0.0775	1.93	0.228	6.05	5.5	-
Mercury	0.2	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Methoxychlor	10.0	-	<0.018	<0.018	<0.018	<0.018	-
Nitrobenzene	2.0	-	<0.05	<0.05	<0.05	<0.05	-
Pentachlorophenol	100.0	-	<0.25	<0.25	<0.25	<0.25	-
Pyridine	5.0	-	<0.25	<0.25	<0.25	<0.25	-
Selenium	1.0	<0.0296	rejected	<0.0296	<0.05	0.129	<0.0296
Silver	5.0	<0.0022	<0.0134	<0.0022	<0.01	<0.0022	<0.0022
Tetrachloroethene	0.7	-	<0.005	<0.005	<0.005	<0.005	<0.015
Toxaphene	0.5	-	<0.024	<0.024	<0.024	<0.024	-
2,4,5-TP (Silvex)	1.0	-	<0.017	<0.017	<0.017	<0.017	-
Trichloroethene	0.5	-	<0.005	<0.005	<0.005	<0.005	<0.015
2,4,5-Trichlorophenol	400.0	-	<0.25	<0.05	<0.05	<0.05	-
2,4,6-Trichlorophenol	2.0	-	<0.05	<0.05	<0.05	<0.05	-
Vinyl chloride	0.2	-	<0.01	<0.01	<0.01	<0.01	<0.015
Zinc		rejected	rejected	rejected	0.024		-

Note: A box surrounding a number indicates a result or detection limit that is above an EPA or OEPA standard.

[a]"Rejected" means that the sample could not be validated.
[b]The sample was not analyzed for the parameter.

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4.2.3 Surface Water and Sediment

The one source of surface water within the battery limits of the Solid Waste Landfill is a drainage ditch which flows from east to west along the north boundary of the subunit. Surface water and sediment samples were collected in this drainage ditch. Chemical and radiological analytical results for surface water were not compared against background concentrations since background concentrations for surface water have not yet been defined for the site. A table of detected constituent concentrations is provided in Appendix C as Tables C-2D through C-2G. A summary of the number of detected analytes is provided as Table 4-7 and Table 4-8. Radionuclide and organic compounds detected in surface media are presented on Figure 4-2 (Volume 2: Oversized Figures).

One surface water sample was collected during Phase I and was analyzed for constituents listed in summary Table 4-7. Seventeen metals and two semivolatile organic compounds were detected from Phase I samples. During Phase II surface water was collected from three locations and analyzed for the constituents listed in summary Table 4-8. Eight metals (silicon was detected for Phase II but not analyzed for Phase I, the other seven were also detected during Phase I), isotopes of two elements (radionuclides were not analyzed for Phase I surface water samples), and one semivolatile organic compound (bis(2-ethylhexyl)phthalate, which was not detected during Phase I) were detected from Phase II samples. A comparison of water sample results on Figure 4-2 from upstream and downstream locations indicates that there is an approximately equal concentration of total uranium (46.1 μg/L and 59.3 μg/L, respectively). A sample of standing water collected after a rain event on April 28, 1993, adjacent to Well 1947 (approximately 50 feet east of the battery limits for the Solid Waste Landfill; see Figure 4-2), detected 70 μg/L total uranium. This is within the same order of magnitude as the two forementioned water samples, and indicates that the Solid Waste Landfill may not be the only source for concentrations of uranium detected in surface water samples in the Solid Waste Landfill drainage ditch.

Sediment sample data were compared to background surface soil data because it was assumed that the source for sediment is eroded surface soil. This comparison was made because background for sediment has not been established; however, Operable Unit 5 will specifically address background sediment levels. A table of detected analytes is provided in Appendix C, Table C-2F and summarized in Table 4-9 and Table 4-10. One sediment sample was collected during Phase I and analyzed for the constituents listed in summary Table 4-9. Total Uranium was the only constituent detected above background. During Phase II sediment samples were collected from two locations and analyzed for

TABLE 4-7

SOLID WASTE LANDFILL
SURFACE WATER[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	1	1	.161	.161	1
Antimony		mg/L	.000	0	1	0	0	0
Arsenic		mg/L	.000	0	1	0	0	0
Barium		mg/L	.000	1	1	.0633	.0633	1
Beryllium		mg/L	.000	1	1	.0015	.0015	1
Cadmium		mg/L	.000	1	1	.0063	.0063	1
Calcium		mg/L	.000	1	1	47	47	1
Chromium		mg/L	.000	1	1	.0175	.0175	1
Cobalt		mg/L	.000	1	1	.0136	.0136	1
Copper		mg/L	.000	1	1	.0156	.0156	1
Iron		mg/L	.000	1	1	.0866	.0866	1
Lead		mg/L	.000	0	1	0	0	0
Magnesium		mg/L	.000	1	1	10.7	10.7	1
Manganese		mg/L	.000	1	1	.0651	.0651	1
Mercury		mg/L	.000	0	1	0	0	0
Molybdenum		mg/L	.000	1	1	.023	.023	1
Nickel		mg/L	.000	1	1	.0159	.0159	1
Potassium		mg/L	.000	1	1	2.02	2.02	1
Selenium		mg/L	.000	0	1	0	0	0
Silver		mg/L	.000	0	1	0	0	0
Sodium		mg/L	.000	1	1	4.96	4.96	1
Thallium		mg/L	.000	0	1	0	0	0
Vanadium		mg/L	.000	1	1	.0187	.0187	1
Zinc		mg/L	.000	1	1	.0325	.0325	1
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Butanone	UNFL	ug/L	.000	0	0	0	0	0

See footnote at end of table

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TABLE 4-7
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	0	1	0	0	0
Benzene	UNFL	ug/L	.000	0	0	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	0	0	0	0
Chloroethane	UNFL	ug/L	.000	0	1	0	0	0
Chloroform	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	0	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	1	0	0	0
Styrene	UNFL	ug/L	.000	0	0	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	1	0	0	0
Toluene	UNFL	ug/L	.000	0	0	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	1	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	1	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	0	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-7
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
2-Chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	1	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	0	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	1	0	0	0
Anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	1	1	3	3	1
Di-n-octyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	1	1	3	3	1
Dimethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Fluorene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Isophorone	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

FER\CRU2RI\TDO\TAB4-7\January 16, 1995 2:02pm

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TABLE 4-7
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	1	0	0	0
Naphthalene	UNFL	ug/L	.000	0	1	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	1	0	0	0
Phenol	UNFL	ug/L	.000	0	1	0	0	0
Pyrene	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	1	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	0	0	0	0
PESTICIDES/PCBs								
4,4'-DDD	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	1	0	0	0
Aldrin	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	1	0	0	0
Dieldrin	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	1	0	0	0
Endrin	UNFL	ug/L	.000	0	1	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	1	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	1	0	0	0
Toxaphene	UNFL	ug/L	.000	0	1	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	1	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
beta-BHC	UNFL	ug/L	.000	0	1	0	0	0
delta-BHC	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-7
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)								
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	1	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	.000	0	1	0	0	0
Chloride	UNFL	mg/L	.000	1	1	12	12	1
Fluoride	UNFL	mg/L	.000	1	1	.14	.14	1
Nitrate	UNFL	mg/L	.000	1	1	1.8	1.8	1
Phenols	UNFL	mg/L	.000	0	1	0	0	0
Phosphorus	UNFL	mg/L	.000	1	1	.27	.27	1
Sulfate	UNFL	mg/L	.000	1	1	36.8	36.8	1
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	1	1	1.0283	1.0283	1
Total Organic Halides	UNFL	mg/L	.000	1	1	.0189	.0189	1
Total Organic Nitrogen	UNFL	mg/L	.000	1	1	1.03	1.03	1

[a]Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available

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TABLE 4-8

SOLID WASTE LANDFILL
SURFACE WATER[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	1	2	.14	.14	1
Antimony		mg/L	.000	0	2	0	0	0
Arsenic		mg/L	.000	0	2	0	0	0
Barium		mg/L	.000	2	2	.0385	.0405	2
Beryllium		mg/L	.000	0	2	0	0	0
Cadmium		mg/L	.000	0	2	0	0	0
Calcium		mg/L	.000	2	2	92.5	105	2
Chromium		mg/L	.000	0	2	0	0	0
Cobalt		mg/L	.000	0	2	0	0	0
Copper		mg/L	.000	0	2	0	0	0
Iron		mg/L	.000	0	2	0	0	0
Lead		mg/L	.000	0	2	0	0	0
Magnesium		mg/L	.000	2	2	23.5	25.7	2
Manganese		mg/L	.000	2	2	.177	.185	2
Mercury		mg/L	.000	0	2	0	0	0
Molybdenum		mg/L	.000	0	2	0	0	0
Nickel		mg/L	.000	0	2	0	0	0
Potassium		mg/L	.000	2	2	.865	.869	2
Selenium		mg/L	.000	0	2	0	0	0
Silicon		mg/L	.000	2	2	1.91	2.03	2
Silver		mg/L	.000	0	2	0	0	0
Sodium		mg/L	.000	2	2	11.3	13	2
Thallium		mg/L	.000	0	2	0	0	0
Vanadium		mg/L	.000	0	2	0	0	0
Zinc		mg/L	.000	0	2	0	0	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	2	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	2	2	24.7	32.9	2
GROSS BETA	UNFL	pCi/L	.000	2	2	11.5	11.8	2
NP-237	UNFL	pCi/L	.000	0	2	0	0	0
PU-238	UNFL	pCi/L	.000	2	2	.035	.196	2
PU-239/240	UNFL	pCi/L	.000	0	2	0	0	0
RA-226	UNFL	pCi/L	.000	0	2	0	0	0
RA-228	UNFL	pCi/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-8
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RU-106	UNFL	pCi/L	.000	0	2	0	0	0
SR-90	UNFL	pCi/L	.000	0	2	0	0	0
TC-99	UNFL	pCi/L	.000	0	2	0	0	0
TH-228	UNFL	pCi/L	.000	0	1	0	0	0
TH-230	UNFL	pCi/L	.000	0	1	0	0	0
TH-232	UNFL	pCi/L	.000	0	1	0	0	0
TH-TOTAL	UNFL	ug/L	.000	0	1	0	0	0
U-234	UNFL	pCi/L	.000	2	2	17.1	17.2	2
U-235/236	UNFL	pCi/L	.000	2	2	.846	1.3	2
U-238	UNFL	pCi/L	.000	2	2	18.7	20.2	2
U-TOTAL	UNFL	ug/L	.000	2	2	46.1	59.3	2
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	2	0	0	0
2-Butanone	UNFL	ug/L	.000	0	2	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	2	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	2	0	0	0
Acetone	UNFL	ug/L	.000	0	2	0	0	0
Benzene	UNFL	ug/L	.000	0	2	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	2	0	0	0
Bromoform	UNFL	ug/L	.000	0	2	0	0	0
Bromomethane	UNFL	ug/L	.000	0	2	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	2	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	2	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
Chloroethane	UNFL	ug/L	.000	0	2	0	0	0
Chloroform	UNFL	ug/L	.000	0	2	0	0	0
Chloromethane	UNFL	ug/L	.000	0	2	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	2	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	2	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	2	0	0	0
Styrene	UNFL	ug/L	.000	0	2	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	2	0	0	0
Toluene	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-8
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Trichloroethene	UNFL	ug/L	.000	0	2	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	2	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	2	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	2	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	2	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	2	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	2	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	2	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	2	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	2	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	2	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	2	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	2	0	0	0
Anthracene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-8
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	2	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	2	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	2	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Carbazole	UNFL	ug/L	.000	0	2	0	0	0
Chrysene	UNFL	ug/L	.000	0	2	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	2	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	2	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	2	0	0	0
Fluorene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	0	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	2	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	2	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	2	0	0	0
Isophorone	UNFL	ug/L	.000	0	2	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	2	0	0	0
Naphthalene	UNFL	ug/L	.000	0	2	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	2	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	2	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	2	0	0	0
Phenol	UNFL	ug/L	.000	0	2	0	0	0
Pyrene	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	1	2	1	1	1
p-Chloroaniline	UNFL	ug/L	.000	0	2	0	0	0
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	2	0	0	0
Aldrin	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-8
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS (Continued)								
Aroclor-1232	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	2	0	0	0
Dieldrin	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	2	0	0	0
Endrin	UNFL	ug/L	.000	0	2	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	2	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	2	0	0	0
Heptachlor	UNFL	ug/L	.000	0	2	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	2	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	2	0	0	0
Toxaphene	UNFL	ug/L	.000	0	2	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	2	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	2	0	0	0
beta-BHC	UNFL	ug/L	.000	0	2	0	0	0
delta-BHC	UNFL	ug/L	.000	0	2	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	2	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	2	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	2	2	276	276.5	0
Ammonia	UNFL	mg/L	.000	0	2	0	0	0
Chloride	UNFL	mg/L	.000	2	2	17.1	24.6	2
Fluoride	UNFL	mg/L	.000	2	2	.19	.22	2
Nitrate	UNFL	mg/L	.000	1	2	2.34	2.34	1
Phenols	UNFL	mg/L	.000	0	2	0	0	0
Sulfate	UNFL	mg/L	.000	1	2	61.01	61.01	1
Sulfide	UNFL	mg/L	.000	1	2	1.01	1.01	0
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	2	2	.2	.23	2
Total Organic Carbon	UNFL	mg/L	.000	2	2	2.7	2.8	2
Total Organic Halides	UNFL	mg/L	.000	0	2	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.000	2	2	.2	.23	2
Total Phosphorous	UNFL	mg/L	.000	2	2	.03	.04	0

[a]Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available

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TABLE 4-9

SOLID WASTE LANDFILL
SEDIMENT[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES							
RA-226	pCi/g	1.420	1	1	.8	.8	0
RA-228	pCi/g	1.250	1	1	1	1	0
U-TOTAL	mg/kg	3.700	1	1	24	24	1

[a]Sediment results are compared to surface soil background values.

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TABLE 4-10

SOLID WASTE LANDFILL
SEDIMENT[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	2	2	7010	8380	0
Antimony	mg/kg	.000	0	2	0	0	0
Arsenic	mg/kg	8.200	2	2	4.5	5.3	0
Barium	mg/kg	94.100	2	2	55.9	62.5	0
Beryllium	mg/kg	.600	0	2	0	0	0
Cadmium	mg/kg	.870	0	2	0	0	0
Calcium	mg/kg	4339.170	2	2	105000	161000	2
Chromium	mg/kg	15.500	1	2	11.5	11.5	0
Cobalt	mg/kg	14.160	1	2	6.4	6.4	0
Copper	mg/kg	14.070	2	2	11.9	15.3	1
Cyanide	mg/kg	.270	0	2	0	0	0
Iron	mg/kg	21728.170	2	2	13400	15400	0
Lead	mg/kg	26.400	2	2	11.4	14.1	0
Magnesium	mg/kg	2776.970	2	2	22500	26000	2
Manganese	mg/kg	1348.040	2	2	424	1640	1
Mercury	mg/kg	.120	0	2	0	0	0
Molybdenum	mg/kg	.000	0	2	0	0	0
Nickel	mg/kg	20.870	1	2	16.4	16.4	0
Potassium	mg/kg	1231.340	2	2	1030	1100	0
Selenium	mg/kg	.720	0	2	0	0	0
Silicon	mg/kg	1797.030	2	2	1280	1330	0
Silver	mg/kg	.000	1	2	4.2	4.2	1
Sodium	mg/kg	51.100	2	2	158	346	2
Thallium	mg/kg	.580	1	2	.76	.76	1
Vanadium	mg/kg	30.370	2	2	19	23.8	0
Zinc	mg/kg	59.610	2	2	45.7	72.6	1
RADIONUCLIDES							
CS-137	pCi/g	.710	0	2	0	0	0
GROSS ALPHA	pCi/g	.000	2	2	15.3	27.7	2
GROSS BETA	pCi/g	.000	2	2	16.3	26.9	2
NP-237	pCi/g	.000	1	2	.62	.62	1
PU-238	pCi/g	.000	1	2	.036	.036	1
PU-239/240	pCi/g	.000	1	2	.039	.039	1
RA-226	pCi/g	1.420	2	2	.9	.97	0
RA-228	pCi/g	1.250	2	2	.75	1.07	0

See footnote at end of table

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TABLE 4-10
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RU-106	pCi/g	.000	0	2	0	0	0
SR-90	pCi/g	.000	2	2	.59	.99	2
TC-99	pCi/g	.000	0	2	0	0	0
TH-228	pCi/g	1.430	1	1	.73	.73	0
TH-230	pCi/g	1.970	1	1	1.05	1.05	0
TH-232	pCi/g	1.360	1	1	.57	.57	0
TH-TOTAL	mg/kg	10.700	1	1	5.2	5.2	0
U-234	pCi/g	1.240	2	2	3.66	4.18	2
U-235/236	pCi/g	.150	1	2	.25	.25	1
U-238	pCi/g	1.220	2	2	4.56	6.8	2
U-TOTAL	mg/kg	3.700	2	2	14.7	22.6	2
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	2	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	2	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	2	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	2	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	2	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	2	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	2	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	2	0	0	0
2-Butanone	ug/kg	.000	0	2	0	0	0
2-Hexanone	ug/kg	.000	0	2	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	2	0	0	0
Acetone	ug/kg	.000	1	2	2	2	1
Benzene	ug/kg	.000	0	2	0	0	0
Bromodichloromethane	ug/kg	.000	0	2	0	0	0
Bromoform	ug/kg	.000	0	2	0	0	0
Bromomethane	ug/kg	.000	0	2	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	2	0	0	0
Carbon disulfide	ug/kg	.000	0	2	0	0	0
Chlorobenzene	ug/kg	.000	0	2	0	0	0
Chloroethane	ug/kg	.000	0	2	0	0	0
Chloroform	ug/kg	.000	0	2	0	0	0
Chloromethane	ug/kg	.000	0	2	0	0	0
Dibromochloromethane	ug/kg	.000	0	2	0	0	0
Ethylbenzene	ug/kg	.000	0	2	0	0	0
Methylene chloride	ug/kg	.000	0	2	0	0	0
Styrene	ug/kg	.000	0	2	0	0	0
Tetrachloroethene	ug/kg	.000	0	2	0	0	0
Toluene	ug/kg	.000	0	2	0	0	0

See footnote at end of table

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TABLE 4-10
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Trichloroethene	ug/kg	.000	0	2	0	0	0
Vinyl Acetate	ug/kg	.000	0	2	0	0	0
Vinyl chloride	ug/kg	.000	0	2	0	0	0
Xylenes, Total	ug/kg	.000	0	2	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	2	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	2	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	2	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	2	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	2	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	2	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	2	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	2	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	2	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	2	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	2	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	2	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	2	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	2	0	0	0
2-Chlorophenol	ug/kg	.000	0	2	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	2	0	0	0
2-Methylphenol	ug/kg	.000	0	2	0	0	0
2-Nitroaniline	ug/kg	.000	0	2	0	0	0
2-Nitrophenol	ug/kg	.000	0	2	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	2	0	0	0
3-Nitroaniline	ug/kg	.000	0	2	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	2	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	2	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	2	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	2	0	0	0
4-Methylphenol	ug/kg	.000	0	2	0	0	0
4-Nitroaniline	ug/kg	.000	0	2	0	0	0
4-Nitrophenol	ug/kg	.000	0	2	0	0	0
Acenaphthene	ug/kg	.000	1	2	98	98	1
Acenaphthylene	ug/kg	.000	0	2	0	0	0
Anthracene	ug/kg	.000	1	2	240	240	1
Benzo(a)anthracene	ug/kg	.000	1	2	500	500	1
Benzo(a)pyrene	ug/kg	.000	1	2	550	550	1
Benzo(b)fluoranthene	ug/kg	.000	1	2	730	730	1
Benzo(g,h,i)perylene	ug/kg	.000	1	2	240	240	1

See footnote at end of table

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TABLE 4-10
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Benzo(k)fluoranthene	ug/kg	.000	1	2	270	270	1
Benzoic acid	ug/kg	.000	0	2	0	0	0
Benzyl alcohol	ug/kg	.000	0	2	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	2	0	0	0
Carbazole	ug/kg	.000	1	2	120	120	1
Chrysene	ug/kg	.000	1	2	510	510	1
Di-n-butyl phthalate	ug/kg	.000	0	2	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	2	0	0	0
Dibenzofuran	ug/kg	.000	0	2	0	0	0
Diethyl phthalate	ug/kg	.000	0	2	0	0	0
Dimethyl phthalate	ug/kg	.000	0	2	0	0	0
Fluoranthene	ug/kg	.000	1	2	1400	1400	1
Fluorene	ug/kg	.000	0	2	0	0	0
Hexachlorobenzene	ug/kg	.000	0	2	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	2	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	2	0	0	0
Hexachloroethane	ug/kg	.000	0	2	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	1	2	310	310	1
Isophorone	ug/kg	.000	0	2	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	2	0	0	0
Naphthalene	ug/kg	.000	0	2	0	0	0
Nitrobenzene	ug/kg	.000	0	2	0	0	0
Pentachlorophenol	ug/kg	.000	0	2	0	0	0
Phenanthrene	ug/kg	.000	1	2	1000	1000	1
Phenol	ug/kg	.000	0	2	0	0	0
Pyrene	ug/kg	.000	2	2	58	990	2
bis(2-Chloroethoxy)methane	ug/kg	.000	0	2	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	2	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	2	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	1	2	53	53	1
p-Chloroaniline	ug/kg	.000	0	2	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	2	0	0	0
4,4'-DDE	ug/kg	.000	0	2	0	0	0
4,4'-DDT	ug/kg	.000	0	2	0	0	0
Aldrin	ug/kg	.000	0	2	0	0	0
Aroclor-1016	ug/kg	.000	0	2	0	0	0
Aroclor-1221	ug/kg	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-10
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Aroclor-1232	ug/kg	.000	0	2	0	0	0
Aroclor-1242	ug/kg	.000	0	2	0	0	0
Aroclor-1248	ug/kg	.000	0	2	0	0	0
Aroclor-1254	ug/kg	.000	0	2	0	0	0
Aroclor-1260	ug/kg	.000	0	2	0	0	0
Dieldrin	ug/kg	.000	0	2	0	0	0
Endosulfan II	ug/kg	.000	0	2	0	0	0
Endosulfan sulfate	ug/kg	.000	0	2	0	0	0
Endosulfan-I	ug/kg	.000	0	2	0	0	0
Endrin	ug/kg	.000	0	2	0	0	0
Endrin aldehyde	ug/kg	.000	0	2	0	0	0
Endrin ketone	ug/kg	.000	0	2	0	0	0
Heptachlor	ug/kg	.000	0	2	0	0	0
Heptachlor epoxide	ug/kg	.000	0	2	0	0	0
Methoxychlor	ug/kg	.000	0	2	0	0	0
Toxaphene	ug/kg	.000	0	2	0	0	0
alpha-BHC	ug/kg	.000	0	2	0	0	0
alpha-Chlordane	ug/kg	.000	0	2	0	0	0
beta-BHC	ug/kg	.000	0	2	0	0	0
delta-BHC	ug/kg	.000	0	2	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	2	0	0	0
gamma-Chlordane	ug/kg	.000	0	2	0	0	0

[a]Sediment results are compared to surface soil background values.

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the constituents listed in summary Table 4-10. Exceeding background concentrations were eight metals, isotopes of four elements (including uranium which was also detected during Phase I), and fifteen organic compounds. Comparing sediment samples collected downstream from the Solid Waste Landfill and the Solid Waste Landfill surface soil samples shows that silver, thallium, zinc, acenapthene, anthracene, Benzo(a)pyrene, phenanthrene, indeno(1,2,3-cd)pyrene, neptunium-237, plutonium-238, strontium-90, uranium-234, uranium-235/236, and uranium-238 were detected in both locations. This indicates that constituent migration from the Solid Waste Landfill into the drainage ditch may have occurred. Except pyrene, none of the organics detected in the downstream sample (SWL-SD-02) were detected upstream from the landfill (SWL-SD-01).

A comparison of Phase I and Phase II sediment samples with the CIS sediment sample data in Appendix C-10 indicates that the parameters detected during the CIS were also detected during Phase I and Phase II, and within the same order of magnitude.

4.2.4 Groundwater

Groundwater analytical data from the 1000-series wells in the Solid Waste Landfill were available from the Phase I and Phase II activities, and these data were compared to perched groundwater background data developed for the site (Appendix C, Table C-18). Analytical data from the Phase I and Phase II sampling are included in Appendix C in Table C-2H and Table C-2I. A summary of analytes detected in 1000-series wells and their frequency of detection is provided in Table 4-11 and Table 4-12.

Phase I sampling was conducted on three 1000-series wells and detected thirteen metals, isotopes of four elements, and no organic compounds that exceeded the background concentrations in eight samples. Phase II sampling was conducted on four 1000-series wells (Wells 1719 and 1947 were dry). During Phase II sixteen metals were detected (Cobalt, Iron, Potassium, and Zinc were not detected above background during Phase I, and Arsenic, Silicon, and Thallium were detected for Phase I but not for Phase II), isotopes of six elements (plutonium-238, Strontium-90, Total thorium, and uranium-235/236 were not detected above background during Phase I), and one organic compound (1,2-dichloroethene) exceeded background concentrations. The concentrations of radionuclides detected in samples from the 1000-series wells during Phase II are presented on Figure 4-5.

A comparison of selected analytes detected in surface and subsurface soil samples and in groundwater samples is provided below:

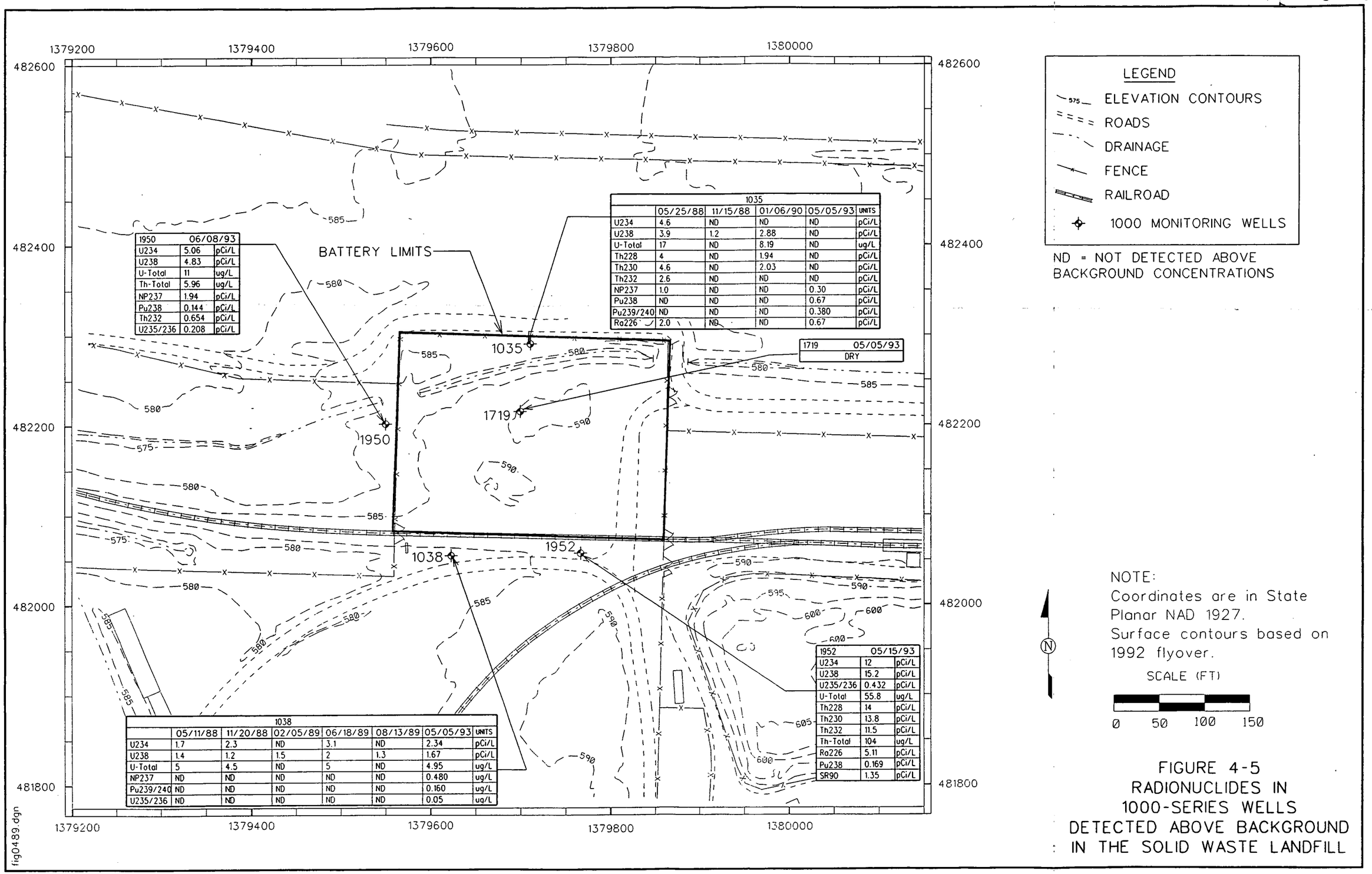
Phase II Detections Above Background for Selected Analytes								
	Metals		Radioisotopes			Organic Compounds		
	Silver	Copper	Cesium-137	Strontium-90	Technetium-99	Volatile Organic Compounds	Polynuclear Aromatic Hydrocarbons	Pesticides
Surface	12/12[a]	6/12	0/12	8/12	0/12	4	18	1
Subsurface	14/37	10/37	6/35	3/33	3/33	13	22	8
Perched Groundwater	0/14	1/15	0/6	2/6	0/6	1	0	0

[a]Number refers to detections above background relative to number of analyses

The data indicate that analytes detected in surface and subsurface soil samples above background are detected in downgradient Well 1952. This indicates impacts on the perched groundwater from the constituents detected in the subsurface soil.

Total uranium data in groundwater for samples collected from the 1000-series and the 2000-series wells are presented in Table 4-13. Upgradient wells in the perched aquifer (Well 1035 and Well 1947) detected total uranium concentrations from on site screening results that ranged from 2.3 μg/L to 11 μg/L. Downgradient wells (Well 1038, Well 1952, and Well 1950) detected concentrations that ranged from 4.11 μg/L to 55.8 μg/L. These data suggest that uranium has leached into the perched groundwater from the waste unit. Table 4-2A, which contains leachate results, indicates that the waste material is leachable and confirms its potential impact on the perched groundwater.

Upgradient wells in the Upper Great Miami Aquifer (Wells 2027, 2949, and 2951) had total uranium concentrations ranging from 0.378 μg/L to 11.0 μg/L. The highest result of 11.0 μg/L was from well 2027, which is located near an Operable Unit 1 waste pit. The downgradient wells had concentrations ranging from 0.5 μg/L to 4.7 μg/L. The highest concentration was found in Well 2052, which is cross-gradient and 300 feet northeast from the waste unit. The groundwater flow direction (see Figure 3-33) indicates that this well would not be impacted by the landfill. The wells which are directly down gradient (Wells 2947 and 2953) had values of 0.5 μg/L and 1.23 μg/L respectively, and are below the total uranium background value of 2.00 μg/L. This indicates that the



1950	06/08/93	
U234	5.06	pCi/L
U238	4.83	pCi/L
U-Total	11	ug/L
Th-Total	5.96	ug/L
NP237	1.94	pCi/L
Pu238	0.144	pCi/L
Th232	0.654	pCi/L
U235/236	0.208	pCi/L

1035					
	05/25/88	11/15/88	01/06/90	05/05/93	UNITS
U234	4.6	ND	ND	ND	pCi/L
U238	3.9	1.2	2.88	ND	pCi/L
U-Total	17	ND	8.19	ND	ug/L
Th228	4	ND	1.94	ND	pCi/L
Th230	4.6	ND	2.03	ND	pCi/L
Th232	2.6	ND	ND	ND	pCi/L
NP237	1.0	ND	ND	0.30	pCi/L
Pu238	ND	ND	ND	0.67	pCi/L
Pu239/240	ND	ND	ND	0.380	pCi/L
Ra226	2.0	ND	ND	0.67	pCi/L

1719	05/05/93
DRY	

1952	05/15/93	
U234	12	pCi/L
U238	15.2	pCi/L
U235/236	0.432	pCi/L
U-Total	55.8	ug/L
Th228	14	pCi/L
Th230	13.8	pCi/L
Th232	11.5	pCi/L
Th-Total	104	ug/L
Ra226	5.11	pCi/L
Pu238	0.169	pCi/L
SR90	1.35	pCi/L

1038							
	05/11/88	11/20/88	02/05/89	06/18/89	08/13/89	05/05/93	UNITS
U234	1.7	2.3	ND	3.1	ND	2.34	pCi/L
U238	1.4	1.2	1.5	2	1.3	1.67	pCi/L
U-Total	5	4.5	ND	5	ND	4.95	ug/L
NP237	ND	ND	ND	ND	ND	0.480	ug/L
Pu239/240	ND	ND	ND	ND	ND	0.160	ug/L
U235/236	ND	ND	ND	ND	ND	0.05	ug/L

FIGURE 4-5
RADIONUCLIDES IN
1000-SERIES WELLS
DETECTED ABOVE BACKGROUND
IN THE SOLID WASTE LANDFILL

TABLE 4-11

SOLID WASTE LANDFILL
GROUNDWATER[a] - 1000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	2	3	.149	.168	2
Antimony		mg/L	.000	0	1	0	0	0
Arsenic		mg/L	.050	1	9	.35	.35	1
Barium		mg/L	.450	10	11	.04	.125	0
Beryllium		mg/L	.002	0	3	0	0	0
Cadmium		mg/L	.005	3	9	.007	.0128	3
Calcium		mg/L	123.837	11	11	81.7	156	6
Chromium		mg/L	.035	4	11	.023	.039	2
Cobalt		mg/L	.000	0	3	0	0	0
Copper		mg/L	.030	2	11	.011	.016	0
Iron		mg/L	3.440	10	11	.009	1.15	0
Lead		mg/L	.015	2	11	.003	.005	0
Magnesium		mg/L	48.546	11	11	29.9	82.4	7
Manganese		mg/L	.050	9	9	.028	.379	6
Mercury		mg/L	.000	1	9	.0012	.0012	1
Molybdenum		mg/L	.025	3	9	.029	.0377	3
Nickel		mg/L	.026	3	11	.0226	.133	2
Potassium		mg/L	26.976	9	9	.958	2.4	0
Selenium		mg/L	.000	0	9	0	0	0
Silicon		mg/L	.000	1	1	7.55	7.55	1
Silver		mg/L	.040	2	11	.0139	.014	0
Sodium		mg/L	47.982	9	9	6.8	37.5	0
Thallium		mg/L	.000	1	1	.337	.337	1
Vanadium		mg/L	.020	2	3	.026	.0279	2
Zinc		mg/L	.032	3	3	.0087	.016	0
RADIONUCLIDES								
NP-237	UNFL	pCi/L	.000	1	8	1	1	1
PU-238	UNFL	pCi/L	.000	0	8	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	8	0	0	0
RA-226	UNFL	pCi/L	1.000	1	8	2	2	1
RA-228	UNFL	pCi/L	5.200	1	8	5	5	0
RU-106	UNFL	pCi/L	.000	0	1	0	0	0
SR-90	UNFL	pCi/L	.000	0	7	0	0	0
TC-99	UNFL	pCi/L	.000	0	8	0	0	0

See footnote at end of table

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TABLE 4-11
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
TH-228	UNFL	pCi/L	1.040	1	8	4	4	1
TH-230	UNFL	pCi/L	2.000	1	8	4.6	4.6	1
TH-232	UNFL	pCi/L	.000	1	8	2.6	2.6	1
TH-TOTAL	UNFL	ug/L	3.000	0	6	0	0	0
U-234	UNFL	pCi/L	1.900	6	8	1.2	4.6	2
U-235/236	UNFL	pCi/L	.000	0	8	0	0	0
U-238	UNFL	pCi/L	1.070	7	8	1	3.9	6
U-TOTAL	UNFL	ug/L	4.000	8	8	2	17	3
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	3	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Butanone	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	0	3	0	0	0
Benzene	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroform	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	1	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	3	0	0	0
Styrene	UNFL	ug/L	.000	0	1	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	3	0	0	0
Toluene	UNFL	ug/L	.000	0	3	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	3	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-11
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Alkalinity as CaCO3	UNFL	mg/L	.000	1	1	535	535	0
Ammonia	UNFL	mg/L	4.340	5	9	.16	.3	0
Chloride	UNFL	mg/L	46.100	9	10	2	25.2	0
Fluoride	UNFL	mg/L	1.298	10	10	.36	.76	0
Nitrate	UNFL	mg/L	.462	4	6	.1	.58	1
Nitrate/nitrite	UNFL	mg/L	.000	0	1	0	0	0
Phenols	UNFL	mg/L	.000	3	8	.02	.02	0
Phosphorus	UNFL	mg/L	.206	8	9	.022	4.9	5
Sulfate	UNFL	mg/L	138.192	10	10	50.3	296.2	5
Sulfide	UNFL	mg/L	.000	0	1	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	3	4	.16	.42	0
Total Organic Carbon	UNFL	mg/L	.000	1	3	7.34	7.34	1
Total Organic Halides	UNFL	mg/L	.000	3	8	.0105	.0612	3
Total Organic Nitrogen	UNFL	mg/L	.000	5	7	.1	4.6	5

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

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TABLE 4-12

SOLID WASTE LANDFILL
GROUNDWATER[a] - 1000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	5	8	.216	53.2	5
Antimony		mg/L	.000	0	8	0	0	0
Arsenic		mg/L	.050	5	8	.0011	.0044	0
Barium		mg/L	.450	8	8	.0425	.466	1
Beryllium		mg/L	.002	1	8	.0022	.0022	1
Cadmium		mg/L	.005	2	8	.0032	.0033	0
Calcium		mg/L	123.837	8	8	90.5	398	4
Chromium		mg/L	.035	1	8	.0583	.0583	1
Cobalt		mg/L	.000	3	8	.0037	.0256	3
Copper		mg/L	.030	1	8	.0705	.0705	1
Cyanide		mg/L	.000	0	4	0	0	0
Iron		mg/L	3.440	5	8	.524	75	2
Lead		mg/L	.015	2	8	.001	.0314	1
Magnesium		mg/L	48.546	8	8	33.3	130	6
Manganese		mg/L	.050	8	8	.0232	1.9	6
Mercury		mg/L	.000	0	8	0	0	0
Molybdenum		mg/L	.025	3	8	.0141	.026	1
Nickel		mg/L	.026	3	8	.0044	.118	2
Potassium		mg/L	26.976	8	8	1.33	15.4	0
Selenium		mg/L	.000	0	8	0	0	0
Silicon		mg/L	.000	8	8	6.36	72.1	8
Silver		mg/L	.040	1	8	.0201	.0201	0
Sodium		mg/L	47.982	8	8	8.42	17.3	0
Thallium		mg/L	.000	0	8	0	0	0
Vanadium		mg/L	.020	1	8	.118	.118	1
Zinc		mg/L	.032	3	8	.0194	.212	1
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	6	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	1	6	25.6	25.6	1
GROSS BETA	UNFL	pCi/L	.000	3	6	13.3	178	3
NP-237	UNFL	pCi/L	.000	2	4	.3	1.94	2
PU-238	UNFL	pCi/L	.000	3	6	.144	.67	3
PU-239/240	UNFL	pCi/L	.000	0	6	0	0	0
RA-226	UNFL	pCi/L	1.000	3	6	.193	5.11	1

See footnote at end of table

000322

TABLE 4-12
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	5.200	1	6	3.72	3.72	0
RU-106	UNFL	pCi/L	.000	0	6	0	0	0
SR-90	UNFL	pCi/L	.000	2	6	.9	1.35	2
TC-99	UNFL	pCi/L	.000	0	6	0	0	0
TH-228	UNFL	pCi/L	1.040	2	6	.566	14	1
TH-230	UNFL	pCi/L	2.000	4	6	.26	13.8	1
TH-232	UNFL	pCi/L	.000	2	6	.654	11.5	2
TH-TOTAL	UNFL	ug/L	3.000	2	6	5.96	104	2
U-234	UNFL	pCi/L	1.900	6	6	1.1	12	5
U-235/236	UNFL	pCi/L	.000	3	6	.208	.432	3
U-238	UNFL	pCi/L	1.070	6	6	.67	15.2	5
U-TOTAL	UNFL	ug/L	4.000	6	6	2.05	55.8	5
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	1	4	16	16	1
1,2-Dichloroethene (Total)	UNFL	ug/L	.000	0	0	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	4	0	0	0
2-Butanone	UNFL	ug/L	.000	0	4	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	4	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	4	0	0	0
Acetone	UNFL	ug/L	.000	0	2	0	0	0
Benzene	UNFL	ug/L	.000	0	4	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	4	0	0	0
Bromoform	UNFL	ug/L	.000	0	4	0	0	0
Bromomethane	UNFL	ug/L	.000	0	4	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	4	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	4	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Chloroethane	UNFL	ug/L	.000	0	4	0	0	0
Chloroform	UNFL	ug/L	.000	0	4	0	0	0
Chloromethane	UNFL	ug/L	.000	0	2	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	4	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	4	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-12
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Styrene	UNFL	ug/L	.000	0	4	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	4	0	0	0
Toluene	UNFL	ug/L	.000	0	4	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	4	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	4	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	4	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	4	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	4	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	4	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	4	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	4	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-12
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	2	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	3	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Carbazole	UNFL	ug/L	.000	0	4	0	0	0
Chrysene	UNFL	ug/L	.000	0	4	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	4	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Fluorene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	4	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Isophorone	UNFL	ug/L	.000	0	4	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	4	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	4	0	0	0
Naphthalene	UNFL	ug/L	.000	0	4	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	4	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	4	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	4	0	0	0
Phenol	UNFL	ug/L	.000	0	4	0	0	0
Pyrene	UNFL	ug/L	.000	0	4	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	4	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-12
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	4	0	0	0
Aldrin	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	4	0	0	0
Dieldrin	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	4	0	0	0
Endrin	UNFL	ug/L	.000	0	4	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	4	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	4	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	4	0	0	0
Toxaphene	UNFL	ug/L	.000	0	4	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	4	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
beta-BHC	UNFL	ug/L	.000	0	4	0	0	0
delta-BHC	UNFL	ug/L	.000	0	4	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	4	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	4	4	44.3	625	0
Alkalinity as CaCO3	UNFL	mg/L	.000	0	0	0	0	0
Ammonia	UNFL	mg/L	4.340	2	4	.11	.12	0
Chloride	UNFL	mg/L	46.100	4	4	3.95	27	0
Fluoride	UNFL	mg/L	1.298	4	4	.19	1.25	0
Nitrate	UNFL	mg/L	.462	3	3	.16	.93	2
Phenols	UNFL	mg/L	.000	0	4	0	0	0
Phosphorus	UNFL	mg/L	.206	1	1	.91	.91	1
Sulfate	UNFL	mg/L	138.192	4	4	67.9	190.7	2
Sulfide	UNFL	mg/L	.000	1	4	7.87	7.87	1

See footnote at end of table

000326

TABLE 4-12
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	3	4	.21	.67	0
Total Organic Carbon	UNFL	mg/L	.000	2	4	2.24	2.8	2
Total Organic Halides	UNFL	mg/L	.000	2	4	.0148	.094	2
Total Organic Nitrogen	UNFL	mg/L	.000	3	4	.21	.67	3
Total Phosphorous	UNFL	mg/L	.000	3	3	.03	.21	0

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

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TABLE 4-13

TOTAL URANIUM IN SAMPLES COLLECTED DURING PHASE II FROM WELLS IN THE SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

1000-SERIES WELLS

Well and Location	Date	Sample		Total Uranium (μg/L)
UPGRADIENT				
1035 (north)	5/5/93	111554	on-site analysis	2.3
Located upgradient outside of waste unit completed within		111555	on-site analysis	2.3
sand lense in till		111553	off-site analysis	2.55
1947 (east)	4/28/93	111650	on-site analysis	10
Located upgradient from waste unit	7/28/93	120488	on-site analysis	11
DOWNGRADIENT				
1038 (south)	5/5/93	111550	on-site analysis	5.0
located directly downgradient of waste unit completed in		111551	on-site analysis	4.7
sand unit		111548	off-site analysis	4.11
		111549	off-site analysis	4.95
1950 (west)	6/8/93	115485	on-site analysis	21
Located downgradient from north end of waste unit		115480	off-site analysis	7.67
completed in sand unit within till				
1952 (south)	5/15/93	115469	on-site analysis	23
Located directly downgradient of waste unit. Completed		115468	off-site analysis	15.8
in till unit above sand lense		115471	off-site analysis	55.8

000378

TABLE 4-13
(Continued)

2000-SERIES WELLS

Well and Location	Date	Sample		Total Uranium (μg/L)
UPGRADIENT				
2027 (southwest)	4/23/93	111544	on-site analysis	11
Located adjacent to a waste pond near Operable Unit 1		111543	off-site analysis	9.15
2949 (north)	4/17/93	111490	on-site analysis	0.4
Located upgradient of waste unit		115479	off-site analysis	0.378
2951 (west)	5/1/93	111538	on-site analysis	0.8
Located upgradient of waste unit		115478	off-site analysis	0.781
		111536	off-site analysis	1.08
DOWNGRADIENT				
2037 (east)	4/22/93	111541	on-site analysis	4.6
Located within waste unit		111540	off-site analysis	4.5
2052 (northeast)	4/29/93	111547	on-site analysis	4.7
Located cross-gradient and approximately 300 feet northeast from waste unit		111546	off-site analysis	3.45
2947 (east)	5/19/93	111573	on-site analysis	0.5
Located downgradient of waste unit		115474	on-site analysis	0.5
2953 (south)	6/23/93	115490	on-site analysis	1.1
Located downgradient of waste unit		115488	off-site analysis	1.23

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Upper Great Miami Aquifer has not been impacted by total uranium from the Solid Waste Landfill.

A comparison of strontium-90 and total thorium values from upgradient and downgradient wells (see Figure 3-31) indicates an increase in downgradient Well 1952. The following table summarizes these data:

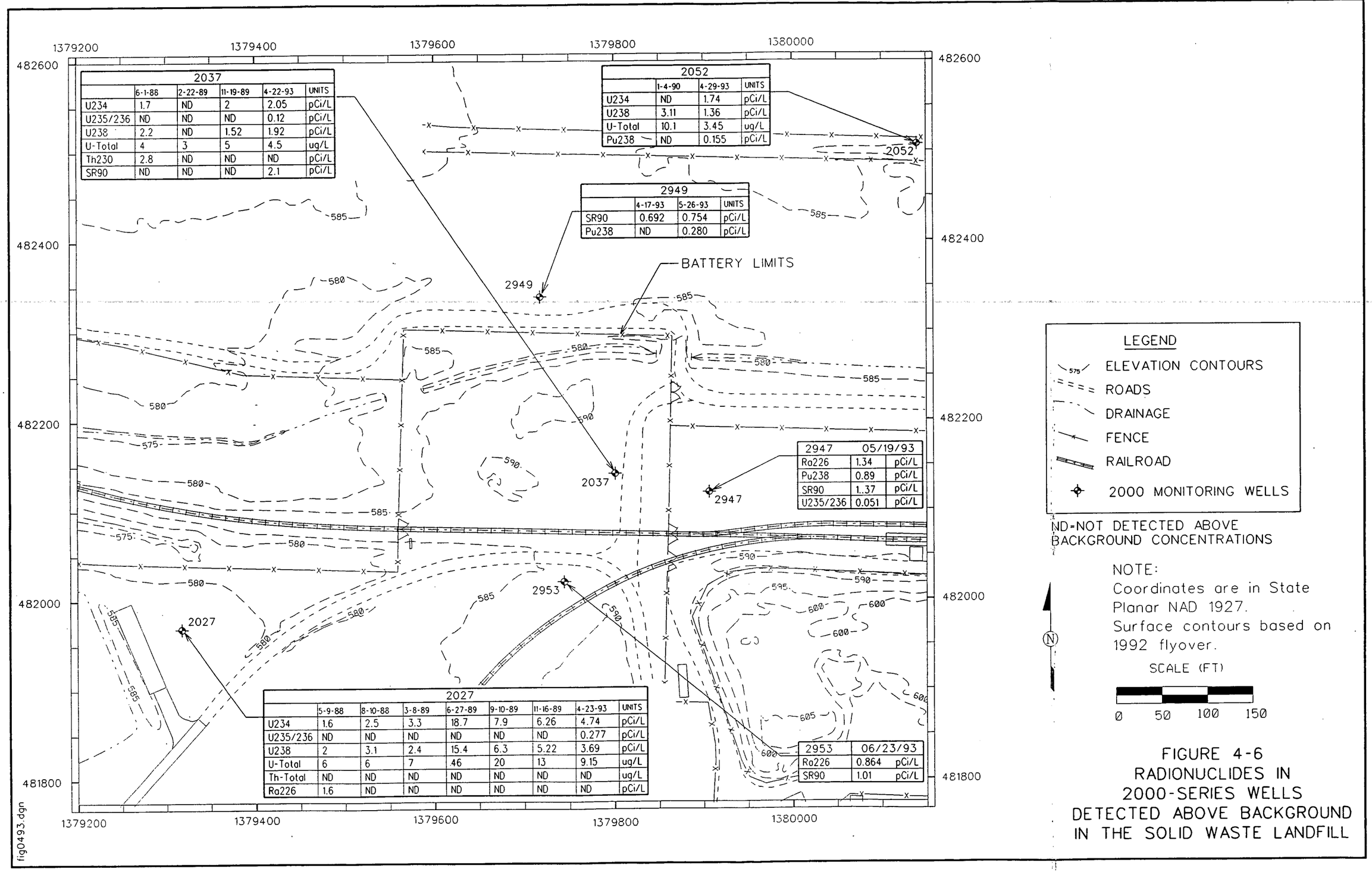
Type of Well	Well No.	Strontium-90	Total Thorium
Upgradient	1035	ND*	<3 pCi/L
Downgradient	1950	ND	5.96 pCi/L
	1038	ND	<3 pCi/L
	1952	0.900 μg/L	104 pCi/L

*ND = Not detected

These data indicate that thorium and strontium-90 have leached from the waste subunit into perched groundwater.

Groundwater analytical data from the 2000-series and 3000-series wells were compared to background data from the regional aquifer. A summary of analytes detected and their frequency of detection is presented in Table 4-14 and Table 4-15. Phase I sampling of three 2000-series wells detected sixteen metals, isotopes of two elements, and eight organic compounds that exceeded background concentrations. Phase II sampling of six 2000-series wells detected seven metals, isotopes of five elements (neptunium-237, plutonium-238, radium-228 strontium-90, and uranium-235/236 were not detected above background for Phase I), and two organic compounds that exceeded background (acetone, which was also detected in Phase I, and butyl benzyl phthalate), which was not detected in Phase I.

Upgradient 2000-series wells (Well 2949 and Well 2951), shown in Figure 4-6, did not detect total uranium above background. Downgradient 2000-series wells (Well 2947 and Well 2953) did not detect concentrations of total uranium above background (Figure 3-33 shows groundwater flow direction). This indicates that total uranium did not impact the regional aquifer outside the battery limits. Uranium-235/236 was detected at a concentration of 0.05 pCi/L in downgradient Well 2947



2037					
	6-1-88	2-22-89	11-19-89	4-22-93	UNITS
U234	1.7	ND	2	2.05	pCi/L
U235/236	ND	ND	ND	0.12	pCi/L
U238	2.2	ND	1.52	1.92	pCi/L
U-Total	4	3	5	4.5	ug/L
Th230	2.8	ND	ND	ND	pCi/L
SR90	ND	ND	ND	2.1	pCi/L

2052			
	1-4-90	4-29-93	UNITS
U234	ND	1.74	pCi/L
U238	3.11	1.36	pCi/L
U-Total	10.1	3.45	ug/L
Pu238	ND	0.155	pCi/L

2949			
	4-17-93	5-26-93	UNITS
SR90	0.692	0.754	pCi/L
Pu238	ND	0.280	pCi/L

2947	05/19/93	
Ra226	1.34	pCi/L
Pu238	0.89	pCi/L
SR90	1..37	pCi/L
U235/236	0.051	pCi/L

2027								
	5-9-88	8-10-88	3-8-89	6-27-89	9-10-89	11-16-89	4-23-93	UNITS
U234	1.6	2.5	3.3	18.7	7.9	6.26	4.74	pCi/L
U235/236	ND	ND	ND	ND	ND	ND	0.277	pCi/L
U238	2	3.1	2.4	15.4	6.3	5.22	3.69	pCi/L
U-Total	6	6	7	46	20	13	9.15	ug/L
Th-Total	ND	ND	ND	ND	ND	ND	ND	ug/L
Ra226	1.6	ND	ND	ND	ND	ND	ND	pCi/L

2953	06/23/93	
Ra226	0.864	pCi/L
SR90	1.01	pCi/L

FIGURE 4-6
RADIONUCLIDES IN
2000-SERIES WELLS
DETECTED ABOVE BACKGROUND
IN THE SOLID WASTE LANDFILL

TABLE 4-14

SOLID WASTE LANDFILL
GROUNDWATER[a] - 2000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	5	8	.0133	.275	3
Antimony		mg/L	.006	2	6	.0005	.0008	0
Arsenic		mg/L	.050	1	12	.0022	.0022	0
Barium		mg/L	.436	14	15	.0537	.15	0
Beryllium		mg/L	.002	1	8	.0024	.0024	1
Cadmium		mg/L	.005	2	13	.007	.0103	2
Calcium		mg/L	134.783	15	15	106	449	10
Chromium		mg/L	.041	6	15	.03	.0527	1
Cobalt		mg/L	.000	1	8	.0128	.0128	1
Copper		mg/L	.120	1	15	.012	.012	0
Iron		mg/L	4.000	15	15	2.7	8.06	6
Lead		mg/L	.015	4	13	.0034	.0066	0
Magnesium		mg/L	37.961	15	15	27.3	72.2	6
Manganese		mg/L	.050	13	13	.218	1.94	13
Mercury		mg/L	.001	1	12	.00078	.00078	1
Molybdenum		mg/L	.025	3	11	.01	.026	1
Nickel		mg/L	.024	2	15	.0257	.0371	2
Osmium		mg/L	.000	0	1	0	0	0
Potassium		mg/L	3.077	12	13	.917	6.4	3
Selenium		mg/L	.004	1	12	.004	.004	0
Silver		mg/L	.014	2	14	.0187	.02	2
Sodium		mg/L	51.267	13	13	10.9	34	0
Thallium		mg/L	.000	0	6	0	0	0
Tin		mg/L	.000	0	1	0	0	0
Vanadium		mg/L	.025	4	8	.015	.0438	3
Zinc		mg/L	.095	8	8	.026	.228	3
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0		0	0	0
NP-237	UNFL	pCi/L	.000	0	11	0	0	0
PU-238	UNFL	pCi/L	.000	0	11	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	11	0	0	0
RA-226	UNFL	pCi/L	1.200	2	9	1.2	1.6	1
RA-228	UNFL	pCi/L	4.000	0	9	0	0	0

See footnote at end of table

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TABLE 4-14
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RU-106	UNFL	pCi/L	.000	0		0	0	0
SR-90	UNFL	pCi/L	.000	0	11	0	0	0
TC-99	UNFL	pCi/L	36.000	0	11	0	0	0
TH-228	UNFL	pCi/L	1.400	0	11	0	0	0
TH-230	UNFL	pCi/L	1.700	0	11	0	0	0
TH-232	UNFL	pCi/L	.000	0	11	0	0	0
TH-TOTAL	UNFL	ug/L	2.000	0	9	0	0	0
U-234	UNFL	pCi/L	1.200	4	10	1.6	3.3	4
U-235/236	UNFL	pCi/L	.000	0	11	0	0	0
U-238	UNFL	pCi/L	.900	4	10	2	2.4	4
U-TOTAL	UNFL	ug/L	2.000	6	11	2	7	5
VOLATILE ORGANICS								
1,1,1,2-Tetrachloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	5	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	5	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	5	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	8	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2,3-Trichloropropane	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dibromo-3-chloropropane	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dibromoethane	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	3	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	5	0	0	0
1,4-Dioxane	UNFL	ug/L	.000	0	2	0	0	0
2-Butanone	UNFL	ug/L	.000	0	3	0	0	0
2-Chloro-1,3-butadiene	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	5	0	0	0
3-Chloropropene	UNFL	ug/L	.000	0	2	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	5	0	0	0
Acetone	UNFL	ug/L	.000	1	8	4	4	1
Acetonitrile	UNFL	ug/L	.000	0	2	0	0	0
Acrolein	UNFL	ug/L	.000	0	2	0	0	0
Acrylonitrile	UNFL	ug/L	.000	0	2	0	0	0
Benzene	UNFL	ug/L	.000	0	4	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	5	0	0	0
Bromoform	UNFL	ug/L	.000	0	5	0	0	0
Bromomethane	UNFL	ug/L	.000	0	4	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	4	0	0	0
Carbon disulfide	UNFL	ug/L	.000	2	5	10	11	2

See footnote at end of table

TABLE 4-14
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Chlorobenzene	UNFL	ug/L	.000	0	3	0	0	0
Chloroethane	UNFL	ug/L	.000	0	5	0	0	0
Chloroform	UNFL	ug/L	.000	0	5	0	0	0
Chloromethane	UNFL	ug/L	.000	0	5	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	5	0	0	0
Dibromomethane	UNFL	ug/L	.000	0	2	0	0	0
Dichlorodifluoromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethyl cyanide	UNFL	ug/L	.000	0	1	0	0	0
Ethyl methacrylate	UNFL	ug/L	.000	0	2	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	5	0	0	0
Iodomethane	UNFL	ug/L	.000	0	2	0	0	0
Isobutyl alcohol	UNFL	ug/L	.000	0	2	0	0	0
Methacrylonitrile	UNFL	ug/L	.000	0	1	0	0	0
Methyl methacrylate	UNFL	ug/L	.000	0	2	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	8	0	0	0
Pyridine	UNFL	ug/L	.000	0	1	0	0	0
Styrene	UNFL	ug/L	.000	0	5	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	8	0	0	0
Toluene	UNFL	ug/L	.000	0	7	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	6	0	0	0
Trichlorofluoromethane	UNFL	ug/L	.000	0	2	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	5	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	5	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	5	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	5	0	0	0
trans-1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	5	0	0	0
trans-1,4-Dichloro-2-butene	UNFL	ug/L	.000	0	2	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4,5-Tetrachlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,3,5-Trinitrobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,3-Dinitrobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,4-Naphthoquinone	UNFL	ug/L	.000	0	2	0	0	0
1-Naphthylamine	UNFL	ug/L	.000	0	2	0	0	0
2,3,4,6-Tetrachlorophenol	UNFL	ug/L	.000	0	0	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

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TABLE 4-14
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2,6-Dichlorophenol	UNFL	ug/L	.000	0	0	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2-Acetylaminofluorene	UNFL	ug/L	.000	0	2	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	3	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	2	0	0	0
2-Naphthylamine	UNFL	ug/L	.000	0	2	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Picoline	UNFL	ug/L	.000	0	2	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	4	0	0	0
3,3'-Dimethylbenzidine	UNFL	ug/L	.000	0	2	0	0	0
3-Methylcholanthrene	UNFL	ug/L	.000	0	2	0	0	0
3-Methylphenol	UNFL	ug/L	.000	0	0	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	3	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Aminobiphenyl	UNFL	ug/L	.000	0	2	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
4-Nitroquinoline-1-oxide	UNFL	ug/L	.000	0	2	0	0	0
5-Nitro-o-toluidine	UNFL	ug/L	.000	0	1	0	0	0
7,12-Dimethylbenz(a)anthracene	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	4	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	4	0	0	0
Acetophenone	UNFL	ug/L	.000	0	2	0	0	0
Aniline	UNFL	ug/L	.000	0	2	0	0	0
Anthracene	UNFL	ug/L	.000	0	4	0	0	0
Aramite	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

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TABLE 4-14
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	2	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	4	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Chrysene	UNFL	ug/L	.000	0	4	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Diallate	UNFL	ug/L	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	4	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Diphenylamine	UNFL	ug/L	.000	0	2	0	0	0
Ethyl methanesulfonate	UNFL	ug/L	.000	0	2	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Fluorene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorophene	UNFL	ug/L	.000	0	0	0	0	0
Hexachloropropene	UNFL	ug/L	.000	0	2	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Isophorone	UNFL	ug/L	.000	0	4	0	0	0
Isosafrole	UNFL	ug/L	.000	0	2	0	0	0
Methapyrilene	UNFL	ug/L	.000	0	2	0	0	0
Methyl methanesulfonate	UNFL	ug/L	.000	0	2	0	0	0
Methyl parathion	UNFL	ug/L	.000	0	4	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	4	0	0	0
N-Nitrosodi-n-butylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiethylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	1	4	3	3	1
N-Nitrosomethylethylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosomorpholine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosopiperidine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosopyrrolidine	UNFL	ug/L	.000	0	2	0	0	0
Naphthalene	UNFL	ug/L	.000	0	4	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	4	0	0	0
O,O,O-Triethylphosphorothioate	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-14
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Parathion	UNFL	ug/L	.000	0	4	0	0	0
Pentachlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
Pentachloroethane	UNFL	ug/L	.000	0	2	0	0	0
Pentachloronitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	2	0	0	0
Phenacetin	UNFL	ug/L	.000	0	2	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	4	0	0	0
Phenol	UNFL	ug/L	.000	0	2	0	0	0
Pronamide	UNFL	ug/L	.000	0	2	0	0	0
Pyrene	UNFL	ug/L	.000	0	4	0	0	0
Safrole	UNFL	ug/L	.000	0	2	0	0	0
Sulfotep	UNFL	ug/L	.000	0	1	0	0	0
a,a-Dimethylphenethylamine	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	3	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	1	4	10	10	1
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	2	4	3	7	2
o-Toluidine	UNFL	ug/L	.000	0	1	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	3	0	0	0
p-Dimethylaminoazobenzene	UNFL	ug/L	.000	0	2	0	0	0
p-Phenylenediamine	UNFL	ug/L	.000	0	2	0	0	0
2,4,5-T	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-TP (Silvex)	UNFL	ug/L	.000	0	1	0	0	0
2,4-D	UNFL	ug/L	.000	0	1	0	0	0
Dinoseb	UNFL	ug/L	.000	0	2	0	0	0
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	5	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	5	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	4	0	0	0
Aldrin	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	5	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	5	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	5	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	5	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	5	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	5	0	0	0
Dieldrin	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	5	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	5	0	0	0

See footnote at end of table

TABLE 4-14
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS (Continued)								
Endosulfan-I	UNFL	ug/L	.000	0	5	0	0	0
Endrin	UNFL	ug/L	.000	0	4	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	5	0	0	0
Heptachlor	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	5	0	0	0
Isodrin	UNFL	ug/L	.000	0	2	0	0	0
Kepone	UNFL	ug/L	.000	0	2	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	5	0	0	0
Toxaphene	UNFL	ug/L	.000	0	5	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	5	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
beta-BHC	UNFL	ug/L	.000	0	5	0	0	0
delta-BHC	UNFL	ug/L	.000	0	5	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	4	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	5	0	0	0
DIOXIN/FURAN								
2,3,7,8-TCDD	UNFL	ug/L	.000	0	2	0	0	0
2,3,7,8-TCDF	UNFL	ug/L	.000	0	1	0	0	0
Heptachlorodibenzo-p-dioxin	UNFL	ug/L	.000	0	2	0	0	0
Heptachlorodibenzofuran	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorodibenzo-p-dioxin	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorodibenzo-p-dioxins	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorodibenzofuran	UNFL	ug/L	.000	1	3	.00038	.00038	1
Octachlorodibenzo-p-dioxin	UNFL	ug/L	.000	0	2	0	0	0
Octachlorodibenzofuran	UNFL	ug/L	.000	0	2	0	0	0
Pentachlorodibenzo-p-dioxin	UNFL	ug/L	.000	0	3	0	0	0
Pentachlorodibenzofuran	UNFL	ug/L	.000	1	3	.00031	.00031	1
Tetrachlorodibenzo-p-dioxin	UNFL	ug/L	.000	0	2	0	0	0
Tetrachlorodibenzofuran	UNFL	ug/L	.000	1	3	.00022	.00022	1
Azinphosmethyl	UNFL	ug/L	.000	0	3	0	0	0
Demeton	UNFL	ug/L	.000	0	3	0	0	0
Diazinon	UNFL	ug/L	.000	0	3	0	0	0
Dimethoate	UNFL	ug/L	.000	0	1	0	0	0
Disulfoton	UNFL	ug/L	.000	0	4	0	0	0
Ethion	UNFL	ug/L	.000	0	3	0	0	0
Famphur	UNFL	ug/L	.000	0	1	0	0	0
Malathion	UNFL	ug/L	.000	0	3	0	0	0
Phorate	UNFL	ug/L	.000	0	1	0	0	0
Thionazin	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-14
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	3.240	9	11	.1	.68	0
Chloride	UNFL	mg/L	120.000	13	14	12	140	1
Fluoride	UNFL	mg/L	.929	14	14	.12	1.8	1
Nitrate	UNFL	mg/L	10.000	1	8	.11	.11	0
Phenols	UNFL	mg/L	.000	4	11	.012	.17	0
Phosphate	UNFL	mg/L	.000	1	1	1	1	0
Phosphorus	UNFL	mg/L	.679	7	8	.02	26.4	2
Sulfate	UNFL	mg/L	352.992	11	11	125	726	3
Sulfide	UNFL	mg/L	30.400	0	2	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	6	8	.39	5	2
Total Organic Carbon	UNFL	mg/L	3.764	2	4	1.49	3.33	0
Total Organic Halides	UNFL	mg/L	.021	3	11	.017	.028	1
Total Organic Nitrogen	UNFL	mg/L	.652	7	10	.22	4.36	3

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

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TABLE 4-15

SOLID WASTE LANDFILL
GROUNDWATER[a] - 2000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	6	11	.0688	1.23	4
Antimony		mg/L	.006	1	11	.0029	.0029	0
Arsenic		mg/L	.050	2	11	.0025	.0025	0
Barium		mg/L	.436	11	11	.0671	.112	0
Beryllium		mg/L	.002	0	11	0	0	0
Cadmium		mg/L	.005	0	11	0	0	0
Calcium		mg/L	134.783	11	11	109	258	8
Chromium		mg/L	.041	1	11	.0198	.0198	0
Cobalt		mg/L	.000	0	11	0	0	0
Copper		mg/L	.120	0	11	0	0	0
Cyanide		mg/L	.000	0	6	0	0	0
Iron		mg/L	4.000	11	11	2.32	7.23	6
Lead		mg/L	.015	2	11	.0028	.0045	0
Magnesium		mg/L	37.961	11	11	24.3	61.3	1
Manganese		mg/L	.050	11	11	.202	.657	11
Mercury		mg/L	.001	0	11	0	0	0
Molybdenum		mg/L	.025	0	11	0	0	0
Nickel		mg/L	.024	0	11	0	0	0
Potassium		mg/L	3.077	11	11	1.24	6.95	3
Selenium		mg/L	.004	0	11	0	0	0
Silicon		mg/L	6.140	11	11	5.91	8.1	9
Silver		mg/L	.014	0	11	0	0	0
Sodium		mg/L	51.267	11	11	11.5	41.9	0
Thallium		mg/L	.000	0	11	0	0	0
Vanadium		mg/L	.025	0	11	0	0	0
Zinc		mg/L	.095	4	11	.0069	.0584	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	8	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0	8	0	0	0
GROSS BETA	UNFL	pCi/L	.000	1	8	12.6	12.6	1
NP-237	UNFL	pCi/L	.000	1	5	.318	.318	1
PU-238	UNFL	pCi/L	.000	3	8	.052	.278	3
PU-239/240	UNFL	pCi/L	.000	0	8	0	0	0
RA-226	UNFL	pCi/L	1.200	8	8	.222	1.34	1

See footnote at end of table

TABLE 4-15
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	4.000	1	8	4.31	4.31	1
RU-106	UNFL	pCi/L	.000	0	8	0	0	0
SR-90	UNFL	pCi/L	.000	6	8	.754	2.38	6
TC-99	UNFL	pCi/L	36.000	0	8	0	0	0
TH-228	UNFL	pCi/L	1.400	1	8	.025	.025	0
TH-230	UNFL	pCi/L	1.700	3	8	.313	.712	0
TH-232	UNFL	pCi/L	.000	0	8	0	0	0
TH-TOTAL	UNFL	ug/L	2.000	0	8	0	0	0
U-234	UNFL	pCi/L	1.200	7	8	.17	4.74	3
U-235/236	UNFL	pCi/L	.000	3	8	.05	.277	3
U-238	UNFL	pCi/L	.900	7	8	.16	3.69	3
U-TOTAL	UNFL	ug/L	2.000	7	8	.378	9.15	3
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	7	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	7	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	7	0	0	0
2-Butanone	UNFL	ug/L	.000	0	7	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	7	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	7	0	0	0
Acetone	UNFL	ug/L	.000	1	7	2	2	1
Benzene	UNFL	ug/L	.000	0	7	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	7	0	0	0
Bromoform	UNFL	ug/L	.000	0	7	0	0	0
Bromomethane	UNFL	ug/L	.000	0	7	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	7	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	7	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
Chloroethane	UNFL	ug/L	.000	0	7	0	0	0
Chloroform	UNFL	ug/L	.000	0	7	0	0	0
Chloromethane	UNFL	ug/L	.000	0	7	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	7	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	7	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	7	0	0	0
Styrene	UNFL	ug/L	.000	0	7	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	7	0	0	0

See footnote at end of table

TABLE 4-15
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Toluene	UNFL	ug/L	.000	0	7	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	7	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	6	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	7	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	7	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	7	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	7	0	0	0
SEMIVOLATILE ORGANICS (Continued)								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	7	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	7	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	7	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	6	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	7	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	7	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	7	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	7	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	7	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	7	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	7	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	7	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	7	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	7	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	7	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	7	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	7	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	7	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	6	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	7	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	7	0	0	0
Anthracene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	7	0	0	0

See footnote at end of table

TABLE 4-15
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	7	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	4	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	6	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	2	7	1	1	2
Carbazole	UNFL	ug/L	.000	0	7	0	0	0
Chrysene	UNFL	ug/L	.000	0	7	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	7	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	7	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	7	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	7	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	7	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	7	0	0	0
Fluorene	UNFL	ug/L	.000	0	7	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	6	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	7	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	7	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	7	0	0	0
Isophorone	UNFL	ug/L	.000	0	7	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	7	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	4	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	7	0	0	0
Naphthalene	UNFL	ug/L	.000	0	7	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	7	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	7	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	7	0	0	0
Phenol	UNFL	ug/L	.000	0	7	0	0	0
Pyrene	UNFL	ug/L	.000	0	7	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	7	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	7	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	7	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	7	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	7	0	0	0
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	7	0	0	0

See footnote at end of table

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TABLE 4-15
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS (Continued)								
4.4'-DDE	UNFL	ug/L	.000	0	7	0	0	0
4.4'-DDT	UNFL	ug/L	.000	0	7	0	0	0
Aldrin	UNFL	ug/L	.000	0	7	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	7	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	7	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	7	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	7	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	7	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	7	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	7	0	0	0
Dieldrin	UNFL	ug/L	.000	0	7	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	7	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	7	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	7	0	0	0
Endrin	UNFL	ug/L	.000	0	7	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	7	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	7	0	0	0
Heptachlor	UNFL	ug/L	.000	0	7	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	7	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	7	0	0	0
Toxaphene	UNFL	ug/L	.000	0	7	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	7	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	7	0	0	0
beta-BHC	UNFL	ug/L	.000	0	7	0	0	0
delta-BHC	UNFL	ug/L	.000	0	7	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	7	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	7	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	5	5	235	410	0
Ammonia	UNFL	mg/L	3.240	3	5	.15	.34	0
Chloride	UNFL	mg/L	120.000	5	5	30.87	135.2	1
Fluoride	UNFL	mg/L	.929	5	5	.15	.26	0
Nitrate	UNFL	mg/L	10.000	1	1	2.33	2.33	0
Phenols	UNFL	mg/L	.000	0	5	0	0	0
Phosphorus	UNFL	mg/L	.679	2	3	.03	.04	0
Sulfate	UNFL	mg/L	352.992	5	5	128.4	333.3	0

See footnote at end of table

TABLE 4-15
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Sulfide	UNFL	mg/L	30.400	1	5	5.66	5.66	0
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	4	4	.11	.58	0
Total Organic Carbon	UNFL	mg/L	3.764	2	5	1.55	3.2	0
Total Organic Halides	UNFL	mg/L	.021	2	5	.0104	.0242	1
Total Organic Nitrogen	UNFL	mg/L	.652	4	5	.11	.24	0
Total Phosphorous	UNFL	mg/L	.000	1	2	.1	.1	0

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

000395

and at a maximum concentration of 0.277 pCi/L in Well 2037, which is within the boundaries of the landfill. This may indicate a minimal impact on the regional aquifer from the landfill outside the battery limits. Radium was detected in downgradient Wells 2947 and 2953 (Figure 4-6), and upgradient Well 2027 (see Figure 3-33 for flow direction). Radium was not detected in Well 2037, which is in the landfill boundaries and upgradient from Well 2947 and 2953. This suggests that radium from the landfill did not impact the groundwater, and the source for the radium is from outside the landfill. A groundwater sample collected from Well 2037, located inside the limits of the Solid Waste Landfill detected elevated uranium isotopes, strontium-90, and carbon disulfide. These constituents were detected in samples collected from Well 1037, located adjacent to Well 2037. Construction information indicates that Well 1037 was completed to within three feet of the top of the regional aquifer. A water level hydrograph prepared for Well 1037 showed that water levels vary from 549.76 to 555.8 feet above MSL approximately 20-25 feet below the perched water in the landfill. These data may indicate that leakage from Well 1037 may be influencing water quality in Well 2037. The downgradient wells didn't exhibit this contamination. This would indicate a localized impact on the upper GMA from the landfill due to poor well construction. Well 1037 has been plugged and abandoned.

A comparison of selected data from paired wells is shown in the following table:

Regional Aquifer	2000-Series Well / 1000-Series Well	Strontium-90	Total Uranium	Total Thorium
Upgradient Well	2949	0.754 μg/L	0.378 pCi/L	<2 pCi/L
	1035	ND*	2.55 pCi/L	<3 pCi/L
	2951	1.740 μg/L	0.781 pCi/L	<2 pCi/L
Upgradient Well	1950	ND	7.67 pCi/L	5.96 pCi/L
Downgradient Well	2953	1.010 μg/L	1.23 pCi/L	<2 pCi/L
	1952	ND	55.8 pCi/L	104 pCi/L

*ND = Not detected

The data indicate that strontium-90, total uranium, and total thorium, which are detected in elevated concentrations in the perched zone, are detected below background concentrations in regional aquifer wells upgradient and downgradient of the Solid Waste Landfill. A comparison of nested wells, for example, Wells Nos. 1952 and 2953 data indicates that vertical leakage from the perched zone to the regional aquifer is not evident.

4.2.5 Biota

The ecological impacts from material left after remediation will be addressed in the Site-Wide Ecological Risk Assessment that will be prepared as part of the Operable Unit 5 RI/FS.

4.2.6 Summary

The following conclusions concerning the Solid Waste Landfill are made:

- The surface soil COCs detected above background in subsurface samples include antimony, arsenic, beryllium, neptunium-237, plutonium-238, radium-226, radium-228, thorium-228, thorium-232, uranium-234, uranium-235/236, uranium-238, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. An additional radionuclide, strontium-90, was also detected above background. These constituents were found in varying concentrations throughout the surface soils for the Solid Waste Landfill.

- The concentrations for subsurface soils constituents are found in varying degrees throughout the landfill. The surface soil COCs detected above background in the subsurface samples include antimony, arsenic, beryllium, neptunium-237, plutonium-238, plutonium-239/240, radium-224, radium-226, radium-228, technetium, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235/236, uranium-238, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Other radionuclides detected above background were lead-210 and strontium-90. The greatest concentrations for the radionuclides are detected in the vicinity of location 11036 (south-central portion). The highest concentrations for the organic constituents are in the vicinity of locations 11039 (east-central) and 1719 (central).

- A comparison of upstream and downstream surface water samples from the Solid Waste Landfill drainage ditch indicated total uranium concentrations of approximate equal value. A standing surface water sample from well 1947, which is east and upstream of the landfill, had total uranium results within the same order of magnitude as the surface water samples collected from the drainage. This indicates that the Solid Waste Landfill may not be the only source for the uranium detected in the drainage ditch.

  Sediment samples were collected downstream of the Solid Waste Landfill and were compared to the Solid Waste Landfill surface soil samples. The surface soil COCs beryllium, neptunium-237, plutonium-238, strontium-90, uranium-234, uranium-235/236, uranium-238, benzo(a)pyrene, benzo(b)fluoranthene, carbazole, and indeno(1,2,3-

cd)pyrene were also detected in the downstream sediment sample. This would indicate that the migration of contaminants from the Solid Waste Landfill to the drainage ditch north of the landfill may have occurred.

- The surface soil COCs, arsenic, beryllium, neptunium-237, radium-226, thorium-228,thorium-230, thorium-232, plutonium-238, uranium-234, uranium-235/236, and uranium-238 (also a cross-media groundwater COC), were detected above background in the perched groundwater. An additional radionuclide, strontium-90, was also detected above background in two Phase II samples. Radium-226, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235/236, and uranium-238 were detected above background downgradient of the landfill indicating an impact on the perched groundwater. Surface soil COC, uranium-235/236, was detected directly downgradient of the landfill in the regional aquifer. However, the concentration was 0.05 pCi/L which would indicate a minimal impact, if any, on the regional aquifer from the landfill.

- A sample of perched groundwater downgradient from the waste unit detected elevated concentrations of uranium-234, uranium-235/236, uranium-238, thorium-232, and strontium-90, which indicates an impact from the landfill. Downgradient wells in the regional aquifer had concentrations of radium-226, plutonium-238, strontium-90, and uranium-235/236 above background. A comparison of data from paired wells indicates that vertical constituent migration from the perched aquifer into the regional aquifer is not evident (see Figures 3-31 and 3-33 for flow directions).

- Waste material analyzed in investigation trenches and borings appears to be of relatively low-level radioactivity, and may have originated in nonprocess areas of the operating plant (i.e., laboratory and manufacturing areas).

- One waste disposal cell (Cell 1) was identified in photographs and in trench and boring samples. Elsewhere, waste material was found mixed with soil at depths from the surface to about 10 feet deep, which is approximately the depth of the fill/till interface. Aerial photos also indicate that there may have been some randomly placed pits, which may have been deeper than ten feet to accommodate waste disposal.

- Concentrations of radionuclides and organic compounds were detected above background levels in surface soil and subsurface soil. Leachate samples from all trenches contained detectable levels of radionuclides and leachate from Trench 2 contained detectable levels of organics.

The surface soil COCs arsenic, beryllium, neptunium, radium, thorium, plutonium, and uranium (also a cross-media groundwater COC) were detected above background in the perched groundwater. An additional radionuclides, strontium-90, was also detected above background in two Phase II samples. Radium, thorium, and uranium were detected above background downgradient of the landfill indicating an impact on the perched groundwater. Surface soil COC, uranium-235/236, was detected

directly downgradient of the landfill in the regional aquifer. However, the concentration was 0.05 pCi/L which would indicate a minimal impact, if any, on the regional aquifer from the landfill.

4.3 LIME SLUDGE PONDS

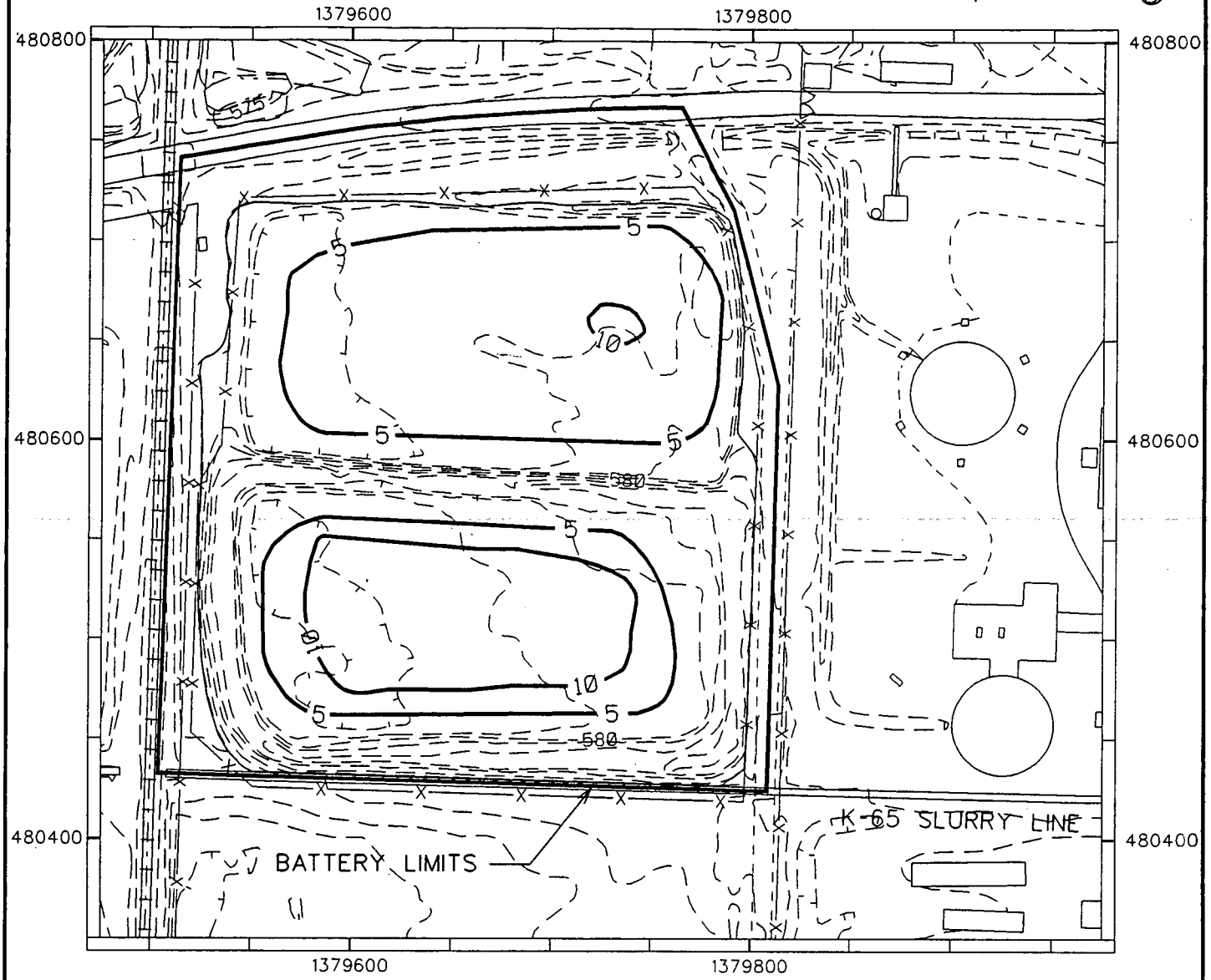
Analytical results for samples collected from the Lime Sludge Ponds are presented in Appendix D. Sample analyses that detected analytes at concentrations above background (defined in Table 4-1A) will be discussed in this section. Geology and hydrogeology of the Lime Sludge Ponds referred to in this section were discussed in more detail in Section 3.3. The North Lime Sludge Pond was in use at the time of the Phase I and Phase II investigations. The South Lime Sludge Pond was no longer in use at the time of the Phase I and Phase II investigations.

4.3.1 Volume and Physical Characteristics

The volume of lime sludge material was estimated by means of digitized topographic maps, boring log data, pre-construction engineering drawings, and interpolation using Intergraph Corporation Microstation PC software. Volume calculations are summarized in Figure 4-7. The volume sludge and berm material is calculated to be approximately 16,493 cubic yards of lime sludge and 5,556 cubic yards of berm material making a total of 22,049 cubic yards of material. The K-65 slurry line trench that is parallel to the south battery limits of the waste unit has not been included in the estimate of waste material, because the line is part of OU3.

Lime sludge was generated from the water softening process applied to the raw groundwater feed for the process plant. The sludge material is the residue of lime used in the softening process and consists primarily of calcium carbonate and precipitated metal hydroxides. Additional solid material has been contributed from solids settled out of coal pile storm runoff and from solids contained in boiler plant blowdown water.

The south battery limit is marked by the K-65 slurry line trench. The trench is a six foot deep by two foot wide concrete containment that houses several steel pipelines. Steel plates that are loosely fitted cover the trench. The K-65 slurry line was used to pump waste material containing high levels of uranium, thorium, and radium to the silos (Operable Unit 4). Waste material in the concrete trench consists of surface runoff that has leaked through gaps between the plates and a thin layer of silt carried in by erosion of the surrounding area. Water in the trench drains west to a sump and then



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- DRAINAGE
- 5 WASTE MATERIAL THICKNESS CONTOUR
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

N

SCALE (FT)
0 80 160

VOLUME OF SLUDGE	= 16,493 Cu. Yds.
VOLUME OF BERMS	= 5,556 Cu.Yds.
TOTAL FILL VOLUME	= 22,409 Cu.Yds.

FIGURE 4-7
VOLUME OF
WASTE MATERIAL,
LIME SLUDGE PONDS

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is pumped out of the trench to the site wide storm water treatment system. No waste material originating from the pipeline was observed in the trench during the Phase II investigation.

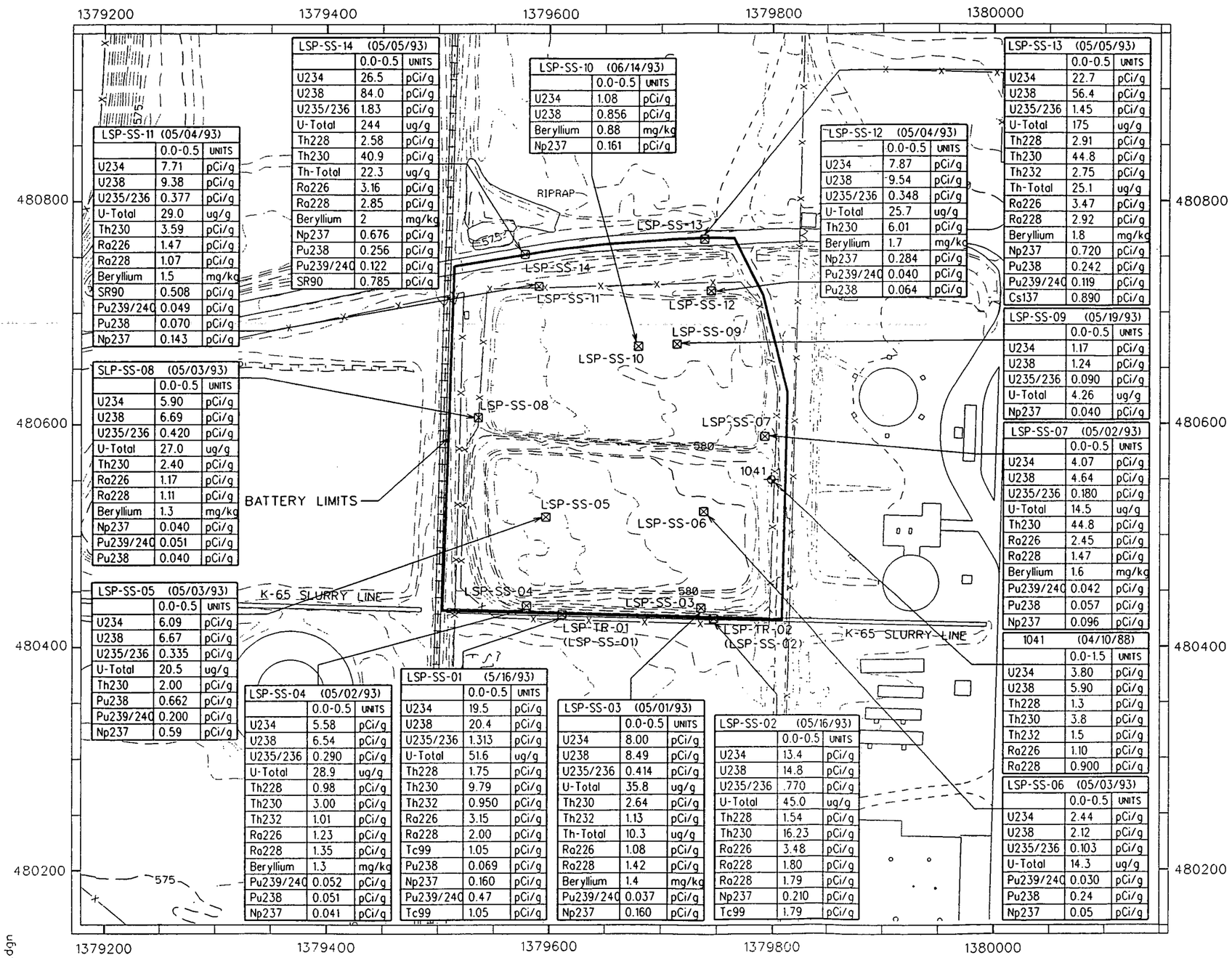
4.3.2 Surface and Subsurface Media

Surface soil samples were collected during Phase II from the ponds, berms, and from the roadway that is at the north boundary. The analytical data values that are detected above background are included in Appendix D, Table D-2A. A summary of the constituents in surface soil is provided in Table 4-16.

Twenty-one metals, isotopes of eight elements, and 21 organic compounds were detected in 14 surface soil samples collected during Phase II. There were three detections of Aroclor-1254 in samples collected from the northeast corner of the north pond and from the adjacent road and are shown on Figure 4-8A.

Concentrations of metals were detected in surface samples collected from sludge, berm material, the roads, and from the K-65 trench. Beryllium and copper were detected in all areas at concentrations above background. Lead was detected in samples from the road and trench, but not in the berms or pond material. Calcium concentrations in sludge were greater than 279 mg/kg, while berm materials had a maximum concentration of 67 mg/kg calcium. Samples collected from within the K-65 trench detected the highest concentrations for the metals: copper (67.1 mg/kg), zinc (107 mg/kg), lead (240 mg/kg), and chromium (54.2 mg/kg). A comparison of berm, roadway, and sludge sample metal concentrations suggests that these are composed of three separate materials.

Radionuclides detected in surface soil are shown on Figure 4-8. The radionuclide data indicate that activity of isotopes is highest in the samples collected within the K-65 slurry line trench (samples LSP-TR-01 and LSP-TR-02), and in samples from the road surface (LSP-SS-13 and LSP-SS-14). A sample collected adjacent to the roads east of the ponds (LSP-SS-07) and samples collected adjacent to the K-65 slurry line trench (LSP-SS-03 and LSP-SS-04) also detected elevated concentrations of uranium and thorium isotopes. These data suggest that the surface soil outside of the ponds has been impacted by the K-65 slurry line trench, possibly during maintenance of the line, and by carry-over from spillage on the haul roads in the former Production Area. There has been verbal confirmation of the type of maintenance activities occurring for th K-65 slurry trench; i.e., the removal of damaged pipe from the trench and the placement of this pipe on the surface adjacent to the trench with possible



LSP-SS-11 (05/04/93)	0.0-0.5	UNITS
U234	7.71	pCi/g
U238	9.38	pCi/g
U235/236	0.377	pCi/g
U-Total	29.0	ug/g
Th230	3.59	pCi/g
Ra226	1.47	pCi/g
Ra228	1.07	pCi/g
Beryllium	1.5	mg/kg
SR90	0.508	pCi/g
Pu239/240	0.049	pCi/g
Pu238	0.070	pCi/g
Np237	0.143	pCi/g

LSP-SS-14 (05/05/93)	0.0-0.5	UNITS
U234	26.5	pCi/g
U238	84.0	pCi/g
U235/236	1.83	pCi/g
U-Total	244	ug/g
Th228	2.58	pCi/g
Th230	40.9	pCi/g
Th-Total	22.3	ug/g
Ra226	3.16	pCi/g
Ra228	2.85	pCi/g
Beryllium	2	mg/kg
Np237	0.676	pCi/g
Pu238	0.256	pCi/g
Pu239/240	0.122	pCi/g
SR90	0.785	pCi/g

LSP-SS-10 (06/14/93)	0.0-0.5	UNITS
U234	1.08	pCi/g
U238	0.856	pCi/g
Beryllium	0.88	mg/kg
Np237	0.161	pCi/g

LSP-SS-12 (05/04/93)	0.0-0.5	UNITS
U234	7.87	pCi/g
U238	9.54	pCi/g
U235/236	0.348	pCi/g
U-Total	25.7	ug/g
Th230	6.01	pCi/g
Beryllium	1.7	mg/kg
Np237	0.284	pCi/g
Pu239/240	0.040	pCi/g
Pu238	0.064	pCi/g

LSP-SS-13 (05/05/93)	0.0-0.5	UNITS
U234	22.7	pCi/g
U238	56.4	pCi/g
U235/236	1.45	pCi/g
U-Total	175	ug/g
Th228	2.91	pCi/g
Th230	44.8	pCi/g
Th232	2.75	pCi/g
Th-Total	25.1	ug/g
Ra226	3.47	pCi/g
Ra228	2.92	pCi/g
Beryllium	1.8	mg/kg
Np237	0.720	pCi/g
Pu238	0.242	pCi/g
Pu239/240	0.119	pCi/g
Cs137	0.890	pCi/g

LSP-SS-09 (05/19/93)	0.0-0.5	UNITS
U234	1.17	pCi/g
U238	1.24	pCi/g
U235/236	0.090	pCi/g
U-Total	4.26	ug/g
Np237	0.040	pCi/g

SLP-SS-08 (05/03/93)	0.0-0.5	UNITS
U234	5.90	pCi/g
U238	6.69	pCi/g
U235/236	0.420	pCi/g
U-Total	27.0	ug/g
Th230	2.40	pCi/g
Ra226	1.17	pCi/g
Ra228	1.11	pCi/g
Beryllium	1.3	mg/kg
Np237	0.040	pCi/g
Pu239/240	0.051	pCi/g
Pu238	0.040	pCi/g

LSP-SS-07 (05/02/93)	0.0-0.5	UNITS
U234	4.07	pCi/g
U238	4.64	pCi/g
U235/236	0.180	pCi/g
U-Total	14.5	ug/g
Th230	44.8	pCi/g
Ra226	2.45	pCi/g
Ra228	1.47	pCi/g
Beryllium	1.6	mg/kg
Pu239/240	0.042	pCi/g
Pu238	0.057	pCi/g
Np237	0.096	pCi/g

LSP-SS-05 (05/03/93)	0.0-0.5	UNITS
U234	6.09	pCi/g
U238	6.67	pCi/g
U235/236	0.335	pCi/g
U-Total	20.5	ug/g
Th230	2.00	pCi/g
Pu238	0.662	pCi/g
Pu239/240	0.200	pCi/g
Np237	0.59	pCi/g

1041 (04/10/88)	0.0-1.5	UNITS
U234	3.80	pCi/g
U238	5.90	pCi/g
Th228	1.3	pCi/g
Th230	3.8	pCi/g
Th232	1.5	pCi/g
Ra226	1.10	pCi/g
Ra228	0.900	pCi/g

LSP-SS-04 (05/02/93)	0.0-0.5	UNITS
U234	5.58	pCi/g
U238	6.54	pCi/g
U235/236	0.290	pCi/g
U-Total	28.9	ug/g
Th228	0.98	pCi/g
Th230	3.00	pCi/g
Th232	1.01	pCi/g
Ra226	1.23	pCi/g
Ra228	1.35	pCi/g
Beryllium	1.3	mg/kg
Pu239/240	0.052	pCi/g
Pu238	0.051	pCi/g
Np237	0.041	pCi/g

LSP-SS-01 (5/16/93)	0.0-0.5	UNITS
U234	19.5	pCi/g
U238	20.4	pCi/g
U235/236	1.313	pCi/g
U-Total	51.6	ug/g
Th228	1.75	pCi/g
Th230	9.79	pCi/g
Th232	0.950	pCi/g
Ra226	3.15	pCi/g
Ra228	2.00	pCi/g
Tc99	1.05	pCi/g
Pu238	0.069	pCi/g
Np237	0.160	pCi/g
Pu239/240	0.47	pCi/g
Tc99	1.05	pCi/g

LSP-SS-03 (05/01/93)	0.0-0.5	UNITS
U234	8.00	pCi/g
U238	8.49	pCi/g
U235/236	0.414	pCi/g
U-Total	35.8	ug/g
Th230	2.64	pCi/g
Th232	1.13	pCi/g
Th-Total	10.3	ug/g
Ra226	1.08	pCi/g
Ra228	1.42	pCi/g
Beryllium	1.4	mg/kg
Pu239/240	0.037	pCi/g
Np237	0.160	pCi/g

LSP-SS-02 (05/16/93)	0.0-0.5	UNITS
U234	13.4	pCi/g
U238	14.8	pCi/g
U235/236	.770	pCi/g
U-Total	45.0	ug/g
Th228	1.54	pCi/g
Th230	16.23	pCi/g
Ra226	3.48	pCi/g
Ra228	1.80	pCi/g
Ra228	1.79	pCi/g
Np237	0.210	pCi/g
Tc99	1.79	pCi/g

LSP-SS-06 (05/03/93)	0.0-0.5	UNITS
U234	2.44	pCi/g
U238	2.12	pCi/g
U235/236	0.103	pCi/g
U-Total	14.3	ug/g
Pu239/240	0.030	pCi/g
Pu238	0.24	pCi/g
Np237	0.05	pCi/g

LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- SURFACE SAMPLE
- 1000 MONITORING WELLS

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100 200

FIGURE 4-8
RADIONUCLIDES, AND METALS OF CONCERN IN SURFACE SOIL SAMPLES DETECTED ABOVE BACKGROUND IN THE LIME SLUDGE PONDS

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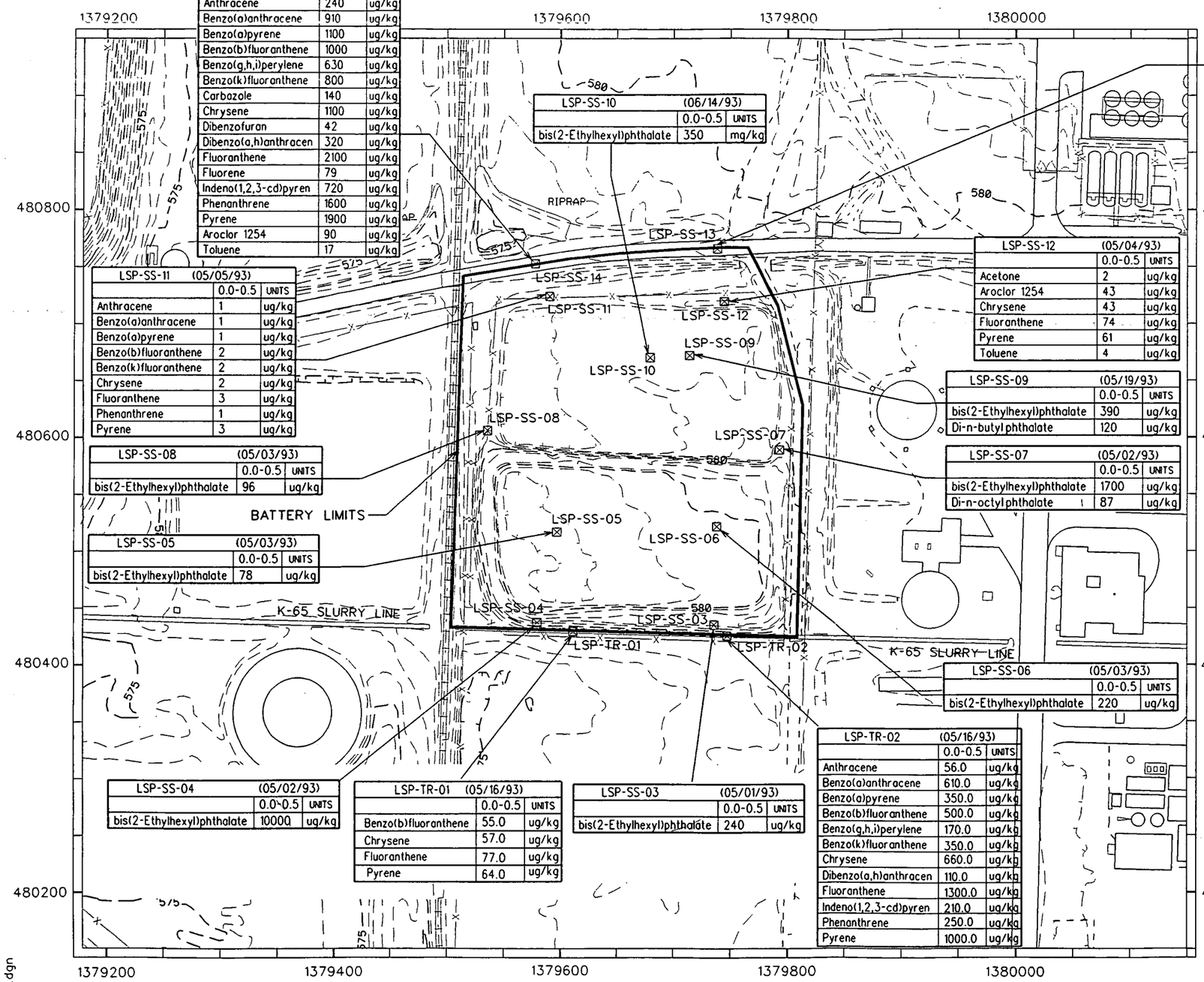

LSP-SS-14	(05/05/93)	
	0.0-0.5	UNITS
Anthracene	240	ug/kg
Benzo(a)anthracene	910	ug/kg
Benzo(a)pyrene	1100	ug/kg
Benzo(b)fluoranthene	1000	ug/kg
Benzo(g,h,i)perylene	630	ug/kg
Benzo(k)fluoranthene	800	ug/kg
Carbazole	140	ug/kg
Chrysene	1100	ug/kg
Dibenzofuran	42	ug/kg
Dibenzo(a,h)anthracen	320	ug/kg
Fluoranthene	2100	ug/kg
Fluorene	79	ug/kg
Indeno(1,2,3-cd)pyren	720	ug/kg
Phenanthrene	1600	ug/kg
Pyrene	1900	ug/kg
Aroclor 1254	90	ug/kg
Toluene	17	ug/kg

LSP-SS-10	(06/14/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	350	mg/kg

LSP-SS-13	(05/05/93)	
	0.0-0.5	UNITS
Anthracene	120	ug/kg
Aroclor 1254	590	ug/kg
Benzo(a)anthracene	630	ug/kg
Benzo(a)pyrene	820	ug/kg
Benzo(b)fluoranthene	680	ug/kg
Benzo(k)fluoranthene	660	ug/kg
Carbazole	71	ug/kg
Chrysene	720	ug/kg
Dibenzo(a,h)anthracen	240	ug/kg
Di-n-butylphthalate	42	ug/kg
Fluoranthene	1300	ug/kg
Indeno(1,2,3-cd)pyren	580	ug/kg
Phenanthrene	640	ug/kg
Pyrene	1100	ug/kg
Toluene	7	ug/kg

LSP-SS-11	(05/05/93)	
	0.0-0.5	UNITS
Anthracene	1	ug/kg
Benzo(a)anthracene	1	ug/kg
Benzo(a)pyrene	1	ug/kg
Benzo(b)fluoranthene	2	ug/kg
Benzo(k)fluoranthene	2	ug/kg
Chrysene	2	ug/kg
Fluoranthene	3	ug/kg
Phenanthrene	1	ug/kg
Pyrene	3	ug/kg

LSP-SS-12	(05/04/93)	
	0.0-0.5	UNITS
Acetone	2	ug/kg
Aroclor 1254	43	ug/kg
Chrysene	43	ug/kg
Fluoranthene	74	ug/kg
Pyrene	61	ug/kg
Toluene	4	ug/kg

LSP-SS-09	(05/19/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	390	ug/kg
Di-n-butylphthalate	120	ug/kg

LSP-SS-08	(05/03/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	96	ug/kg

LSP-SS-07	(05/02/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	1700	ug/kg
Di-n-octylphthalate	87	ug/kg

LSP-SS-05	(05/03/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	78	ug/kg

LSP-SS-06	(05/03/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	220	ug/kg

LSP-SS-04	(05/02/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	10000	ug/kg

LSP-TR-01	(05/16/93)	
	0.0-0.5	UNITS
Benzo(b)fluoranthene	55.0	ug/kg
Chrysene	57.0	ug/kg
Fluoranthene	77.0	ug/kg
Pyrene	64.0	ug/kg

LSP-SS-03	(05/01/93)	
	0.0-0.5	UNITS
bis(2-Ethylhexyl)phthalate	240	ug/kg

LSP-TR-02	(05/16/93)	
	0.0-0.5	UNITS
Anthracene	56.0	ug/kg
Benzo(a)anthracene	610.0	ug/kg
Benzo(a)pyrene	350.0	ug/kg
Benzo(b)fluoranthene	500.0	ug/kg
Benzo(g,h,i)perylene	170.0	ug/kg
Benzo(k)fluoranthene	350.0	ug/kg
Chrysene	660.0	ug/kg
Dibenzo(a,h)anthracen	110.0	ug/kg
Fluoranthene	1300.0	ug/kg
Indeno(1,2,3-cd)pyren	210.0	ug/kg
Phenanthrene	250.0	ug/kg
Pyrene	1000.0	ug/kg

LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- SURFACE SAMPLE
- 1000 MONITORING WELLS

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100 200

fig0482.dgn

FIGURE 4-8A
ORGANIC COMPOUNDS IN SURFACE SOIL SAMPLES DETECTED ABOVE BACKGROUND IN THE LIME SLUDGE PONDS

TABLE 4-16

LIME SLUDGE PONDS
SURFACE SOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	14	14	4070	12800	5
Antimony	mg/kg	.000	0	13	0	0	0
Arsenic	mg/kg	8.200	14	14	3.5	9.5	1
Barium	mg/kg	94.100	14	14	62	101	5
Beryllium	mg/kg	.600	10	14	.47	2	9
Cadmium	mg/kg	.870	7	14	.96	1.2	7
Calcium	mg/kg	4339.170	14	14	20100	350000	14
Chromium	mg/kg	15.500	12	14	5.1	54.2	9
Cobalt	mg/kg	14.160	12	14	4.1	13.8	0
Copper	mg/kg	14.070	14	14	16.5	67.1	14
Cyanide	mg/kg	.270	7	12	.15	.82	5
Iron	mg/kg	21728.170	14	14	3960	74000	5
Lead	mg/kg	26.400	14	14	1.5	240	4
Magnesium	mg/kg	2776.970	14	14	8160	27500	14
Manganese	mg/kg	1348.040	14	14	460	1210	0
Mercury	mg/kg	.120	1	14	.27	.27	1
Molybdenum	mg/kg	.000	3	14	1.6	21	3
Nickel	mg/kg	20.870	12	14	5.2	24.6	4
Potassium	mg/kg	1231.340	12	14	58.7	2080	6
Selenium	mg/kg	.720	2	14	.26	.37	0
Silicon	mg/kg	1797.030	14	14	485	3550	3
Silver	mg/kg	.000	2	14	7.1	20.8	2
Sodium	mg/kg	51.100	14	14	90.1	410	14
Thallium	mg/kg	.580	0	14	0	0	0
Vanadium	mg/kg	30.370	13	14	3.6	39.1	2
Zinc	mg/kg	59.610	13	14	33.6	107	4
RADIONUCLIDES							
CS-137	pCi/g	.710	11	14	.064	.89	1
GROSS ALPHA	pCi/g	.000	12	14	12.9	145	12
GROSS BETA	pCi/g	.000	14	14	7.74	108	14
NP-237	pCi/g	.000	14	14	.04	.72	14
PU-238	pCi/g	.000	11	14	.04	.662	11
PU-239/240	pCi/g	.000	11	14	.03	.47	11
RA-226	pCi/g	1.420	12	14	.205	3.48	6
RA-228	pCi/g	1.250	10	14	.709	2.92	7
RU-106	pCi/g	.000	0	14	0	0	0

TABLE 4-16
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
SR-90	pCi/g	.000	2	13	.508	.785	2
TC-99	pCi/g	.000	2	14	1.05	1.79	2
TH-228	pCi/g	1.430	12	13	.082	2.91	4
TH-230	pCi/g	1.970	13	13	.373	44.8	11
TH-232	pCi/g	1.360	11	12	.037	2.75	1
TH-TOTAL	mg/kg	10.700	13	13	.34	25.1	2
U-234	pCi/g	1.240	14	14	1.08	26.5	12
U-235/236	pCi/g	.150	14	14	.025	1.83	11
U-238	pCi/g	1.220	14	14	.856	84	13
U-TOTAL	mg/kg	3.700	14	14	2.45	244	13
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	14	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	14	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	14	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	14	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	14	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	14	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	14	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	14	0	0	0
2-Butanone	ug/kg	.000	0	14	0	0	0
2-Hexanone	ug/kg	.000	0	14	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	14	0	0	0
Acetone	ug/kg	.000	1	14	2	2	1
Benzene	ug/kg	.000	0	14	0	0	0
Bromodichloromethane	ug/kg	.000	0	14	0	0	0
Bromoform	ug/kg	.000	0	14	0	0	0
Bromomethane	ug/kg	.000	0	14	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	14	0	0	0
Carbon disulfide	ug/kg	.000	0	14	0	0	0
Chlorobenzene	ug/kg	.000	0	14	0	0	0
Chloroethane	ug/kg	.000	0	14	0	0	0
Chloroform	ug/kg	.000	0	14	0	0	0
Chloromethane	ug/kg	.000	0	14	0	0	0
Dibromochloromethane	ug/kg	.000	0	14	0	0	0
Ethylbenzene	ug/kg	.000	0	14	0	0	0
Methylene chloride	ug/kg	.000	0	14	0	0	0
Styrene	ug/kg	.000	0	14	0	0	0
Tetrachloroethene	ug/kg	.000	0	14	0	0	0
Toluene	ug/kg	.000	3	14	4	17	3
Trichloroethene	ug/kg	.000	0	14	0	0	0
Vinyl Acetate	ug/kg	.000	0	9	0	0	0
Vinyl chloride	ug/kg	.000	0	14	0	0	0
Xylenes, Total	ug/kg	.000	0	14	0	0	0

TABLE 4-16
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS							
cis-1,3-Dichloropropene	ug/kg	.000	0	14	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	14	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	14	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	14	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	14	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	14	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	13	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	13	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	13	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	13	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	9	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	14	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	14	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	4	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	14	0	0	0
2-Chlorophenol	ug/kg	.000	0	13	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	14	0	0	0
2-Methylphenol	ug/kg	.000	0	13	0	0	0
2-Nitroaniline	ug/kg	.000	0	14	0	0	0
2-Nitrophenol	ug/kg	.000	0	13	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	14	0	0	0
3-Nitroaniline	ug/kg	.000	0	14	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	9	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	14	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	13	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	14	0	0	0
4-Methylphenol	ug/kg	.000	0	13	0	0	0
4-Nitroaniline	ug/kg	.000	0	11	0	0	0
4-Nitrophenol	ug/kg	.000	0	8	0	0	0
Acenaphthene	ug/kg	.000	0	14	0	0	0
Acenaphthylene	ug/kg	.000	0	14	0	0	0
Anthracene	ug/kg	.000	4	14	1	240	4
Benzo(a)anthracene	ug/kg	.000	4	14	1	910	4
Benzo(a)pyrene	ug/kg	.000	4	14	1	1100	4
Benzo(b)fluoranthene	ug/kg	.000	5	14	2	1000	5
Benzo(g,h,i)perylene	ug/kg	.000	2	14	170	630	2
Benzo(k)fluoranthene	ug/kg	.000	4	14	2	800	4
Benzoic acid	ug/kg	.000	0	7	0	0	0
Benzyl alcohol	ug/kg	.000	0	10	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	10	0	0	0
Carbazole	ug/kg	.000	2	14	71	140	2

TABLE 4-16
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Chrysene	ug/kg	.000	6	14	2	1100	6
Di-n-butyl phthalate	ug/kg	.000	2	14	42	120	2
Di-n-octyl phthalate	ug/kg	.000	1	10	87	87	1
Dibenzo(a,h)anthracene	ug/kg	.000	3	14	110	320	3
Dibenzofuran	ug/kg	.000	1	14	42	42	1
Diethyl phthalate	ug/kg	.000	0	14	0	0	0
Dimethyl phthalate	ug/kg	.000	0	14	0	0	0
Fluoranthene	ug/kg	.000	6	14	3	2100	6
Fluorene	ug/kg	.000	1	14	79	79	1
Hexachlorobenzene	ug/kg	.000	0	14	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	10	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	14	0	0	0
Hexachloroethane	ug/kg	.000	0	14	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	3	14	210	720	3
Isophorone	ug/kg	.000	0	14	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	14	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	1	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	14	0	0	0
Naphthalene	ug/kg	.000	0	14	0	0	0
Nitrobenzene	ug/kg	.000	0	14	0	0	0
Pentachlorophenol	ug/kg	.000	0	13	0	0	0
Phenanthrene	ug/kg	.000	4	14	1	1600	4
Phenol	ug/kg	.000	0	13	0	0	0
Pyrene	ug/kg	.000	6	14	3	1900	6
Tributyl phosphate	ug/kg	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	14	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	14	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	14	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	8	14	78	10000	8
p-Chloroaniline	ug/kg	.000	0	14	0	0	0
PESTICIDES/PCBS							
4,4'-DDD	ug/kg	.000	0	15	0	0	0
4,4'-DDE	ug/kg	.000	0	15	0	0	0
4,4'-DDT	ug/kg	.000	0	15	0	0	0
Aldrin	ug/kg	.000	0	15	0	0	0
Aroclor-1016	ug/kg	.000	0	15	0	0	0
Aroclor-1221	ug/kg	.000	0	15	0	0	0
Aroclor-1232	ug/kg	.000	0	15	0	0	0
Aroclor-1242	ug/kg	.000	0	15	0	0	0
Aroclor-1248	ug/kg	.000	0	15	0	0	0
Aroclor-1254	ug/kg	.000	3	15	43	590	3
Aroclor-1260	ug/kg	.000	0	15	0	0	0

TABLE 4-16
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS (Continued)							
Dieldrin	ug/kg	.000	0	15	0	0	0
Endosulfan II	ug/kg	.000	0	15	0	0	0
Endosulfan sulfate	ug/kg	.000	0	15	0	0	0
Endosulfan-I	ug/kg	.000	0	15	0	0	0
Endrin	ug/kg	.000	0	15	0	0	0
Endrin aldehyde	ug/kg	.000	0	15	0	0	0
Endrin ketone	ug/kg	.000	0	15	0	0	0
Heptachlor	ug/kg	.000	0	15	0	0	0
Heptachlor epoxide	ug/kg	.000	0	15	0	0	0
Methoxychlor	ug/kg	.000	0	15	0	0	0
Toxaphene	ug/kg	.000	0	15	0	0	0
alpha-BHC	ug/kg	.000	0	15	0	0	0
alpha-Chlordane	ug/kg	.000	0	15	0	0	0
beta-BHC	ug/kg	.000	0	15	0	0	0
delta-BHC	ug/kg	.000	0	15	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	15	0	0	0
gamma-Chlordane	ug/kg	.000	0	15	0	0	0

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subsequent leakage of residual contaminated material onto the surface. As the K-65 slurry line trench is part of Operable Unit 3, it will be fully characterized during the Operable Unit 3 RI.
Organic analytical data is shown on Figure 4-8A. Maximum concentrations for organic compounds detected in surface samples of the sludge included bis(2-ethy(hexyl)phthalate (390 μg/kg) and di-n-butyl phthalate (120 μg/kg). Maximum concentrations for the following compounds were detected in samples from the road along the north boundary: chrysene (1100 μg/kg), and benzo(a)pyrene (1100 μg/kg), Aroclor 1254 (590 μg/kg), benzo(k)fluoranthene (800 μg/kg). A comparison of the number of organic compounds detected in surface samples and their location suggests that the haul road north of the Lime Sludge Ponds has contributed to the organic compounds detected in surface soil samples from the unit. Aroclor-1254 is an indicator that the source for organic compounds in LSP-SS-12 (north pond berm) is the same as for LSP-SS-13 and LSP-SS-14 (the haul road). Concentrations of PCBs were higher in samples collected from the road (590 μg/kg and 90 μg/kg, Aroclor-1254) when compared to pond surface samples (one detection of 43 μg/kg Aroclor-1254 at LSP-SS-12).

A comparison of Phase I and Phase II surface soil samples with the CIS data (Appendix D-16A) indicates that the parameters detected in the CIS were detected in Phase I and Phase II and within the same order of magnitude.

Concentrations of constituents detected above background in subsurface samples collected from the Lime Sludge Ponds are presented in Appendix D in Table D-2B and Table D-2C. A summary of the analytes for Phase I and II is provided in Table 4-17 and Table 4-18. Twelve metals, isotopes of three elements, and one organic compound (2-hexanone) were detected above background for Phase I from two sample locations. From thirty sample locations during Phase II there were twenty four metals (Aluminum, Arsenic, Barium, Cobalt, Iron, Lead, Manganese, Mercury, Nickel, Potassium, Selenium, and Vanadium were detected above background for Phase II but not for Phase I; and Thallium was detected above background for Phase I but not Phase II), isotopes of eight elements (cesium-137, neptunium-237, plutonium-238, plutonium-239/240, radium-226, radium-228, technetium-99, thorium-total, and uranium-235/236 were detected above background for Phase II but not Phase I), and thirteen organic compounds were detected above background for Phase II.

The concentration of selected metals in sludge and underlying soil was compared as shown in Table 4-19. The data shows that soil background concentrations were most frequently exceeded in sludge

TABLE 4-17

LIME SLUDGE PONDS
SUBSURFACE SOIL
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	2	2	2700	4580	0
Antimony	mg/kg	.000	2	2	20	22.1	2
Arsenic	mg/kg	9.570	2	2	1.7	4.2	0
Barium	mg/kg	119.170	2	2	63.4	71.1	0
Beryllium	mg/kg	.620	2	2	.65	.76	2
Boron	mg/kg	42.950	2	2	28.9	37	0
Cadmium	mg/kg	.910	2	2	2.5	4	2
Calcium	mg/kg	150000.000	2	2	323000	339000	2
Chromium	mg/kg	20.680	2	2	28.1	28.2	2
Cobalt	mg/kg	15.750	2	2	3.9	5.1	0
Copper	mg/kg	20.030	2	2	8.4	20.5	1
Cyanide	mg/kg	.130	1	2	1.7	1.7	1
Iron	mg/kg	30700.000	2	2	3240	3980	0
Lead	mg/kg	15.580	2	2	.98	2	0
Magnesium	mg/kg	42648.210	2	2	13300	19600	0
Manganese	mg/kg	1300.000	2	2	499	515	0
Mercury	mg/kg	.290	0	2	0	0	0
Molybdenum	mg/kg	2.700	2	2	5.7	8.2	2
Nickel	mg/kg	34.350	2	2	9	11.7	0
Potassium	mg/kg	1979.990	1	2	68.7	68.7	0
Selenium	mg/kg	.000	0	2	0	0	0
Silicon	mg/kg	1593.080	2	2	3220	5920	2
Silver	mg/kg	.000	2	2	21.7	22	2
Sodium	mg/kg	285.000	2	2	327	599	2
Thallium	mg/kg	.490	1	2	.51	.51	1
Tin	mg/kg	.000	0	2	0	0	0
Vanadium	mg/kg	37.800	2	2	17.1	17.5	0
Zinc	mg/kg	72.580	2	2	8.2	13.8	0
RADIONUCLIDES							
CS-137	pCi/g	.000	0	6	0	0	0
NP-237	pCi/g	.000	0	4	0	0	0
PU-238	pCi/g	.000	0	6	0	0	0
PU-239/240	pCi/g	.000	0	4	0	0	0
RA-226	pCi/g	1.470	5	6	.35	1.1	0

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TABLE 4-17
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RA-228	pCi/g	1.310	2	6	.9	1.2	0
RU-106	pCi/g	.000	0	6	0	0	0
SR-90	pCi/g	.560	1	6	6	6	1
TC-99	pCi/g	.000	0	3	0	0	0
TH-228	pCi/g	1.330	5	6	.7	1.46	1
TH-230	pCi/g	1.880	4	6	1.3	3.8	2
TH-232	pCi/g	1.260	3	6	.9	1.5	2
TH-TOTAL	mg/kg	9.470	0	2	0	0	0
U-234	pCi/g	1.040	5	6	.8	3.8	2
U-235/236	pCi/g	.150	0	6	0	0	0
U-238	pCi/g	1.120	5	6	.7	5.9	2
U-TOTAL	mg/kg	3.400	2	2	2.08	5.49	1
VOLATILE ORGANICS							
1,1,1,2-Tetrachloroethane	ug/kg	.000	0	2	0	0	0
1,1,1-Trichloroethane	ug/kg	.000	0	2	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	2	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	2	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	2	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	2	0	0	0
1,2,3-Trichloropropane	ug/kg	.000	0	2	0	0	0
1,2-Dibromo-3-chloropropane	ug/kg	.000	0	2	0	0	0
1,2-Dibromoethane	ug/kg	.000	0	2	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	2	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	2	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	2	0	0	0
2-Butanone	ug/kg	.000	0	2	0	0	0
2-Chloro-1,3-butadiene	ug/kg	.000	0	2	0	0	0
2-Hexanone	ug/kg	.000	1	2	2	2	1
3-Chloropropene	ug/kg	.000	0	2	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	2	0	0	0
Acetone	ug/kg	.000	0	2	0	0	0
Acetonitrile	ug/kg	.000	0	2	0	0	0
Acrolein	ug/kg	.000	0	2	0	0	0
Benzene	ug/kg	.000	0	2	0	0	0
Bromodichloromethane	ug/kg	.000	0	2	0	0	0
Bromoform	ug/kg	.000	0	2	0	0	0
Bromomethane	ug/kg	.000	0	2	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	2	0	0	0
Carbon disulfide	ug/kg	.000	0	2	0	0	0

000441

TABLE 4-17
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Chlorobenzene	ug/kg	.000	0	2	0	0	0
Chloroethane	ug/kg	.000	0	2	0	0	0
Chloroform	ug/kg	.000	0	2	0	0	0
Chloromethane	ug/kg	.000	0	2	0	0	0
Dibromochloromethane	ug/kg	.000	0	2	0	0	0
Dibromomethane	ug/kg	.000	0	2	0	0	0
Ethyl cyanide	ug/kg	.000	0	2	0	0	0
Ethyl methacrylate	ug/kg	.000	0	2	0	0	0
Ethylbenzene	ug/kg	.000	0	2	0	0	0
Iodomethane	ug/kg	.000	0	2	0	0	0
Isobutyl alcohol	ug/kg	.000	0	2	0	0	0
Methacrylonitrile	ug/kg	.000	0	2	0	0	0
Methyl methacrylate	ug/kg	.000	0	2	0	0	0
Methylene chloride	ug/kg	.000	0	2	0	0	0
Pyridine	ug/kg	.000	0	2	0	0	0
Styrene	ug/kg	.000	0	2	0	0	0
Tetrachloroethene	ug/kg	.000	0	2	0	0	0
Toluene	ug/kg	.000	0	2	0	0	0
Trichloroethene	ug/kg	.000	0	2	0	0	0
Trichlorofluoromethane	ug/kg	.000	0	2	0	0	0
Vinyl Acetate	ug/kg	.000	0	2	0	0	0
Vinyl chloride	ug/kg	.000	0	2	0	0	0
Xylenes, Total	ug/kg	.000	0	2	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	2	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	2	0	0	0
trans-1,4-Dichloro-2-butene	ug/kg	.000	0	2	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4,5-Tetrachlorobenzene	ug/kg	.000	0	2	0	0	0
1,2,4-Trichlorobenzene	ug/kg	.000	0	2	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	2	0	0	0
1,3,5-Trinitrobenzene	ug/kg	.000	0	2	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	2	0	0	0
1,3-Dinitrobenzene	ug/kg	.000	0	2	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	2	0	0	0
1,4-Naphthoquinone	ug/kg	.000	0	2	0	0	0
1-Naphthylamine	ug/kg	.000	0	2	0	0	0
2,3,4,6-Tetrachlorophenol	ug/kg	.000	0	2	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	2	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	2	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	2	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	2	0	0	0

TABLE 4-17
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
2,4-Dinitrophenol	ug/kg	.000	0	2	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	2	0	0	0
2,6-Dichlorophenol	ug/kg	.000	0	2	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	2	0	0	0
2-Acetylaminofluorene	ug/kg	.000	0	2	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	2	0	0	0
2-Chlorophenol	ug/kg	.000	0	2	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	2	0	0	0
2-Methylphenol	ug/kg	.000	0	2	0	0	0
2-Naphthylamine	ug/kg	.000	0	2	0	0	0
2-Nitroaniline	ug/kg	.000	0	2	0	0	0
2-Nitrophenol	ug/kg	.000	0	2	0	0	0
2-Picoline	ug/kg	.000	0	2	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	2	0	0	0
3,3'-Dimethylbenzidine	ug/kg	.000	0	2	0	0	0
3-Methylcholanthrene	ug/kg	.000	0	2	0	0	0
3-Methylphenol	ug/kg	.000	0	2	0	0	0
3-Nitroaniline	ug/kg	.000	0	2	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	2	0	0	0
4-Aminobiphenyl	ug/kg	.000	0	2	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	2	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	2	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	2	0	0	0
4-Methylphenol	ug/kg	.000	0	2	0	0	0
4-Nitroaniline	ug/kg	.000	0	2	0	0	0
4-Nitrophenol	ug/kg	.000	0	2	0	0	0
5-Nitro-o-toluidine	ug/kg	.000	0	2	0	0	0
7,12-Dimethylbenz(a)anthracene	ug/kg	.000	0	2	0	0	0
Acenaphthene	ug/kg	.000	0	2	0	0	0
Acenaphthylene	ug/kg	.000	0	2	0	0	0
Acetophenone	ug/kg	.000	0	2	0	0	0
Aniline	ug/kg	.000	0	2	0	0	0
Anthracene	ug/kg	.000	0	2	0	0	0
Aramite	ug/kg	.000	0	2	0	0	0
Benzo(a)anthracene	ug/kg	.000	0	2	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	2	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	2	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	2	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	2	0	0	0
Benzoic acid	ug/kg	.000	0	2	0	0	0
Benzyl alcohol	ug/kg	.000	0	2	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	2	0	0	0

TABLE 4-17
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Chrysene	ug/kg	.000	0	2	0	0	0
Di-n-butyl phthalate	ug/kg	.000	0	2	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	2	0	0	0
Diallate	ug/kg	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	2	0	0	0
Dibenzofuran	ug/kg	.000	0	2	0	0	0
Diethyl phthalate	ug/kg	.000	0	2	0	0	0
Dimethyl phthalate	ug/kg	.000	0	2	0	0	0
Diphenylamine	ug/kg	.000	0	2	0	0	0
Ethyl methanesulfonate	ug/kg	.000	0	2	0	0	0
Fluoranthene	ug/kg	.000	0	2	0	0	0
Fluorene	ug/kg	.000	0	2	0	0	0
Hexachlorobenzene	ug/kg	.000	0	2	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	2	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	2	0	0	0
Hexachloroethane	ug/kg	.000	0	2	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	2	0	0	0
Isophorone	ug/kg	.000	0	2	0	0	0
Isosafrole	ug/kg	.000	0	2	0	0	0
Methapyrilene	ug/kg	.000	0	2	0	0	0
Methyl methanesulfonate	ug/kg	.000	0	2	0	0	0
Methyl parathion	ug/kg	.000	0	2	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodi-n-butylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodiethylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosomethylethylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosomorpholine	ug/kg	.000	0	2	0	0	0
N-Nitrosopiperidine	ug/kg	.000	0	2	0	0	0
N-Nitrosopyrrolidine	ug/kg	.000	0	2	0	0	0
Naphthalene	ug/kg	.000	0	2	0	0	0
Nitrobenzene	ug/kg	.000	0	2	0	0	0
O,O,O-Triethylphosphorothioate	ug/kg	.000	0	2	0	0	0
Parathion	ug/kg	.000	0	2	0	0	0
Pentachlorobenzene	ug/kg	.000	0	2	0	0	0
Pentachloroethane	ug/kg	.000	0	2	0	0	0
Pentachloronitrobenzene	ug/kg	.000	0	2	0	0	0
Pentachlorophenol	ug/kg	.000	0	2	0	0	0
Phenacetin	ug/kg	.000	0	2	0	0	0
Phenanthrene	ug/kg	.000	0	2	0	0	0

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TABLE 4-17
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Phenol	ug/kg	.000	0	2	0	0	0
Pronamide	ug/kg	.000	0	2	0	0	0
Pyrene	ug/kg	.000	0	2	0	0	0
Safrole	ug/kg	.000	0	2	0	0	0
Sulfotep	ug/kg	.000	0	2	0	0	0
Tributyl phosphate	ug/kg	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	2	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	2	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	2	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	0	2	0	0	0
o-Toluidine	ug/kg	.000	0	2	0	0	0
p-Chloroaniline	ug/kg	.000	0	2	0	0	0
p-Dimethylaminoazobenzene	ug/kg	.000	0	2	0	0	0
PESTICIDES/PCBS							
2,4,5-T	ug/kg	.000	0	2	0	0	0
2,4,5-TP (Silvex)	ug/kg	.000	0	2	0	0	0
2,4-D	ug/kg	.000	0	2	0	0	0
Dinoseb	ug/kg	.000	0	2	0	0	0
4,4'-DDD	ug/kg	.000	0	2	0	0	0
4,4'-DDE	ug/kg	.000	0	2	0	0	0
4,4'-DDT	ug/kg	.000	0	2	0	0	0
Aldrin	ug/kg	.000	0	2	0	0	0
Aroclor-1016	ug/kg	.000	0	2	0	0	0
Aroclor-1221	ug/kg	.000	0	2	0	0	0
Aroclor-1232	ug/kg	.000	0	2	0	0	0
Aroclor-1242	ug/kg	.000	0	2	0	0	0
Aroclor-1248	ug/kg	.000	0	2	0	0	0
Aroclor-1254	ug/kg	.000	0	2	0	0	0
Aroclor-1260	ug/kg	.000	0	2	0	0	0
Chlorobenzilate	ug/kg	.000	0	2	0	0	0
Dieldrin	ug/kg	.000	0	2	0	0	0
Endosulfan II	ug/kg	.000	0	2	0	0	0
Endosulfan sulfate	ug/kg	.000	0	2	0	0	0
Endosulfan-I	ug/kg	.000	0	2	0	0	0
Endrin	ug/kg	.000	0	2	0	0	0
Endrin ketone	ug/kg	.000	0	2	0	0	0
Heptachlor	ug/kg	.000	0	2	0	0	0
Heptachlor epoxide	ug/kg	.000	0	2	0	0	0
Isodrin	ug/kg	.000	0	2	0	0	0
Kepone	ug/kg	.000	0	2	0	0	0
Methoxychlor	ug/kg	.000	0	2	0	0	0
Toxaphene	ug/kg	.000	0	2	0	0	0

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TABLE 4-17
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS (Continued)							
alpha-BHC	ug/kg	.000	0	2	0	0	0
alpha-Chlordane	ug/kg	.000	0	2	0	0	0
beta-BHC	ug/kg	.000	0	2	0	0	0
delta-BHC	ug/kg	.000	0	2	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	2	0	0	0
gamma-Chlordane	ug/kg	.000	0	2	0	0	0
DIOXIN/FURAN							
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
1,2,3,4,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
1,2,3,6,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
1,2,3,7,8,9-Hexachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
1,2,3,7,8-Pentachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
2,3,4,6,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
2,3,4,7,8-Pentachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
2,3,7,8-TCDD	ug/kg	.000	0	2	0	0	0
2,3,7,8-TCDF	ug/kg	.000	0	2	0	0	0
Heptachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
Heptachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
Hexachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
Octachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
Octachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
Pentachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
Pentachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
Tetrachlorodibenzo-p-dioxin	ug/kg	.000	0	2	0	0	0
Tetrachlorodibenzofuran	ug/kg	.000	0	2	0	0	0
GENERAL CHEMISTRY							
Sulfide	mg/kg	.000	0	2	0	0	0
MISCELLANEOUS							
Dimethoate	ug/kg	.000	0	2	0	0	0
Disulfoton	ug/kg	.000	0	2	0	0	0
Famphur	ug/kg	.000	0	2	0	0	0
Phorate	ug/kg	.000	0	2	0	0	0

TABLE 4-17
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
MISCELLANEOUS (Continued)							
Tetraethylpyrophosphate	ug/kg	.000	0	2	0	0	0
Thionazin	ug/kg	.000	0	2	0	0	0

TABLE 4-18

LIME SLUDGE POND
SUBSURFACE SOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	33	33	2990	19700	5
Antimony	mg/kg	.000	3	32	21.8	29.2	3
Arsenic	mg/kg	9.570	33	33	1.1	14.6	3
Barium	mg/kg	119.170	33	33	15.4	166	8
Beryllium	mg/kg	.620	21	33	.4	2.1	17
Cadmium	mg/kg	.910	14	33	.65	1.6	13
Calcium	mg/kg	150000.000	33	33	4980	353000	7
Chromium	mg/kg	20.680	30	33	2.2	22.1	3
Cobalt	mg/kg	15.750	29	33	2.7	30.2	5
Copper	mg/kg	20.030	25	33	8.4	44.6	18
Cyanide	mg/kg	.130	3	26	.11	.3	2
Iron	mg/kg	30700.000	32	32	3330	48100	2
Lead	mg/kg	15.580	31	33	.77	104	5
Magnesium	mg/kg	42648.210	33	33	4660	40300	0
Manganese	mg/kg	1300.000	33	33	285	1360	1
Mercury	mg/kg	.290	3	33	.21	2.3	2
Molybdenum	mg/kg	2.700	9	33	1.4	8.9	6
Nickel	mg/kg	34.350	27	33	7	46.7	2
Potassium	mg/kg	1979.990	26	33	739	3170	6
Selenium	mg/kg	.000	4	33	.26	.55	4
Silicon	mg/kg	1593.080	33	33	150	7220	11
Silver	mg/kg	.000	5	33	2.5	7.8	5
Sodium	mg/kg	285.000	33	33	70	1620	8
Thallium	mg/kg	.490	3	32	.22	.33	0
Vanadium	mg/kg	37.800	31	33	3.4	42.2	3
Zinc	mg/kg	72.580	32	32	11.8	122	6
RADIONUCLIDES							
CS-137	pCi/g	.000	11	33	.029	.17	11
GROSS ALPHA	pCi/g	.000	22	33	9.73	61.4	22
GROSS BETA	pCi/g	.000	29	33	6.43	43.36	29
NP-237	pCi/g	.000	23	24	.03	.541	23
PU-238	pCi/g	.000	22	33	.016	.536	22
PU-239/240	pCi/g	.000	20	33	.011	.133	20
RA-226	pCi/g	1.470	33	33	.37	5.93	3
RA-228	pCi/g	1.310	27	33	.59	1.72	7
RU-106	pCi/g	.000	0	33	0	0	0
SR-90	pCi/g	.560	8	33	.237	.959	3

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TABLE 4-18
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
TC-99	pCi/g	.000	1	33	.89	.89	1
TH-228	pCi/g	1.330	27	30	.11	1.75	1
TH-230	pCi/g	1.880	30	31	.294	32.2	14
TH-232	pCi/g	1.260	29	30	.06	1.43	2
TH-TOTAL	mg/kg	9.470	29	30	.551	13	6
U-234	pCi/g	1.040	33	33	.62	5.45	27
U-235/236	pCi/g	.150	32	33	.03	.96	16
U-238	pCi/g	1.120	33	33	.59	8.75	27
U-TOTAL	mg/kg	3.400	33	33	2.17	26.4	32
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	33	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	33	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	33	0	0	0
1,1-Dichloroethane	ug/kg	.000	1	33	5	5	1
1,1-Dichloroethene	ug/kg	.000	0	33	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	33	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	33	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	33	0	0	0
2-Butanone	ug/kg	.000	3	33	1	5	3
2-Hexanone	ug/kg	.000	0	33	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	33	0	0	0
Acetone	ug/kg	.000	11	33	3	38	11
Benzene	ug/kg	.000	0	33	0	0	0
Bromodichloromethane	ug/kg	.000	0	33	0	0	0
Bromoform	ug/kg	.000	0	33	0	0	0
Bromomethane	ug/kg	.000	0	33	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	33	0	0	0
Carbon disulfide	ug/kg	.000	0	33	0	0	0
Chlorobenzene	ug/kg	.000	0	33	0	0	0
Chloroethane	ug/kg	.000	0	33	0	0	0
Chloroform	ug/kg	.000	0	33	0	0	0
Chloromethane	ug/kg	.000	0	32	0	0	0
Dibromochloromethane	ug/kg	.000	0	33	0	0	0
Ethylbenzene	ug/kg	.000	0	33	0	0	0
Methylene chloride	ug/kg	.000	1	33	31	31	1
Styrene	ug/kg	.000	0	33	0	0	0
Tetrachloroethene	ug/kg	.000	0	33	0	0	0
Toluene	ug/kg	.000	6	33	2	11	6
Trichloroethene	ug/kg	.000	0	33	0	0	0
Vinyl Acetate	ug/kg	.000	0	29	0	0	0
Vinyl chloride	ug/kg	.000	0	33	0	0	0

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TABLE 4-18
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Xylenes, Total	ug/kg	.000	0	33	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	33	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	33	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	33	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	33	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	33	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	33	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	33	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	33	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	33	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	33	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	27	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	33	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	33	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	23	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	34	0	0	0
2-Chlorophenol	ug/kg	.000	0	33	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	34	0	0	0
2-Methylphenol	ug/kg	.000	0	33	0	0	0
2-Nitroaniline	ug/kg	.000	0	33	0	0	0
2-Nitrophenol	ug/kg	.000	0	33	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	33	0	0	0
3-Nitroaniline	ug/kg	.000	0	32	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	29	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	33	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	33	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	33	0	0	0
4-Methylphenol	ug/kg	.000	0	33	0	0	0
4-Nitroaniline	ug/kg	.000	0	30	0	0	0
4-Nitrophenol	ug/kg	.000	0	29	0	0	0
Acenaphthene	ug/kg	.000	0	34	0	0	0
Acenaphthylene	ug/kg	.000	0	34	0	0	0
Anthracene	ug/kg	.000	1	34	82	82	1
Benzo(a)anthracene	ug/kg	.000	0	34	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	34	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	34	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	34	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	34	0	0	0
Benzoic acid	ug/kg	.000	2	21	90	160	2
Benzyl alcohol	ug/kg	.000	0	19	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	29	0	0	0
Carbazole	ug/kg	.000	0	34	0	0	0

TABLE 4-18
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Chrysene	ug/kg	.000	0	34	0	0	0
Di-n-butyl phthalate	ug/kg	.000	8	33	2	140	8
Di-n-octyl phthalate	ug/kg	.000	0	29	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	34	0	0	0
Dibenzofuran	ug/kg	.000	0	33	0	0	0
Diethyl phthalate	ug/kg	.000	0	33	0	0	0
Dimethyl phthalate	ug/kg	.000	0	33	0	0	0
Fluoranthene	ug/kg	.000	1	34	57	57	1
Fluorene	ug/kg	.000	0	34	0	0	0
Hexachlorobenzene	ug/kg	.000	0	33	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	30	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	33	0	0	0
Hexachloroethane	ug/kg	.000	0	33	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	34	0	0	0
Isophorone	ug/kg	.000	0	33	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	33	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	1	19	5	5	1
N-Nitrosodiphenylamine	ug/kg	.000	0	33	0	0	0
Naphthalene	ug/kg	.000	0	34	0	0	0
Nitrobenzene	ug/kg	.000	0	33	0	0	0
Pentachlorophenol	ug/kg	.000	0	33	0	0	0
Phenanthrene	ug/kg	.000	1	34	82	82	1
Phenol	ug/kg	.000	0	33	0	0	0
Pyrene	ug/kg	.000	1	34	51	51	1
Tributyl phosphate	ug/kg	.000	0	19	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	33	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	33	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	33	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	19	33	2	4800	19
p-Chloroaniline	ug/kg	.000	0	33	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	34	0	0	0
4,4'-DDE	ug/kg	.000	0	34	0	0	0
4,4'-DDT	ug/kg	.000	0	34	0	0	0
Aldrin	ug/kg	.000	0	34	0	0	0
Aroclor-1016	ug/kg	.000	0	34	0	0	0
Aroclor-1221	ug/kg	.000	0	34	0	0	0
Aroclor-1232	ug/kg	.000	0	34	0	0	0
Aroclor-1242	ug/kg	.000	0	34	0	0	0
Aroclor-1248	ug/kg	.000	0	34	0	0	0
Aroclor-1254	ug/kg	.000	0	34	0	0	0
Aroclor-1260	ug/kg	.000	0	34	0	0	0
Dieldrin	ug/kg	.000	0	34	0	0	0

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TABLE 4-18
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Endosulfan II	ug/kg	.000	0	34	0	0	0
Endosulfan sulfate	ug/kg	.000	0	34	0	0	0
Endosulfan-I	ug/kg	.000	0	34	0	0	0
Endrin	ug/kg	.000	0	34	0	0	0
Endrin aldehyde	ug/kg	.000	0	34	0	0	0
Endrin ketone	ug/kg	.000	0	34	0	0	0
Heptachlor	ug/kg	.000	0	34	0	0	0
Heptachlor epoxide	ug/kg	.000	0	34	0	0	0
Methoxychlor	ug/kg	.000	0	34	0	0	0
Toxaphene	ug/kg	.000	0	34	0	0	0
alpha-BHC	ug/kg	.000	0	34	0	0	0
alpha-Chlordane	ug/kg	.000	0	34	0	0	0
beta-BHC	ug/kg	.000	0	34	0	0	0
delta-BHC	ug/kg	.000	0	34	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	34	0	0	0
gamma-Chlordane	ug/kg	.000	0	34	0	0	0

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TABLE 4-19

COMPARISON OF METALS CONCENTRATIONS IN LIME SLUDGE AND SOIL CONSTITUTENTS IN MG/KG
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Boring	Depth (feet)	Matrix [a]	Copper	Arsenic	Lead	Beryllium	Zinc	Antimony	Vanadium	Chromium	Number of Samples that Exceed Soil Background
1956	0.0 - 4.0	SL	29.8	11.2	104	0.72	72.6	0.44	8.9	2.2	5/8
	6.0 - 7.0	SL/S	36.6	7.4	14	0.79	79.8	0.27	15.7	12.1	3/8
1957	0.5 - 2.0	SL	25	6	13.7	0.52	69.6	1.70	18.8	11.1	1/8
	4.0 - 5.0	S	25.1	14.6	17.3	0.85	73.2	15.8	29.6	13	5/8
1958	0.5 - 2.5	SL	18.1	8.4	3.6	0.12	N/A	23.2	2.5	6	0/8
	4.5 - 5.0	S	28.3	13.8	17.6	1	84.1	15.5	40.3	20	6/8
1959	3.0 - 5.0	SL	44.6	6.1	6.4	1.5	122	29.2	42.2	21.1	5/8
	8.0 - 8.5	SL	16.5	8.7	15.1	0.21	28.5	15.2	1.2	2.3	0/8
	11.0 - 13.5	S	23.7	7.5	10.9	0.82	70	15.4	23.6	14.6	2/8
1960	5.0 - 6.0	SL	2.1	2.1	0.45	0.43	11.8	1.1	3.4	2.5	0/8
	13.0 - 13.5	S	9.6	3.8	6.2	0.46	30.3	1.2	14	4.7	0/8

See footnotes at end of table

TABLE 4-19
(Continued)

Boring	Depth (feet)	Matrix [a]	Copper	Arsenic	Lead	Beryllium	Zinc	Antimony	Vanadium	Chromium	Number of Samples that Exceed Soil Background
1961	2.0 - 4.0	SL	4.1	4.0	0.81	0.83	25.6	2.7	7.5	6.1	1/8
	12.0 -13.0	S	20.3	4.3	10.2	0.47	64.6	1.2	28.3	13.7	0/8
1963	2.0 - 4.0	SL/S	3.3	2.5	0.77	0.66	16.9	1.7	5.0	3.4	1/8
	12.0 - 13.0	SL/S	8.4	2.8	5.9	0.43	30.4	1.1	14.4	4.8	0/8
	17.0 - 18.0	S	16.4	3.8	9.0	0.68	46.3	1.0	18.5	9.2	1/8
Number of Sludge Samples that Exceed Background			3/7	1/7	1/7	3/7	2/7	7/7	1/7	1/7	
Number of Soil Samples that Exceed Soil Background			4/9	2/9	2/9	6/9	3/9	9/9	1/9	0/9	

[a]Matrix SL = lime sludge
Matrix S = till
Matrix SL/S = A mixture of till and lime sludge
[b]Shaded numbers exceed background soil concentrations for those metals

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for antimony (seven of seven samples), copper (three of seven samples), beryllium (three of seven samples), and zinc (two of seven samples). Soil samples collected from beneath the lime sludge exceeded background concentrations most frequently for antimony (nine of nine samples), beryllium (six of nine samples), copper (four of nine samples), zinc (three of nine samples), arsenic (two of nine samples), and lead (two of nine samples). A comparison of sludge data and data from soil underlying the sludge indicates that the underlying soil has higher concentrations that the sludge for antimony, copper, beryllium, and zinc.

Two locations in the north pond contained concentrations of metals that most frequently exceeded background concentrations. As seen on Table 4-19, Boring No. 1956 (northwest corner) four of eight metals in sludge and Boring No. 1959 (northeast corner) detected five of eight metals in sludge above background concentrations. The highest lead, copper, zinc, vanadium, and chromium concentrations were detected in sludge from these two borings, which are adjacent to the north edge of the north pond.

Radionuclide data presented in Table 4-20 and shown on Figure 4-9 (see Volume 2, Oversized Figures) indicate that activities measured in sludge, soil beneath the sludge, and in the berm materials exceeded background levels. Berm samples detected higher activities of uranium-238 when compared to sludge samples. When subsurface sludge, soil, and berm sample data are compared, the following conclusions can be made:

- Thorium was detected more frequently and at higher concentrations in samples of the native material underlying the lime sludge.
- Concentrations of total uranium were approximately the same or lower in samples collected from the sludge when compared to the underlying soil.
- Samples from the berm were, on average, higher in total uranium than the lime sludge.

The data suggests that the upper one foot of the berms has a supplemental source of radioisotopes when compared to the lime sludge material. Samples of sludge and underlying soil indicated that the sludge contains lower concentrations of the radionuclides than the soil. A possible scenario for the elevated radionuclide concentrations underlying the lime sludge is that the soils were already contaminated prior to and after the excavation of the lime sludge ponds and then the lime sludge was

TABLE 4-20

SUMMARY OF SELECTED RADIOISOTOPES AND ORGANIC DATA FROM SOIL SAMPLES COLLECTED WITH DEPTH IN THE LIME SLUDGE POND

Location	Sample/Material	Depth (ft. below surface)	Analyte Concentration							
			BP[a] µg/kg	DBP[b] µg/kg	Ra-226 pCi/g	Th-228 pCi/g	Th-230 pCi/g	Th Total mg/g	U-238 pCi/g	U-Total µg/g
Background data	soil	>0.5	0	0	1.325	1.341	1.897	9.47	1.222	2.54
1956	114857/Lime Sludge	0-4	440	<0.780	0.78	0.310	1.09	2.27	3.17	16.8
At northwest corner of N. Lime Sludge Pond	114859/Lime Sludge	6-7	88	75	0.90	0.710	1.24	9.08	0.97	13.7
1957	114835/Lime Sludge	0.5-2	91	<0.550	0.59	0.599	1.37	4.84	2.84	9.73
at southwest corner of N. Lime Sludge Pond	114838/soil	4-5	410	59	1.440	1.270	1.51	12.3	1.14	11.1
1958	114821/Lime Sludge	0.5-2.5	92	<0.680	0.458	0.130	0.294	0.551	1.84	14
SE corner of N Lime Sludge Pond	114823/soil	4.5-5.0	ND	<0.420	1.180	1.070	1.35	11	1.37	13.1
1959	114812/sludge	3-5	260	140	0.460	0.228	0.405	1.02	2.47	15
NE corner of N Lime Sludge Pond	114814/sludge	8-8.5	ND	48	1.060	1.020	1.28	11.5	1.15	
	114815//soil	11-13.5	ND	62	1.050	0.811	0.857	5.74	1.15	11.3
1960	114734/sludge	5-6	ND	<0.590	0.362	0.111	1.88	0.75	1.59	3.72
NW corner of S Lime Sludge Pond	114737/soil	13-13.5	ND	<0.410	0.670	0.540	4.51	3.31	0.66	12.3
1961	114745/sludge	2-4	ND	<0.740	0.960	0.780	2.7	2.09	1.86	13.5
SW corner of S Lime Sludge Pond	114743/soil	12-13	78	68	0.490	0.260		7.84	1.17	14.3
1962	114605/sludge	4.5-7	ND	72	0.500	0.113	3.06	1.34	3.33	6.76
SE corner of Lime Sludge Pond	114607/soil	12.5-14	2	2	.842	0.536	2.470	3.050	0.732	2.170
1963	114762/Lime Sludge	2-4	88	<0.620	0.400	0.110	0.48	1.02	0.67	10.6
NE corner of S Lime Sludge Pond	114766/soil	13.5-15.5	ND	<0.390	0.730	0.481	0.48	3.95	0.59	8.61
	114874/soil	17-18.5	93	<0.410	0.890	0.919	1.34	8.56	1.02	4.01
LSP-SS-11 N. Berm of N. Pond	114500/BERM	0.5-1	ND	<0.400	1.080	0.898	1.150	7.750	4.050	11.20

See footnotes at end of table

TABLE 4-20
(Continued)

Location	Sample/Material	Depth (ft. below surface)	Analyte Concentration							
			BP[a] µg/kg	DBP[b] µg/kg	Ra-226 pCi/g	Th-228 pCi/g	Th-230 pCi/g	Th Total mg/g	U-238 pCi/g	U-Total µg/g
LSP-SS-12 N. Berm of N. Pond	114503/BERM	0.5-1	ND	<0.390	0.983	0.859	2.020	7.460	4.100	13.700
LSP-SS-8 W. Berm of N. Pond	114490/BERM	0.5-1	230	<0.400	1.330	0.960	2.900	8.550	4.680	22.700
LSP-SS-04 S. Berm of S. Pond	114476/BERM	0.5-1	580	<0.400	1.120	0.960	1.800	8.5400	4.520	20.700
LSP-SS-03 S. Berm of S. Pond	114469/BERM	0.5-1	140	<0.400	1.330	1.070	2.000	9.400	4.690	24.000
LSP-SS-07 E. Berm of N. Pond	114479/BERM	0.5-1	4800	<0.400	1.320	1.270	5.190	9.840	5.090	26.40

[a]bis(2-Ethylhexyl)pthalate

[b]Di-n-butyl phthalate

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disposed of on top of the contaminated soil. However, contamination or additional contamination to the soil below the lime sludge may have occurred from the leaching of the lime sludge.
A comparison of the Phase I and Phase II subsurface soil results with the CIS profile sample results (Appendix D-16B) indicates the radionuclide parameters detected during the CIS were also detected in Phase I and Phase II and were within the same order of magnitude.

Two volatile organic compounds, acetone and toluene, were detected in surface and subsurface soil samples. These are believed to be laboratory induced contaminants since they are detected at random depths and locations. Trace levels of 2-butanone were detected in two borings. This volatile is a common lab contaminant and also believed to be a lab contaminant in this case since it was detected in soil underlying the pond in Boring No. 1963 but not in overlying material. Trace concentrations of 1,1-dichloroethane (5 μg/kg) and methylene chloride (31 μg/kg) were detected in Boring Nos. 1959 and 1958, respectively.

Eight semivolatile organics were detected in subsurface samples. All were detected two times or less except for di-n-butyl phthalate and bis(2-Ethylhexyl)phthalate. Detected concentrations of these compounds are summarized in Table 4-20. Concentrations and sample depth do not appear to be correlated and this indicates that the compound is integrated into the sludge, underlying soil, and berm materials. In contrast to the 18 organic compounds detected in surface samples, eight compounds were detected in subsurface samples. Five compounds (anthracene, phenanthrene, fluoranthene, pyrene, and n-nitrosodimetlylamine) were detected once in samples from the north edge of the north pond, the west berm, and the exploratory trench dug parallel to the K-65 trench. This indicates that these areas are a possible source for the organic compounds detected in sludge samples. Contamination increased with depth in locations 1947, 1961, 1962, and 1963. The berms were constructed prior to lime sludge disposal. If the berms were constructed of contaminated material, then it is likely that surface water ran off into the ponds from the contaminated berms, causing contamination at depth due to leaching. Also, as time went on, the levels of berm surface contamination decreased due to this run-off. The Lime Sludge Pond is also a potential source to the subsurface soils.

An investigation trench approximately 275 feet long was excavated parallel to and south of the concrete K-65 slurry line (Figure 4-9) in an effort to locate areas of possible leakage from the slurry line. This trench will be fully characterized by Operable Unit 3 during their RI. Field soil

radioactivity measurements ranged from 90 cpm to 460 cpm, which were above the background measured each day (60 to 80 cpm). Field measurements did not define soil containing elevated radioactivity where historical leakage from the slurry line containment had occurred. Soil samples from the trench were collected from two locations: one location was selected adjacent to Well 1042 and one location was selected adjacent to Well 1934. Data from these samples are provided in samples is provided on Table 4-21. A comparison between the data from samples collected within the Appendix D in Table D-2C. A summary of selected laboratory analytical results for these soil concrete K-65 slurry line and data from soil outside the slurry line indicates the following:

- Comparison of chromium, nickel, vanadium, and zinc concentrations indicates that these are elevated for slurry line samples. Elevated concentrations for the same metals were detected in soil samples collected adjacent to the slurry line in the investigation trench.

- The highest concentration for total uranium (51.6 μg/g) detected in the concrete K-65 slurry line trench was similar to elevated concentrations in the soil outside of the trench (24.8 μg/g). The subsurface soil background concentration for total uranium is 3.4 μg/g.

- The highest activity measured for radium-226 (3.48 pCi/g), thorium-230 (16.23 pCi/g), and uranium-238 (20.4 pCi/g) in samples from the concrete trench were similar to elevated concentrations in the soil outside of the trench. Samples of the soil detected elevated concentrations of radium-226 (5.93 pCi/g), thorium-230 (20.3 pCi/g), and uranium-238 (5.5 pCi/g). Subsurface soil background concentrations for the radioisotopes are 1.47 pCi/g for radium-226, 1.88 pCi/g for thorium-230, and 1.12 pCi/g for uranium-238.

This comparison of sample data indicates that leakage from the trench may be a source of the elevated concentrations of these isotopes in the soil adjacent and south of to the trench.

Composite samples of the lime sludge were collected from eight borings, and TCLP tests were conducted. A summary of the analytical data is provided in Appendix D, Table D-12 and the results are summarized in Table 4-22. Eight samples were collected and tested to determine hazardous waste characteristics by the TCLP method. Five samples indicated the presence of barium and chromium in trace concentrations, but none of the detections exceeded the RCRA standard that defines hazardous waste. The Lime Sludge Ponds are currently classified as Solid Waste Management Units (SWMUs). Results from the TCLP analyses confirm that the materials are not characteristically hazardous.

TABLE 4-21

SUMMARY OF LABORATORY ANALYSES OF SAMPLES COLLECTED DURING THE K-65 TRENCH INVESTIGATION LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Location	Sample	On-Site Total U (μg/L)	Analyte and Soil Background Concentration								
			(mg/kg)				(pCi/g)			(μg/g)	
			Cr	Ni	V	Zn	Ra-226	Th-230	U-238	Total U	Total Th
Background Concentrations for Surface and Susurface Soil											
Surface Soil Background	NA[a]		15.5	20.87	30.37	59.61	1.42	1.97	1.22	3.7	10.7
Subsurface Soil Background	NA		20.68	34.35	37.8	72.58	1.47	1.88	1.12	3.4	9.47
Soil Samples From Investigation Trench Adjacent to K-65 Slurry Trench											
Soil Adjacent to Well 1042 (composite 0'-6' deep)	114767		17.8	27.5	42.1	80.2	2.32	20.30	5.50	24.8	13.0
Soil Adjacent to Well 1934 (composite 0'-6' deep)	114776		11	21.1	23.5	55.7	5.93	5.34	3.91	11.5	8.31
Soil and Water Samples From Within The K-65 Slurry Trench											
Water sample from trench	114770	77									
Residue LSP-SS-01	114589		54.2	24.6	39.1	107	3.15	9.79	20.4	51.6	8.63
Residue LSP-SS-02	114591		22.9	16.3	25.1	94.4	3.48	16.23	14.8	45	8.41

[a]NA = Not Applicable

TABLE 4-22

LIME SLUDGE PONDS TCLP RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard[a] (mg/L)	Location/Sample Number and Result (mg/L)							
			1956	1957	1958	1959	1960	1961	1962	1963
			114858	114836	114822	114813	114733	114746	114609	114763
Arsenic	5.0	1.5	<0.04	<0.04	<0.04	<0.04	<0.050	<0.04	<0.05	<0.04
Barium	100.0	30.0	0.67	0.8	0.39	0.4	0.256	<0.35	0.274	<0.28
Benzene	0.5		<0.025	<0.025	<0.025	<0.025	<0.005	<0.025	<0.005	<0.025
Cadmium	1.0	0.3	0.005	0.005	<0.005	<0.005	<0.005	0.019	<0.005	<0.005
Carbon Tetrachloride	0.5		<0.025	<0.025	<0.025	<0.025	<0.005	<0.025	<0.005	<0.025
Chlordane	0.03		<0.006	<0.006	<0.006	<0.006	<0.005	<0.006	<0.0005	<0.006
Chlorobenzene	100.0		<0.025	<0.025	<0.025	<0.025	<0.005	<0.025	<0.005	<0.025
Chloroform	6.0		<0.025	<0.025	<0.025	<0.025	<0.005	<0.025	<0.005	<0.025
Chromium	5.0	1.5	0.02	0.02	0.02	0.01	<0.01	0.11	<0.01	0.01
2,4-D	10.0		<0.4	<0.4	<0.4	<0.4	<0.01	<0.4	<0.01	<0.4
1,4-Dichlorobenzene	7.5		<0.04	<0.04	<0.04	<0.04	<0.02	<0.04	<0.02	<0.04
1,2-Dichloroethane	0.5		<0.025	<0.025	<0.025	<0.025	<0.005	<0.025	<0.005	<0.025
1,1-Dichloroethene	0.7		<0.025	<0.025	-[b]	<0.025	<0.005	<0.025	<0.005	<0.025
2,4-Dinitrotoluene	0.13		<0.04	<0.04	<0.04	<0.04	<0.02	<0.04	<0.02	<0.04
Endrin	0.02		<0.004	<0.004	<0.004	<0.004	<0.0001	<0.004	<0.0001	<0.004
Heptachlor	0.008		<0.001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.0001	<0.001
Heptachlor epoxide	0.008		<0.001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.0001	<0.001
Hexachlorobenzene	0.13		<0.04	<0.04	<0.04	<0.04	<0.02	<0.04	<0.02	<0.04
Hexachlorobutadiene	0.5		<0.04	<0.04	<0.04	<0.04	<0.02	<0.04	<0.02	<0.04
Hexachloroethane	3.0		<0.04	<0.04	<0.04	<0.04	<0.02	<0.04	<0.02	<0.04
Lead	5.0	1.5	<0.04	<0.04	<0.04	<0.04	<0.04	0.05	<0.04	<0.04
Lindane	0.4		<0.008	<0.008	<0.008	<0.008	<0.0001	<0.008	<0.0001	<0.008
Mercury	0.2	0.06	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.001	<0.0002	<0.001

See footnote at end of table

TABLE 4-22
(Continued)

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard[a] (mg/L)	Location/Sample Number and Result (mg/L)							
			1956	1957	1958	1959	1960	1961	1962	1963
			114858	114836	114822	114813	114733	114746	114609	114763
Methoxychlor	10.0		<0.08	<0.08	<0.08	<0.08	<0.0005	<0.08	<0.0005	<0.08
Nitrobenzene	2.0		<0.04	<0.04	<0.04	<0.04	<0.02	<0.04	<0.02	<0.04
Pentachlorophenol	100.0		<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.2
Pyridine	5.0		<0.4	<0.4	<0.4	<0.4	<0.2	<0.4	<0.2	<0.4
Selenium	1.0	0.3	<0.06	<0.06	<0.06	<0.06	<0.08	<0.06	<0.08	<0.06
Silver	5.0		<0.005	<0.005	<0.005	<0.005	<0.01	0.012	<0.01	<0.005
Tetrachloroethene	0.7		<0.025	<0.025	<0.025	<0.025	<0.005	<0.025	<0.005	<0.025
Toxaphene	0.5		<0.1	<0.1	<0.1	<0.1	<0.001	<0.1	<0.001	<0.1
2,4,5-TP (Silvex)	1.0		<0.2	<0.2	<0.2	<0.2	<0.0018	<0.2	<0.0018	<0.2
Trichloroethene	0.5		<0.025	<0.025	<0.025	<0.025	<0.005	<0.025	<0.005	<0.025
2,4,5-Trichlorophenol	400.0		<0.2	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.2
2,4,6-Trichlorophenol	2.0		<0.04	<0.04	<0.04	<0.04	<0.02	<0.04	<0.02	<0.04
Vinyl chloride	0.2		<0.05	<0.05	<0.05	<0.05	<0.01	<0.05	<0.01	<0.05

[a]These standards are from OEPA Policy 4.07 "Design Criteria: Disposal of Non-Toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Waste.

[b]The sample was not analyzed for the parameter.

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4.3.3 Surface Water and Sediment

There are no perennial sources of running surface water within the battery limits of the Lime Sludge Ponds. A channelized drainage at the north edge of the battery limits is the only drainage identified in the subunit. Flow to this drainage originates from the road and enters a sewer at the northwest corner of the battery limits. No sediment or surface water samples were collected from the drainage since the data would not be representative of impacts from subunit sources. The North Lime Sludge Pond has a free water surface that changes according to inflow from storm water and water process discharges. When approximately one-half of the pond surface is covered with water, the standing water is pumped to the general sump and treated before discharge. The pond does not have a potential for overflow. One surface water sampling location was identified during Phase II activities within the north pond. Chemical and radiological analytical results for surface water were not compared against background concentrations since there is no background value for surface water. A table of detected constituent concentrations is provided in Appendix D (Table D-9) while a summary of the analytes is presented in Tables 4-23 and 4-24. One surface water sample was collected during Phase I and one was collected during Phase II. Phase I sampling detected 20 metals; no volatile, semivolatile or pesticide/PCB analytes were detected. One Phase II surface water sample detected seven metals (these seven metals were also detected in Phase I; Aluminum, Arsenic, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Silver, Vanadium, and Zinc were detected in Phase I samples but not Phase II), Th-230 was the only isotope detected (the Phase I sample was not analyzed for radionuclides), and one organic compound (bis(2-ethylhexyl)phthalate) was detected above background.

4.3.4 Groundwater

Chemical and radiological analytical results from groundwater samples were compared to background concentrations, and a table of the constituents detected above background is provided in Appendix D on Table D-2G through Table D-2I. A summary of the analytes in 1000-series wells is provided in Tables 4-25 and 4-26. Groundwater analytical data from the 1000-series wells were compared to background data from the perched groundwater developed for the site. Phase I sampling, conducted on three 1000-series wells within the battery limits of the subunit, detected eight metals, isotopes of uranium and thorium, and one organic compound phenol at 50 μg/L that exceeded background concentrations. Six 1000-series wells sampled during Phase II detected thirteen metals above background (Antimony was not detected during Phase I, Cadmium, and Molybdenum were detected

TABLE 4-23

LIME SLUDGE PONDS
SURFACE WATER[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	4	4	.095	.127	4
Antimony		mg/L	.000	2	4	.0333	.0369	2
Arsenic		mg/L	.000	2	4	.0026	.0036	2
Barium		mg/L	.000	4	4	.033	.0607	4
Beryllium		mg/L	.000	0	4	0	0	0
Boron		mg/L	.000	3	3	.211	.359	3
Cadmium		mg/L	.000	4	4	.0037	.0092	4
Calcium		mg/L	.000	4	4	43.3	71	4
Chromium		mg/L	.000	4	4	.0118	.0207	4
Cobalt		mg/L	.000	0	4	0	0	0
Copper		mg/L	.000	0	4	0	0	0
Iron		mg/L	.000	3	4	.0232	.0333	3
Lead		mg/L	.000	1	4	.002	.002	1
Magnesium		mg/L	.000	4	4	24.4	47.8	4
Manganese		mg/L	.000	4	4	.0058	.114	4
Mercury		mg/L	.000	1	4	.001	.001	1
Molybdenum		mg/L	.000	3	4	.0106	.0183	3
Nickel		mg/L	.000	0	4	0	0	0
Potassium		mg/L	.000	4	4	8.54	13.2	4
Selenium		mg/L	.000	0	3	0	0	0
Silicon		mg/L	.000	4	4	.402	1.04	4
Silver		mg/L	.000	3	4	.0107	.0168	3
Sodium		mg/L	.000	4	4	185	299	4
Thallium		mg/L	.000	0	3	0	0	0
Tin		mg/L	.000	0	3	0	0	0
Vanadium		mg/L	.000	1	4	.0102	.0102	1
Zinc		mg/L	.000	3	4	.0083	.193	3
VOLATILE ORGANICS								
1,1,1,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-23
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
1,2,3-Trichloropropane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dibromo-3-chloropropane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dibromoethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Butanone	UNFL	ug/L	.000	0	1	0	0	0
2-Chloro-1,3-butadiene	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
3-Chloropropene	UNFL	ug/L	.000	0	1	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	0	1	0	0	0
Acetonitrile	UNFL	ug/L	.000	0	1	0	0	0
Acrolein	UNFL	ug/L	.000	0	1	0	0	0
Benzene	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroethane	UNFL	ug/L	.000	0	1	0	0	0
Chloroform	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromomethane	UNFL	ug/L	.000	0	1	0	0	0
Ethyl cyanide	UNFL	ug/L	.000	0	1	0	0	0
Ethyl methacrylate	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	1	0	0	0
Iodomethane	UNFL	ug/L	.000	0	1	0	0	0
Isobutyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Methacrylonitrile	UNFL	ug/L	.000	0	1	0	0	0
Methyl methacrylate	UNFL	ug/L	.000	0	1	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	1	0	0	0
Pyridine	UNFL	ug/L	.000	0	1	0	0	0
Styrene	UNFL	ug/L	.000	0	1	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	1	0	0	0
Toluene	UNFL	ug/L	.000	0	1	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	1	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-23
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,4-Dichloro-2-butene	UNFL	ug/L	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4,5-Tetrachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3,5-Trinitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dinitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Naphthoquinone	UNFL	ug/L	.000	0	1	0	0	0
1-Naphthylamine	UNFL	ug/L	.000	0	1	0	0	0
2,3,4,6-Tetrachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2-Acetylaminofluorene	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
2-Naphthylamine	UNFL	ug/L	.000	0	1	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Picoline	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dimethylbenzidine	UNFL	ug/L	.000	0	1	0	0	0
3-Methylcholanthrene	UNFL	ug/L	.000	0	1	0	0	0
3-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-23
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Aminobiphenyl	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroquinoline-1-oxide	UNFL	ug/L	.000	0	1	0	0	0
5-Nitro-o-toluidine	UNFL	ug/L	.000	0	1	0	0	0
7,12-Dimethylbenz(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	1	0	0	0
Acetophenone	UNFL	ug/L	.000	0	1	0	0	0
Aniline	UNFL	ug/L	.000	0	1	0	0	0
Anthracene	UNFL	ug/L	.000	0	1	0	0	0
Aramite	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Diallate	UNFL	ug/L	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Diphenylamine	UNFL	ug/L	.000	0	1	0	0	0
Ethyl methanesulfonate	UNFL	ug/L	.000	0	1	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Fluorene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-23
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorophene	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Isophorone	UNFL	ug/L	.000	0	1	0	0	0
Isosafrole	UNFL	ug/L	.000	0	1	0	0	0
Methapyrilene	UNFL	ug/L	.000	0	1	0	0	0
Methyl methanesulfonate	UNFL	ug/L	.000	0	1	0	0	0
Methyl parathion	UNFL	ug/L	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodi-n-butylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiethylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosomethylethylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosomorpholine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosopiperidine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosopyrrolidine	UNFL	ug/L	.000	0	1	0	0	0
Naphthalene	UNFL	ug/L	.000	0	1	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
O,O,O-Triethylphosphorothioate	UNFL	ug/L	.000	0	1	0	0	0
Parathion	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Pentachloronitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenacetin	UNFL	ug/L	.000	0	1	0	0	0
Phenol	UNFL	ug/L	.000	0	1	0	0	0
Pronamide	UNFL	ug/L	.000	0	1	0	0	0
Pyrene	UNFL	ug/L	.000	0	1	0	0	0
Safrole	UNFL	ug/L	.000	0	1	0	0	0
Sulfotep	UNFL	ug/L	.000	0	1	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	1	0	0	0
a,a-Dimethylphenethylamine	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	1	0	0	0
o-Toluidine	UNFL	ug/L	.000	0	1	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	1	0	0	0
p-Dimethylaminoazobenzene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-23
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS								
p-Phenylenediamine	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-T	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-TP (Silvex)	UNFL	ug/L	.000	0	1	0	0	0
2,4-D	UNFL	ug/L	.000	0	1	0	0	0
Dinoseb	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDD	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	1	0	0	0
Aldrin	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzilate	UNFL	ug/L	.000	0	1	0	0	0
Dieldrin	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	1	0	0	0
Endrin	UNFL	ug/L	.000	0	1	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	1	0	0	0
Isodrin	UNFL	ug/L	.000	0	1	0	0	0
Kepone	UNFL	ug/L	.000	0	1	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	1	0	0	0
Toxaphene	UNFL	ug/L	.000	0	1	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	1	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
beta-BHC	UNFL	ug/L	.000	0	1	0	0	0
delta-BHC	UNFL	ug/L	.000	0	1	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	1	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
MISCELLANEOUS								
Dimethoate	UNFL	ug/L	.000	0	1	0	0	0
Disulfoton	UNFL	ug/L	.000	0	1	0	0	0
Famphur	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-23
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
MISCELLANEOUS (Continued)								
Phorate	UNFL	ug/L	.000	0	1	0	0	0
Tetraethylpyrophosphate	UNFL	ug/L	.000	0	1	0	0	0
Thionazin	UNFL	ug/L	.000	0	1	0	0	0

[a]Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available.

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TABLE 4-24

LIME SLUDGE PONDS
SURFACE WATER[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	0	1	0	0	0
Antimony		mg/L	.000	1	1	.0052	.0052	1
Arsenic		mg/L	.000	0	1	0	0	0
Barium		mg/L	.000	1	1	.0175	.0175	1
Beryllium		mg/L	.000	0	1	0	0	0
Cadmium		mg/L	.000	0	1	0	0	0
Calcium		mg/L	.000	1	1	17.2	17.2	1
Chromium		mg/L	.000	0	1	0	0	0
Cobalt		mg/L	.000	0	1	0	0	0
Copper		mg/L	.000	0	1	0	0	0
Cyanide		mg/L	.000	0	1	0	0	0
Iron		mg/L	.000	0	1	0	0	0
Lead		mg/L	.000	0	1	0	0	0
Magnesium		mg/L	.000	1	1	17.9	17.9	1
Manganese		mg/L	.000	0	1	0	0	0
Mercury		mg/L	.000	0	1	0	0	0
Molybdenum		mg/L	.000	0	1	0	0	0
Nickel		mg/L	.000	0	1	0	0	0
Potassium		mg/L	.000	1	1	3.93	3.93	1
Selenium		mg/L	.000	0	1	0	0	0
Silicon		mg/L	.000	1	1	.572	.572	1
Silver		mg/L	.000	0	1	0	0	0
Sodium		mg/L	.000	1	1	40.6	40.6	1
Thallium		mg/L	.000	0	1	0	0	0
Vanadium		mg/L	.000	0	1	0	0	0
Zinc		mg/L	.000	0	1	0	0	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	1	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0	1	0	0	0
GROSS BETA	UNFL	pCi/L	.000	1	1	4.22	4.22	1
NP-237	UNFL	pCi/L	.000	0	1	0	0	0
PU-238	UNFL	pCi/L	.000	0	1	0	0	0
RA-226	UNFL	pCi/L	.000	0	1	0	0	0
RA-228	UNFL	pCi/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-24
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RU-106	UNFL	pCi/L	.000	0	1	0	0	0
SR-90	UNFL	pCi/L	.000	0	1	0	0	0
TC-99	UNFL	pCi/L	.000	0	1	0	0	0
TH-228	UNFL	pCi/L	.000	0	1	0	0	0
TH-230	UNFL	pCi/L	.000	1	1	.21	.21	1
TH-232	UNFL	pCi/L	.000	0	1	0	0	0
TH-TOTAL	UNFL	ug/L	.000	0	1	0	0	0
U-234	UNFL	pCi/L	.000	0	1	0	0	0
U-235/236	UNFL	pCi/L	.000	0	1	0	0	0
U-238	UNFL	pCi/L	.000	0	1	0	0	0
U-TOTAL	UNFL	ug/L	.000	0	1	0	0	0
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Butanone	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	0	1	0	0	0
Benzene	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
VOLATILE ORGANICS (Continued)								
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroethane	UNFL	ug/L	.000	0	1	0	0	0
Chloroform	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	1	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-24
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Styrene	UNFL	ug/L	.000	0	1	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	1	0	0	0
Toluene	UNFL	ug/L	.000	0	1	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	1	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	1	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS (Continued)								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	1	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	1	0	0	0
Anthracene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-24
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Carbazole	UNFL	ug/L	.000	0	1	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Fluorene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Isophorone	UNFL	ug/L	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	1	0	0	0
Naphthalene	UNFL	ug/L	.000	0	1	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	1	0	0	0
Phenol	UNFL	ug/L	.000	0	1	0	0	0
Pyrene	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	1	1	2	2	1
p-Chloroaniline	UNFL	ug/L	.000	0	1	0	0	0
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-24
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS (Continued)								
4,4'-DDE	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	1	0	0	0
Aldrin	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	1	0	0	0
Dieldrin	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	1	0	0	0
Endrin	UNFL	ug/L	.000	0	1	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	1	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	1	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	1	0	0	0
Toxaphene	UNFL	ug/L	.000	0	1	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	1	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
beta-BHC	UNFL	ug/L	.000	0	1	0	0	0
delta-BHC	UNFL	ug/L	.000	0	1	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	1	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	1	1	63	63	0
Ammonia	UNFL	mg/L	.000	0	1	0	0	0
Chloride	UNFL	mg/L	.000	1	1	72	72	1
Fluoride	UNFL	mg/L	.000	1	1	.11	.11	1
Phenols	UNFL	mg/L	.000	0	1	0	0	0
Sulfate	UNFL	mg/L	.000	1	1	39.3	39.3	1
Sulfide	UNFL	mg/L	.000	0	1	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	1	1	.17	.17	1
Total Organic Carbon	UNFL	mg/L	.000	1	1	2.24	2.24	1
Total Organic Halides	UNFL	mg/L	.000	1	1	.0228	.0228	1
Total Organic Nitrogen	UNFL	mg/L	.000	1	1	.17	.17	1

See footnote at end of table

TABLE 4-24
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Total Phosphorous	UNFL	mg/L	.000	0	1	0	0	0

aFiltered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available.

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TABLE 4-25

LIME SLUDGE PONDS
GROUNDWATER[a] - 1000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	0	1	0	0	0
Antimony		mg/L	.000	0	1	0	0	0
Arsenic		mg/L	.050	0	12	0	0	0
Barium		mg/L	.450	11	12	.087	.459	1
Beryllium		mg/L	.002	0	1	0.	0	0
Cadmium		mg/L	.005	2	12	.007	.01	2
Calcium		mg/L	123.837	12	12	92.9	274	8
Chromium		mg/L	.035	3	12	.02	.035	0
Cobalt		mg/L	.000	0	1	0	0	0
Copper		mg/L	.030	3	12	.016	.017	0
Iron		mg/L	3.440	11	12	.04	1.8	0
Lead		mg/L	.015	3	12	.002	.004	0
Magnesium		mg/L	48.546	12	12	30.1	109.6	8
Manganese		mg/L	.050	12	12	.029	.986	11
Mercury		mg/L	.000	1	12	.0004	.0004	0
Molybdenum		mg/L	.025	4	12	.02	.03	1
Nickel		mg/L	.026	2	12	.023	.026	0
Potassium		mg/L	26.976	9	12	.48	1.33	0
Selenium		mg/L	.000	0	12	0	0	0
Silver		mg/L	.040	0	12	0	0	0
Sodium		mg/L	47.982	12	12	14	350	4
Thallium		mg/L	.000	0	1	0	0	0
Vanadium		mg/L	.020	0	1	0	0	0
Zinc		mg/L	.032	1	1	.14	.14	1
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0		0	0	0
NP-237	UNFL	pCi/L	.000	0	11	0	0	0
PU-238	UNFL	pCi/L	.000	0	9	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	9	0	0	0
RA-226	UNFL	pCi/L	1.000	1	11	.3	.3	0
RA-228	UNFL	pCi/L	5.200	1	11	3.8	3.8	0
RU-106	UNFL	pCi/L	.000	0		0	0	0
SR-90	UNFL	pCi/L	.000	0	11	0	0	0
TC-99	UNFL	pCi/L	.000	0	11	0	0	0

See footnote at end of table

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TABLE 4-25
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
TH-228	UNFL	pCi/L	1.040	2	11	1.1	1.2	2
TH-230	UNFL	pCi/L	2.000	3	11	1.4	1.6	0
TH-232	UNFL	pCi/L	.000	0	11	0	0	0
TH-TOTAL	UNFL	ug/L	3.000	0	8	0	0	0
U-234	UNFL	pCi/L	1.900	6	9	.5	3.3	2
U-235/236	UNFL	pCi/L	.000	0	11	0	0	0
U-238	UNFL	pCi/L	1.070	8	11	.3	9.7	7
U-TOTAL	UNFL	ug/L	4.000	13	14	1	58	10
VOLATILE ORGANICS								
Phenol	UNFL	ug/L	.000	1	1	50	50	1
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	4.340	5	12	.12	.5	0
Chloride	UNFL	mg/L	46.100	11	12	57.5	1095	11
Fluoride	UNFL	mg/L	1.298	12	12	.16	3.5	3
Nitrate	UNFL	mg/L	.462	4	11	.12	.49	1
Phenols	UNFL	mg/L	.000	7	11	.011	.025	0
Phosphorus	UNFL	mg/L	.206	8	9	.02	.872	3
Sulfate	UNFL	mg/L	138.192	11	11	56	246	2
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	5	9	.103	21	1
Total Organic Halides	UNFL	mg/L	.000	0	5	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.000	4	10	.103	.7	4

[a]Filtered radionuclides and organics, general chemistry are not included because background concentrations were not available.

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TABLE 4-26

LIME SLUDGE PONDS
GROUNDWATER[a] - 1000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	6	9	.0904	15.4	4
Antimony		mg/L	.000	0	9	0	0	0
Arsenic		mg/L	.050	4	9	.0022	.0054	0
Barium		mg/L	.450	9	9	.0781	.217	0
Beryllium		mg/L	.002	1	9	.0019	.0019	0
Cadmium		mg/L	.005	0	9	0	0	0
Calcium		mg/L	123.837	9	9	96	446	7
Chromium		mg/L	.035	3	9	.012	.0323	0
Cobalt		mg/L	.000	1	9	.0094	.0094	1
Copper		mg/L	.030	2	9	.009	.328	1
Cyanide		mg/L	.000	0	5	0	0	0
Iron		mg/L	3.440	6	9	.0402	26.4	3
Lead		mg/L	.015	3	9	.0105	.017	2
Magnesium		mg/L	48.546	9	9	44.9	144	8
Manganese		mg/L	.050	9	9	.0319	1.29	8
Mercury		mg/L	.000	0	9	0	0	0
Molybdenum		mg/L	.025	4	9	.0051	.0142	0
Nickel		mg/L	.026	6	9	.0037	.042	4
Potassium		mg/L	26.976	6	9	.753	7.4	0
Selenium		mg/L	.000	0	9	0	0	0
Silicon		mg/L	.000	9	9	5.28	31	9
Silver		mg/L	.040	0	9	0	0	0
Sodium		mg/L	47.982	9	9	12.3	157	5
Thallium		mg/L	.000	0	9	0	0	0
Vanadium		mg/L	.020	3	9	.0274	.0376	3
Zinc		mg/L	.032	4	9	.0035	.105	3
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	7	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	2	7	27.12	42.8	2
GROSS BETA	UNFL	pCi/L	.000	2	7	15.3	20.9	2
NP-237	UNFL	pCi/L	.000	2	5	.149	.339	2
PU-238	UNFL	pCi/L	.000	0	7	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	7	0	0	0
RA-226	UNFL	pCi/L	1.000	4	7	.21	1.21	1

See footnote at end of table

TABLE 4-26
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	5.200	1	6	3.68	3.68	0
RU-106	UNFL	pCi/L	.000	0	7	0	0	0
SR-90	UNFL	pCi/L	.000	1	7	3.45	3.45	1
TC-99	UNFL	pCi/L	.000	0	7	0	0	0
TH-228	UNFL	pCi/L	1.040	3	7	.78	2.37	2
TH-230	UNFL	pCi/L	2.000	4	7	1.29	3.04	2
TH-232	UNFL	pCi/L	.000	3	7	.74	1.91	3
TH-TOTAL	UNFL	ug/L	3.000	3	7	6.83	17.4	3
U-234	UNFL	pCi/L	1.900	7	7	1.81	11.02	6
U-235/236	UNFL	pCi/L	.000	7	7	.076	.7	7
U-238	UNFL	pCi/L	1.070	7	7	1.89	11.81	7
U-TOTAL	UNFL	ug/L	4.000	7	7	4.77	30.4	7
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	6	0	0	0
2-Butanone	UNFL	ug/L	.000	0	6	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	5	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	5	0	0	0
Acetone	UNFL	ug/L	.000	0	4	0	0	0
Benzene	UNFL	ug/L	.000	0	6	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	6	0	0	0
Bromoform	UNFL	ug/L	.000	0	6	0	0	0
Bromomethane	UNFL	ug/L	.000	0	6	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	6	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	5	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
Chloroethane	UNFL	ug/L	.000	0	6	0	0	0
Chloroform	UNFL	ug/L	.000	0	6	0	0	0
Chloromethane	UNFL	ug/L	.000	0	6	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	6	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	6	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	6	0	0	0
Styrene	UNFL	ug/L	.000	0	6	0	0	0

See footnote at end of table

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TABLE 4-26
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Tetrachloroethene	UNFL	ug/L	.000	0	6	0	0	0
Toluene	UNFL	ug/L	.000	0	6	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	6	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	4	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	6	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	6	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	6	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	6	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	6	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	6	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	6	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	6	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	6	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	6	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	6	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	6	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	6	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	6	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	6	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	6	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	6	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	6	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	3	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	5	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	6	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	6	0	0	0
Anthracene	UNFL	ug/L	.000	0	6	0	0	0

See footnote at end of table

TABLE 4-26
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(a)anthracene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	6	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	4	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	5	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Carbazole	UNFL	ug/L	.000	0	6	0	0	0
Chrysene	UNFL	ug/L	.000	0	6	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	5	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	6	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	6	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	6	0	0	0
Fluorene	UNFL	ug/L	.000	0	6	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	6	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	6	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	6	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	6	0	0	0
Isophorone	UNFL	ug/L	.000	0	6	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	6	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	6	0	0	0
Naphthalene	UNFL	ug/L	.000	0	6	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	6	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	6	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	6	0	0	0
Phenol	UNFL	ug/L	.000	0	6	0	0	0
Pyrene	UNFL	ug/L	.000	0	6	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	6	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	6	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	6	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	2	6	1	2	2
p-Chloroaniline	UNFL	ug/L	.000	0	5	0	0	0

See footnote at end of table

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TABLE 4-26
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	6	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	6	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	6	0	0	0
Aldrin	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	6	0	0	0
Dieldrin	UNFL	ug/L	.000	0	6	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	6	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	6	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	6	0	0	0
Endrin	UNFL	ug/L	.000	0	6	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	6	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	6	0	0	0
Heptachlor	UNFL	ug/L	.000	0	6	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	6	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	6	0	0	0
Toxaphene	UNFL	ug/L	.000	0	6	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	6	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	6	0	0	0
beta-BHC	UNFL	ug/L	.000	0	6	0	0	0
delta-BHC	UNFL	ug/L	.000	0	6	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	6	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	6	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	5	5	245	437.9	0
Alkalinity as CaCO3	UNFL	mg/L	.000	1	1	250	250	0
Ammonia	UNFL	mg/L	4.340	2	6	.14	.15	0
Chloride	UNFL	mg/L	46.100	6	6	44.07	573.8	5
Fluoride	UNFL	mg/L	1.298	6	6	.2	.44	0
Nitrate	UNFL	mg/L	.462	0		0	0	0
Phenols	UNFL	mg/L	.000	0	6	0	0	0

See footnote at end of table

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TABLE 4-26
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Phosphorus	UNFL	mg/L	.206	1	2	.04	.04	0
Sulfate	UNFL	mg/L	138.192	6	6	57.4	147.5	1
Sulfide	UNFL	mg/L	.000	1	6	1.35	1.35	1
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	5	6	.13	.5	0
Total Organic Carbon	UNFL	mg/L	.000	6	6	1.04	1.65	6
Total Organic Halides	UNFL	mg/L	.000	5	6	.0179	.0668	5
Total Organic Nitrogen	UNFL	mg/L	.000	5	6	.13	1.2	5
Total Phosphorous	UNFL	mg/L	.000	4	4	.22	4.13	0

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

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in Phase I but not in Phase II), isotopes of five elements (radium-226, neptunium-237, and Strontium-90 were not detected in Phase I), and be organic compound (bis(2-Ethylhexyl) phthalate).

Concentrations of selected analytes detected in samples from 1000-series wells are presented in Table 4-27. Radionuclides detected above background in 1000-series wells are plotted in Figure 4-10. A comparison of concentrations in upgradient Well 1039 and the downgradient wells indicated the following:

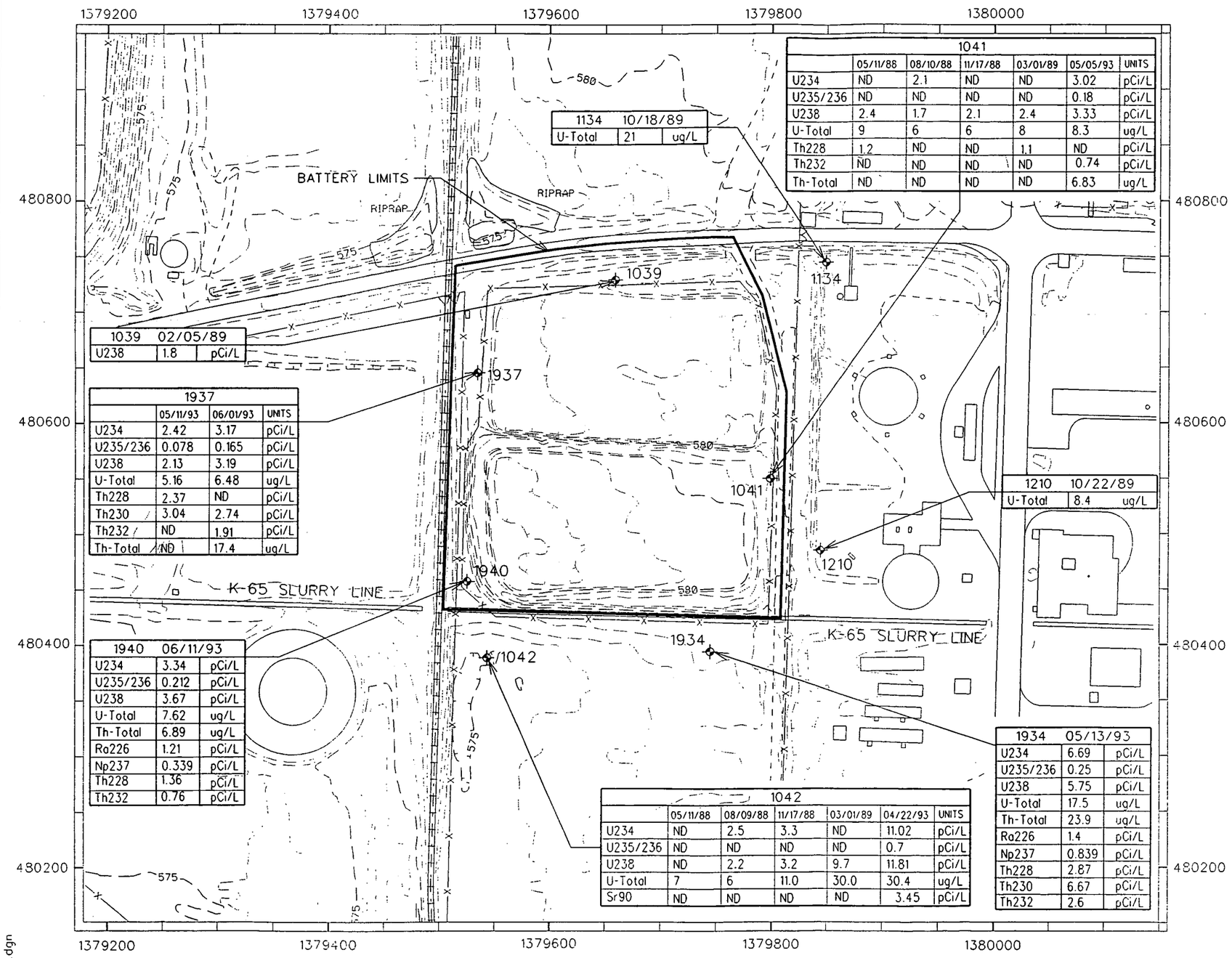
- Chloride and sulfate concentrations decrease in the downgradient direction from 360.23 mg/L and 123.4 mg/L (Well 1039) to 47.1 mg/L and 77.0 mg/L (Well 1934), respectively. The chloride and sulfate concentrations in the north pond surface water were 72 mg/L and 39.3 mg/L, respectively (Appendix D-9). The source of elevated chloride concentrations in the upgradient well may be due to the leaching of salt used in salting the road adjacent to the north boundary during the winter. This indicates that precipitative recharge occurs in this area.

- Metals detected in elevated concentrations, both in the sludge and samples of groundwater beneath the ponds (Well 1041) and downgradient (Well 1934), include chromium, copper, beryllium, and vanadium. These data suggest that metals, have leached from the pond sludge and have impacted perched groundwater.

- Total uranium concentration is elevated in downgradient Well 1042 (30.4 μg/L) and Well 1934 (17.5 μg/L) relative to the upgradient Well 1039 (less than 1 μg/L). The increase may be due to impacts from the K-65 slurry line trench (discussed in Section 4.3.2), which is in the flow path between the ponds and the wells.

- Thorium-230 and radium-226 activities are higher in downgradient Well 1934 (6.67 and 1.40 pCi/L, respectively) relative to upgradient Well 1039 (0.251 and <0.183 pCi/L, respectively) and upgradient Well 1041 (1.37 pCi/L and 0.310 pCi/L, respectively). The increase may also be due to impacts from the K-65 slurry line trench. Also, neptunium-237, strontium-90, and technetium-99 were detected above background in the perched groundwater. One of the most notable detections was 17.4 total thorium in downgradient well 1937. This may indicate that the Lime Sludge Ponds impacted the perched groundwater.

Groundwater analytical data from the 2000-series wells were compared to background data from the regional aquifer and a summary of the analytes is provided in Tables 4-28 and 4-29. Phase I sampling on one 2000-series well detected two metals, isotopes of thorium and uranium, and two organic compounds (acetone at 7 μg/L and phenol at 50 μg/L) that exceeded background concentrations. Phase II sampling of four wells detected three metals (Aluminum, Manganese, and Potassium; Aluminum and Potassium were not detected during Phase I), isotopes of three elements (neptunium-237 and plutonium-238 were not detected for Phase I, thorium-228 was detected during



1134	10/18/89	
U-Total	21	ug/L

1039	02/05/89	
U238	1.8	pCi/L

1041	05/11/88	08/10/88	11/17/88	03/01/89	05/05/93	UNITS
U234	ND	2.1	ND	ND	3.02	pCi/L
U235/236	ND	ND	ND	ND	0.18	pCi/L
U238	2.4	1.7	2.1	2.4	3.33	pCi/L
U-Total	9	6	6	8	8.3	ug/L
Th228	1.2	ND	ND	1.1	ND	pCi/L
Th232	ND	ND	ND	ND	0.74	pCi/L
Th-Total	ND	ND	ND	ND	6.83	ug/L

1937	05/11/93	06/01/93	UNITS
U234	2.42	3.17	pCi/L
U235/236	0.078	0.165	pCi/L
U238	2.13	3.19	pCi/L
U-Total	5.16	6.48	ug/L
Th228	2.37	ND	pCi/L
Th230	3.04	2.74	pCi/L
Th232	ND	1.91	pCi/L
Th-Total	ND	17.4	ug/L

1210	10/22/89	
U-Total	8.4	ug/L

1940	06/11/93	
U234	3.34	pCi/L
U235/236	0.212	pCi/L
U238	3.67	pCi/L
U-Total	7.62	ug/L
Th-Total	6.89	ug/L
Ra226	1.21	pCi/L
Np237	0.339	pCi/L
Th228	1.36	pCi/L
Th232	0.76	pCi/L

1934	05/13/93	
U234	6.69	pCi/L
U235/236	0.25	pCi/L
U238	5.75	pCi/L
U-Total	17.5	ug/L
Th-Total	23.9	ug/L
Ra226	1.4	pCi/L
Np237	0.839	pCi/L
Th228	2.87	pCi/L
Th230	6.67	pCi/L
Th232	2.6	pCi/L

1042	05/11/88	08/09/88	11/17/88	03/01/89	04/22/93	UNITS
U234	ND	2.5	3.3	ND	11.02	pCi/L
U235/236	ND	ND	ND	ND	0.7	pCi/L
U238	ND	2.2	3.2	9.7	11.81	pCi/L
U-Total	7	6	11.0	30.0	30.4	ug/L
Sr90	ND	ND	ND	ND	3.45	pCi/L

LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- 1000 MONITORING WELLS

ND = NOT DETECTED ABOVE BACKGROUND CONCENTRATIONS

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100 200

FIGURE 4-10
RADIONUCLIDES IN 1000-SERIES WELLS DETECTED ABOVE BACKGROUND IN THE LIME SLUDGE PONDS

fig0496.dgn

TABLE 4-27

CONCENTRATIONS OF SELECTED ANALYSIS DETECTED IN GROUNDWATER SAMPLES COLLECTED DURING PHASE II LIME SLUDGE POND OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Location	Sample	Analytes				
		Chloride mg/L	Sulfate mg/L	Thorium-230 pCi/L	Uranium-238 pCi/L	Uranium Total µg/L
1000 SERIES WELLS						
Background Concentrations		110.15	141.89	2	1.07	4
1039. Upgradient of South Lime Sludge Pond	111990 (Unfiltered)	360.23	123.4			
	111990 (Filtered)			0.251	0.416	<1.00
1041. Upgradient of South Lime Sludge Pond	116220 (Unfiltered)	44.07	72.1	1.37	3.33	7.8
	116221 (Filtered)			0.410	2.72	8.3
1934. Downgradient of South Lime Sludge Pond	114620 (Unfiltered)	47.1	77.8	0.308	1.89	4.77
	114622 (Unfiltered)			6.67	5.75	17.5
1937. Downgradient of North Lime Sludge Pond	114617 (Unfiltered)	573.8	57.4	3.014	2.13	5.16
	114782 (Unfiltered)			2.74	3.19	6.48
1940. Downgradient of South Pond	114784 (Filtered)		147.5	0.120	2.58	6.3
	114785 (Unfiltered)			1.29	3.67	7.62
1042. Downgradient of South Pond	110889 (Unfiltered)	88.09	138	0.170	11.81	30.4
Surface Water in North Lime Sludge Pond	114595 (Unfiltered)	68.6	43	0.287	0.285	0.060
	114593 (Unfiltered)	72	39.3	0.210	0.272	1.000

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TABLE 4-27
(Continued)

Location	Sample	Analytes				
		Chloride mg/L	Sulfate mg/L	Thorium-230 pCi/L	Uranium-238 pCi/L	Uranium Total µg/L
2000 SERIES WELLS						
Background Concentrations		145.04	359.85	1.79	0.90	2.92
2939. Upgradient of Ponds	114924 (Unfiltered)	26.86	106.8	0.186	0.579	1.600
	114924 (Filtered)			0.173	0.592	1.630
2936. Downgradient of North Lime Sludge Pond	114788 (Unfiltered)	27.3	120	0.119	1.940	3.64
2935. Directly downgradient of Lime Ponds	114921 (Unfiltered)	23	118.9	0.192	1.23	2.86
	114921 (Filtered)	N/A	N/A	0.181	1.18	2.59
2042. Side gradient to South Lime Sludge Pond	110989 (Unfiltered)	18.82	130.8	0.25	1.23	2.91
	110990 (Filtered)	N/A	N/A	0.160	1.31	3.1

000458

TABLE 4-28

LIME SLUDGE PONDS
GROUNDWATER[a] - 2000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	0	2	0	0	0
Antimony		mg/L	.006	1	2	.06	.06	1
Arsenic		mg/L	.050	0	4	0	0	0
Barium		mg/L	.436	3	4	.038	.043	0
Beryllium		mg/L	.002	0	2	0	0	0
Cadmium		mg/L	.005	0	4	0	0	0
Calcium		mg/L	134.783	4	4	79.8	120	0
Chromium		mg/L	.041	1	4	.02	.02	0
Cobalt		mg/L	.000	0	2	0	0	0
Copper		mg/L	.120	0	4	0	0	0
Cyanide		mg/L	.000	0		0	0	0
Iron		mg/L	4.000	4	4	.18	.321	0
Lead		mg/L	.015	0	4	0	0	0
Magnesium		mg/L	37.961	4	4	21.91	26	0
Manganese		mg/L	.050	4	4	.11	.233	4
Mercury		mg/L	.001	0	4	0	0	0
Molybdenum		mg/L	.025	2	4	.01	.022	0
Nickel		mg/L	.024	0	4	0	0	0
Potassium		mg/L	3.077	2	4	2.37	2.9	0
Selenium		mg/L	.004	0	4	0	0	0
Silver		mg/L	.014	0	3	0	0	0
Sodium		mg/L	51.267	4	4	10.91	12	0
Thallium		mg/L	.000	0	2	0	0	0
Vanadium		mg/L	.025	0	2	0	0	0
Zinc		mg/L	.095	1	2	.05	.05	0
RADIONUCLIDES								
NP-237	UNFL	pCi/L	.000	0	5	0	0	0
PU-238	UNFL	pCi/L	.000	0	4	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	4	0	0	0
RA-226	UNFL	pCi/L	1.200	0	5	0	0	0
RA-228	UNFL	pCi/L	4.000	0	5	0	0	0
SR-90	UNFL	pCi/L	.000	0	5	0	0	0

See footnote at end of table

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TABLE 4-28
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
TC-99	UNFL	pCi/L	36.000	0	5	0	0	0
TH-228	UNFL	pCi/L	1.400	1	5	1.6	1.6	1
TH-230	UNFL	pCi/L	1.700	1	5	1	1	0
TH-232	UNFL	pCi/L	.000	0	5	0	0	0
TH-TOTAL	UNFL	ug/L	2.000	0	2	0	0	0
U-234	UNFL	pCi/L	1.200	2	4	1.1	1.4	1
U-235/236	UNFL	pCi/L	.000	0	5	0	0	0
U-238	UNFL	pCi/L	.900	1	5	1.5	1.5	1
U-TOTAL	UNFL	ug/L	2.000	3	3	2	4	2
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Butanone	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	1	1	7	7	1
Benzene	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroethane	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	1	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	1	0	0	0
Styrene	UNFL	ug/L	.000	0	1	0	0	0
Toluene	UNFL	ug/L	.000	0	1	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	1	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-28
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	1	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	1	0	0	0
Anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-28
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Fluorene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1.2.3-cd)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Isophorone	UNFL	ug/L	.000	0	1	0	0	0
Methyl parathion	UNFL	ug/L	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	1	0	0	0
Naphthalene	UNFL	ug/L	.000	0	1	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Parathion	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	1	0	0	0
Phenol	UNFL	ug/L	.000	1	1	50	50	1
Pyrene	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	1	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	1	0	0	0
PESTICIDES/PCBS								
Azinphosmethyl	UNFL	ug/L	.000	0	1	0	0	0
Demeton	UNFL	ug/L	.000	0	1	0	0	0
Diazinon	UNFL	ug/L	.000	0	1	0	0	0
Ethion	UNFL	ug/L	.000	0	1	0	0	0
Malathion	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	3.240	1	4	.3	.3	0
Chloride	UNFL	mg/L	120.000	3	4	18	36.7	0
Fluoride	UNFL	mg/L	.929	4	4	.14	1.2	1
Nitrate	UNFL	mg/L	10.000	3	4	.2	.9	0
Phenols	UNFL	mg/L	.000	0	4	0	0	0
Phosphorus	UNFL	mg/L	.679	2	3	.056	.55	0
Sulfate	UNFL	mg/L	352.992	4	4	.042	103	0

See footnote at end of table

TABLE 4-28
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	1	3	.6	.6	0
Total Organic Halides	UNFL	mg/L	.021	0	1	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.652	2	4	.26	.3	0

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

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TABLE 4-29

LIME SLUDGE PONDS
GROUNDWATER[a] - 2000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	5	8	.0336	.26	1
Antimony		mg/L	.006	0	8	0	0	0
Arsenic		mg/L	.050	3	8	.0011	.0012	0
Barium		mg/L	.436	8	8	.0277	.0698	0
Beryllium		mg/L	.002	0	8	0	0	0
Cadmium		mg/L	.005	0	8	0	0	0
Calcium		mg/L	134.783	8	8	106	118	0
Chromium		mg/L	.041	1	8	.0055	.0055	0
Cobalt		mg/L	.000	0	8	0	0	0
Copper		mg/L	.120	1	8	.0053	.0053	0
Cyanide		mg/L	.000	0	3	0	0	0
Iron		mg/L	4.000	7	8	1.03	2.38	0
Lead		mg/L	.015	0	8	0	0	0
Magnesium		mg/L	37.961	8	8	25.7	27	0
Manganese		mg/L	.050	8	8	.0947	1.29	8
Mercury		mg/L	.001	0	8	0	0	0
Molybdenum		mg/L	.025	3	8	.0071	.0088	0
Nickel		mg/L	.024	0	8	0	0	0
Potassium		mg/L	3.077	2	8	3.1	3.16	2
Selenium		mg/L	.004	0	8	0	0	0
Silicon		mg/L	6.140	8	8	4.28	5.71	0
Silver		mg/L	.014	0	8	0	0	0
Sodium		mg/L	51.267	8	8	13.1	17.9	0
Thallium		mg/L	.000	0	8	0	0	0
Vanadium		mg/L	.025	0	8	0	0	0
Zinc		mg/L	.095	1	8	.0338	.0338	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	5	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0	5	0	0	0
GROSS BETA	UNFL	pCi/L	.000	2	5	5.08	5.23	2
NP-237	UNFL	pCi/L	.000	2	4	.1	.52	2
PU-238	UNFL	pCi/L	.000	2	5	.05	.05	2
PU-239/240	UNFL	pCi/L	.000	0	5	0	0	0
RA-226	UNFL	pCi/L	1.200	3	5	.12	.791	0

See footnote at end of table

TABLE 4-29
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	4.000	0	5	0	0	0
RU-106	UNFL	pCi/L	.000	0	5	0	0	0
SR-90	UNFL	pCi/L	.000	0	5	0	0	0
TC-99	UNFL	pCi/L	36.000	0	5	0	0	0
TH-228	UNFL	pCi/L	1.400	0	5	0	0	0
TH-230	UNFL	pCi/L	1.700	2	5	.144	.25	0
TH-232	UNFL	pCi/L	.000	0	5	0	0	0
TH-TOTAL	UNFL	ug/L	2.000	0	5	0	0	0
U-234	UNFL	pCi/L	1.200	2	5	1.33	1.41	2
U-235/236	UNFL	pCi/L	.000	2	5	.076	.16	2
U-238	UNFL	pCi/L	.900	5	5	.579	1.94	4
U-TOTAL	UNFL	ug/L	2.000	5	5	1.63	3.79	4
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	4	0	0	0
2-Butanone	UNFL	ug/L	.000	0	4	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	4	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	0	4	0	0	0
Benzene	UNFL	ug/L	.000	0	4	0	0	0
Bromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	3	0	0	0
Bromoform	UNFL	ug/L	.000	0	4	0	0	0
Bromomethane	UNFL	ug/L	.000	0	4	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	4	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	4	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Chloroethane	UNFL	ug/L	.000	0	4	0	0	0
Chloroform	UNFL	ug/L	.000	0	4	0	0	0
Chloromethane	UNFL	ug/L	.000	0	4	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	4	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	4	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

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TABLE 4-29
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Styrene	UNFL	ug/L	.000	0	4	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	4	0	0	0
Toluene	UNFL	ug/L	.000	0	4	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	4	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	1	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	4	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	4	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	3	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	3	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	4	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	4	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	4	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	4	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-29
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	3	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	3	4	1	2	3
Carbazole	UNFL	ug/L	.000	0	4	0	0	0
Chrysene	UNFL	ug/L	.000	0	4	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	3	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	4	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Fluorene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	4	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Isophorone	UNFL	ug/L	.000	0	4	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	4	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	3	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	4	0	0	0
Naphthalene	UNFL	ug/L	.000	0	4	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	4	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	4	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	4	0	0	0
Phenol	UNFL	ug/L	.000	0	4	0	0	0
Pyrene	UNFL	ug/L	.000	0	4	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	3	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	4	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

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TABLE 4-29
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	4	0	0	0
Aldrin	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	4	0	0	0
Dieldrin	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	4	0	0	0
Endrin	UNFL	ug/L	.000	0	4	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	4	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	4	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	4	0	0	0
Toxaphene	UNFL	ug/L	.000	0	4	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	4	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
beta-BHC	UNFL	ug/L	.000	0	4	0	0	0
delta-BHC	UNFL	ug/L	.000	0	4	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	4	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	4	4	255.5	332.5	0
Ammonia	UNFL	mg/L	3.240	0	4	0	0	0
Chloride	UNFL	mg/L	120.000	4	4	18.82	27.3	0
Fluoride	UNFL	mg/L	.929	4	4	.13	.17	0
Nitrate	UNFL	mg/L	10.000	2	2	.89	1.46	0
Phenols	UNFL	mg/L	.000	0	4	0	0	0
Sulfate	UNFL	mg/L	352.992	4	4	106.8	130.8	0
Sulfide	UNFL	mg/L	30.400	3	4	.51	10.75	0
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	1	4	.11	.11	0

See footnote at end of table

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TABLE 4-29
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Total Organic Carbon	UNFL	mg/L	3.764	0	4	0	0	0
Total Organic Halides	UNFL	mg/L	.021	1	4	.0102	.0102	0
Total Organic Nitrogen	UNFL	mg/L	.652	1	4	.11	.11	0
Total Phosphorous	UNFL	mg/L	.000	3	4	.04	.05	0

[a]Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available.

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Phase I but not Phase II), and one organic compound (Butyl benzyl phthalate). Concentrations of selected radionuclides detected in samples collected from the 2000-series wells during Phase II are shown on Figure 4-11 and presented in Table 4-27. A comparison of concentrations in samples from upgradient and downgradient wells indicates the following:

- Chloride concentrations are similar in upgradient Well 2939 (26.86 mg/L) and downgradient Well 2935 (23 mg/L) and Well 2042 (18.82 mg/L). This indicates that no impacts are present from the Lime Sludge Ponds.

- Isotopes of neptunium and plutonium were detected above background (which was 0.00 pCi/L) in water samples from all of the wells. Isotopes of uranium were detected above background (2.71 μg/L) in all three downgradient wells (2042, 2935, and 2936). The background value for total uranium (2.92 μg/L) was exceeded slightly in Well 2042 (3.39 μg/L) and Well 2935 (2.86 μg/L). These data do not indicate an impact from the waste unit upon the regional groundwater.

4.3.5 Biota

The ecological impacts from material left after remediation will be addressed in the Site-Wide Ecological Risk Assessment that will be prepared as part of the Operable Unit 5 RI/FS.

4.3.6 Summary

The following conclusions concerning the Lime Sludge Ponds are possible:

- There are no perennial sources of running surface water within the battery limits of the Lime Sludge Ponds. Precipitation remains in the ponds since they are contained. the only source of surface water runoff is the steep outside berms of the south pond, and since the surface area of the berms is small and has a vegetative cover, the runoff is minimal and runs off in sheet flow. The only drainage in the subunit battery limits is a channelized ditch at the north edge of the battery limits.

- The surface soil COCs detected above surface soil background were cesium-137, radium-226, radium-228, thorium-228, thorium-230, thorium-232, total uranium, and arsenic.

- Subsurface samples (including lime sludge and soil) contained trace amounts of organic compounds including six volatile and eight semivolatile organic compounds. With the exception of phenol in Phase I and bis(2-ethylhexyl)phthalate in Phase II (which are common laboratory contaminants), organic compounds were not detected in samples of perched groundwater, indicating that organics have not leached from the sludge to the perched groundwater.

- The surface soil COCs cesium-137, radium-226, radium-228, thorium-228, thorium-230, thorium-232, uranium-238 , and total uranium were detected above background in the subsurface samples. Other radionuclides detected above background were plutonium, strontium, and technetium.

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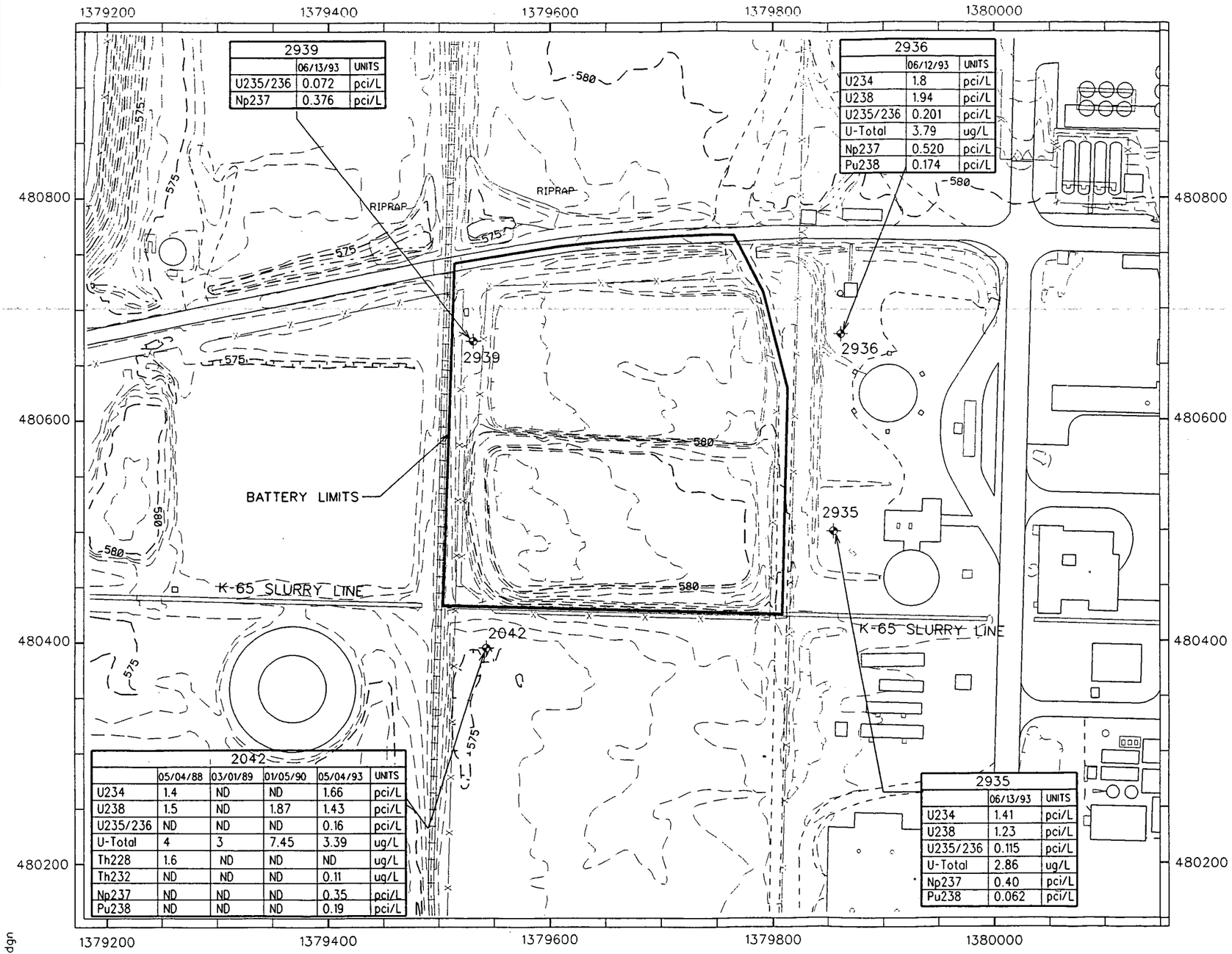

2939		
	06/13/93	UNITS
U235/236	0.072	pci/L
Np237	0.376	pci/L

2936		
	06/12/93	UNITS
U234	1.8	pci/L
U238	1.94	pci/L
U235/236	0.201	pci/L
U-Total	3.79	ug/L
Np237	0.520	pci/L
Pu238	0.174	pci/L

2042					
	05/04/88	03/01/89	01/05/90	05/04/93	UNITS
U234	1.4	ND	ND	1.66	pci/L
U238	1.5	ND	1.87	1.43	pci/L
U235/236	ND	ND	ND	0.16	pci/L
U-Total	4	3	7.45	3.39	ug/L
Th228	1.6	ND	ND	ND	ug/L
Th232	ND	ND	ND	0.11	ug/L
Np237	ND	ND	ND	0.35	pci/L
Pu238	ND	ND	ND	0.19	pci/L

2935		
	06/13/93	UNITS
U234	1.41	pci/L
U238	1.23	pci/L
U235/236	0.115	pci/L
U-Total	2.86	ug/L
Np237	0.40	pci/L
Pu238	0.062	pci/L

LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- 2000 MONITORING WELLS

ND=NOT DETECTED ABOVE BACKGROUND

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100 200

FIGURE 4-11
RADIONUCLIDES IN 2000-SERIES WELLS DETECTED ABOVE BACKGROUND IN THE LIME SLUDGE PONDS

fig0486.dgn

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- Chemical and radiological samples indicate that the sludge, the roadway, and the berm materials have different constituents and concentrations and are considered distinct waste materials.

- Samples collected from sludge and underlying soil indicate that the underlying soil has higher concentrations than the sludge for most constituents.

- In perched groundwater, the surface soil COCs radium-226, thorium-228, thorium-230, thorium-232, uranium-238, and uranium total were detected above background. An additional radionuclide, strontium-90, was also detected above background.

- Elevated concentrations of uranium and thorium were detected in downgradient perched groundwater wells. This may be due to both the Lime Sludge Ponds and the K-65 slurry line trench impacting the perched groundwater.

- Concentrations of metals were elevated in sludge and in downgradient perched groundwater wells. This suggests that there has been a possible impact by metals leaching from the sludge into the perched groundwater.

- Samples of regional aquifer groundwater detected uranium above background concentrations in two of three downgradient wells. However, the concentrations are very close to background suggesting that the impact of radioisotopes from the Lime Sludge Ponds is minimal.

- Samples of regional aquifer groundwater detected six metals commonly associated with the soil matrix.

- The surface soil COCs thorium-228, thorium-232, uranium-238, and total uranium were detected above background in 2000-series wells in the regional aquifer. An additional radionuclide, plutonium, was also detected above background.

4.4 INACTIVE FLYASH PILE

Analytical results for samples collected from the Inactive Flyash Pile are presented in Appendix E. Sample analyses that detected analytes at concentrations above background (defined in Table 4-1A) will be discussed in this section. Analyte concentrations at or below background will be considered as expected for soil or flyash and will not be discussed further. Geology and hydrogeology of the Inactive Flyash Pile referred to in this section were discussed in more detail in Section 3.4.

4.4.1 Volume and Physical Characteristics of the Waste

The volume of flyash and waste materials was estimated for the Inactive Flyash Pile as 95,891 cubic yards, and the contours of waste thickness are shown on Figure 4-12. Flyash was originally coal that was burned at the boiler plant and would be expected to contain elevated concentrations of metals and radionuclides when compared to background soil concentrations since coal has elevated

concentrations. A discussion of expected concentrations of radionuclides and metals in flyash was provided in Section 4.1.4. Aerial photographs and interviews with workers indicate that the flyash was deposited as in-filling of depressions in the till surface by dump trucks. Flyash was dumped off a steep till embankment near to Paddys Run and thereafter, worked by bulldozers. There were no discernable dumping patterns observed in the aerial photographs, and it appears that dumping occurred at different working faces within the north South Field and Inactive Flyash Pile areas during the 1950s, although the south end of the Inactive Flyash Pile was active during a short period in 1986.

Analyses of subsurface soils collected during Phase II activities were evaluated to determine if correlations existed between analytes detected above background. The constituents selected were Aroclor-1254, arsenic, beryllium, benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, radium-228, thorium-228, and uranium-238 (see Table 4-29A). Radium-228 and thorium-228 varied sympathetically, as did arsenic and beryllium, and benzo(a)anthracene and benzo(a)pyrene. Correlation between these radionuclides, metals, and organic compounds suggests that they were deposited at approximately the same time and place. Poor correlation with other analytes, for example uranium, suggests that the other analytes were deposited over a different time period and in different locations. No other correlations in concentrations were noted. A more detailed comparison of semi-volatile organics in the Solid Waste Landfill (anthracene, phenanthrene, benzo(a)anthracene, benzo(g,h,i)perylene, benzo(k)fluoranthene, fluoranthene, and pyrene) showed that these constituents varied sympathetically. This is consistent with data from the Inactive Flyash Pile and indicates that disposal of similar mixtures of materials, possibly from the same manufacturing areas, were deposited at both locations. The lack of correlation between other organic and radionuclide constituents suggest that they were not co-disposed.

The southern portion of the Inactive Flyash Pile has an approximate 7-foot soil/fill cover with a moderate vegetative cover. The northern portion, as indicated by the soil boring logs, does not have a soil cover. However, the northern portion is covered with moderate vegetation and stands of deciduous trees.

Samples of flyash collected from borings detected dry to moist conditions but never detected water saturated samples. Very moist to wet conditions were detected at the interface of the Inactive Flyash Pile and the native till surface. The highest beta gamma readings were also detected in samples

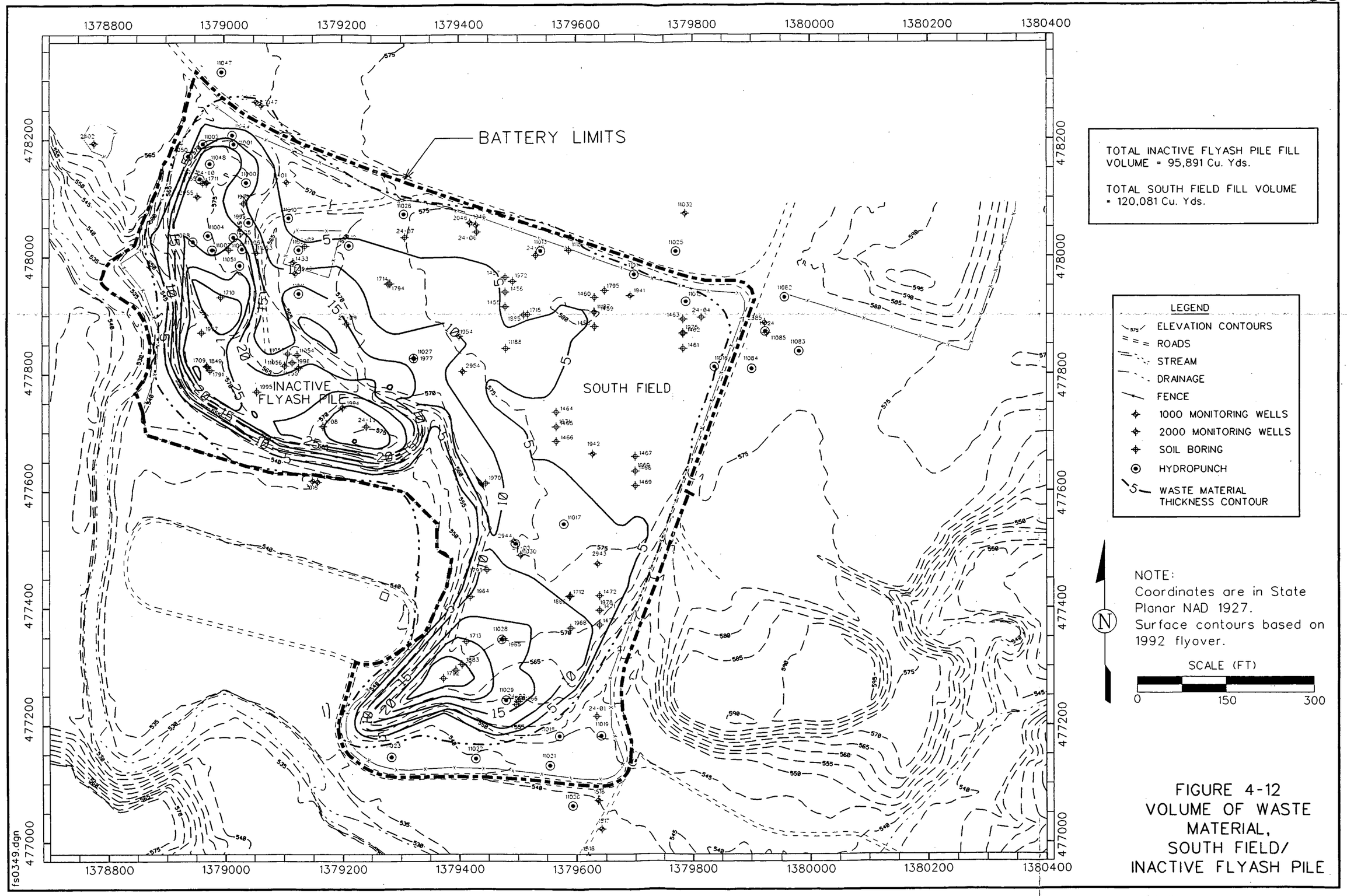

FIGURE 4-12
VOLUME OF WASTE MATERIAL, SOUTH FIELD/ INACTIVE FLYASH PILE

collected from this interface or from underlying sand layers within the glacial till overburden. Soil samples collected from several soil borings drilled in the flyash detected solid waste materials of sludge, concrete, and construction rubble near to the till surface beneath the flyash at Hydropunch™ 11006, 11051, 11055 and in Boring No.1996. Flyash was the major material identified in most of the other subsurface samples collected from the Inactive Flyash Pile.

4.4.2 Surface and Subsurface Media

Chemical and radiological analytical results for surface media were compared to soil background results. A listing of analytes detected above background is provided in Appendix E, Table E-2A. A summary of the analytes in surface media is provided in Table 4-30. Fifteen metals, isotopes of six elements, and twelve organic compounds exceeded background concentrations in samples of the surface media collected during the Phase II field program. Surface soils were not collected for Phase I. Radionuclide data for Phase I are presented on Figure 4-13. Total uranium concentrations were detected at elevated concentrations in all surface soils, ranging from 5.01 microgram per gram (μg/g) to 32.1 μg/g (background concentrations is 3.7 μg/g). Strontium-90 was detected in five of seven surface samples and total thorium was detected at 7.74 μg/g and 21.4 μg/g at IFP-SS-05 and IFP-SS-01, respectively. These data do not suggest a pattern of surface disposal at one location with subsequent surface spreading; they support the conclusion that disposal of waste occurred over a larger area.

Beryllium and silver were detected in six and five of seven Phase II surface samples, respectively. The metals arsenic, copper, cyanide, selenium, and lead were detected above background in the surface sample IFP-SS-01. This sample also contained the highest values for radium and thorium isotopes. Three volatile organics (trace concentrations of acetone, toluene, and 2-butanone) were detected in surface soil samples. Nine semi-volatile organics (2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, carbazole, dibenzo(a,h)anthracene, fluorene, dibenzofuran, and naphthalene) were detected in sample IFP-SS-07 at the north end of the Inactive Flyash Pile. This indicates that the north area is a potential source of organic compound sediments that are taken off-site by surface erosion, and that the remainder of the surface is covered by relatively clean fill that does not contain organic compounds.

Phase I and Phase II surface soil data were compared to CIS and ES data (Appendices E-4 and E-5). Analytes detected in these preliminary studies were also detected in Phase I and Phase II and within the same order of magnitude.

Chemical and radiological analytical results from subsurface samples were compared against soil background concentrations. A table of the resulting constituent concentrations above background values is provided in Appendix E in Table E-2B and Table E-2C. A summary of the analytes in subsurface soil is presented as Table 4-31 and Table 4-32. Radionuclides and metals of concern are shown on Figure 4-14 (see Volume 2, Oversized Figures). Fifteen metals, isotopes of ten elements, and 24 organic compounds exceeded background concentrations at 11 sample locations from the Inactive Flyash Pile during the Phase I field program. During the Phase II sampling twenty metals (Calcium, Chromium, Cobalt, Magnesium, Nickel, Potassium, and Vanadium were not detected for Phase I), isotopes of seven elements (lead-210, and technetium-99 were detected above background for Phase I and not for Phase II), and thirty four organic compounds were detected above background in samples collected from twelve locations (2-butanone, chlorobenzene, chloromethane, methylene chloride, tetrachloroethene, trichloroethane, 4-methylphenol, benzo(g,h,i)perylene, carbazole, dibenzo(a,h)anthracene, diethylphthalate, indeno(1,2,3-cd)pyrene, isophorone, phenol, tributyl phosphate, and alph-chlordane were detected for Phase II but not Phase I; 2-hexanone, carbon disulfide, styrene, vinyl acetate, benzoic acid, and Aroclor-1260 were detected for Phase I but not Phase II). As indicated on Figure 4-4, locations 1710 (27-28.5 ft) and 11051 (21-22 ft and 22-24 ft) have different isotopic thorium to total thorium ratios than other locations. These values have been validated and apparently are correct. The ratios are different from the other values due to the high values of thorium-230.

Metals detected above soil background in 40 percent or more of Phase I samples include antimony, arsenic, barium, beryllium, copper, cyanide, molybdenum, selenium, and silver. If the data are compared to metal concentrations expected for flyash, cyanide (ten samples), potassium (twelve samples), sodium (ten samples), and thallium (three samples) are above background concentrations. When Phase II samples are compared to flyash background the following metals are detected above background in 22 samples:

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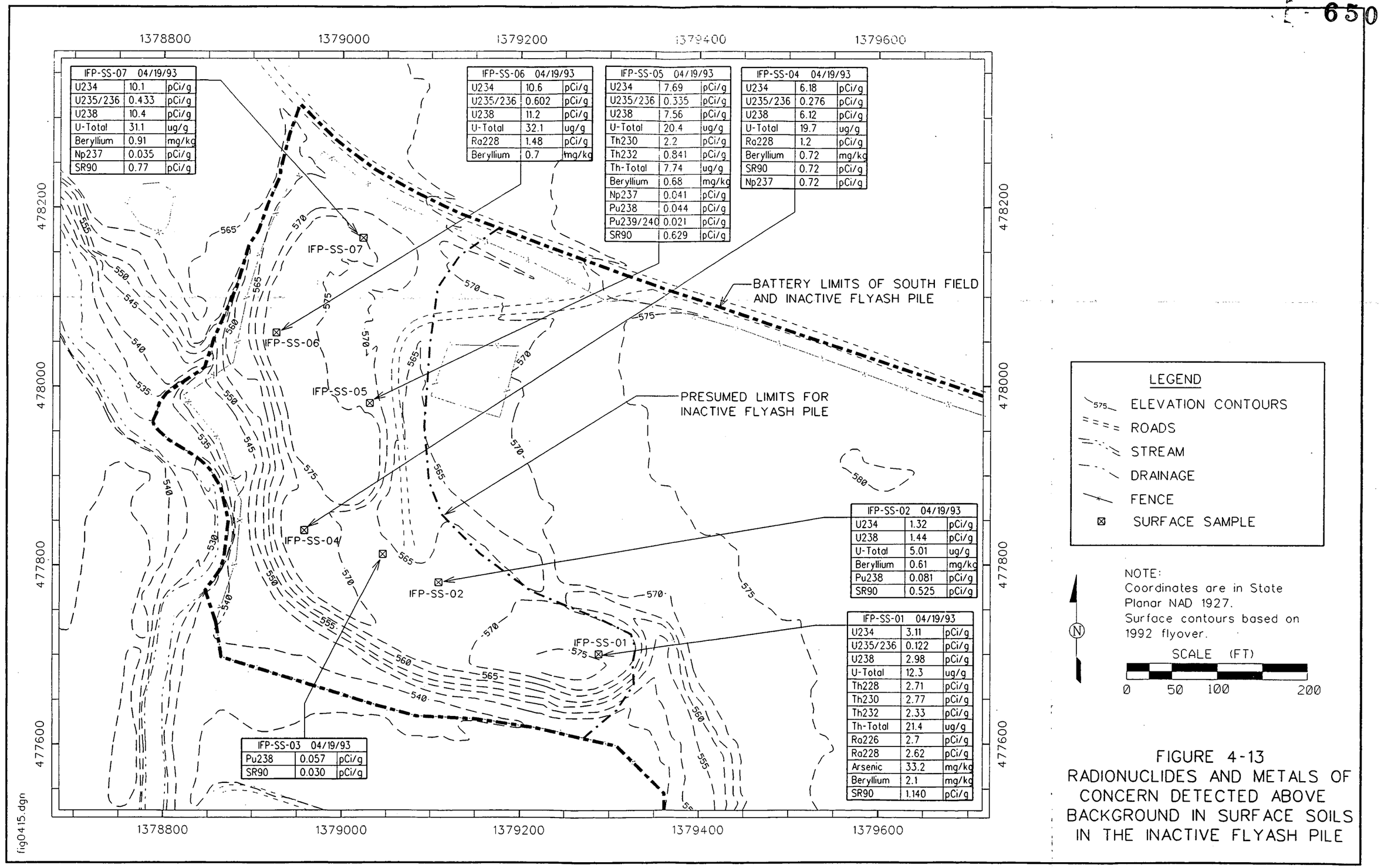

FIGURE 4-13
RADIONUCLIDES AND METALS OF CONCERN DETECTED ABOVE BACKGROUND IN SURFACE SOILS IN THE INACTIVE FLYASH PILE

TABLE 4-30

INACTIVE FLYASH PILE
SURFACE SOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	7	7	1430	10100	0
Antimony	mg/kg	.000	0	7	0	0	0
Arsenic	mg/kg	8.200	7	7	1.9	33.2	1
Barium	mg/kg	94.100	7	7	7.3	105	1
Beryllium	mg/kg	.600	6	7	.61	2.1	6
Cadmium	mg/kg	.870	1	7	3.1	3.1	1
Calcium	mg/kg	4339.170	7	7	2730	142000	6
Chromium	mg/kg	15.500	7	7	2.5	12.9	0
Cobalt	mg/kg	14.160	7	7	2.9	10.2	0
Copper	mg/kg	14.070	7	7	4.8	41.1	2
Cyanide	mg/kg	.270	3	7	.14	.7	1
Iron	mg/kg	21728.170	7	7	2770	17000	0
Lead	mg/kg	26.400	7	7	3.2	31.3	1
Magnesium	mg/kg	2776.970	7	7	741	55000	6
Manganese	mg/kg	1348.040	7	7	38	1020	0
Mercury	mg/kg	.120	0	7	0	0	0
Molybdenum	mg/kg	.000	3	7	4.8	7.2	3
Nickel	mg/kg	20.870	7	7	5.8	19.7	0
Potassium	mg/kg	1231.340	7	7	221	2030	4
Selenium	mg/kg	.720	1	7	8.2	8.2	1
Silicon	mg/kg	1797.030	7	7	219	1220	0
Silver	mg/kg	.000	5	7	2.8	5	5
Sodium	mg/kg	51.100	7	7	74.5	223	7
Thallium	mg/kg	.580	0	7	0	0	0
Vanadium	mg/kg	30.370	7	7	4.9	32.3	1
Zinc	mg/kg	59.610	7	7	12.6	55.1	0
RADIONUCLIDES							
CS-137	pCi/g	.710	5	7	.0871	.641	0
GROSS ALPHA	pCi/g	.000	6	7	20.1	60.2	6
GROSS BETA	pCi/g	.000	7	7	11.9	43.9	7
NP-237	pCi/g	.000	4	4	.0298	.137	4
PU-238	pCi/g	.000	3	6	.0441	.081	3
PU-239/240	pCi/g	.000	1	6	.0205	.0205	1
RA-226	pCi/g	1.420	7	7	.523	2.7	1
RA-228	pCi/g	1.250	7	7	.415	2.62	2
RU-106	pCi/g	.000	0	7	0	0	0

TABLE 4-30
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
SR-90	pCi/g	.000	5	7	.525	1.14	5
TC-99	pCi/g	.000	0	7	0	0	0
TH-228	pCi/g	1.430	2	2	.79	2.71	1
TH-230	pCi/g	1.970	2	2	2.2	2.77	2
TH-232	pCi/g	1.360	2	2	.841	2.33	1
TH-TOTAL	mg/kg	10.700	2	2	7.74	21.4	1
U-234	pCi/g	1.240	7	7	.433	10.6	6
U-235/236	pCi/g	.150	7	7	.038	.602	4
U-238	pCi/g	1.220	7	7	.422	11.2	6
U-TOTAL	mg/kg	3.700	7	7	.824	32.1	6
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	7	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	7	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	7	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	7	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	7	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	7	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	7	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	7	0	0	0
2-Butanone	ug/kg	.000	1	7	3	3	1
2-Hexanone	ug/kg	.000	0	7	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	7	0	0	0
Acetone	ug/kg	.000	3	7	2	12	3
Benzene	ug/kg	.000	0	7	0	0	0
Bromodichloromethane	ug/kg	.000	0	7	0	0	0
Bromoform	ug/kg	.000	0	7	0	0	0
Bromomethane	ug/kg	.000	0	7	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	7	0	0	0
Carbon disulfide	ug/kg	.000	0	7	0	0	0
Chlorobenzene	ug/kg	.000	0	7	0	0	0
Chloroethane	ug/kg	.000	0	7	0	0	0
Chloroform	ug/kg	.000	0	7	0	0	0
Chloromethane	ug/kg	.000	0	7	0	0	0
Dibromochloromethane	ug/kg	.000	0	7	0	0	0
Ethylbenzene	ug/kg	.000	0	7	0	0	0
Methylene chloride	ug/kg	.000	0	7	0	0	0
Styrene	ug/kg	.000	0	7	0	0	0
Tetrachloroethene	ug/kg	.000	0	7	0	0	0
Toluene	ug/kg	.000	3	7	3	55	3
Trichloroethene	ug/kg	.000	0	7	0	0	0
Vinyl Acetate	ug/kg	.000	0	7	0	0	0
Vinyl chloride	ug/kg	.000	0	7	0	0	0

TABLE 4-30
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Xylenes, Total	ug/kg	.000	0	7	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	7	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	7	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	7	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	7	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	7	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	7	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	7	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	7	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	7	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	7	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	7	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	7	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	7	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	7	0	0	0
2-Chlorophenol	ug/kg	.000	0	7	0	0	0
2-Methylnaphthalene	ug/kg	.000	1	7	160	160	1
2-Methylphenol	ug/kg	.000	0	7	0	0	0
2-Nitroaniline	ug/kg	.000	0	7	0	0	0
2-Nitrophenol	ug/kg	.000	0	7	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	7	0	0	0
3-Nitroaniline	ug/kg	.000	0	7	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0		0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	7	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	7	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	7	0	0	0
4-Methylphenol	ug/kg	.000	0	7	0	0	0
4-Nitroaniline	ug/kg	.000	0		0	0	0
4-Nitrophenol	ug/kg	.000	0	7	0	0	0
Acenaphthene	ug/kg	.000	1	7	460	460	1
Acenaphthylene	ug/kg	.000	1	7	1800	1800	1
Anthracene	ug/kg	.000	1	7	1700	1700	1
Benzo(a)anthracene	ug/kg	.000	0	7	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	7	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	7	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	7	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	7	0	0	0
Benzoic acid	ug/kg	.000	0	7	0	0	0
Benzyl alcohol	ug/kg	.000	0	7	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	7	0	0	0
Carbazole	ug/kg	.000	1	7	510	510	1

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TABLE 4-30
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Chrysene	ug/kg	.000	0	7	0	0	0
Di-n-butyl phthalate	ug/kg	.000	0	7	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	7	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	1	7	2200	2200	1
Dibenzofuran	ug/kg	.000	1	7	250	250	1
Diethyl phthalate	ug/kg	.000	0	7	0	0	0
Dimethyl phthalate	ug/kg	.000	0	7	0	0	0
Fluoranthene	ug/kg	.000	0	7	0	0	0
Fluorene	ug/kg	.000	1	7	510	510	1
Hexachlorobenzene	ug/kg	.000	0	7	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	7	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	7	0	0	0
Hexachloroethane	ug/kg	.000	0	7	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	7	0	0	0
Isophorone	ug/kg	.000	0	7	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	7	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	7	0	0	0
Naphthalene	ug/kg	.000	1	7	100	100	1
Nitrobenzene	ug/kg	.000	0	7	0	0	0
Pentachlorophenol	ug/kg	.000	0	7	0	0	0
Phenanthrene	ug/kg	.000	0	7	0	0	0
Phenol	ug/kg	.000	0	7	0	0	0
Pyrene	ug/kg	.000	0	7	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	7	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	7	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	7	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	0	7	0	0	0
p-Chloroaniline	ug/kg	.000	0	7	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	7	0	0	0
4,4'-DDE	ug/kg	.000	0	7	0	0	0
4,4'-DDT	ug/kg	.000	0	7	0	0	0
Aldrin	ug/kg	.000	0	7	0	0	0
Aroclor-1016	ug/kg	.000	0	7	0	0	0
Aroclor-1221	ug/kg	.000	0	7	0	0	0
Aroclor-1232	ug/kg	.000	0	7	0	0	0
Aroclor-1242	ug/kg	.000	0	7	0	0	0
Aroclor-1248	ug/kg	.000	0	7	0	0	0
Aroclor-1254	ug/kg	.000	0	7	0	0	0
Aroclor-1260	ug/kg	.000	0	7	0	0	0
Dieldrin	ug/kg	.000	0	7	0	0	0
Endosulfan II	ug/kg	.000	0	7	0	0	0

TABLE 4-30
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Endosulfan sulfate	ug/kg	.000	0	7	0	0	0
Endosulfan-I	ug/kg	.000	0	7	0	0	0
Endrin	ug/kg	.000	0	7	0	0	0
Endrin aldehyde	ug/kg	.000	0	7	0	0	0
Endrin ketone	ug/kg	.000	0	7	0	0	0
Heptachlor	ug/kg	.000	0	7	0	0	0
Heptachlor epoxide	ug/kg	.000	0	7	0	0	0
Methoxychlor	ug/kg	.000	0	7	0	0	0
Toxaphene	ug/kg	.000	0	7	0	0	0
alpha-BHC	ug/kg	.000	0	7	0	0	0
alpha-Chlordane	ug/kg	.000	0	7	0	0	0
beta-BHC	ug/kg	.000	0	7	0	0	0
delta-BHC	ug/kg	.000	0	7	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	7	0	0	0
gamma-Chlordane	ug/kg	.000	0	7	0	0	0

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TABLE 4-31

INACTIVE FLYASH PILE
SUBSOIL
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	12	12	2130	9550	0
Antimony	mg/kg	.000	4	8	8.8	16.3	4
Arsenic	mg/kg	9.570	12	12	1.7	74.8	6
Barium	mg/kg	119.170	12	12	13.1	892	8
Beryllium	mg/kg	.620	12	12	.54	6.7	9
Cadmium	mg/kg	.910	9	12	.65	4.1	4
Calcium	mg/kg	150000.000	12	12	2510	123000	0
Chromium	mg/kg	20.680	12	12	5.1	19.6	0
Cobalt	mg/kg	15.750	12	12	5.2	12.1	0
Copper	mg/kg	20.030	12	12	12.1	44.9	9
Cyanide	mg/kg	.130	10	10	.18	1.2	10
Iron	mg/kg	30700.000	12	12	4610	20100	0
Lead	mg/kg	15.580	12	12	6.4	67.1	2
Magnesium	mg/kg	42648.210	12	12	377	25100	0
Manganese	mg/kg	1300.000	12	12	22.7	736	0
Mercury	mg/kg	.290	2	9	.18	.44	1
Molybdenum	mg/kg	2.700	12	12	3.2	9.4	12
Nickel	mg/kg	34.350	12	12	9.7	19.6	0
Potassium	mg/kg	1979.990	12	12	456	1430	0
Selenium	mg/kg	.000	9	12	.73	4.1	9
Silver	mg/kg	.000	7	12	2.7	8.3	7
Sodium	mg/kg	285.000	10	12	91.7	294	1
Thallium	mg/kg	.490	3	12	.8	1	3
Vanadium	mg/kg	37.800	12	12	10.7	34.9	0
Zinc	mg/kg	72.580	12	12	9.4	102	1
RADIONUCLIDES							
CS-137	pCi/g	.000	1	19	.2	.2	1
GROSS ALPHA	pCi/g	.000	0		0	0	0
GROSS BETA	pCi/g	.000	0		0	0	0
NP-237	pCi/g	.000	3	18	.6	.78	3
PB-210	pCi/g	.810	10	10	.71	16.8	7
PU-238	pCi/g	.000	1	19	.6	.6	1
PU-239/240	pCi/g	.000	0	16	0	0	0
RA-224	pCi/g	1.010	10	10	1.02	3.49	10
RA-226	pCi/g	1.470	18	19	.4	36	12
RA-228	pCi/g	1.310	16	19	.6	3.13	10

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TABLE 4-31
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RU-106	pCi/g	.000	1	19	1	1	1
SR-90	pCi/g	.560	7	19	.7	4	7
TC-99	pCi/g	.000	2	19	.9	1.5	2
TH-228	pCi/g	1.330	16	18	.79	4.1	12
TH-230	pCi/g	1.880	16	18	.9	54.6	11
TH-232	pCi/g	1.260	15	18	.6	4	9
TH-TOTAL	mg/kg	9.470	16	16	2.79	36.1	11
U-234	pCi/g	1.040	15	18	.7	187	14
U-235/236	pCi/g	.150	7	18	.687	18.5	7
U-238	pCi/g	1.120	23	25	.7	191	21
U-TOTAL	mg/kg	3.400	16	19	1.59	873	15
VOLATILE ORGANICS							
1.1.1-Trichloroethane	ug/kg	.000	9	14	4	170	9
1.1.2.2-Tetrachloroethane	ug/kg	.000	0	5	0	0	0
1.1.2-Trichloroethane	ug/kg	.000	0	7	0	0	0
1.1-Dichloroethane	ug/kg	.000	0	13	0	0	0
1.1-Dichloroethene	ug/kg	.000	0	13	0	0	0
1.2-Dichloroethane	ug/kg	.000	0	12	0	0	0
1.2-Dichloroethene	ug/kg	.000	0	13	0	0	0
1.2-Dichloropropane	ug/kg	.000	0	7	0	0	0
2-Butanone	ug/kg	.000	0	11	0	0	0
2-Hexanone	ug/kg	.000	1	5	3	3	1
4-Methyl-2-pentanone	ug/kg	.000	2	6	1	2	2
Acetone	ug/kg	.000	5	12	10	190	5
Benzene	ug/kg	.000	0	7	0	0	0
Bromodichloromethane	ug/kg	.000	0	7	0	0	0
Bromoform	ug/kg	.000	0	7	0	0	0
Bromomethane	ug/kg	.000	0	13	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	7	0	0	0
Carbon disulfide	ug/kg	.000	1	13	20	20	1
Chlorobenzene	ug/kg	.000	0	5	0	0	0
Chloroethane	ug/kg	.000	0	13	0	0	0
Chloroform	ug/kg	.000	0	12	0	0	0
Chloromethane	ug/kg	.000	0	13	0	0	0
Dibromochloromethane	ug/kg	.000	0	7	0	0	0
Ethylbenzene	ug/kg	.000	0	5	0	0	0
Methylene chloride	ug/kg	.000	0	13	0	0	0
Styrene	ug/kg	.000	1	6	2	2	1
Tetrachloroethene	ug/kg	.000	0	6	0	0	0
Toluene	ug/kg	.000	6	10	3	110	6
Trichloroethene	ug/kg	.000	0	7	0	0	0

TABLE 4-31
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Vinyl Acetate	ug/kg	.000	1	8	2	2	1
Vinyl chloride	ug/kg	.000	0	13	0	0	0
Xylenes, Total	ug/kg	.000	0	5	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	7	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	7	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	16	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	16	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	16	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	16	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	16	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	16	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	16	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	16	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	16	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	16	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	16	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	16	0	0	0
2-Chlorophenol	ug/kg	.000	0	16	0	0	0
2-Methylnaphthalene	ug/kg	.000	4	16	50	89	4
2-Methylphenol	ug/kg	.000	0	16	0	0	0
2-Nitroaniline	ug/kg	.000	0	16	0	0	0
2-Nitrophenol	ug/kg	.000	0	16	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	16	0	0	0
3-Nitroaniline	ug/kg	.000	0	16	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	16	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	16	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	16	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	16	0	0	0
4-Methylphenol	ug/kg	.000	0	16	0	0	0
4-Nitroaniline	ug/kg	.000	0	16	0	0	0
4-Nitrophenol	ug/kg	.000	0	16	0	0	0
Acenaphthene	ug/kg	.000	0	16	0	0	0
Acenaphthylene	ug/kg	.000	0	16	0	0	0
Anthracene	ug/kg	.000	1	16	49	49	1
Benzo(a)anthracene	ug/kg	.000	1	16	110	110	1
Benzo(a)pyrene	ug/kg	.000	1	16	130	130	1
Benzo(b)fluoranthene	ug/kg	.000	1	16	360	360	1
Benzo(g,h,i)perylene	ug/kg	.000	0	16	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	1	16	260	260	1
Benzoic acid	ug/kg	.000	2	16	97	150	2

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TABLE 4-31
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Benzyl alcohol	ug/kg	.000	0	16	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	16	0	0	0
Carbazole	ug/kg	.000	0		0	0	0
Chrysene	ug/kg	.000	1	16	150	150	1
Di-n-butyl phthalate	ug/kg	.000	1	16	46	46	1
Di-n-octyl phthalate	ug/kg	.000	0	16	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	16	0	0	0
Dibenzofuran	ug/kg	.000	0	16	0	0	0
Diethyl phthalate	ug/kg	.000	0	16	0	0	0
Dimethyl phthalate	ug/kg	.000	0	16	0	0	0
Fluoranthene	ug/kg	.000	1	16	94	94	1
Fluorene	ug/kg	.000	0	16	0	0	0
Hexachlorobenzene	ug/kg	.000	0	16	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	16	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	16	0	0	0
Hexachloroethane	ug/kg	.000	0	16	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	16	0	0	0
Isophorone	ug/kg	.000	0	16	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	16	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	16	0	0	0
Naphthalene	ug/kg	.000	2	16	53	53	2
Nitrobenzene	ug/kg	.000	0	16	0	0	0
Pentachlorophenol	ug/kg	.000	0	16	0	0	0
Phenanthrene	ug/kg	.000	2	16	41	49	2
Phenol	ug/kg	.000	0	16	0	0	0
Pyrene	ug/kg	.000	1	16	120	120	1
bis(2-Chloroethoxy)methane	ug/kg	.000	0	16	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	16	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	16	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	1	16	620	620	1
p-Chloroaniline	ug/kg	.000	0	16	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	12	0	0	0
4,4'-DDE	ug/kg	.000	0	12	0	0	0
4,4'-DDT	ug/kg	.000	0	12	0	0	0
Aldrin	ug/kg	.000	0	12	0	0	0
Aroclor-1016	ug/kg	.000	0	12	0	0	0
Aroclor-1221	ug/kg	.000	0	12	0	0	0
Aroclor-1232	ug/kg	.000	0	12	0	0	0
Aroclor-1242	ug/kg	.000	0	12	0	0	0
Aroclor-1248	ug/kg	.000	0	12	0	0	0
Aroclor-1254	ug/kg	.000	1	12	210	210	1

TABLE 4-31
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Aroclor-1260	ug/kg	.000	1	12	390	390	1
Dieldrin	ug/kg	.000	0	12	0	0	0
Endosulfan II	ug/kg	.000	0	12	0	0	0
Endosulfan sulfate	ug/kg	.000	0	12	0	0	0
Endosulfan-I	ug/kg	.000	0	12	0	0	0
Endrin	ug/kg	.000	0	12	0	0	0
Endrin ketone	ug/kg	.000	0	12	0	0	0
Heptachlor	ug/kg	.000	0	12	0	0	0
Heptachlor epoxide	ug/kg	.000	0	12	0	0	0
Methoxychlor	ug/kg	.000	0	12	0	0	0
Toxaphene	ug/kg	.000	0	12	0	0	0
alpha-BHC	ug/kg	.000	0	12	0	0	0
alpha-Chlordane	ug/kg	.000	0	12	0	0	0
beta-BHC	ug/kg	.000	0	12	0	0	0
delta-BHC	ug/kg	.000	0	12	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	12	0	0	0
gamma-Chlordane	ug/kg	.000	0	12	0	0	0
GENERAL CHEMISTRY							
Total Organic Carbon	mg/kg	.000	6	6	7840	192011	6

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TABLE 4-32

INACTIVE FLYASH PILE
SUBSOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	22	22	2260	13900	0
Antimony	mg/kg	.000	2	14	2.1	5.5	2
Arsenic	mg/kg	9.570	22	22	3	81.8	11
Barium	mg/kg	119.170	22	22	8	1080	10
Beryllium	mg/kg	.620	19	22	.31	8.7	17
Cadmium	mg/kg	.910	10	22	.47	1.2	4
Calcium	mg/kg	150000.000	22	22	2990	219000	1
Chromium	mg/kg	20.680	22	22	3.6	34.8	3
Cobalt	mg/kg	15.750	22	22	3	18.2	1
Copper	mg/kg	20.030	21	22	7	258	13
Cyanide	mg/kg	.130	10	21	.13	.84	9
Iron	mg/kg	30700.000	22	22	3430	29800	0
Lead	mg/kg	15.580	22	22	3.3	400	7
Magnesium	mg/kg	42648.210	22	22	512	55900	3
Manganese	mg/kg	1300.000	22	22	23.1	1200	0
Mercury	mg/kg	.290	6	22	.17	1.3	4
Molybdenum	mg/kg	2.700	14	22	.72	9.2	9
Nickel	mg/kg	34.350	22	22	8.1	82.3	3
Potassium	mg/kg	1979.990	22	22	474	2900	3
Selenium	mg/kg	.000	9	22	.98	11.1	9
Silicon	mg/kg	1593.080	22	22	474	1250	0
Silver	mg/kg	.000	8	22	.49	9.4	8
Sodium	mg/kg	285.000	22	22	73.4	663	7
Thallium	mg/kg	.490	6	22	.25	3.6	5
Vanadium	mg/kg	37.800	22	22	11.3	53.2	3
Zinc	mg/kg	72.580	20	22	17.7	383	3
RADIONUCLIDES							
CS-137	pCi/g	.000	5	24	.079	.55	5
GROSS ALPHA	pCi/g	.000	24	24	7.81	2030	24
GROSS BETA	pCi/g	.000	24	24	12.41	1810	24
NP-237	pCi/g	.000	20	20	.086	37.3	20
PU-238	pCi/g	.000	18	23	.031	1.85	18
PU-239/240	pCi/g	.000	16	23	.0348	1.77	16
RA-226	pCi/g	1.470	24	24	.56	42.3	15
RA-228	pCi/g	1.310	23	24	.34	3.04	14
RU-106	pCi/g	.000	0	24	0	0	0

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TABLE 4-32
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
SR-90	pCi/g	.560	3	24	.26	.86	1
TC-99	pCi/g	.000	0	24	0	0	0
TH-228	pCi/g	1.330	23	23	.308	3.08	11
TH-230	pCi/g	1.880	23	23	.874	121	16
TH-232	pCi/g	1.260	23	23	.264	2.65	12
TH-TOTAL	mg/kg	9.470	23	23	2.41	24.1	14
U-234	pCi/g	1.040	24	24	.49	1380	18
U-235/236	pCi/g	.150	24	24	.0303	68.8	15
U-238	pCi/g	1.120	24	24	.471	1570	18
U-TOTAL	mg/kg	3.400	24	24	2.62	3580	23
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	10	30	1	920	10
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	27	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	29	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	30	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	30	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	30	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	30	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	29	0	0	0
2-Butanone	ug/kg	.000	1	30	3	3	1
2-Hexanone	ug/kg	.000	0	28	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	2	28	3	6	2
Acetone	ug/kg	.000	10	30	3	29	10
Benzene	ug/kg	.000	0	29	0	0	0
Bromodichloromethane	ug/kg	.000	0	29	0	0	0
Bromoform	ug/kg	.000	0	29	0	0	0
Bromomethane	ug/kg	.000	0	30	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	29	0	0	0
Carbon disulfide	ug/kg	.000	0	30	0	0	0
Chlorobenzene	ug/kg	.000	1	27	14	14	1
Chloroethane	ug/kg	.000	0	30	0	0	0
Chloroform	ug/kg	.000	0	30	0	0	0
Chloromethane	ug/kg	.000	1	30	52	52	1
Dibromochloromethane	ug/kg	.000	0	29	0	0	0
Ethylbenzene	ug/kg	.000	0	27	0	0	0
Methylene chloride	ug/kg	.000	6	30	53	180	6
Styrene	ug/kg	.000	0	27	0	0	0
Tetrachloroethene	ug/kg	.000	1	27	1	1	1
Toluene	ug/kg	.000	19	29	1	1800	19
Trichloroethene	ug/kg	.000	1	30	2	2	1
Vinyl Acetate	ug/kg	.000	0	22	0	0	0
Vinyl chloride	ug/kg	.000	0	30	0	0	0

TABLE 4-32
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Xylenes, Total	ug/kg	.000	0	27	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	29	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	29	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	31	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	31	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	31	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	31	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	31	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	31	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	31	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	31	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	31	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	31	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	31	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	3	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	31	0	0	0
2-Chlorophenol	ug/kg	.000	0	31	0	0	0
2-Methylnaphthalene	ug/kg	.000	1	31	74	74	1
2-Methylphenol	ug/kg	.000	0	31	0	0	0
2-Nitroaniline	ug/kg	.000	0	31	0	0	0
2-Nitrophenol	ug/kg	.000	0	31	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	31	0	0	0
3-Nitroaniline	ug/kg	.000	0	25	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	31	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	31	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	31	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	31	0	0	0
4-Methylphenol	ug/kg	.000	2	31	10	54	2
4-Nitroaniline	ug/kg	.000	0	28	0	0	0
4-Nitrophenol	ug/kg	.000	0	31	0	0	0
Acenaphthene	ug/kg	.000	0	31	0	0	0
Acenaphthylene	ug/kg	.000	0	31	0	0	0
Anthracene	ug/kg	.000	2	31	3	49	2
Benzo(a)anthracene	ug/kg	.000	4	31	8	130	4
Benzo(a)pyrene	ug/kg	.000	3	31	7	98	3
Benzo(b)fluoranthene	ug/kg	.000	3	31	5	140	3
Benzo(g,h,i)perylene	ug/kg	.000	3	31	4	59	3
Benzo(k)fluoranthene	ug/kg	.000	4	31	6	190	4
Benzoic acid	ug/kg	.000	0	14	0	0	0
Benzyl alcohol	ug/kg	.000	0	12	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	31	0	0	0

TABLE 4-32
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Carbazole	ug/kg	.000	1	31	1	1	1
Chrysene	ug/kg	.000	4	31	8	150	4
Di-n-butyl phthalate	ug/kg	.000	4	31	43	110	4
Di-n-octyl phthalate	ug/kg	.000	0	31	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	1	31	2	2	1
Dibenzofuran	ug/kg	.000	0	31	0	0	0
Diethyl phthalate	ug/kg	.000	2	31	52	180	2
Dimethyl phthalate	ug/kg	.000	0	31	0	0	0
Fluoranthene	ug/kg	.000	4	31	16	340	4
Fluorene	ug/kg	.000	0	31	0	0	0
Hexachlorobenzene	ug/kg	.000	0	31	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	28	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	31	0	0	0
Hexachloroethane	ug/kg	.000	0	31	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	3	31	4	63	3
Isophorone	ug/kg	.000	1	31	4	4	1
N-Nitroso-di-n-propylamine	ug/kg	.000	0	31	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	31	0	0	0
Naphthalene	ug/kg	.000	1	31	81	81	1
Nitrobenzene	ug/kg	.000	0	31	0	0	0
Pentachlorophenol	ug/kg	.000	0	31	0	0	0
Phenanthrene	ug/kg	.000	5	31	10	280	5
Phenol	ug/kg	.000	1	31	2	2	1
Pyrene	ug/kg	.000	4	31	14	260	4
Tributyl phosphate	ug/kg	.000	2	3	2	200	2
bis(2-Chloroethoxy)methane	ug/kg	.000	0	31	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	31	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	31	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	22	31	2	2800	22
p-Chloroaniline	ug/kg	.000	0	31	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	30	0	0	0
4,4'-DDE	ug/kg	.000	0	30	0	0	0
4,4'-DDT	ug/kg	.000	0	30	0	0	0
Aldrin	ug/kg	.000	0	30	0	0	0
Aroclor-1016	ug/kg	.000	0	31	0	0	0
Aroclor-1221	ug/kg	.000	0	31	0	0	0
Aroclor-1232	ug/kg	.000	0	31	0	0	0
Aroclor-1242	ug/kg	.000	0	31	0	0	0
Aroclor-1248	ug/kg	.000	0	31	0	0	0
Aroclor-1254	ug/kg	.000	3	31	120	570	3

TABLE 4-32
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Aroclor-1260	ug/kg	.000	0	31	0	0	0
Dieldrin	ug/kg	.000	0	30	0	0	0
Endosulfan II	ug/kg	.000	0	30	0	0	0
Endosulfan sulfate	ug/kg	.000	0	30	0	0	0
Endosulfan-I	ug/kg	.000	0	30	0	0	0
Endrin	ug/kg	.000	0	30	0	0	0
Endrin aldehyde	ug/kg	.000	0	30	0	0	0
Endrin ketone	ug/kg	.000	0	30	0	0	0
Heptachlor	ug/kg	.000	0	30	0	0	0
Heptachlor epoxide	ug/kg	.000	0	30	0	0	0
Methoxychlor	ug/kg	.000	0	30	0	0	0
Toxaphene	ug/kg	.000	0	31	0	0	0
alpha-BHC	ug/kg	.000	0	30	0	0	0
alpha-Chlordane	ug/kg	.000	1	30	3.3	3.3	1
beta-BHC	ug/kg	.000	0	30	0	0	0
delta-BHC	ug/kg	.000	0	30	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	30	0	0	0
gamma-Chlordane	ug/kg	.000	0	30	0	0	0

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Metal	Number of Sample(s)	Material/Location
calcium	1 sample	Boring 1998 at a depth of 10 to 11.5 feet
cyanide	10 samples	multiple locations, various depths
lead	1 sample	sludge material at a depth of 22 to 24 feet
magnesium	3 samples	multiple locations, various depths
mercury	1 sample	Boring No. 1997 at a depth of 10 to 11 feet
potassium	22 samples	multiple locations, various depths
silicon	22 samples	multiple locations, various depths
sodium	22 samples	multiple locations, various depths
thallium	6 samples	multiple locations, various depths

Phase II metal samples detected elevated copper, lead, and mercury associated with a sludge material found at 19 to 24 feet depths beneath the flyash. These data indicate that the metals copper, cyanide, mercury, and thallium are possible indicators of waste derived metal contamination in the flyash.

Radionuclides detected above background concentrations in Phase I subsurface samples included the fission products cesium-137 (one sample), ruthenium-106 (one sample), strontium-90 (seven samples), and technetium-99 (two samples). This suggests that fission products were not a significant percentage of the waste material deposited at the Inactive Flyash Pile.

Uranium, thorium, and radium isotopes comprise the major part of the radionuclides detected above background in subsurface samples. Thorium and radium are closely correlated, while uranium does not appear to be closely correlated with thorium. The highest concentration of uranium was detected in samples from a sludge material detected at 20 to 24 foot depths near Hydropunch™ 11006. This depth corresponds to the original till surface and may be the surface upon which 1950s era waste material was deposited. Other samples from this depth detected total uranium; Borings Nos. 1710 (660 μg/g), 11051 (3580 μg/g), and 11052 (294 μg/g) and Hydropunch™ 11006 (1714 μg/g).

Soil boring data indicate that glacial overburden thins and does not extend beneath the far west and southern half of the Inactive Flyash Pile; therefore, waste/fill material sits directly on the Great Miami Aquifer. Concentrations of total uranium in samples collected at the interface of the flyash/fill and underlying till detected the following elevated levels: 873 μg/g (1791 at 27 to 28.5 feet), 68.2 μg/g (1708 at 30 to 31.5 feet), and 50.7 μg/g (1994 at 26 to 27.5 feet). These data indicate that the Inactive Flyash Pile is potentially a source for the uranium contamination in the regional aquifer.

Data for organic compounds detected above background in subsurface soil are provided in Table E-2C in Appendix E and are presented on Figure 4-15 (see Volume 2, Oversized Figures). The most common volatile organic compound detected in Phase I samples was TCA which was detected in 9 of 14 samples throughout the Inactive Flyash Pile and at variable depths. The most common semi-volatile compound was 2-methylnaphthalene, which was detected in 4 of 16 samples. Phase II samples detected TCA in 10 of 30 samples and also detected acetone (10 samples) and toluene (19 samples). Bis(2-Ethylhexyl) phthalate was the most common semivolatile compound and was detected in 22 of 31 samples; 2-methylnaphthalene was detected once in 31 samples.

Organic compounds detected in subsurface samples from the Inactive Flyash Pile were predominantly semivolatile compounds detected in samples collected from the till/flyash interface in Borings Nos. 11006 and 11051. These sample locations correlate to the highest uranium concentrations in waste samples found in the Inactive Flyash Pile and are related to the sludge like material observed in these borings. The sludge like material was only observed in these two borings and appears to be a very localized material. The pervasive character of trace organic contamination detected elsewhere suggests that the organics within the flyash originated in liquid form and that it was sprayed upon the Inactive Flyash Pile. Aroclor-1254 was detected in five locations in subsurface samples in the Inactive Flyash Pile: at Borings Nos. 1995 (2 feet deep), 1710 (28.5 feet deep), 1711 (18.5 feet deep), 11006 (22.5 feet deep), and 11051 (22 feet deep). Aroclor was detected in trace concentrations and in combination with other organic compounds, suggesting that the PCB was in a mixture when it was disposed of.

Six samples were collected to complete waste characteristic determination TCLP, and the results are presented Table 4-33. No analyses detected concentrations that exceeded the RCRA standard for hazardous waste. Detection limits for heptachlor epoxide exceeded the TCLP regulatory limit; however, this compound was not detected above background in direct analysis of 30 soil samples.

Waste materials were identified from samples collected from four borings in the Inactive Flyash Pile. A summary of selected constituents detected above soil background is presented in Table 4-34 along with background concentrations for soil and flyash. The determination of flyash background concentrations was discussed in Section 4.1.3. The concentration of metals appears elevated in comparison to background soil concentrations. The elevated concentrations of these materials may be due to its association/contact with process material/waste.

TABLE 4-33

CHARACTERISTICS OF WASTE MATERIAL DETECTED AT THE TILL/FLYASH INTERFACE, INACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Location and Description	Depth Below Ground (ft.)	Copper mg/kg	Lead mg/kg	Nickel mg/kg	Silver mg/kg	Zinc mg/kg	Arsenic mg/kg	Chromium mg/kg	Radium-226 pCi/g	Thorium Total μg/g	Uranium-238 pCi/g	Uranium Total μg/g
Soil Background		20.03	15.58	34.35	0	72.58	9.57	20.68	1.47	9.47	1.12	3.4
Flyash Background		382.2	194.0	215.6	14.0	677.3	141.0	218.0	5.3	330.0	6.1	19.0
11006, Clayey Sludge (113492)	22.5-24	249	96.6	82.3	8.1	383	6.7	34.8	9.74	10.3	803	1714
11051 (116438) at flyash/till interface	21-22	ANA[a]	ANA	ANA	ANA	ANA	ANA	ANA	37.8	23.1	1570	3580
11051 (116441) at flyash/till interface	22-24	258	400	65.1	9.4	372	49.7	32.1	42.3	16.1	763	2280
11052 (116427) in clay material above Great Miami Aquifer	19-21	92.3	193	54.4	7.9	324	35.5	22	4.06	12.3	115.8	294

[a]ANA means analyte not analyzed

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TABLE 4-34

INACTIVE FLYASH PILE TCLP RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard[a] (mg/L)	Location/Sample Number and Result (mg/L)					
			1994	1995	1996	1997	1998	1998
			116295	116114	112081	116216	116074	116075
Arsenic	5.0	1.5	<0.05	rejected[b]	rejected	<0.0633	<0.05	-[c]
Barium	100.0	30.0	0.85	<0.913	1.48	1.58	1.07	-
Benzene	0.5		<0.005	<0.005	<0.005	<0.005	-	<0.005
Cadmium	1.0	0.3	<0.005	<0.0021	<0.0021	<0.0021	<0.005	-
Carbon Tetrachloride	0.5		<0.005	<0.005	<0.005	<0.005	-	<0.005
Chlordane	0.03		<0.0005	<0.0014	<0.0014	<0.0014	<0.0005	-
Chlorobenzene	100.0		<0.005	<0.005	<0.005	<0.005	-	<0.005
Chloroform	6.0		<0.005	<0.005	<0.005	<0.005	-	<0.005
Chromium	5.0	1.5	<0.01	<0.0031	<0.0031	<0.0031	<0.01	-
Copper			<0.01	0.002	0.0029	<0.0017	<0.01	-
2,4-D	10.0		<0.01	<0.12	<0.12	<0.12	<0.01	-
1,4-Dichlorobenzene	7.5		<0.02	<0.05	<0.05	<0.05	<0.02	-
1,2-Dichloroethane	0.5		<0.005	<0.005	<0.005	<0.005	-	<0.005
1,1-Dichloroethene	0.7		<0.005	<0.005	<0.005	<0.005	-	<0.005
2,4-Dinitrotoluene	0.13		<0.02	<0.05	<0.05	<0.05	<0.02	-
Endrin	0.02		<0.0001	<0.0006	<0.0006	<0.0006	<0.0001	-
Heptachlor	0.008		<0.0001	<0.0003	<0.0003	<0.0003	<0.0001	-

See footnotes at end of table

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TABLE 4-34
(Continued)

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard[a] (mg/L)	Location/Sample Number and Result (mg/L)					
			1994	1995	1996	1997	1998	1998
			116295	116114	112081	116216	116074	116075
Heptachlor epoxide	0.008		<0.0001	<0.0083	<0.0083	<0.0083	<0.0001	-
Hexachlorobenzene	0.13		<0.02	<0.05	<0.05	<0.05	<0.02	-
Hexachlorobutadiene	0.5		<0.02	<0.05	<0.05	<0.05	<0.02	-
Hexachloroethane	3.0		<0.02	<0.05	<0.05	<0.05	<0.02	-
Iron			<0.109	0.114	0.007	<0.0158	1.21	-
Lead	5.0	1.5	<0.04	<0.0155	<0.0155	<0.0155	<0.04	-
Lindane	0.4		<0.0001	<0.0004	<0.0004	<0.0004	<0.0001	-
Manganese			<0.102	0.0946	0.105	0.0974	0.432	-
Mercury	0.2	0.06	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-
Methoxychlor	10.0		<0.0005	<0.018	<0.018	<0.018	<0.0005	-
Nitrobenzene	2.0		<0.02	<0.05	<0.05	<0.05	<0.02	-
Pentachlorophenol	100.0		<0.1	<0.25	<0.25	<0.25	<0.1	-
Pyridine	5.0		<0.2	<0.25	<0.25	<0.25	<0.2	-
Selenium	1.0	0.3	<0.08	rejected	rejected	0.0935	<0.08	-
Silver	5.0		rejected	<0.0022	<0.0022	<0.0022	<0.01	-
Tetrachloroethene	0.7		<0.005	<0.005	<0.005	<0.005	-	<0.005
Toxaphene	0.5		<0.001	<0.024	<0.024	<0.024	<0.001	-
2,4,5-TP (Silvex)	1.0		<0.0018	<0.017	<0.017	<0.017	<0.0018	-
Trichloroethene	0.5		<0.005	<0.005	<0.005	<0.005	-	<0.005
2,4,5-Trichlorophenol	400.0		<0.1	<0.05	<0.05	<0.05	<0.1	-

See footnotes at end of table

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TABLE 4-34
(Continued)

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard[a] (mg/L)	Location/Sample Number and Result (mg/L)					
			1994	1995	1996	1997	1998	1998
			116295	116114	112081	116216	116074	116075
2,4,6-Trichlorophenol	2.0		<0.02	<0.05	<0.05	<0.05	<0.02	-
Vinyl chloride	0.2		<0.01	<0.01	<0.01	<0.01	-	<0.01
Zinc			<0.0757	rejected	rejected	rejected	<0.207	-

Note: A box surrounding a number indicates a result or detection limit that is above and EPA or OEPA standard.

[a]These standards are from OEPA Policy 4.07 "Design Criteria: Disposal of Non-Toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Waste."
[b]"Rejected" means that the sample could not be validated.
[c]The sample was not analyzed for the parameter.

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Phase I and Phase II subsurface soil data were compared to CIS and ES data (Appendices E-7 and E-8). Analytes detected in these preliminary studies were also detected in Phase I and Phase II and within the same order of magnitude.

A comparison of metals, radionuclides, and organic compounds detected in surface and subsurface soil indicates the following:

- Subsurface concentrations of antimony, cyanide, mercury, and silver are consistent with background flyash. Above background concentrations of copper, lead, and mercury were associated with sludge material, which indicates that the analytes, when above flyash background, may be waste derived.
- Concentrations of organic compounds and radionuclides are significantly higher in subsurface samples. This indicates that disposal of contaminated material occurred throughout the Inactive Flyash Pile over the time period the pile was active.
- There does not appear to be a single distribution pattern for analytes that defines a boundary of disposal activity on the surface or subsurface.

4.4.3 Surface Water and Sediment

There are no perennial sources of surface water within the battery limits of the Inactive Flyash Pile, so surface water was not present at several of the proposed drainage sampling locations. Surface water samples were collected on an "as-possible" basis after rainstorms. Drainage within a channel at the west side of the flyash pile was observed to flow for several days after significant rain events, and samples were collected at multiple locations to characterize seeps from the Inactive Flyash Pile.

A summary of detected analytes and radionuclides in surface water is provided in Appendix E in Table E-2D and Table E-2E. A summary of the analytes is provided in Table 4-35 and Table 4-36. Locations that were sampled during Phase II field sampling programs are shown on Figure 4-16 (see Volume 2, Oversized Figures). Chemical and radiological analytical results for surface water were not compared to background concentrations since none are developed for surface water. One surface water sample was collected during Phase I at an upstream location in the west drainage channel. Sixteen metals, isotopes of one element (40 μg/L total uranium were detected) and no organic compounds were detected. Metals included cadmium, chromium, lead, mercury, nickel, silver, and vanadium. These metals were also detected in soil samples from the Inactive Flyash Pile. Thirteen metals (Arsenic, Cyanide, Selenium, and Zinc were not detected during Phase I; Cadmium, Chromium, Lead, Mercury, Nickel, Silver, and Vanadium were detected for Phase I but not

TABLE 4-35

INACTIVE FLYASH PILE
SURFACE WATER[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	1	2	.0764	.0764	1
Antimony		mg/L	.000	0	0	0	0	0
Arsenic		mg/L	.000	0	3	0	0	0
Barium		mg/L	.000	3	3	.0267	.047	3
Beryllium		mg/L	.000	0	0	0	0	0
Cadmium		mg/L	.000	2	3	.0016	.003	2
Calcium		mg/L	.000	3	3	38.3	86.9	3
Chromium		mg/L	.000	1	3	.026	.026	1
Cobalt		mg/L	.000	0	0	0	0	0
Copper		mg/L	.000	0	3	0	0	0
Iron		mg/L	.000	3	3	.024	.284	3
Lead		mg/L	.000	3	3	.006	.0093	3
Magnesium		mg/L	.000	3	3	10.1	20.9	3
Manganese		mg/L	.000	3	3	.009	.0462	3
Mercury		mg/L	.000	2	3	.0003	.0008	2
Molybdenum		mg/L	.000	0	3	0	0	0
Nickel		mg/L	.000	2	3	.008	.025	2
Potassium		mg/L	.000	3	3	1.68	3.03	3
Selenium		mg/L	.000	0	3	0	0	0
Silicon		mg/L	.000	2	2	2.25	4.61	2
Silver		mg/L	.000	1	3	.013	.013	1
Sodium		mg/L	.000	3	3	1.99	9.75	3
Thallium		mg/L	.000	0	0	0	0	0
Vanadium		mg/L	.000	1	2	.013	.013	1
Zinc		mg/L	.000	0	0	0	0	0

See footnote at end of table

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TABLE 4-35
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	0	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0	0	0	0	0
GROSS BETA	UNFL	pCi/L	.000	0	0	0	0	0
NP-237	UNFL	pCi/L	.000	0	2	0	0	0
PU-238	UNFL	pCi/L	.000	0	2	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	2	0	0	0
RA-226	UNFL	pCi/L	.000	0	2	0	0	0
RA-228	UNFL	pCi/L	.000	0	3	0	0	0
RU-106	UNFL	pCi/L	.000	0	0	0	0	0
SR-90	UNFL	pCi/L	.000	0	2	0	0	0
TC-99	UNFL	pCi/L	.000	0	2	0	0	0
TH-228	UNFL	pCi/L	.000	0	2	0	0	0
TH-230	UNFL	pCi/L	.000	0	2	0	0	0
TH-232	UNFL	pCi/L	.000	0	2	0	0	0
TH-TOTAL	UNFL	ug/L	.000	0	1	0	0	0
U-234	UNFL	pCi/L	.000	2	2	2.5	5	2
U-235/236	UNFL	pCi/L	.000	0	2	0	0	0
U-238	UNFL	pCi/L	.000	2	2	2.6	6.8	2
U-TOTAL	UNFL	ug/L	.000	2	2	9	40	2
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	0	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	0	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	0	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	0	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	0	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	0	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	0	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	0	0	0	0
2-Butanone	UNFL	ug/L	.000	0	0	0	0	0

See footnote at end of table

TABLE 4-35
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
2-Hexanone	UNFL	ug/L	.000	0	0	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	0	0	0	0
Acetone	UNFL	ug/L	.000	0	0	0	0	0
Benzene	UNFL	ug/L	.000	0	0	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	0	0	0	0
Bromoform	UNFL	ug/L	.000	0	0	0	0	0
Bromomethane	UNFL	ug/L	.000	0	0	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	0	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	0	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	0	0	0	0
Chloroethane	UNFL	ug/L	.000	0	0	0	0	0
Chloroform	UNFL	ug/L	.000	0	0	0	0	0
Chloromethane	UNFL	ug/L	.000	0	0	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	0	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	0	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	0	0	0	0
Styrene	UNFL	ug/L	.000	0	0	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	0	0	0	0
Toluene	UNFL	ug/L	.000	0	0	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	0	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	0	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	0	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	0	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	0	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	0	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	0	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	0	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	0	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	0	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	0	0	0	0

See footnote at end of table

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TABLE 4-35
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	0	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	0	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	0	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	0	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	0	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	0	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	0	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	0	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	0	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	0	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	0	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	0	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	0	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	0	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	0	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	0	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	0	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	0	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	0	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	0	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	0	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	0	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	0	0	0	0
Anthracene	UNFL	ug/L	.000	0	0	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	0	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	0	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	0	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	0	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	0	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	0	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	0	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	0	0	0	0

See footnote at end of table

TABLE 4-35
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Chrysene	UNFL	ug/L	.000	0	0	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	0	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	0	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	0	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	0	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	0	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	0	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	0	0	0	0
Fluorene	UNFL	ug/L	.000	0	0	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	0	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	0	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	0	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	0	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	0	0	0	0
Isophorone	UNFL	ug/L	.000	0	0	0	0	0
Methyl parathion	UNFL	ug/L	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	0	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	0	0	0	0
Naphthalene	UNFL	ug/L	.000	0	0	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	0	0	0	0
Parathion	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	0	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	0	0	0	0
Phenol	UNFL	ug/L	.000	0	0	0	0	0
Pyrene	UNFL	ug/L	.000	0	0	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	0	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	0	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	0	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	0	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	0	0	0	0

See footnote at end of table

TABLE 4-35
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs								
4,4'-DDD	UNFL	ug/L	.000	0	0	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	0	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	0	0	0	0
Aldrin	UNFL	ug/L	.000	0	0	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	0	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	0	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	0	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	0	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	0	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	0	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	0	0	0	0
Dieldrin	UNFL	ug/L	.000	0	0	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	0	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	0	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	0	0	0	0
Endrin	UNFL	ug/L	.000	0	0	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	0	0	0	0
Heptachlor	UNFL	ug/L	.000	0	0	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	0	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	0	0	0	0
Toxaphene	UNFL	ug/L	.000	0	0	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	0	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	0	0	0	0
beta-BHC	UNFL	ug/L	.000	0	0	0	0	0
delta-BHC	UNFL	ug/L	.000	0	0	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	0	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	0	0	0	0
Azinphosmethyl	UNFL	ug/L	.000	0	1	0	0	0
Demeton	UNFL	ug/L	.000	0	1	0	0	0
Diazinon	UNFL	ug/L	.000	0	1	0	0	0
Disulfoton	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-35
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)								
Ethion	UNFL	ug/L	.000	0	1	0	0	0
Malathion	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	.000	2	4	.1626	.452	2
Chloride	UNFL	mg/L	.000	4	4	3.5	19.99	4
Fluoride	UNFL	mg/L	.000	4	4	.18	.3	4
Nitrate	UNFL	mg/L	.000	4	4	.14	12.1	4
Phenols	UNFL	mg/L	.000	1	4	.02	.02	0
Phosphorus	UNFL	mg/L	.000	3	4	.17	.842	3
Sulfate	UNFL	mg/L	.000	3	3	37	57.36	3
Sulfide	UNFL	mg/L	.000	0	1	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	3	3	.347	1.81	3
Total Organic Carbon	UNFL	mg/L	.000	1	2	5.59	5.59	1
Total Organic Halides	UNFL	mg/L	.000	2	3	.01	.0159	2
Total Organic Nitrogen	UNFL	mg/L	.000	4	4	.347	1.36	4

[a]Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available.

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TABLE 4-36

INACTIVE FLYASH PILE
SURFACE WATER[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	4	6	.0478	.131	4
Antimony		mg/L	.000	0	6	0	0	0
Arsenic		mg/L	.000	1	6	.0014	.0014	1
Barium		mg/L	.000	6	6	.0366	.0661	6
Beryllium		mg/L	.000	0	6	0	0	0
Cadmium		mg/L	.000	0	6	0	0	0
Calcium		mg/L	.000	6	6	82.6	132	6
Chromium		mg/L	.000	0	6	0	0	0
Cobalt		mg/L	.000	0	6	0	0	0
Copper		mg/L	.000	0	6	0	0	0
Cyanide		mg/L	.000	2	4	.001	.0038	2
Iron		mg/L	.000	1	6	.0729	.0729	1
Lead		mg/L	.000	0	6	0	0	0
Magnesium		mg/L	.000	6	6	22.7	45.7	6
Manganese		mg/L	.000	6	6	.0128	.0286	6
Mercury		mg/L	.000	0	6	0	0	0
Molybdenum		mg/L	.000	0	6	0	0	0
Nickel		mg/L	.000	0	6	0	0	0
Potassium		mg/L	.000	6	6	1.74	1.93	6
Selenium		mg/L	.000	1	6	.004	.004	1
Silicon		mg/L	.000	6	6	1.08	7.04	6
Silver		mg/L	.000	0	6	0	0	0
Sodium		mg/L	.000	6	6	2.72	12.8	6
Thallium		mg/L	.000	0	6	0	0	0
Vanadium		mg/L	.000	0	6	0	0	0
Zinc		mg/L	.000	1	6	.0149	.0149	1
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	6	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	2	6	72.9	426	2
GROSS BETA	UNFL	pCi/L	.000	3	6	8.56	172	3
NP-237	UNFL	pCi/L	.000	2	4	.435	.79	2
PU-238	UNFL	pCi/L	.000	2	6	.17	2.91	2
PU-239/240	UNFL	pCi/L	.000	3	6	.2	.266	3

See footnote at end of table

TABLE 4-36
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-226	UNFL	pCi/L	.000	1	6	.148	.148	1
RA-228	UNFL	pCi/L	.000	0	6	0	0	0
RU-106	UNFL	pCi/L	.000	0	6	0	0	0
SR-90	UNFL	pCi/L	.000	0	6	0	0	0
TC-99	UNFL	pCi/L	.000	0	6	0	0	0
TH-228	UNFL	pCi/L	.000	1	6	.027	.027	1
TH-230	UNFL	pCi/L	.000	5	6	.26	.653	5
TH-232	UNFL	pCi/L	.000	0	6	0	0	0
TH-TOTAL	UNFL	ug/L	.000	0	6	0	0	0
U-234	UNFL	pCi/L	.000	6	6	1.42	265	6
U-235/236	UNFL	pCi/L	.000	3	6	.16	14	3
U-238	UNFL	pCi/L	.000	6	6	1.74	257	6
U-TOTAL	UNFL	ug/L	.000	6	6	4.57	820	6
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	6	0	0	0
2-Butanone	UNFL	ug/L	.000	0	6	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	6	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	6	0	0	0
Acetone	UNFL	ug/L	.000	0	6	0	0	0
Benzene	UNFL	ug/L	.000	0	6	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	6	0	0	0
Bromoform	UNFL	ug/L	.000	0	6	0	0	0
Bromomethane	UNFL	ug/L	.000	0	6	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	6	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	6	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
Chloroethane	UNFL	ug/L	.000	0	6	0	0	0
Chloroform	UNFL	ug/L	.000	0	6	0	0	0
Chloromethane	UNFL	ug/L	.000	0	6	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	6	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	6	0	0	0

See footnote at end of table

TABLE 4-36
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Methylene chloride	UNFL	ug/L	.000	0	6	0	0	0
Styrene	UNFL	ug/L	.000	0	6	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	6	0	0	0
Toluene	UNFL	ug/L	.000	1	6	2	2	1
Trichloroethene	UNFL	ug/L	.000	0	6	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	6	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	6	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	6	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	6	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	6	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	6	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	6	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	6	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	3	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	6	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	6	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	6	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	6	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	6	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	6	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	6	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	6	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	6	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	6	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	6	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	6	0	0	0

See footnote at end of table

TABLE 4-36
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
4-Nitroaniline	UNFL	ug/L	.000	0	6	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	4	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	6	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	6	0	0	0
Anthracene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	6	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	6	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	6	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Carbazole	UNFL	ug/L	.000	0	6	0	0	0
Chrysene	UNFL	ug/L	.000	0	6	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	6	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	6	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	6	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	6	0	0	0
Fluorene	UNFL	ug/L	.000	0	6	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	6	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	6	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	6	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	6	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	6	0	0	0
Isophorone	UNFL	ug/L	.000	0	6	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	6	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	3	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	6	0	0	0
Naphthalene	UNFL	ug/L	.000	0	6	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	6	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	6	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	6	0	0	0
Phenol	UNFL	ug/L	.000	0	6	0	0	0
Pyrene	UNFL	ug/L	.000	0	6	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	3	0	0	0

See footnote at end of table

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TABLE 4-36
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	6	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	6	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	6	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	1	6	1	1	1
p-Chloroaniline	UNFL	ug/L	.000	0	6	0	0	0
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	6	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	6	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	6	0	0	0
Aldrin	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	6	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	6	0	0	0
Dieldrin	UNFL	ug/L	.000	0	6	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	6	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	6	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	6	0	0	0
Endrin	UNFL	ug/L	.000	0	6	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	6	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	6	0	0	0
Heptachlor	UNFL	ug/L	.000	0	6	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	6	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	6	0	0	0
Toxaphene	UNFL	ug/L	.000	0	6	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	6	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	6	0	0	0
beta-BHC	UNFL	ug/L	.000	0	6	0	0	0
delta-BHC	UNFL	ug/L	.000	0	6	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	6	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	6	0	0	0

See footnote at end of table

TABLE 4-36
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	6	6	195	395	0
Ammonia	UNFL	mg/L	.000	1	5	.13	.13	1
Chloride	UNFL	mg/L	.000	6	6	2.33	25.72	6
Fluoride	UNFL	mg/L	.000	6	6	.19	.39	6
Nitrate	UNFL	mg/L	.000	3	3	.14	1.64	3
Phenols	UNFL	mg/L	.000	0	6	0	0	0
Phosphorus	UNFL	mg/L	.000	2	2	.05	.06	2
Sulfate	UNFL	mg/L	.000	6	6	62.9	133.9	6
Sulfide	UNFL	mg/L	.000	1	6	.57	.57	0
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	6	6	.18	.9	6
Total Organic Carbon	UNFL	mg/L	.000	6	6	1.98	5.77	6
Total Organic Halides	UNFL	mg/L	.000	1	6	.0106	.0106	1
Total Organic Nitrogen	UNFL	mg/L	.000	5	6	.18	.77	5
Total Phosphorous	UNFL	mg/L	.000	4	4	.03	.2	0

[a]Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available.

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Phase II), and isotopes of five elements (neptunium-237, plutonium-238, plutonium-239/240, radium-226, thorium-228, thorium-230, and uranium-235/236 were not detected for Phase I), and two organic compounds [toluene at 2 μg/L and bis(2-ethylhexyl)phthalate at 1 μg/L] were detected in six surface water samples collected during Phase II from the Inactive Flyash Pile. Metals that were detected in surface water samples collected during Phase II from the drainage include arsenic, cyanide, selenium, and zinc. Phase II analyses did not detect the following analytes detected during Phase I: chromium, cadmium, lead, mercury, nickel, silver, or vanadium. The CIS and ES sampling programs did not include surface water sampling around the Inactive Flyash Pile.

Total uranium analyses of surface water in the west drainage were used to define the location of possible springs or seeps contributing to drainage from the Inactive Flyash Pile. Data presented in Figure 4-16 suggest that seepage from the west edge of the Inactive Flyash Pile is surfacing in the drainage in at least one location. Total uranium analyses of surface water samples that were collected to locate seeps below the Inactive Flyash Pile are summarized in Table 4-37. One location of observed seepage was sampled at IFP-SW-11 on May 18, 1993, and detected 820 μg/L total uranium. Upstream and downstream concentrations were 23 μg/L (IFP-SW-06) and 910 μg/L (IFP-SW-05), respectively on May 2, 1993. Surface water drainage was traced downstream to where it drained through the bottom of a sandy stream channel. Total uranium in a sample collected slightly upstream of this location was 370 μg/L (IFP-SW-12) on May 18, 1993. Field observations, therefore, indicate that recharge to the regional aquifer occurs by surface water from the west drainage. Analytical data indicate that the recharge water has elevated concentrations of uranium.

Two sediment samples collected during Phase I detected five metals and total uranium in two samples; no organic compounds were detected. Three Phase II sediment samples were collected at the same time and location as surface water samples but at different locations than for Phase I. Analytical data for sediment samples is provided in Appendix E in Table E-2F and Table E-2G. A summary of the analytes is provided in Table 4-38 and Table 4-39. During Phase II four metals (Beryllium was not detected for Phase I; Cadmium and Chromium were detected for Phase I but not Phase II), isotopes of four elements (neptunium-237, plutonium-238, plutonium-239/240, Strontium-90, uranium-234, and uranium-238 were not detected for Phase I), and twenty one organic compounds were detected above background. Beryllium was detected at 1.2 mg/kg, and toluene and acetone were detected in samples from Paddys Run. Five semivolatile organic compounds were detected at trace concentrations in the west drainage. These were detected in the down stream sediment sample from

TABLE 4-37

INACTIVE FLYASH PILE
SUMMARY OF DETECTED ANALYTES IN PHASE II
SURFACE WATER AND SEDIMENT SAMPLES
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

OFF-SITE ANALYSES OF SEDIMENT AND SURFACE WATER

Location	Description	Sample Number	Collection Date	Analyses					
				Uranium-238	Total-Uranium	Pyrene	bis (2-Ethylhexyl phthalate)	Chrysene	Fluoranthene
IFP-SW-02	West drainage	111828	4-26-93	59.7 pCi/L	165 μg/L	ND	ND	ND	ND
IFP-SW-02	Surface Water	112022	4-30-93	257 pCi/L	820 μg/L				
IFP-SD-02	Sediment from	111812	4-17/93	1.68 pCi/g	12 μg/g		593 μg/g		
IFP-SD-02	above location	112021	4-30-93		12.3 μg/g		1200 μg/g		
IFP-SW-03	Paddys Run	111819	4-21-93	1.74 pCi/L	5.25 μg/L	ND	ND	ND	ND
IFP-SW-03	upstream of West drainage Surface Water	112027	5-01-93	2.13 pCi/L	5.03 μg/L				
IFP-SD-03	Sediment	111813	4-17-93			47 μg/g	51 μg/g		66 μg/g
IFP-SD-03		116219	5-01-93	0.9 pCi/g	4.09 μg/g		2200 μg/g		
IFP-SW-04	Paddys Run	11820	4-21-93	2.26 pCi/L	5.87 μg/L				
IFP-SW-04	downstream of West drainage Surface Water	112015	4-29-93	1.84 pCi/L	4.57 μg/L	ND	ND	ND	ND
IFP-SD-04	Sediment	111815	4-17-93	ND	ND	100 μg/g	70 μg/g	61 μg/g	120 μg/g
		112017	4-29-93	ND	9.9 μg/g		700 μg/g		

ON-SITE ANALYSES OF TOTAL URANIUM IN SEEPS AND DRAINAGES

Location	Description	Surface Water Sample Number	Collection Date	Total Uranium μg/L
IFP-SW-02	Collected below seep area (medium flow)	111829	4-26-93	160
IFP-SW-02	Collected below seep (low flow)	112024	4-30-93	830
IFP-SW-03	Collected from Paddys Run upstream of confluence with drainage	111824	4-21-93	6
IFP-SW-03	Collected from Paddys Run upstream of confluence with drainage	112026	5-01-93	5.5
IFP-SW-04	Collected from Paddys Run downstream of confluence with drainage	111822	4-21-93	6
IFP-SW-04	Collected from Paddys Run upstream of confluence with drainage	112019	4-29-93	5
IFP-SW-05	Collected downstream of seep (low flow)	112029	5-02-93	910
IFP-SW-06	Upstream of possible seep from East bank of drainage	112030	5-02-93	23
IFP-SW-06	Upstream of possible seep from East bank of drainage	112031	5-02-93	23
IFP-SW-07	At confluence of North road drainage channel and the East drainage	112032	5-02-93	20
IFP-SW-08	Farthest upstream, collected just below drain culvert under North access road	112033	5-02-93	11
IFP-SW-09	Collected from upstream of seep in drainage channel	112034	5-03-93	81
IFP-SW-10	Collected from mixing zone in drainage adjacent to seep	113491	5-07-93	280
IFP-SW-11	Collected at seep into drainage after recession in drainage after heavy rain	116459	5-18-93	820
IFP-SW-12	Collected at confluence of drainage and Paddys Run above sand unit where drainage recharges to the GMA	116460	5-18-93	370

*Note: Sample locations shown on Figure 4-17.
ND = Not detected

TABLE 4-38

INACTIVE FLYASH PILE
SEDIMENT[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	1	1	2080	2080	0
Antimony	mg/kg	.000	0	0	0	0	0
Arsenic	mg/kg	8.200	1	1	2.7	2.7	0
Barium	mg/kg	94.100	1	1	21	21	0
Beryllium	mg/kg	.600	1	1	.5	.5	0
Cadmium	mg/kg	.870	1	1	4.5	4.5	1
Calcium	mg/kg	4339.170	1	1	110000	110000	1
Chromium	mg/kg	15.500	1	1	17.4	17.4	1
Cobalt	mg/kg	14.160	1	1	4.7	4.7	0
Copper	mg/kg	14.070	1	1	11.7	11.7	0
Cyanide	mg/kg	.270	0	1	0	0	0
Iron	mg/kg	21728.170	1	1	5940	5940	0
Lead	mg/kg	26.400	0	1	0	0	0
Magnesium	mg/kg	2776.970	1	1	26600	26600	1
Manganese	mg/kg	1348.040	1	1	362	362	0
Mercury	mg/kg	.120	0	1	0	0	0
Molybdenum	mg/kg	.000	0	1	0	0	0
Nickel	mg/kg	20.870	1	1	16.4	16.4	0
Potassium	mg/kg	1231.340	1	1	366	366	0
Selenium	mg/kg	.720	0	1	0	0	0
Silver	mg/kg	.000	0	1	0	0	0
Sodium	mg/kg	51.100	1	1	188	188	1
Thallium	mg/kg	.580	0	1	0	0	0
Vanadium	mg/kg	30.370	1	1	13.7	13.7	0
Zinc	mg/kg	59.610	1	1	13.4	13.4	0
RADIONUCLIDES							
GROSS ALPHA	pCi/g	.000	0	0	0	0	0
GROSS BETA	pCi/g	.000	0	0	0	0	0
RA-226	pCi/g	1.420	5	5	.4	.885	0
RA-228	pCi/g	1.250	2	5	.69	.901	0
U-TOTAL	mg/kg	3.700	4	5	1	13.9	2

See footnote at end of table

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TABLE 4-38
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	1	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	1	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	1	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	1	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	1	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	1	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	1	0	0	0
2-Butanone	ug/kg	.000	0	1	0	0	0
2-Hexanone	ug/kg	.000	0	1	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	1	0	0	0
Acetone	ug/kg	.000	0	1	0	0	0
Benzene	ug/kg	.000	0	1	0	0	0
Bromodichloromethane	ug/kg	.000	0	1	0	0	0
Bromoform	ug/kg	.000	0	1	0	0	0
Bromomethane	ug/kg	.000	0	1	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	1	0	0	0
Carbon disulfide	ug/kg	.000	0	1	0	0	0
Chlorobenzene	ug/kg	.000	0	1	0	0	0
Chloroethane	ug/kg	.000	0	1	0	0	0
Chloroform	ug/kg	.000	0	1	0	0	0
Chloromethane	ug/kg	.000	0	1	0	0	0
Dibromochloromethane	ug/kg	.000	0	1	0	0	0
Ethylbenzene	ug/kg	.000	0	1	0	0	0
Methylene chloride	ug/kg	.000	0	1	0	0	0
Styrene	ug/kg	.000	0	1	0	0	0
Tetrachloroethene	ug/kg	.000	0	1	0	0	0
Toluene	ug/kg	.000	0	1	0	0	0
Trichloroethene	ug/kg	.000	0	1	0	0	0
Vinyl Acetate	ug/kg	.000	0	1	0	0	0
Vinyl chloride	ug/kg	.000	0	1	0	0	0
Xylenes, Total	ug/kg	.000	0	1	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	1	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	1	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-38
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
1,4-Dichlorobenzene	ug/kg	.000	0	1	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	1	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	1	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	1	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	1	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	1	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	1	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	1	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	1	0	0	0
2-Chlorophenol	ug/kg	.000	0	1	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	1	0	0	0
2-Methylphenol	ug/kg	.000	0	1	0	0	0
2-Nitroaniline	ug/kg	.000	0	1	0	0	0
2-Nitrophenol	ug/kg	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	1	0	0	0
3-Nitroaniline	ug/kg	.000	0	1	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	1	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	1	0	0	0
4-Methylphenol	ug/kg	.000	0	1	0	0	0
4-Nitroaniline	ug/kg	.000	0	1	0	0	0
4-Nitrophenol	ug/kg	.000	0	1	0	0	0
Acenaphthene	ug/kg	.000	0	1	0	0	0
Acenaphthylene	ug/kg	.000	0	1	0	0	0
Anthracene	ug/kg	.000	0	1	0	0	0
Benzo(a)anthracene	ug/kg	.000	0	1	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	1	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	1	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	1	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	1	0	0	0
Benzoic acid	ug/kg	.000	0	1	0	0	0
Benzyl alcohol	ug/kg	.000	0	1	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	1	0	0	0
Chrysene	ug/kg	.000	0	1	0	0	0
Di-n-butyl phthalate	ug/kg	.000	0	1	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	1	0	0	0
Dibenzofuran	ug/kg	.000	0	1	0	0	0
Diethyl phthalate	ug/kg	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-38
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Dimethyl phthalate	ug/kg	.000	0	1	0	0	0
Fluoranthene	ug/kg	.000	0	1	0	0	0
Fluorene	ug/kg	.000	0	1	0	0	0
Hexachlorobenzene	ug/kg	.000	0	1	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	1	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	1	0	0	0
Hexachloroethane	ug/kg	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	1	0	0	0
Isophorone	ug/kg	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	1	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	1	0	0	0
Naphthalene	ug/kg	.000	0	1	0	0	0
Nitrobenzene	ug/kg	.000	0	1	0	0	0
Pentachlorophenol	ug/kg	.000	0	1	0	0	0
Phenanthrene	ug/kg	.000	0	1	0	0	0
Phenol	ug/kg	.000	0	1	0	0	0
Pyrene	ug/kg	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	0	1	0	0	0
p-Chloroaniline	ug/kg	.000	0	1	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	1	0	0	0
4,4'-DDE	ug/kg	.000	0	1	0	0	0
4,4'-DDT	ug/kg	.000	0	1	0	0	0
Aldrin	ug/kg	.000	0	1	0	0	0
Aroclor-1016	ug/kg	.000	0	1	0	0	0
Aroclor-1221	ug/kg	.000	0	1	0	0	0
Aroclor-1232	ug/kg	.000	0	1	0	0	0
Aroclor-1242	ug/kg	.000	0	1	0	0	0
Aroclor-1248	ug/kg	.000	0	1	0	0	0
Aroclor-1254	ug/kg	.000	0	1	0	0	0
Aroclor-1260	ug/kg	.000	0	1	0	0	0
Dieldrin	ug/kg	.000	0	1	0	0	0
Endosulfan II	ug/kg	.000	0	1	0	0	0
Endosulfan sulfate	ug/kg	.000	0	1	0	0	0
Endosulfan-I	ug/kg	.000	0	1	0	0	0
Endrin	ug/kg	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-38
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Endrin ketone	ug/kg	.000	0	1	0	0	0
Heptachlor	ug/kg	.000	0	1	0	0	0
Heptachlor epoxide	ug/kg	.000	0	1	0	0	0
Methoxychlor	ug/kg	.000	0	1	0	0	0
Toxaphene	ug/kg	.000	0	1	0	0	0
alpha-BHC	ug/kg	.000	0	1	0	0	0
alpha-Chlordane	ug/kg	.000	0	1	0	0	0
beta-BHC	ug/kg	.000	0	1	0	0	0
delta-BHC	ug/kg	.000	0	1	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	1	0	0	0
gamma-Chlordane	ug/kg	.000	0	1	0	0	0

[a]Sediment results are compared to surface soil background values.

TABLE 4-39

INACTIVE FLYASH PILE SEDIMENT[a] PHASE II FIELD INVESTIGATION OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	6	6	1580	5120	0
Antimony	mg/kg	.000	0	5	0	0	0
Arsenic	mg/kg	8.200	6	6	1.7	7.3	0
Barium	mg/kg	94.100	6	6	16.5	50.2	0
Beryllium	mg/kg	.600	1	6	1.2	1.2	1
Cadmium	mg/kg	.870	2	6	.67	.73	0
Calcium	mg/kg	4339.170	6	6	56000	191000	6
Chromium	mg/kg	15.500	6	6	3.7	6.6	0
Cobalt	mg/kg	14.160	6	6	1.8	5.4	0
Copper	mg/kg	14.070	4	6	5	9.5	0
Cyanide	mg/kg	.270	1	6	.16	.16	0
Iron	mg/kg	21728.170	6	6	4260	10300	0
Lead	mg/kg	26.400	6	6	4.1	22.4	0
Magnesium	mg/kg	2776.970	6	6	13500	29800	6
Manganese	mg/kg	1348.040	6	6	253	781	0
Mercury	mg/kg	.120	0	6	0	0	0
Molybdenum	mg/kg	.000	0	6	0	0	0
Nickel	mg/kg	20.870	5	6	4.4	11.7	0
Potassium	mg/kg	1231.340	6	6	253	812	0
Selenium	mg/kg	.720	0	6	0	0	0
Silicon	mg/kg	1797.030	6	6	496	867	0
Silver	mg/kg	.000	0	6	0	0	0
Sodium	mg/kg	51.100	6	6	120	175	6
Thallium	mg/kg	.580	1	6	.52	.52	0
Vanadium	mg/kg	30.370	5	6	10.9	14.1	0
Zinc	mg/kg	59.610	5	6	23.2	41.7	0
RADIONUCLIDES							
CS-137	pCi/g	.710	0	4	0	0	0
GROSS ALPHA	pCi/g	.000	4	4	14	16.64	4
GROSS BETA	pCi/g	.000	4	4	16.3	21.44	4
NP-237	pCi/g	.000	3	4	.019	.171	3
PU-238	pCi/g	.000	3	4	.019	.05	3
PU-239/240	pCi/g	.000	2	4	.03	.057	2
RA-226	pCi/g	1.420	4	4	.65	.996	0

See footnote at end of table

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TABLE 4-39
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RA-228	pCi/g	1.250	4	4	.51	.67	0
RU-106	pCi/g	.000	0	4	0	0	0
SR-90	pCi/g	.000	1	4	.48	.48	1
TC-99	pCi/g	.000	0	4	0	0	0
TH-228	pCi/g	1.430	4	4	.41	.517	0
TH-230	pCi/g	1.970	4	4	.75	1.28	0
TH-232	pCi/g	1.360	4	4	.39	.65	0
TH-TOTAL	mg/kg	10.700	4	4	3.57	5.92	0
U-234	pCi/g	1.240	4	4	.64	1.5	1
U-235/236	pCi/g	.150	4	4	.027	.12	0
U-238	pCi/g	1.220	4	4	.72	1.68	1
U-TOTAL	mg/kg	3.700	4	4	4.09	12.3	4
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	6	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	6	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	6	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	6	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	6	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	6	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	6	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	6	0	0	0
2-Butanone	ug/kg	.000	0	6	0	0	0
2-Hexanone	ug/kg	.000	0	6	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	6	0	0	0
Acetone	ug/kg	.000	2	6	12	22	2
Benzene	ug/kg	.000	0	6	0	0	0
Bromodichloromethane	ug/kg	.000	0	6	0	0	0
Bromoform	ug/kg	.000	0	6	0	0	0
Bromomethane	ug/kg	.000	0	6	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	6	0	0	0
Carbon disulfide	ug/kg	.000	0	6	0	0	0
Chlorobenzene	ug/kg	.000	0	6	0	0	0
Chloroethane	ug/kg	.000	0	6	0	0	0
Chloroform	ug/kg	.000	0	6	0	0	0
Chloromethane	ug/kg	.000	0	6	0	0	0
Dibromochloromethane	ug/kg	.000	0	6	0	0	0
Ethylbenzene	ug/kg	.000	0	6	0	0	0
Methylene chloride	ug/kg	.000	0	6	0	0	0
Styrene	ug/kg	.000	0	6	0	0	0

See footnote at end of table

TABLE 4-39
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Tetrachloroethene	ug/kg	.000	0	6	0	0	0
Toluene	ug/kg	.000	1	6	35	35	1
Trichloroethene	ug/kg	.000	0	6	0	0	0
Vinyl Acetate	ug/kg	.000	0	4	0	0	0
Vinyl chloride	ug/kg	.000	0	6	0	0	0
Xylenes, Total	ug/kg	.000	0	6	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	6	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	6	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	6	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	6	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	6	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	6	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	6	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	3	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	6	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	6	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	6	0	0	0
2-Chlorophenol	ug/kg	.000	0	6	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	6	0	0	0
2-Methylphenol	ug/kg	.000	0	6	0	0	0
2-Nitroaniline	ug/kg	.000	0	6	0	0	0
2-Nitrophenol	ug/kg	.000	0	6	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	6	0	0	0
3-Nitroaniline	ug/kg	.000	0	6	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	3	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	6	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	6	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	6	0	0	0
4-Methylphenol	ug/kg	.000	2	6	190	310	2
4-Nitroaniline	ug/kg	.000	0	4	0	0	0
4-Nitrophenol	ug/kg	.000	0	5	0	0	0
Acenaphthene	ug/kg	.000	0	6	0	0	0
Acenaphthylene	ug/kg	.000	0	6	0	0	0
Anthracene	ug/kg	.000	1	6	67	67	1
Benzo(a)anthracene	ug/kg	.000	1	6	48	48	1

See footnote at end of table

TABLE 4-39
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Benzo(a)pyrene	ug/kg	.000	2	6	9	60	2
Benzo(b)fluoranthene	ug/kg	.000	1	6	39	39	1
Benzo(g,h,i)perylene	ug/kg	.000	2	6	38	130	2
Benzo(k)fluoranthene	ug/kg	.000	1	6	53	53	1
Benzoic acid	ug/kg	.000	1	3	45	45	1
Benzyl alcohol	ug/kg	.000	0	6	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	6	0	0	0
Carbazole	ug/kg	.000	2	6	7	7	2
Chrysene	ug/kg	.000	1	6	61	61	1
Di-n-butyl phthalate	ug/kg	.000	0	6	0	0	0
Di-n-octyl phthalate	ug/kg	.000	2	6	2	7	2
Dibenzo(a,h)anthracene	ug/kg	.000	0	6	0	0	0
Dibenzofuran	ug/kg	.000	0	6	0	0	0
Diethyl phthalate	ug/kg	.000	1	6	14	14	1
Dimethyl phthalate	ug/kg	.000	0	6	0	0	0
Fluoranthene	ug/kg	.000	2	6	66	120	2
Fluorene	ug/kg	.000	1	6	7	7	1
Hexachlorobenzene	ug/kg	.000	0	6	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	4	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	6	0	0	0
Hexachloroethane	ug/kg	.000	0	6	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	1	6	35	35	1
Isophorone	ug/kg	.000	0	6	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	6	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	6	0	0	0
Naphthalene	ug/kg	.000	0	6	0	0	0
Nitrobenzene	ug/kg	.000	0	6	0	0	0
Pentachlorophenol	ug/kg	.000	0	6	0	0	0
Phenanthrene	ug/kg	.000	1	6	67	67	1
Phenol	ug/kg	.000	2	6	24	42	2
Pyrene	ug/kg	.000	2	6	47	100	2
bis(2-Chloroethoxy)methane	ug/kg	.000	0	6	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	6	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	6	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	6	6	51	2200	6
p-Chloroaniline	ug/kg	.000	0	6	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	6	0	0	0
4,4'-DDE	ug/kg	.000	0	6	0	0	0

See footnote at end of table

TABLE 4-39
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
4,4'-DDT	ug/kg	.000	0	6	0	0	0
Aldrin	ug/kg	.000	0	6	0	0	0
Aroclor-1016	ug/kg	.000	0	6	0	0	0
Aroclor-1221	ug/kg	.000	0	6	0	0	0
Aroclor-1232	ug/kg	.000	0	6	0	0	0
Aroclor-1242	ug/kg	.000	0	6	0	0	0
Aroclor-1248	ug/kg	.000	0	6	0	0	0
Aroclor-1254	ug/kg	.000	0	6	0	0	0
Aroclor-1260	ug/kg	.000	0	6	0	0	0
Dieldrin	ug/kg	.000	0	6	0	0	0
Endosulfan II	ug/kg	.000	0	6	0	0	0
Endosulfan sulfate	ug/kg	.000	0	6	0	0	0
Endosulfan-I	ug/kg	.000	0	6	0	0	0
Endrin	ug/kg	.000	0	6	0	0	0
Endrin aldehyde	ug/kg	.000	0	6	0	0	0
Endrin ketone	ug/kg	.000	0	6	0	0	0
Heptachlor	ug/kg	.000	0	6	0	0	0
Heptachlor epoxide	ug/kg	.000	0	6	0	0	0
Methoxychlor	ug/kg	.000	0	6	0	0	0
Toxaphene	ug/kg	.000	0	6	0	0	0
alpha-BHC	ug/kg	.000	0	6	0	0	0
alpha-Chlordane	ug/kg	.000	0	6	0	0	0
beta-BHC	ug/kg	.000	0	6	0	0	0
delta-BHC	ug/kg	.000	0	6	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	6	0	0	0
gamma-Chlordane	ug/kg	.000	0	6	0	0	0

[a]Sediment results are compared to surface soil background values.

See footnote at end of table

Paddys Run. Four compounds detected in the west drainage and in the downstream sediment sample were not detected in the upstream Paddys Run sample. This fact suggests that the drainage has contributed sediment contaminated with semivolatile organic compounds to Paddys Run.

All of the semivolatile organic compounds, except benzoic acid, that were detected in the upstream Paddys Run sediment sample were detected in the downstream sample. However, an additional nine semivolatile compounds were detected in downstream Paddys run sediment samples that were not detected at upstream locations. Only two of these [dimethyl phthalate and indeno(1,2,3-cd)pyrene] were not detected in soil samples from the Inactive Flyash Pile. These data indicate that the Inactive Flyash Pile may be the original source for the nine semivolatile compounds detected in the downstream Paddys Run sediment samples but not detected at upstream locations.

Phase I and Phase II sediment sample data were compared to CIS data (Appendix E-10). Analytes detected in this preliminary study were also detected in Phase I and Phase II and within the same order of magnitude.

Sediment and surface water data for the same sample locations are shown in Table 4-37. A comparison of the data indicate that radionuclides concentration in Paddys Run upstream and downstream of the drainage channel did not detect an impact on April 21, 1993 from the Inactive Flyash Pile.

4.4.4 Groundwater

Monitoring Well 1711 is the only monitoring well completed in the upper perched groundwater zone within the Inactive Flyash Pile. Other wells included in the dataset are completed in the perched zone at the edge of the Inactive Flyash Pile. This is because the perched zone is limited in horizontal extent to the north half of the Inactive Flyash Pile. Wells 1047 and 1711 were sampled during Phase I; however, there was insufficient water in Well 1711 for radionuclide analyses. Ten metals were detected above background in a sample from Well 1711 including cobalt, nickel, and thallium. These metals were also detected at elevated concentrations in flyash. There was insufficient water to collect a sample during Phase II field activities, so upgradient Well 1047 data are discussed below. Groundwater analytical data from Well 1047 was compared to background concentrations for perched water. The analytical data are provided in Appendix E, Table E-2G and Table E-2H. A summary of the number of detected analytes is 1000-series wells is provided in Table 4-40 and Table 4-41.

TABLE 4-40

INACTIVE FLYASH PILE
GROUNDWATER - 1000 SERIES[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	1	2	.0516	.0516	0
Antimony		mg/L	.000	0	2	0	0	0
Arsenic		mg/L	.050	0	4	0	0	0
Barium		mg/L	.450	4	4	.048	.154	0
Beryllium		mg/L	.002	0	2	0	0	0
Cadmium		mg/L	.005	1	4	.009	.009	1
Calcium		mg/L	123.837	4	4	103	233	2
Chromium		mg/L	.035	1	4	.024	.024	0
Cobalt		mg/L	.000	2	2	.0275	.0733	2
Copper		mg/L	.030	1	4	.011	.011	0
Iron		mg/L	3.440	3	4	.066	25.5	2
Lead		mg/L	.015	0	4	0	0	0
Magnesium		mg/L	48.546	4	4	44.3	53.8	3
Manganese		mg/L	.050	4	4	.019	3.85	2
Mercury		mg/L	.000	0	4	0	0	0
Molybdenum		mg/L	.025	2	4	.0878	.147	2
Nickel		mg/L	.026	3	4	.025	2.43	2
Potassium		mg/L	26.976	4	4	2.34	34	1
Selenium		mg/L	.000	0	4	0	0	0
Silicon		mg/L	.000	2	2	19.2	20.1	2
Silver		mg/L	.040	1	4	.012	.012	0
Sodium		mg/L	47.982	4	4	22.3	59.5	1
Thallium		mg/L	.000	2	2	.422	.435	2
Vanadium		mg/L	.020	0	2	0	0	0
Zinc		mg/L	.032	2	2	.0119	.0138	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0		0	0	0
NP-237	UNFL	pCi/L	.000	0	2	0	0	0
PU-238	UNFL	pCi/L	.000	0	3	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	3	0	0	0
RA-226	UNFL	pCi/L	1.000	0	3	0	0	0
RA-228	UNFL	pCi/L	5.200	0	3	0	0	0
RU-106	UNFL	pCi/L	.000	0		0	0	0
SR-90	UNFL	pCi/L	.000	0	3	0	0	0

See footnote at end of table

TABLE 4-40
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
TC-99	UNFL	pCi/L	.000	0	3	0	0	0
TH-228	UNFL	pCi/L	1.040	0	3	0	0	0
TH-230	UNFL	pCi/L	2.000	0	3	0	0	0
TH-232	UNFL	pCi/L	.000	0	3	0	0	0
TH-TOTAL	UNFL	ug/L	3.000	1	2	5	5	1
U-234	UNFL	pCi/L	1.900	3	3	3.7	7.4	3
U-235/236	UNFL	pCi/L	.000	0	3	0	0	0
U-238	UNFL	pCi/L	1.070	3	3	2.1	3.2	3
U-TOTAL	UNFL	ug/L	4.000	2	2	6	9	2
GENERAL CHEMISTRY								
Alkalinity as CaCO3	UNFL	mg/L	.000	0		0	0	0
Ammonia	UNFL	mg/L	4.340	0	1	0	0	0
Chloride	UNFL	mg/L	46.100	0	1	0	0	0
Fluoride	UNFL	mg/L	1.298	1	1	.8	.8	0
Nitrate	UNFL	mg/L	.462	0		0	0	0
Phenols	UNFL	mg/L	.000	0	1	0	0	0
Phosphorus	UNFL	mg/L	.206	1	1	.4	.4	1
Sulfate	UNFL	mg/L	138.192	1	1	180	180	1
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	1	1	.2	.2	0
Total Organic Halides	UNFL	mg/L	.000	0	2	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.000	1	1	.2	.2	1

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available.

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TABLE 4-41

INACTIVE FLYASH PILE
GROUNDWATER - 1000 SERIES[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	0	1	0	0	0
Antimony		mg/L	.000	0	1	0	0	0
Arsenic		mg/L	.050	0	1	0	0	0
Barium		mg/L	.450	1	1	.0459	.0459	0
Beryllium		mg/L	.002	0	1	0	0	0
Cadmium		mg/L	.005	0	1	0	0	0
Calcium		mg/L	123.837	1	1	112	112	0
Chromium		mg/L	.035	0	1	0	0	0
Cobalt		mg/L	.000	0	1	0	0	0
Copper		mg/L	.030	0	1	0	0	0
Cyanide		mg/L	.000	0	1	0	0	0
Iron		mg/L	3.440	0	1	0	0	0
Lead		mg/L	.015	0	1	0	0	0
Magnesium		mg/L	48.546	1	1	50.6	50.6	1
Manganese		mg/L	.050	0	1	0	0	0
Mercury		mg/L	.000	0	1	0	0	0
Molybdenum		mg/L	.025	1	1	.0055	.0055	0
Nickel		mg/L	.026	0	1	0	0	0
Potassium		mg/L	26.976	1	1	1.5	1.5	0
Selenium		mg/L	.000	0	1	0	0	0
Silicon		mg/L	.000	1	1	6.22	6.22	1
Silver		mg/L	.040	0	1	0	0	0
Sodium		mg/L	47.982	1	1	40.9	40.9	0
Thallium		mg/L	.000	0	1	0	0	0
Vanadium		mg/L	.020	0	1	0	0	0
Zinc		mg/L	.032	1	1	.0066	.0066	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	1	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0	1	0	0	0
GROSS BETA	UNFL	pCi/L	.000	0	1	0	0	0
NP-237	UNFL	pCi/L	.000	0	1	0	0	0
PU-238	UNFL	pCi/L	.000	0	1	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	1	0	0	0
RA-226	UNFL	pCi/L	1.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-41
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	5.200	1	1	5.93	5.93	1
RU-106	UNFL	pCi/L	.000	0	1	0	0	0
SR-90	UNFL	pCi/L	.000	0	1	0	0	0
TC-99	UNFL	pCi/L	.000	0	1	0	0	0
TH-228	UNFL	pCi/L	1.040	0	1	0	0	0
TH-230	UNFL	pCi/L	2.000	1	1	.227	.227	0
TH-232	UNFL	pCi/L	.000	0	1	0	0	0
TH-TOTAL	UNFL	ug/L	3.000	0	1	0	0	0
U-234	UNFL	pCi/L	1.900	1	1	2.33	2.33	1
U-235/236	UNFL	pCi/L	.000	0	1	0	0	0
U-238	UNFL	pCi/L	1.070	1	1	1.62	1.62	1
U-TOTAL	UNFL	ug/L	4.000	1	1	5.36	5.36	1
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Butanone	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	0	1	0	0	0
Benzene	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroethane	UNFL	ug/L	.000	0	1	0	0	0
Chloroform	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-41
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Methylene chloride	UNFL	ug/L	.000	0	1	0	0	0
Styrene	UNFL	ug/L	.000	0	1	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	1	0	0	0
Toluene	UNFL	ug/L	.000	0	1	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	1	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	1	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	1	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	0	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	0	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-41
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Acenaphthylene	UNFL	ug/L	.000	0	1	0	0	0
Anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Carbazole	UNFL	ug/L	.000	0	1	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Fluorene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Isophorone	UNFL	ug/L	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	1	0	0	0
Naphthalene	UNFL	ug/L	.000	0	1	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	1	0	0	0
Phenol	UNFL	ug/L	.000	0	1	0	0	0
Pyrene	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	1	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	0	0	0	0

See footnote at end of table

TABLE 4-41
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	1	0	0	0
Aldrin	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	1	0	0	0
Dieldrin	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	1	0	0	0
Endrin	UNFL	ug/L	.000	0	1	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	1	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	1	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	1	0	0	0
Toxaphene	UNFL	ug/L	.000	0	1	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	1	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
beta-BHC	UNFL	ug/L	.000	0	1	0	0	0
delta-BHC	UNFL	ug/L	.000	0	1	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	1	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	1	0	0	0

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available.

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Twelve metals and the isotopes of two elements and no organic compounds were detected in four samples collected during both Phase I and Phase II; no organic compounds were detected.

In order to characterize the perched groundwater system beneath the Inactive Flyash Pile, twelve groundwater samples were collected from 17 Hydropunch™ sample locations. On-site analyses were used to define the distribution of uranium in perched groundwater at the subunit. These data are presented in Table 4-42 and the locations are shown on Figure 4-23 (see Volume 2, Oversized Figures). Perched water was encountered beneath the north end of the Inactive Flyash Pile but not during attempted sampling in April to May 1993 at the south end of the Inactive Flyash Pile.

A comparison of total uranium concentrations in soil and water samples collected during the Hydropunch™ activities is presented on Table 4-42 and indicates the following:

- Water samples collected from Hydropunch™ 1999, 11000, 11001, 11002, 11004, 11007, 11048 and 11050 had total uranium ranging from 9.5 μg/L to 6700 μg/L. These Hydropunch™ samples were collected from intervals where no waste material other than flyash or fill were identified. This suggests that the source for the water contamination was upgradient of the Hydropunch™ locations in the northern portion of the Inactive Flyash Pile.

- Water samples from Hydropunch™ 11003 and 11051 had total uranium in water of 720 μg/L and 74 μg/L, had 378 mg/kg and 1010 mg/kg, respectively. These Hydropunch™ water samples are believed to be associated with waste materials in the perched zone.

Hydropunch™ data suggest that, in the northern portion of Inactive Flyash Pile, perched groundwater is flowing through waste materials in the Inactive Flyash Pile containing uranium upgradient from the Hydropunch™ locations. A comparison of the surface water uranium concentrations from the west drainage, downgradient from the identified seepage, and the perched water uranium concentrations indicates that the northern portion of the Inactive Flyash Pile may be the source for the uranium concentrations associated with the seepage.

Four 2000-series wells were sampled during Phase I. Wells 21190 (1016), 2016, 2042, and 2402, which are located on the northeast and southern battery limits of the Inactive Flyash Pile. Aluminum, calcium, and chromium were detected above background in Wells 21190(1016) and 2016. Uranium and two organic compounds were detected. The nested Wells 3016 and 4016 were also sampled and detected trace lead, manganese, and uranium. The highest concentrations of total uranium in the

TABLE 4-42

SUMMARY OF TOTAL URANIUM IN PERCHED GROUNDWATER HYDROPUNCH™ SAMPLES FROM THE INACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Hydropunch	Sample I.D.	Date Collected	Soil Sample Depth (ft.)	Location	Soil* Total Uranium µg/g	Water Total Uranium µg/L
1999	111922	4/19/93	12-13	Water sample collected from Flyash - till interface 8'-12'	<11	460
11000	11759	4/15/93	16.5-18	Water and soil from silty sand unit within till 13'-15' deep	<11	410
11001	111690	4/13/93	21.5-22	Water collected from silty sand unit in clay till 17'-21' deep	<11	280
11002	116461	5/5/93	16.5	Waste encountered at 13' deep; water collected from waste/till 13'-17' deep	<11	6700
11003	111840	4/17/93	25.5-26	Drilled adjacent to Well 1711, sandy silt unit in till 22'-26' deep	378	720
11004	111855	4/18/93	24-25	Wet sand and gravel unit overlying clay layer 20'-24' deep	<11	29
11005		4/29/93	10.5-11	Dry	165	-
11006		4/26/93	22.5-24	Wet gray clay-like sludge; material, no flow to hydropunch	3300	-
11007	110679	4/21/93	22.5-23	Water may be from clay and sand at 19.5'	<11	9.5
11008		5/2/93	21-21.5	Dry	<11	-
11047	116318	5/16/93		Sand unit within till 8'-12'	-	19
11048	116351	5/25/93	21-22	Sand unit within till 22'-24'	<11	430
11049	116356	5/27/93	11.5-12.5	Silty clay (note: very moist clay from surface to 11.5') 7.5-11.5	<11	77
11050	116454	6/27/93	16-18	Silty fine sand unit in till under Flyash 10.5'-14.5'	<11	370
11051	116437	5/27/93	21-22 22-24 28-30	Waste material at Flyash - till interface; sample collected from 17'-21' deep	1010 1470 <11	- 74 -
11052		5/25/93	19-21 25-27	Clay material beneath Flyash	1000 <11	-
11053		5/21/93	18-26	Great Miami Aquifer Material	<11	-

*Note: Soil analyses for sample collected from saturated interval tested by hydropunch.

21190(1016)-2016-3016 well group in 1989 was 9 μg/g, 22 μg/g, and 7 μg/g, respectively. These data indicate a possible impact from the subunit upon groundwater. Well 2955 was installed in the Inactive Flyash Pile during Phase II. Analytical data from the 2000-series wells were compared to background data from the regional aquifer. Analytes detected above background are provided in Appendix E in Table E-2I while a summary of the analytes is provided in Table 4-43 and Table 4-44. Phase II sampling detected aluminum and manganese, isotopes of four elements (neptunium-237, plutonium-238, plutonium-259/240, thorium-232, and uranium-235/236 were not detected during Phase I), and three organic compounds (Carbon disulfide and Butyl benzyl phthalate were not detected for Phase I; bis(2-Ethylhexyl)phthalate was detected above back ground for Phase I but not Phase II) that exceeded background values in four samples.

Concentrations of selected analytes detected above background are presented in Table 4-45. A comparison of the concentration of total uranium in upgradient Well 2402 (5.62 μg/L) and downgradient Well 2945 (2070 μg/L) or downgradient Well 2954 (1167 μg/L) indicates that there has been a release of uranium from the subunit to the regional aquifer. Concentrations of uranium in the downgradient wells (see Figure 3-50 for groundwater elevation contours) are similar to those detected in perched groundwater samples collected from the seep (820 μg/L at IFP-SW-10), from the drainage as it infiltrates into the regional aquifer (910 μg/L at IFP-SW-05), and from perched groundwater (6700 μg/L from Hydropunch™ 11002).

Total uranium analysis in Well 2955 (in the north end of the subunit) and Well 2401 (downgradient of 2955 in the South Field) detected 8.19 μg/L and 5.13 μg/L, respectively. These data indicate that there has not been a release of uranium from the subunit in this area to the regional aquifer and suggest that the origin of regional aquifer uranium contamination is southeast of these wells, possibly near to 11051 where 2280 μg/g total uranium was detected in a soil sample at 24 feet deep.

A comparison of the concentration of constituents other than uranium detected in the upgradient and downgradient wells does not identify any constituent that appears to increase in concentration from wells located downgradient of the subunit. This suggests that uranium is the primary constituent in water recharging the regional aquifer beneath the Inactive Flyash Pile.

TABLE 4-43

INACTIVE FLYASH PILE
GROUNDWATER[a] - 2000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	5	8	.113	.374	2
Antimony		mg/L	.006	0	2	0	0	0
Arsenic		mg/L	.050	0	16	0	0	0
Barium		mg/L	.436	14	15	.03	.064	0
Beryllium		mg/L	.002	0	2	0	0	0
Cadmium		mg/L	.005	7	15	.003	.0051	1
Calcium		mg/L	134.783	15	15	19.2	198	2
Chromium		mg/L	.041	8	15	.0138	.127	1
Cobalt		mg/L	.000	0	2	0	0	0
Copper		mg/L	.120	6	15	.0102	.023	0
Cyanide		mg/L	.000	0		0	0	0
Iron		mg/L	4.000	12	15	.02	2.5	0
Lead		mg/L	.015	4	16	.002	.005	0
Magnesium		mg/L	37.961	15	15	18.8	37.9	0
Manganese		mg/L	.050	12	15	.002	.039	0
Mercury		mg/L	.001	3	16	.0002	.0005	0
Molybdenum		mg/L	.025	0	13	0	0	0
Nickel		mg/L	.024	0	13	0	0	0
Potassium		mg/L	3.077	13	16	1.5	2.92	0
Selenium		mg/L	.004	3	16	.0013	.005	1
Silicon		mg/L	6.140	6	6	2.53	4.01	0
Silver		mg/L	.014	1	15	.0102	.0102	0
Sodium		mg/L	51.267	15	15	4.1	17.1	0
Thallium		mg/L	.000	0	2	0	0	0
Vanadium		mg/L	.025	5	8	.0123	.0164	0
Zinc		mg/L	.095	2	2	.027	.034	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	1	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0		0	0	0
GROSS BETA	UNFL	pCi/L	.000	0		0	0	0
NP-237	UNFL	pCi/L	.000	0	8	0	0	0
PU-238	UNFL	pCi/L	.000	0	10	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	10	0	0	0
RA-226	UNFL	pCi/L	1.200	0	7	0	0	0

See footnote at end of table

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TABLE 4-43
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	4.000	0	10	0	0	0
RU-106	UNFL	pCi/L	.000	0	1	0	0	0
SR-90	UNFL	pCi/L	.000	0	9	0	0	0
TC-99	UNFL	pCi/L	36.000	0	10	0	0	0
TH-228	UNFL	pCi/L	1.400	0	11	0	0	0
TH-230	UNFL	pCi/L	1.700	0	10	0	0	0
TH-232	UNFL	pCi/L	.000	0	10	0	0	0
TH-TOTAL	UNFL	ug/L	2.000	0	8	0	0	0
U-234	UNFL	pCi/L	1.200	10	11	2.5	7.73	10
U-235/236	UNFL	pCi/L	.000	0	10	0	0	0
U-238	UNFL	pCi/L	.900	9	10	2.6	8	9
U-TOTAL	UNFL	ug/L	2.000	8	8	9	29.4	8
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	1	2	2	2	1
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	2	0	0	0
2-Butanone	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	2	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	2	0	0	0
Acetone	UNFL	ug/L	.000	0	2	0	0	0
Benzene	UNFL	ug/L	.000	0	2	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	2	0	0	0
Bromoform	UNFL	ug/L	.000	0	2	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	2	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	2	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroethane	UNFL	ug/L	.000	0	2	0	0	0
Chloroform	UNFL	ug/L	.000	0	2	0	0	0
Chloromethane	UNFL	ug/L	.000	0	2	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	2	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	2	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

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TABLE 4-43
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Styrene	UNFL	ug/L	.000	0	2	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	2	0	0	0
Toluene	UNFL	ug/L	.000	0	2	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	2	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	2	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	2	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	2	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	2	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	2	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	2	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	2	0	0	0
Anthracene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-43
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	2	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	2	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Fluorene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	2	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	2	0	0	0
Isophorone	UNFL	ug/L	.000	0	2	0	0	0
Methyl parathion	UNFL	ug/L	.000	0	2	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	2	0	0	0
Naphthalene	UNFL	ug/L	.000	0	2	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	2	0	0	0
Parathion	UNFL	ug/L	.000	0	2	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	2	0	0	0
Phenol	UNFL	ug/L	.000	0	2	0	0	0
Pyrene	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	1	2	4	4	1
p-Chloroaniline	UNFL	ug/L	.000	0	2	0	0	0
PESTICIDES/PCBs								
4,4'-DDD	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	1	0	0	0
Aldrin	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

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TABLE 4-43
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)								
Aroclor-1016	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	2	0	0	0
Dieldrin	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	2	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	2	0	0	0
Heptachlor	UNFL	ug/L	.000	0	2	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	1	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	1	0	0	0
Toxaphene	UNFL	ug/L	.000	0	2	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	2	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	2	0	0	0
beta-BHC	UNFL	ug/L	.000	0	1	0	0	0
delta-BHC	UNFL	ug/L	.000	0	1	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	2	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
Azinphosmethyl	UNFL	ug/L	.000	0	2	0	0	0
Demeton	UNFL	ug/L	.000	0	2	0	0	0
Diazinon	UNFL	ug/L	.000	0	2	0	0	0
Disulfoton	UNFL	ug/L	.000	0	2	0	0	0
Ethion	UNFL	ug/L	.000	0	2	0	0	0
Malathion	UNFL	ug/L	.000	0	2	0	0	0
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	3.240	0	13	0	0	0
Chloride	UNFL	mg/L	120.000	12	13	6.8	30	0
Fluoride	UNFL	mg/L	.929	12	13	.1	.77	0
Hexavalent Chromium	UNFL	mg/L	.000	0	2	0	0	0
Nitrate	UNFL	mg/L	10.000	11	13	1.18	5.3	0
Phenols	UNFL	mg/L	.000	3	13	.005	.0546	0
Phosphate	UNFL	mg/L	.000	2	2	.28	.3	0
Phosphorus	UNFL	mg/L	.679	12	12	.03	.758	1
Sulfate	UNFL	mg/L	352.992	12	12	26	146	0
Sulfide	UNFL	mg/L	30.400	1	6	28.1	28.1	0

See footnote at end of table

TABLE 4-43
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	5	8	.16	1.2	0
Total Organic Carbon	UNFL	mg/L	3.764	5	7	1.65	3.71	0
Total Organic Halides	UNFL	mg/L	.021	3	11	.01	.07	2
Total Organic Nitrogen	UNFL	mg/L	.652	7	14	.16	.9	1

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available.

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TABLE 4-44

INACTIVE FLYASH PILE
GROUNDWATER[a] - 2000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	2	6	.366	.676	2
Antimony		mg/L	.006	0	6	0	0	0
Arsenic		mg/L	.050	1	6	.0016	.0016	0
Barium		mg/L	.436	6	6	.0457	.0506	0
Beryllium		mg/L	.002	0	6	0	0	0
Cadmium		mg/L	.005	0	6	0	0	0
Calcium		mg/L	134.783	6	6	83.7	98.4	0
Chromium		mg/L	.041	1	6	.0055	.0055	0
Cobalt		mg/L	.000	0	6	0	0	0
Copper		mg/L	.120	0	6	0	0	0
Cyanide		mg/L	.000	0	4	0	0	0
Iron		mg/L	4.000	3	6	.206	2.67	0
Lead		mg/L	.015	2	6	.0013	.0039	0
Magnesium		mg/L	37.961	6	6	23.5	27.4	0
Manganese		mg/L	.050	2	6	.0262	.0677	1
Mercury		mg/L	.001	0	6	0	0	0
Molybdenum		mg/L	.025	0	6	0	0	0
Nickel		mg/L	.024	1	6	.0075	.0075	0
Potassium		mg/L	3.077	6	6	2.26	2.77	0
Selenium		mg/L	.004	0	6	0	0	0
Silicon		mg/L	6.140	6	6	3.3	4.3	0
Silver		mg/L	.014	0	6	0	0	0
Sodium		mg/L	51.267	6	6	8.97	12.9	0
Thallium		mg/L	.000	0	6	0	0	0
Vanadium		mg/L	.025	0	6	0	0	0
Zinc		mg/L	.095	3	6	.0037	.0411	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	3	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	3	3	6.97	9.52	3
GROSS BETA	UNFL	pCi/L	.000	3	3	5.05	9.34	3
NP-237	UNFL	pCi/L	.000	2	3	.28	.71	2
PU-238	UNFL	pCi/L	.000	1	3	.16	.16	1
PU-239/240	UNFL	pCi/L	.000	1	3	.06	.06	1

See footnote at end of table

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TABLE 4-44
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-226	UNFL	pCi/L	1.200	2	3	.2	.275	0
RA-228	UNFL	pCi/L	4.000	0	3	0	0	0
RU-106	UNFL	pCi/L	.000	0	3	0	0	0
SR-90	UNFL	pCi/L	.000	0	3	0	0	0
TC-99	UNFL	pCi/L	36.000	0	3	0	0	0
TH-228	UNFL	pCi/L	1.400	0	3	0	0	0
TH-230	UNFL	pCi/L	1.700	3	3	.277	.8	0
TH-232	UNFL	pCi/L	.000	1	3	.14	.14	1
TH-TOTAL	UNFL	ug/L	2.000	1	3	1.27	1.27	0
U-234	UNFL	pCi/L	1.200	3	3	2.17	6.02	3
U-235/236	UNFL	pCi/L	.000	3	3	.15	.698	3
U-238	UNFL	pCi/L	.900	3	3	3.01	6.5	3
U-TOTAL	UNFL	ug/L	2.000	3	3	5.62	17.1	3
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	1	4	1	1	1
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	4	0	0	0
2-Butanone	UNFL	ug/L	.000	0	4	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	4	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	4	0	0	0
Acetone	UNFL	ug/L	.000	0	3	0	0	0
Benzene	UNFL	ug/L	.000	0	4	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	4	0	0	0
Bromoform	UNFL	ug/L	.000	0	4	0	0	0
Bromomethane	UNFL	ug/L	.000	0	4	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	4	0	0	0
Carbon disulfide	UNFL	ug/L	.000	1	4	26	26	1
Chlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Chloroethane	UNFL	ug/L	.000	0	4	0	0	0
Chloroform	UNFL	ug/L	.000	0	4	0	0	0
Chloromethane	UNFL	ug/L	.000	0	3	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	4	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

000543

TABLE 4-44
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Methylene chloride	UNFL	ug/L	.000	0	4	0	0	0
Styrene	UNFL	ug/L	.000	0	4	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	4	0	0	0
Toluene	UNFL	ug/L	.000	0	4	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	4	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	3	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	4	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	4	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	4	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	4	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	3	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-44
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Acenaphthene	UNFL	ug/L	.000	0	4	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	4	0	0	0
Anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	2	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	4	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	1	4	1	1	1
Carbazole	UNFL	ug/L	.000	0	4	0	0	0
Chrysene	UNFL	ug/L	.000	0	4	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	4	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Fluorene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	4	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Isophorone	UNFL	ug/L	.000	0	4	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	4	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	4	0	0	0
Naphthalene	UNFL	ug/L	.000	0	4	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	4	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	4	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	4	0	0	0
Phenol	UNFL	ug/L	.000	0	4	0	0	0
Pyrene	UNFL	ug/L	.000	0	4	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-44
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	4	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	3	0	0	0
PESTICIDES/PCBs								
4,4'-DDD	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	4	0	0	0
Aldrin	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	4	0	0	0
Dieldrin	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	4	0	0	0
Endrin	UNFL	ug/L	.000	0	4	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	4	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	4	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	4	0	0	0
Toxaphene	UNFL	ug/L	.000	0	4	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	4	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
beta-BHC	UNFL	ug/L	.000	0	4	0	0	0
delta-BHC	UNFL	ug/L	.000	0	4	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	4	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	3	3	209.9	258	0
Alkalinity as CaCO3	UNFL	mg/L	.000	1	1	224	224	0
Ammonia	UNFL	mg/L	3.240	0	4	0	0	0
Chloride	UNFL	mg/L	120.000	4	4	20.28	29.1	0
Fluoride	UNFL	mg/L	.929	4	4	.2	.28	0

See footnote at end of table

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6505

TABLE 4-44
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Nitrate	UNFL	mg/L	10.000	3	3	1.72	2.46	0
Phenols	UNFL	mg/L	.000	0	4	0	0	0
Phosphorus	UNFL	mg/L	.679	0	1	0	0	0
Sulfate	UNFL	mg/L	352.992	4	4	68.5	84.1	0
Sulfide	UNFL	mg/L	30.400	0	4	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	3	4	.12	3.01	0
Total Organic Carbon	UNFL	mg/L	3.764	1	4	1.12	1.12	0
Total Organic Halides	UNFL	mg/L	.021	1	3	.0108	.0108	0
Total Organic Nitrogen	UNFL	mg/L	.652	3	4	.12	2.9	1
Total Phosphorous	UNFL	mg/L	.000	2	3	.06	.14	0

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available.

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TABLE 4-45

CONCENTRATIONS OF SELECTED ANALYTES FROM 2000 SERIES WELLS DURING PHASE II INACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Analyte and Concentration						
Well I.D./Location	Total U µg/L	Chloride mg/L	Sulfate mg/L	Alkalinity mg/L	Fluoride mg/L	Bis (2-Ethylhexyl) Phthalate	Butyl Benzylphthalate
2047 - North of Flyash Pile; possible upgradient	9.51	24.48	80.8	NA	0.2	ND	ND
2402 - West of Flyash Pile; upgradient well	5.62	20.28	68.5	209.9	0.28	ND	ND
2955 - Within Flyash Pile; North end	8.19	29.1	72.7	258	0.22	ND	1
2401 - Directly downgradient from North end of Flyash Pile	5.13	23.6	53.5	339	0.20	ND	ND
2945 - Downgradient[a] of central part of Flyash Pile	2670/1820	4.62	69.7	455	0.51	ND	ND
2954 - Downgradient[a] of both 2945 and South of Flyash Pile	1167	20.8	95.4	420	0.09	6	ND
2016 - South of Inactive Flyash Pile; possibly downgradient of South end	17.1	28.35	84.1	245	0.2	ND	ND
Paddys Run (at IFP-SW-03); upstream of out fall of East drainage channel	5.25, 5.03	ND	62.9, 77.4	255, 195	0.2, 0.21	ND	ND

Note: NA means not analyzed.
ND means not detected.

[a]These wells are located in the South Field

4.4.5 Biota

The ecological impacts from material left after remediation will be addressed in the Site-Wide Ecological Risk Assessment that will be prepared as part of the Operable Unit 5 RI/FS.

4.4.6 Summary

Soil, waste material, and water sample data indicate the following about the Inactive Flyash Pile:

- Metals, organic compounds, and radionuclides were detected above background for the surface of the Inactive Flyash Pile, and included the surface soil COCs arsenic, radium-228, thorium-228, thorium-232, and dibenzo(a,h)anthracene. These constituents were also found at varied depths in most of the samples, indicating that contaminated material has been disposed of throughout the operating period of the Inactive Flyash Pile. Other radionuclides detected above background were plutonium and strontium.

- The surface soil analytical results do not suggest a pattern of surface disposal at one location in the Inactive Flyash Pile with subsequent surface spreading; a more likely scenario is the disposal of waste took place throughout the Inactive Flyash Pile.

- There are indications from field observations that elevated concentrations of uranium exist in the surface water from the drainage west of the Inactive Flyash Pile, and is contributing to the recharge of the Great Miami Aquifer.

- Semivolatile compounds were detected in trace concentrations in the drainage west of the Inactive Flyash Pile. Of these, four were detected in the downstream sediment sample in Paddys Run and not in the upstream sediment sample. This suggests that the Inactive Flyash Pile may be impacting Paddys Run. Furthermore, there were additional semivolatiles detected in the downstream sediment sample which were not detected in the upstream sample, giving further credence to the Inactive Flyash Pile's impact on Paddys Run.

- Waste materials identified in samples collected from soil borings in the subunit included localized sludge-like material, clay tile drain pipe, wood, nails, wire, construction debris, and flyash. The recovered materials from the borings, except the flyash, produced elevated field measured radioactivity by an alpha-beta meter. These elevated/readings may be due to the materials having been associated with or in contact and/or cross contaminated with process materials or waste.

- The subsurface soils had the surface soil COCs arsenic, radium-228, thorium-228, thorium-232, and dibenzo(a,h)anthracene. Other radionuclides detected above background were lead-210, plutonium, ruthenium, strontium, and technetium.

- Identifiable waste materials appear to be resting on or near the interface of flyash and glacial overburden near the center of the Inactive Flyash Pile.

- Flyash and fill are in contact with the Great Miami Aquifer in the western and southern portions under the Inactive Flyash Pile.

- The highest concentrations of Aroclor-1254 and total uranium were found associated with the trace of a buried drainage that existed before the Inactive Flyash Pile was developed.

- The occurrence of uranium in the perched groundwater appears to be related to waste materials within the pile or close to it since upgradient Hydropunch™ 11047 and upgradient Well 1047 data have uranium concentrations close to background and two orders of magnitude lower than downgradient Hydropunch™ concentrations.

- Seepage in the drainage to the west may be associated with the perched groundwater. The correlation can be made that the total uranium concentrations from the Hydropunch™ samples upgradient of the seepage were of the same order of magnitude as that collected from the proximity of the seep. Also, seepage continued for extended periods after precipitation events, which may indicate that perched groundwater is charging the seepage.

- The perched groundwater analyses detected the surface soil COCs radium and uranium (also a cross-media groundwater COC). The perched groundwater is located in saturated silty sand lenses within the till beneath the flyash, and in a saturated zone of flyash that is directly above the till surface. The till under the flyash pile is suspected to slope to the west, southwest, and south. Therefore, the fill till interface truncates on the surface of the Great Miami Aquifer. This is a possible existing mechanism to transport contaminants to the Great Miami Aquifer. Also, it is suspected that the saturated flyash/fill comes into direct contact with the Great Miami Aquifer, which would be another mechanism for introducing contaminants to the Great Miami Aquifer.

- In the Upper Great Miami Aquifer (2000-series wells) no surface soil COCs (also a cross-media groundwater COC) were detected. However, uranium-234, uranium-235/236, uranium-238, total uranium, neptunium-237, and plutonium-238 were detected above background, suggesting a potential impact on the Great Miami Aquifer.

4.5 SOUTH FIELD

Analytical results for samples collected from the South Field are presented in Appendix F. Sample analyses that detected analytes at concentrations above background (defined in Table 4-1A) will be discussed in this section. Geology and hydrogeology of the South Field referred to in this section were discussed in more detail Section 3.4.

4.5.1 Volume and Physical Characteristics of Waste

Materials in soil samples and trenches in the South Field are comprised of clean fill, construction debris, and radioactive materials mixed with the above materials and the native till. A map showing the estimated thickness of the fill material was presented as Figure 4-12. An estimated volume for the fill and waste materials in the South Field is 120,081 cubic yards. A geophysical survey was conducted during Phase II, and 16 trenches were excavated during Phase I and Phase II to locate and sample typical waste materials buried in the South Field. The geophysical survey during Phase II

identified ten areas of anomalous electromagnetic readings, and these areas were selected for trenching. The Phase I and Phase II surveys are in agreement with the CIS geophysical survey. Visual observations of the waste materials in the trenches are summarized in Table 4-46. Table 4-46 and indicate that a wide range of waste materials were buried in the fill above the till. Samples of soil scraped from the objects were analyzed for metals, radionuclides, and semivolatile compounds. Results of the analyses, shown on Table 4-46, indicate that soil associated with the waste materials contains elevated amounts of metals, radionuclides, and semivolatile compounds. Field screening of dry wipe samples from the surfaces of the waste materials are summarized in Table 4-47; screening data indicate that radioactive contamination is located on the surface and can be removed by wipe sampling.

4.5.2 Surface and Subsurface Soils

Chemical and radiological analytical results from surface samples were compared against soil background concentrations, and a table of the resulting constituent concentrations is provided in Appendix F, Table F-2A. A summary of the analytes are shown in Table 4-48A. Nineteen metals, isotopes of eight elements, and 26 organic compounds exceeded background concentrations in 21 analyses of surface samples collected during the Phase II field program at the South Field. Metals that were detected in over 40 percent of the samples included beryllium (15 samples), copper (17 samples), and silver (20 samples). These metals were widely distributed throughout the South Field and were close to the background limits except for silver, which had a background concentration of 0 mg/kg.

Sample location and radionuclide data collected from surface samples in the South Field are shown on Figure 4-17 (see Volume 2, Oversized Figures). Highest radionuclide activities were detected in two samples (11186 and Boring No. 1972) collected near the north boundary. This location corresponds to the location of waste piles seen in a 1957 aerial photograph of the site. The surface sample 11186 detected the highest activities of radium-226 (30.8 pCi/g) of any surface sample collected from the South Field. The data do not indicate a correlation between thorium, uranium or radium. The distribution of radionuclide concentrations suggests multiple surficial areas elevated concentration which correlate with surface FIDLER scans conducted during the CIS (see Figure F-15A on Page F-15-159). Surface soil data confirm the CIS field data (Table F-4, Appendix F) and indicate that surface dumping occurred adjacent to the north boundary road. Figure 4-18 (See Volume II, Oversized Figures) identifies the organics in surface samples detected above background in the South

TABLE 4-46

SUMMARY OF PHASE II TRENCHING DATA, SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Trench	Waste Types and Description	Field Readings	Analytical Data	
1	Wire, concrete slabs, cinder blocks, flyash, contaminated pipe. Fluorescent yellow material, wire	up 1500 cpm 15000 cpm 22000 cpm	Sample 113105 Total Uranium 165 μg/kg Total Thorium 28.9 μg/kg Radium-226 1.8 pCi/g Radium-228 3.7 pCi/g Total Uranium (on site) 143 μg/kg	113718 bis(2)ethylhexyl 340 μg/kg Zn 71,000 μg/kg Aroclor 1254 170 μg/kg Tributyl phosphate 170 μg/kg Fluorenthene 140 μg/kg
2	Tar-like material, black construction material, concrete wire Fill/native till interface 12'	25,000 cpm 10,000 cpm 1200 cpm	Sample 113724 Total Uranium = 724 μg/kg Total Thorium = <18 μg/kg Radium-226 12 pCi/g Radium-228 97 pCi/g Sample 113725 Total Uranium = 34 μg/kg Total Thorium = 3540 μg/kg Radium-9.3 pCi/g Radium-228 85 pCi/g	No analyses
3	Metal pipe construction debris	400 cpm	no samples	
4	Concrete, debris 6' concrete slab 6" thick	3000 cpm	Sample 113722 Zinc = 508,000 μg/kg Total Uranium = 1,170,000 μg/kg	Benzopyrene = 64,000 μg/kg Lead = 385,000 μg/kg bis(2 ethylhexyl)phthalate = 610,000 μg/kg
	Metal bars, brick	1000 cpm	(on site) Total Uranium = 951 μg/kg	
5	Sheet metal, little debris saturated conditions at 10' Fill/till interface at 6-7'	220 cpm	no samples	
6	Wire, concrete, brick, wood, re-bar, cable, section of trench detected debris in all areas Fill/native till interface at 8-9' deep	80-100 cpm	no samples	
7	Concrete, pipe Floor drain, metal plate Demolition debris interface of trench/native till at 9'	5-100 cpm 5000 cpm 500 cpm	no samples	
8	concrete sheet metal 6" ID pipe Fill/till interface at 3' deep	600 cpm	no samples	

TABLE 4-46
(Continued)

Trench	Waste Types and Description	Field Readings	Analytical Data	
9	Brick, concrete, wire cinder block small pieces of brick and concrete. Wet at base of fill at till surface (11')	40 cpm	no samples	
10	Native soil at 2', bedding plane of original surface identifiable metal piece 10' x 6' x 1/8" Fill/till interface at 2' deep	4,600 cpm	no samples	

TABLE 4-47

SCREENING RESULTS OF WIPE SAMPLES COLLECTED FROM WASTE MATERIAL IN TRENCHES IN THE SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Material and Description	Sample Number	Activity of Dry Wipe DPM[a]
Trench 1.		
concrete (2' x 1')	T-1-1	15,000
orange stained concrete (0.5' x 0.5")	T-1-2	40,000
insulated wire (5")	T-1-3	10,000
metal (0.5' x 0.3')	T-1-4	30,000
metal (1.4' x	T-1-5	15,000
Trench 2		
metal (3' x 4')	T-2-1	20,000
wood (2" x 4" x 2.5')	T-2-2	25,000
concrete (irregular shapes) connected by rebar	T-2-3	2000-3000
red corrosion on concrete	T-2-4	150,000
wire projecting from concrete	T-2-5	80,000
Trench 4		
crushed metal drum	T-4-1	2,000
pipe (1.75" x 4')	T-4-2	20,000
corrugated metal	T-4-3	2,000
curved metal	T-4-4	30,000
pipe (1" x 6")	T-4-5	10,000
roof tile (4" x 5")	T-4-6	35,000
pipe (2" x 6")	T-4-7	25,000
concrete (3" x 4")	T-4-8	25,000

[a]DPM means Disintegration Per Minute, which is equivalent to 27 pCi.

TABLE 4-48A

SOUTH FIELD
SURFACE SOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	21	21	7110	16300	4
Antimony	mg/kg	.000	2	10	1.2	1.9	2
Arsenic	mg/kg	8.200	21	21	4.6	9.3	3
Barium	mg/kg	94.100	21	21	55.1	151	5
Beryllium	mg/kg	.600	20	21	.49	1.9	15
Cadmium	mg/kg	.870	0	21	0	0	0
Calcium	mg/kg	4339.170	21	21	12900	140000	21
Chromium	mg/kg	15.500	20	21	8.8	21.5	3
Cobalt	mg/kg	14.160	21	21	3.7	13.9	0
Copper	mg/kg	14.070	21	21	9.3	19.6	17
Cyanide	mg/kg	.270	10	21	.12	.32	1
Iron	mg/kg	21728.170	21	21	12800	20700	0
Lead	mg/kg	26.400	21	21	13.7	46	4
Magnesium	mg/kg	2776.970	21	21	6490	31600	21
Manganese	mg/kg	1348.040	21	21	368	2650	1
Mercury	mg/kg	.120	0	21	0	0	0
Molybdenum	mg/kg	.000	17	21	4	6.2	17
Nickel	mg/kg	20.870	20	21	11.9	22.7	1
Potassium	mg/kg	1231.340	21	21	903	2170	16
Selenium	mg/kg	.720	4	21	.52	.72	0
Silicon	mg/kg	1797.030	21	21	406	1080	0
Silver	mg/kg	.000	20	21	3.2	6.5	20
Sodium	mg/kg	51.100	21	21	69.5	328	21
Thallium	mg/kg	.580	0	21	0	0	0
Vanadium	mg/kg	30.370	21	21	17.8	30.8	1
Zinc	mg/kg	59.610	21	21	33.3	67.8	3

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TABLE 4-48A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES							
CS-137	pCi/g	.710	19	21	.089	.836	3
GROSS ALPHA	pCi/g	.000	21	21	18.7	237	21
GROSS BETA	pCi/g	.000	21	21	27.7	113	21
NP-237	pCi/g	.000	13	15	.056	.483	13
PU-238	pCi/g	.000	14	17	.019	.341	14
PU-239/240	pCi/g	.000	13	17	.019	.076	13
RA-226	pCi/g	1.420	21	21	.874	30.8	8
RA-228	pCi/g	1.250	21	21	.917	3.88	6
RU-106	pCi/g	.000	0	21	0	0	0
SR-90	pCi/g	.000	5	21	.16	1	5
TC-99	pCi/g	.000	1	21	142	142	1
TH-228	pCi/g	1.430	16	16	.658	4.41	2
TH-230	pCi/g	1.970	16	16	.117	13.8	8
TH-232	pCi/g	1.360	16	16	.19	3.99	2
TH-TOTAL	mg/kg	10.700	16	16	6.2	36.7	3
U-234	pCi/g	1.240	21	21	2.73	16.3	21
U-235/236	pCi/g	.150	21	21	.149	.887	20
U-238	pCi/g	1.220	21	21	2.87	16.6	21
U-TOTAL	mg/kg	3.700	21	21	1.86	50.6	20
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	21	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	21	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	21	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	21	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	21	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	21	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	21	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	21	0	0	0
2-Butanone	ug/kg	.000	0	21	0	0	0
2-Hexanone	ug/kg	.000	0	21	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	21	0	0	0

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TABLE 4-48A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Acetone	ug/kg	.000	5	21	7	68	5
Benzene	ug/kg	.000	0	21	0	0	0
Bromodichloromethane	ug/kg	.000	0	21	0	0	0
Bromoform	ug/kg	.000	0	21	0	0	0
Bromomethane	ug/kg	.000	0	21	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	21	0	0	0
Carbon disulfide	ug/kg	.000	0	21	0	0	0
Chlorobenzene	ug/kg	.000	0	21	0	0	0
Chloroethane	ug/kg	.000	0	21	0	0	0
Chloroform	ug/kg	.000	0	21	0	0	0
Chloromethane	ug/kg	.000	0	17	0	0	0
Dibromochloromethane	ug/kg	.000	0	21	0	0	0
Ethylbenzene	ug/kg	.000	0	21	0	0	0
Methylene chloride	ug/kg	.000	2	21	3	5	2
Styrene	ug/kg	.000	0	21	0	0	0
Tetrachloroethene	ug/kg	.000	0	21	0	0	0
Toluene	ug/kg	.000	0	21	0	0	0
Trichloroethene	ug/kg	.000	0	21	0	0	0
Vinyl Acetate	ug/kg	.000	0	21	0	0	0
Vinyl chloride	ug/kg	.000	0	21	0	0	0
Xylenes, Total	ug/kg	.000	0	21	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	21	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	21	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	21	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	21	0	0	0
1,2-Diphenylhydrazine	ug/kg	.000	0	17	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	21	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	21	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	21	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	21	0	0	0

TABLE 4-48A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
2,4-Dichlorophenol	ug/kg	.000	0	21	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	21	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	13	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	21	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	21	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	21	0	0	0
2-Chlorophenol	ug/kg	.000	0	21	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	21	0	0	0
2-Methylphenol	ug/kg	.000	0	21	0	0	0
2-Nitroaniline	ug/kg	.000	0	21	0	0	0
2-Nitrophenol	ug/kg	.000	0	21	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	21	0	0	0
3-Nitroaniline	ug/kg	.000	0	21	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	13	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	21	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	21	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	21	0	0	0
4-Methylphenol	ug/kg	.000	0	21	0	0	0
4-Nitroaniline	ug/kg	.000	0	21	0	0	0
4-Nitrophenol	ug/kg	.000	0	18	0	0	0
Acenaphthene	ug/kg	.000	1	20	140	140	1
Acenaphthylene	ug/kg	.000	5	21	55	1200	5
Anthracene	ug/kg	.000	6	21	59	730	6
Benzo(a)anthracene	ug/kg	.000	12	21	44	5500	12
Benzo(a)pyrene	ug/kg	.000	12	21	51	9400	12
Benzo(b)fluoranthene	ug/kg	.000	12	21	46	6200	12
Benzo(g,h,i)perylene	ug/kg	.000	12	21	51	6200	12
Benzo(k)fluoranthene	ug/kg	.000	13	21	49	7300	13
Benzoic acid	ug/kg	.000	10	17	52	270	10
Benzyl alcohol	ug/kg	.000	0	13	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	21	0	0	0

TABLE 4-48A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Carbazole	ug/kg	.000	3	21	48	170	3
Chrysene	ug/kg	.000	13	21	60	6000	13
Di-n-butyl phthalate	ug/kg	.000	0	21	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	21	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	7	21	43	1900	7
Dibenzofuran	ug/kg	.000	1	21	130	130	1
Diethyl phthalate	ug/kg	.000	0	21	0	0	0
Dimethyl phthalate	ug/kg	.000	1	21	62	62	1
Fluoranthene	ug/kg	.000	16	21	45	9200	16
Fluorene	ug/kg	.000	1	21	220	220	1
Hexachlorobenzene	ug/kg	.000	0	21	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	21	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	21	0	0	0
Hexachloroethane	ug/kg	.000	0	21	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	10	21	45	6000	10
Isophorone	ug/kg	.000	0	21	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	21	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	17	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	21	0	0	0
Naphthalene	ug/kg	.000	0	21	0	0	0
Nitrobenzene	ug/kg	.000	0	21	0	0	0
Pentachlorophenol	ug/kg	.000	0	21	0	0	0
Phenanthrene	ug/kg	.000	9	21	48	2300	9
Phenol	ug/kg	.000	0	21	0	0	0
Pyrene	ug/kg	.000	13	21	62	8200	13
Tributyl phosphate	ug/kg	.000	0	17	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	21	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	21	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	21	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	19	21	64	110	19
p-Chloroaniline	ug/kg	.000	0	21	0	0	0

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TABLE 4-48A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS							
4,4'-DDD	ug/kg	.000	0	21	0	0	0
4,4'-DDE	ug/kg	.000	0	21	0	0	0
4,4'-DDT	ug/kg	.000	0	21	0	0	0
Aldrin	ug/kg	.000	0	21	0	0	0
Aroclor-1016	ug/kg	.000	0	21	0	0	0
Aroclor-1221	ug/kg	.000	0	21	0	0	0
Aroclor-1232	ug/kg	.000	0	21	0	0	0
Aroclor-1242	ug/kg	.000	0	21	0	0	0
Aroclor-1248	ug/kg	.000	0	21	0	0	0
Aroclor-1254	ug/kg	.000	1	21	89	89	1
Aroclor-1260	ug/kg	.000	2	21	38	52	2
Dieldrin	ug/kg	.000	1	21	9.7	9.7	1
Endosulfan II	ug/kg	.000	0	21	0	0	0
Endosulfan sulfate	ug/kg	.000	0	21	0	0	0
Endosulfan-I	ug/kg	.000	0	21	0	0	0
Endrin	ug/kg	.000	0	21	0	0	0
Endrin aldehyde	ug/kg	.000	0	21	0	0	0
Endrin ketone	ug/kg	.000	1	20	5.9	5.9	1
Heptachlor	ug/kg	.000	0	21	0	0	0
Heptachlor epoxide	ug/kg	.000	0	21	0	0	0
Methoxychlor	ug/kg	.000	0	21	0	0	0
Toxaphene	ug/kg	.000	0	21	0	0	0
alpha-BHC	ug/kg	.000	0	21	0	0	0
alpha-Chlordane	ug/kg	.000	0	21	0	0	0
beta-BHC	ug/kg	.000	0	21	0	0	0
delta-BHC	ug/kg	.000	0	21	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	21	0	0	0
gamma-Chlordane	ug/kg	.000	0	21	0	0	0

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Field. The highest concentrations of organic compounds were detected in samples collected from the northern half of the South Field. Some samples have high concentrations of both radionuclides and organics (SF-SS-17 had 28.4 μg/g total uranium and 36,862 μg/kg total SVOCs) while other samples had high activities of radionuclides but relatively low concentrations of organic compounds (1965 had 49 μg/g total uranium and 205 μg/kg total organics). This pattern suggests that the constituents were not consistently disposed of together on the surface of the South Field.

Samples collected for lead analysis at the Firing Range are shown on Figure 4-18A and are presented on Table 4-48B. Analytical data indicate that shallow samples (approximately 0-3 feet deep) have concentrations of lead that range from 408 mg/kg to 2820 mg/kg. Highest concentrations were detected in samples from SP-2 and SP-5, which are aligned with the center of the Firing Range. Concentrations of lead rapidly decrease with distance into the face of the firing range, which corresponds roughly to the depth of samples shown on Table 4-48B. For example, one sample out of five was detected above background at 3 to 4 feet deep. A horizontal boring detected elevated concentrations in a composite sample from 0-5 feet beyond the surface of the firing range (see table below), but below background in deeper samples. The data suggest that lead from bullets was stopped in the soil within 5 feet of the slope that formed the backdrop of the Firing Range.

Depth (ft)	Background (mg/kg)	Total Lead (mg/kg)	TCLP Lead (mg/L)
0-5	15.58	1020	0.27
5-10	15.58	4.8	NA
10-15	15.58	6.1	NA
15-20	15.58	4.5	NA
20-25	15.58	6.9	NA
25-30	15.58	5.3	NA
30-35	15.58	4.6	NA
35-40	15.58	7.2	NA
40-45	15.58	4.6	NA
45-50	15.58	5.5	NA

NA = Not analyzed
Note: Samples sieved with No. 10 sieve to remove lead fragments greater than 2 mm.

Samples collected from subsurface soil borings drilled in the South Field were compared to subsurface soil background concentrations, and a table of the resulting constituent concentrations detected above

fig0418.dgn

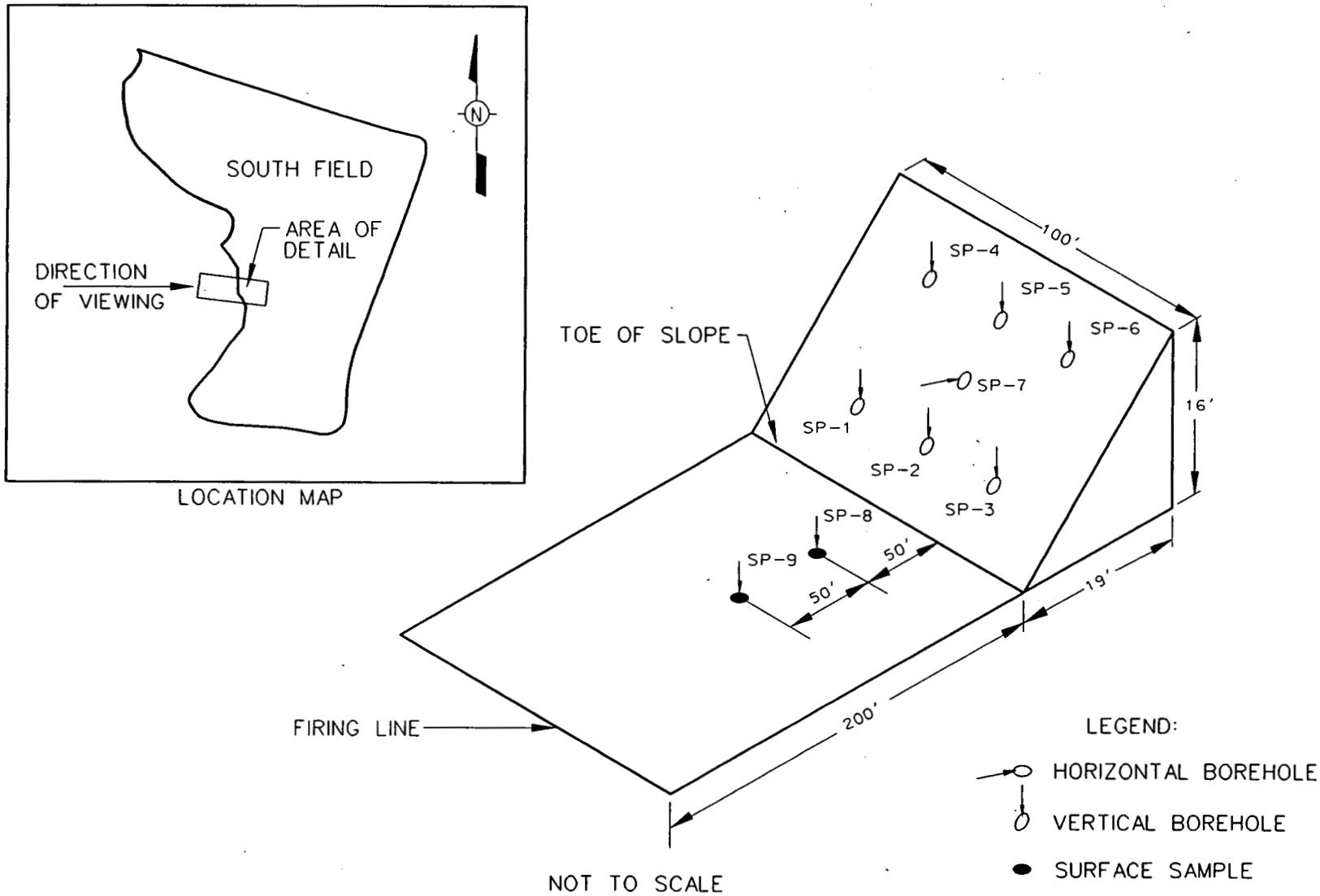

FIGURE 4-18a
SUBSURFACE SAMPLING LOCATIONS FOR
FIRING RANGE REMOVAL SITE EVALUATION

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TABLE 4-48B

LEAD CONCENTRATIONS IN VERTICAL BORINGS AT THE FEMP FIRING RANGE

Depth Interval (ft)	Background	Boring Numbers											
		SP-1		SP-2		SP-3		SP-4		SP-5		SP-6	
		Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)
0.0-0.5	26.4	665	6.9	1250	2.0	123	0.4	63.2	NA[a]	2820	101	64.4	NA
0.5-1.0	15.58	154	1.8	2200	4.8	5.6	NA	7.7	NA	2270	21.2	31.3	NA
1.0-2.0	15.58	6.1	NA	2460 1380	8.8 9.3	4.8	NA	11.2 7.0	NA	503	1.3	35.7	NA
2.0-3.0	15.58	6.6	NA	345	1.4	5.1 17.5	NA	12.8	NA	204	2.9	17.6	NA
3.0-4.0	15.58	4.9	NA	57.4	NA	4.0	NA	7.9	NA	2.1	NA	NA	NA
4.0-5.0	15.58	5.6	NA	29.6	NA	1.6	NA	7.5	NA	11.6	NA	NA	NA

[a]NA = not analyzed.

Source: Westinghouse Environmental Management Company of Ohio

Note: Samples sieved with No. 10 sieve to remove lead fragments greater than 2 mm

	SP-7 - Horizontal Boring									
Depth (ft)	0-5	5-10	10-15	15-20	20-25	25-30	30-50	35-40	40-45	45-50
Total Lead (mg/kg)	1020	4.8	6.1	4.5	6.9	5.3	4.6	7.2	4.6	5.5

Background = 15.8 mg/kg.
TCLP = 0.27 mg/l at 0-5 feet; not analyzed below 5 feet.

background is provided in Appendix F, Table F-2B. A summary of the analytes is provided in Table 4-49 and Table 4-50. Fifteen metals, isotopes of nine elements, and 25 organic compounds exceeded background concentrations in sub-surface samples collected during the Phase I program at the South Field. Metals detected in 40 percent of Phase I samples included antimony, beryllium, cadmium, chromium, copper, and silver. Most Phase I samples were collected to a maximum depth of 7.5 feet. These metals were also detected above background in surface soil samples and indicate that metals have been mixed into the upper filled area. Twenty-two metals (Aluminum, Arsenic, Iron, Magnesium, Potassium, Silicon, Thallium, Vanadium, and Zinc were not detected above background for Phase I; Cadmium, and Cobalt were detected above background for Phase I but not Phase II), isotopes of seven elements (ruthenium-106 and technetium-99 were detected above background for Phase I but not Phase II), and 30 organic compounds (carbon disulfide, toluene, acenaphthaulene, benzo(k)flouanthene, dibenzo(a,h,)anthracene, naphthalene, tributyl phosphate, Aroclor-126-, dieldrin, endrin ketone, alpha-chlordane, and gamma-chlordane were detected above background for the Phase II and not for Phase I; 4-methyl-2pentanone, chloroform, methylene chloride, total xylenes, di-n-octyl phthalate, diethyl phthalate, tetrachlorodibenzofuran were detected above background for Phase I but not Phase II) were detected above background concentrations in Phase II. Lead and copper were detected at up to 20 times background (436 mg/kg copper and 385 mg/kg lead) in a sample from Trench 4. Elsewhere, concentrations were near background concentrations. The distribution of metal concentrations suggest multiple disposal sites. The trench sample data suggest that lead and copper are waste derived metals within the subsurface soil.

Radionuclide data from sub-surface samples collected from the South Field during Phase I and Phase II are shown on Figure 4-19 (see Volume 2, Oversized Figures). In the north part of the South Field, concentrations of total uranium appear to decrease in samples collected from the native material beneath the fill/till interface. For example, samples from Boring No. 11187 detect concentrations of total uranium that decrease from 228 mg/kg at 5.5 feet deep to 12.3 mg/kg at 10.5 feet deep. Similar trends are observed in total uranium concentrations (in μg/g) in other borings sampled in the north part of the South Field: Boring No. 1942 (47.6 at 4 feet, 14.4 at 9 feet), Boring No. 1972 (47.6 at 4 feet, 14.4 at 9 feet) and Boring No. 1977 (35.9 at 10 feet, 3.5 at 18.5 feet). These data indicate that the native material has attenuated vertical movement of uranium.

TABLE 4-49

SOUTH FIELD
SUBSURFACE SOIL
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	18	18	4860	13500	0
Antimony	mg/kg	.000	9	12	7.8	29.7	9
Arsenic	mg/kg	9.570	17	18	2.9	8.1	0
Barium	mg/kg	119.170	18	18	52.5	198	4
Beryllium	mg/kg	.620	14	18	.77	1.6	14
Boron	mg/kg	42.950	5	7	17.1	36	0
Cadmium	mg/kg	.910	14	18	.69	4.9	13
Calcium	mg/kg	150000.000	18	18	3720	165000	1
Chromium	mg/kg	20.680	18	18	11	31.9	15
Cobalt	mg/kg	15.750	18	18	8.2	23.2	2
Copper	mg/kg	20.030	18	18	9.7	26.8	7
Cyanide	mg/kg	.130	1	18	2.6	2.6	1
Iron	mg/kg	30700.000	18	18	14900	29200	0
Lead	mg/kg	15.580	18	18	6.8	1140	9
Magnesium	mg/kg	42648.210	18	18	3810	35300	0
Manganese	mg/kg	1300.000	18	18	303	1060	0
Mercury	mg/kg	.290	3	18	.23	.31	1
Molybdenum	mg/kg	2.700	12	18	3.4	15.8	12
Nickel	mg/kg	34.350	18	18	17.3	39.5	3
Potassium	mg/kg	1979.990	18	18	548	1920	0
Selenium	mg/kg	.000	0	12	0	0	0
Silicon	mg/kg	1593.080	7	7	636	1530	0
Silver	mg/kg	.000	12	18	1.8	16.2	12
Sodium	mg/kg	285.000	16	18	37.5	522	1
Thallium	mg/kg	.490	2	18	.19	.2	0
Vanadium	mg/kg	37.800	18	18	15.9	34.1	0
Zinc	mg/kg	72.580	18	18	26.9	68.1	0
RADIONUCLIDES							
CS-137	pCi/g	.000	18	71	.2	.2	18
GROSS ALPHA	pCi/g	.000	0		0	0	0
GROSS BETA	pCi/g	.000	0		0	0	0
NP-237	pCi/g	.000	41	104	.6	.6	41
PU-238	pCi/g	.000	41	112	.6	.6	41
PU-239/240	pCi/g	.000	42	112	.6	1.23	42
RA-226	pCi/g	1.470	62	71	.39	15.7	10
RA-228	pCi/g	1.310	55	70	.5	19	11
RU-106	pCi/g	.000	17	71	1	1	17
SR-90	pCi/g	.560	46	91	.5	1.91	8

TABLE 4-49
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
TC-99	pCi/g	.000	43	78	.9	.9	43
TH-228	pCi/g	1.330	97	112	.6	20.3	16
TH-230	pCi/g	1.880	106	112	.6	57.3	26
TH-232	pCi/g	1.260	91	112	.6	17.5	11
TH-TOTAL	mg/kg	9.470	99	103	1.26	158	23
U-234	pCi/g	1.040	96	102	.6	119	62
U-235/236	pCi/g	.150	53	102	.6	20.6	53
U-238	pCi/g	1.120	95	102	.6	131	61
U-TOTAL	mg/kg	3.400	68	74	1	394	48
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	18	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	18	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	18	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	18	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	18	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	18	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	18	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	18	0	0	0
2-Butanone	ug/kg	.000	1	18	42	42	1
2-Hexanone	ug/kg	.000	0	18	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	2	18	1	3	2
Acetone	ug/kg	.000	6	18	5	56	6
Benzene	ug/kg	.000	0	18	0	0	0
Bromodichloromethane	ug/kg	.000	0	18	0	0	0
Bromoform	ug/kg	.000	0	18	0	0	0
Bromomethane	ug/kg	.000	0	17	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	18	0	0	0
Carbon disulfide	ug/kg	.000	0	18	0	0	0
Chlorobenzene	ug/kg	.000	0	18	0	0	0
Chloroethane	ug/kg	.000	0	18	0	0	0
Chloroform	ug/kg	.000	2	18	3	7	2
Chloromethane	ug/kg	.000	0	18	0	0	0
Dibromochloromethane	ug/kg	.000	0	18	0	0	0
Ethylbenzene	ug/kg	.000	0	18	0	0	0
Methylene chloride	ug/kg	.000	3	18	2	57	3
Styrene	ug/kg	.000	0	18	0	0	0
Tetrachloroethene	ug/kg	.000	0	18	0	0	0
Toluene	ug/kg	.000	0	18	0	0	0
Trichloroethene	ug/kg	.000	0	18	0	0	0
Vinyl Acetate	ug/kg	.000	0	18	0	0	0

000556

TABLE 4-49
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Vinyl chloride	ug/kg	.000	0	18	0	0	0
Xylenes, Total	ug/kg	.000	2	18	1	2	2
cis-1,3-Dichloropropene	ug/kg	.000	0	18	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	18	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	14	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	14	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	14	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	14	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	14	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	14	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	14	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	14	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	14	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	14	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	14	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	14	0	0	0
2-Chlorophenol	ug/kg	.000	0	14	0	0	0
2-Methylnaphthalene	ug/kg	.000	1	15	56	56	1
2-Methylphenol	ug/kg	.000	0	14	0	0	0
2-Nitroaniline	ug/kg	.000	0	14	0	0	0
2-Nitrophenol	ug/kg	.000	0	14	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	14	0	0	0
3-Nitroaniline	ug/kg	.000	0	13	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	14	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	14	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	14	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	14	0	0	0
4-Methylphenol	ug/kg	.000	0	14	0	0	0
4-Nitroaniline	ug/kg	.000	0	14	0	0	0
4-Nitrophenol	ug/kg	.000	0	14	0	0	0
Acenaphthene	ug/kg	.000	0	14	0	0	0
Acenaphthylene	ug/kg	.000	0	14	0	0	0
Anthracene	ug/kg	.000	1	14	58	58	1
Benzo(a)anthracene	ug/kg	.000	5	14	78	270	5
Benzo(a)pyrene	ug/kg	.000	3	14	46	230	3
Benzo(b)fluoranthene	ug/kg	.000	5	14	88	360	5
Benzo(g,h,i)perylene	ug/kg	.000	2	14	45	100	2
Benzo(k)fluoranthene	ug/kg	.000	0	14	0	0	0
Benzoic acid	ug/kg	.000	5	17	47	150	5
Benzyl alcohol	ug/kg	.000	0	14	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	14	0	0	0

000587

TABLE 4-49
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATLE ORGANICS (Continued)							
Carbazole	ug/kg	.000	0	2	0	0	0
Chrysene	ug/kg	.000	5	14	70	300	5
Di-n-butyl phthalate	ug/kg	.000	1	14	80	80	1
Di-n-octyl phthalate	ug/kg	.000	1	15	210	210	1
Dibenzo(a,h)anthracene	ug/kg	.000	0	14	0	0	0
Dibenzofuran	ug/kg	.000	0	13	0	0	0
Diethyl phthalate	ug/kg	.000	1	15	84	84	1
Dimethyl phthalate	ug/kg	.000	0	14	0	0	0
Fluoranthene	ug/kg	.000	7	15	39	610	7
Fluorene	ug/kg	.000	0	14	0	0	0
Hexachlorobenzene	ug/kg	.000	0	14	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	14	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	14	0	0	0
Hexachloroethane	ug/kg	.000	0	14	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	1	14	84	84	1
Isophorone	ug/kg	.000	0	14	0	0	0
Methyl parathion	ug/kg	.000	0	15	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	14	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	14	0	0	0
Naphthalene	ug/kg	.000	0	14	0	0	0
Nitrobenzene	ug/kg	.000	0	14	0	0	0
O,O,O-Triethylphosphorothioate	ug/kg	.000	0	10	0	0	0
Parathion	ug/kg	.000	0	15	0	0	0
Pentachlorophenol	ug/kg	.000	0	14	0	0	0
Phenanthrene	ug/kg	.000	5	14	93	370	5
Phenol	ug/kg	.000	0	14	0	0	0
Pyrene	ug/kg	.000	10	17	43	500	10
Sulfotep	ug/kg	.000	0	15	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	14	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	14	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	14	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	1	14	40	40	1
p-Chloroaniline	ug/kg	.000	0	14	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	19	0	0	0
4,4'-DDE	ug/kg	.000	0	19	0	0	0
4,4'-DDT	ug/kg	.000	0	19	0	0	0
Aldrin	ug/kg	.000	0	19	0	0	0
Aroclor-1016	ug/kg	.000	0	19	0	0	0
Aroclor-1221	ug/kg	.000	0	19	0	0	0
Aroclor-1232	ug/kg	.000	0	19	0	0	0
Aroclor-1242	ug/kg	.000	0	19	0	0	0
Aroclor-1248	ug/kg	.000	0	19	0	0	0
Aroclor-1254	ug/kg	.000	7	19	32	1100	7

TABLE 4-49
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Aroclor-1260	ug/kg	.000	0	19	0	0	0
Dieldrin	ug/kg	.000	0	19	0	0	0
Endosulfan II	ug/kg	.000	0	19	0	0	0
Endosulfan sulfate	ug/kg	.000	0	19	0	0	0
Endosulfan-I	ug/kg	.000	0	19	0	0	0
Endrin	ug/kg	.000	0	19	0	0	0
Endrin ketone	ug/kg	.000	0	19	0	0	0
Heptachlor	ug/kg	.000	0	19	0	0	0
Heptachlor epoxide	ug/kg	.000	0	19	0	0	0
Methoxychlor	ug/kg	.000	0	19	0	0	0
Toxaphene	ug/kg	.000	0	19	0	0	0
alpha-BHC	ug/kg	.000	0	19	0	0	0
alpha-Chlordane	ug/kg	.000	0	19	0	0	0
beta-BHC	ug/kg	.000	0	19	0	0	0
delta-BHC	ug/kg	.000	0	19	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	19	0	0	0
gamma-Chlordane	ug/kg	.000	0	19	0	0	0
DIOXIN/FURAN							
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
1,2,3,4,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
1,2,3,6,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
1,2,3,7,8,9-Hexachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
1,2,3,7,8-Pentachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
2,3,4,6,7,8-Hexachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
2,3,4,7,8-Pentachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
2,3,7,8-TCDD	ug/kg	.000	0	10	0	0	0
2,3,7,8-TCDF	ug/kg	.000	0	10	0	0	0
Heptachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
Heptachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
Hexachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
Hexachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
Octachlorodibenzo-p-dioxin	ug/kg	.000	10	10	.12	3.6	10
Octachlorodibenzofuran	ug/kg	.000	0	10	0	0	0
Pentachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
Pentachlorodibenzofuran	ug/kg	.000	0	10	0	0	0

000539

TABLE 4-49
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
DIOXIN/FURAN (Continued)							
Tetrachlorodibenzo-p-dioxin	ug/kg	.000	0	10	0	0	0
Tetrachlorodibenzofuran	ug/kg	.000	1	10	.018	.018	1
PESTICIDES/PCBs							
Demeton	ug/kg	.000	0	8	0	0	0
Diazinon	ug/kg	.000	0	7	0	0	0
Dimethoate	ug/kg	.000	0	15	0	0	0
Disulfoton	ug/kg	.000	0	15	0	0	0
Ethion	ug/kg	.000	0	9	0	0	0
Famphur	ug/kg	.000	0	15	0	0	0
Malathion	ug/kg	.000	0	7	0	0	0
Phorate	ug/kg	.000	0	15	0	0	0
Tetraethylpyrophosphate	ug/kg	.000	0	7	0	0	0
Thionazin	ug/kg	.000	0	16	0	0	0

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TABLE 4-50

SOUTH FIELD
SUBSURFACE SOIL
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	43	43	2680	22800	5
Antimony	mg/kg	.000	2	37	1.2	1.8	2
Arsenic	mg/kg	9.570	43	43	1.5	14.1	4
Barium	mg/kg	119.170	43	43	12.8	203	5
Beryllium	mg/kg	.620	31	43	.46	2.2	16
Cadmium	mg/kg	.910	0	43	0	0	0
Calcium	mg/kg	150000.000	43	43	1620	252000	3
Chromium	mg/kg	20.680	41	43	5	36.2	2
Cobalt	mg/kg	15.750	38	43	3	14.2	0
Copper	mg/kg	20.030	42	43	8.3	436	15
Cyanide	mg/kg	.130	8	42	.12	.78	7
Iron	mg/kg	30700.000	43	43	7300	44100	6
Lead	mg/kg	15.580	43	43	3.3	385	10
Magnesium	mg/kg	42648.210	43	43	2780	50800	1
Manganese	mg/kg	1300.000	43	43	186	1140	0
Mercury	mg/kg	.290	5	43	.12	.73	1
Molybdenum	mg/kg	2.700	31	43	4	17.5	31
Nickel	mg/kg	34.350	39	43	8.8	74.2	3
Potassium	mg/kg	1979.990	43	43	520	2590	5
Selenium	mg/kg	.000	0	43	0	0	0
Silicon	mg/kg	1593.080	43	43	5.5	3370	1
Silver	mg/kg	.000	37	43	2.8	14.1	37
Sodium	mg/kg	285.000	43	43	51.7	294	2
Thallium	mg/kg	.490	3	43	.43	.58	1
Vanadium	mg/kg	37.800	43	43	9.8	47.9	4
Zinc	mg/kg	72.580	43	43	23.5	508	7
RADIONUCLIDES							
CS-137	pCi/g	.000	9	43	.07	.547	9
GROSS ALPHA	pCi/g	.000	41	43	8.72	267	41
GROSS BETA	pCi/g	.000	43	43	13.9	530	43
NP-237	pCi/g	.000	30	37	.0321	6.53	30
PU-238	pCi/g	.000	27	43	.016	.735	27
PU-239/240	pCi/g	.000	15	43	.0147	.083	15
RA-226	pCi/g	1.470	43	45	.6	31.2	10
RA-228	pCi/g	1.310	45	45	.44	675	11
RU-106	pCi/g	.000	0	43	0	0	0

000571

TABLE 4-50
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
SR-90	pCi/g	.560	21	43	.443	2.39	18
TC-99	pCi/g	.000	0	43	0	0	0
TH-228	pCi/g	1.330	34	34	.33	595	5
TH-230	pCi/g	1.880	34	34	.83	51.6	15
TH-232	pCi/g	1.260	34	34	.33	600	6
TH-TOTAL	mg/kg	9.470	32	32	3	28.9	5
U-234	pCi/g	1.040	44	44	.57	378	33
U-235/236	pCi/g	.150	44	44	.0196	19.7	19
U-238	pCi/g	1.120	44	44	.385	397	31
U-TOTAL	mg/kg	3.400	43	45	1.8	1170	41
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	42	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	42	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	42	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	42	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	42	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	42	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	42	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	42	0	0	0
2-Butanone	ug/kg	.000	4	42	1	11	4
2-Hexanone	ug/kg	.000	0	42	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	42	0	0	0
Acetone	ug/kg	.000	13	42	3	56	13
Benzene	ug/kg	.000	0	42	0	0	0
Bromodichloromethane	ug/kg	.000	0	42	0	0	0
Bromoform	ug/kg	.000	0	42	0	0	0
Bromomethane	ug/kg	.000	0	42	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	42	0	0	0
Carbon disulfide	ug/kg	.000	2	42	2	4	2
Chlorobenzene	ug/kg	.000	0	42	0	0	0
Chloroethane	ug/kg	.000	0	42	0	0	0
Chloroform	ug/kg	.000	0	42	0	0	0
Chloromethane	ug/kg	.000	0	41	0	0	0
Dibromochloromethane	ug/kg	.000	0	42	0	0	0
Ethylbenzene	ug/kg	.000	0	42	0	0	0
Methylene chloride	ug/kg	.000	0	42	0	0	0
Styrene	ug/kg	.000	0	42	0	0	0
Tetrachloroethene	ug/kg	.000	0	42	0	0	0
Toluene	ug/kg	.000	18	42	1	52	18
Trichloroethene	ug/kg	.000	0	42	0	0	0
Vinyl Acetate	ug/kg	.000	0	41	0	0	0
Vinyl chloride	ug/kg	.000	0	42	0	0	0

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TABLE 4-50
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Xylenes, Total	ug/kg	.000	0	42	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	42	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	42	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	42	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	42	0	0	0
1,2-Diphenylhydrazine	ug/kg	.000	0	10	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	42	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	42	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	42	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	42	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	42	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	42	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	38	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	42	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	42	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	4	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	42	0	0	0
2-Chlorophenol	ug/kg	.000	0	42	0	0	0
2-Methylnaphthalene	ug/kg	.000	1	42	91	91	1
2-Methylphenol	ug/kg	.000	0	42	0	0	0
2-Nitroaniline	ug/kg	.000	0	42	0	0	0
2-Nitrophenol	ug/kg	.000	0	42	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	42	0	0	0
3-Nitroaniline	ug/kg	.000	0	42	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	22	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	42	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	42	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	42	0	0	0
4-Methylphenol	ug/kg	.000	0	42	0	0	0
4-Nitroaniline	ug/kg	.000	0	30	0	0	0
4-Nitrophenol	ug/kg	.000	0	41	0	0	0
Acenaphthene	ug/kg	.000	0	42	0	0	0
Acenaphthylene	ug/kg	.000	1	42	410	410	1
Anthracene	ug/kg	.000	2	42	62	250	2
Benzo(a)anthracene	ug/kg	.000	5	42	44	1100	5
Benzo(a)pyrene	ug/kg	.000	6	41	3	1800	6
Benzo(b)fluoranthene	ug/kg	.000	4	41	42	1600	4
Benzo(g,h,i)perylene	ug/kg	.000	4	41	52	1200	4
Benzo(k)fluoranthene	ug/kg	.000	5	41	48	1600	5
Benzoic acid	ug/kg	.000	4	38	44	57	4
Benzyl alcohol	ug/kg	.000	0	41	0	0	0

TABLE 4-50
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Butyl benzyl phthalate	ug/kg	.000	0	42	0	0	0
Carbazole	ug/kg	.000	1	42	51	51	1
Chrysene	ug/kg	.000	5	42	53	1400	5
Di-n-butyl phthalate	ug/kg	.000	1	42	49	49	1
Di-n-octyl phthalate	ug/kg	.000	0	41	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	1	41	440	440	1
Dibenzofuran	ug/kg	.000	0	42	0	0	0
Diethyl phthalate	ug/kg	.000	0	42	0	0	0
Dimethyl phthalate	ug/kg	.000	0	42	0	0	0
Fluoranthene	ug/kg	.000	7	42	83	1800	7
Fluorene	ug/kg	.000	0	42	0	0	0
Hexachlorobenzene	ug/kg	.000	0	42	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	42	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	42	0	0	0
Hexachloroethane	ug/kg	.000	0	42	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	3	41	42	210	3
Isophorone	ug/kg	.000	0	42	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	42	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	14	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	42	0	0	0
Naphthalene	ug/kg	.000	1	42	61	61	1
Nitrobenzene	ug/kg	.000	0	42	0	0	0
Pentachlorophenol	ug/kg	.000	0	42	0	0	0
Phenanthrene	ug/kg	.000	6	42	52	350	6
Phenol	ug/kg	.000	0	42	0	0	0
Pyrene	ug/kg	.000	7	42	44	1400	7
Tributyl phosphate	ug/kg	.000	1	14	170	170	1
bis(2-Chloroethoxy)methane	ug/kg	.000	0	42	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	42	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	42	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	15	41	44	340	15
p-Chloroaniline	ug/kg	.000	0	42	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	43	0	0	0
4,4'-DDE	ug/kg	.000	0	43	0	0	0
4,4'-DDT	ug/kg	.000	0	43	0	0	0
Aldrin	ug/kg	.000	0	43	0	0	0
Aroclor-1016	ug/kg	.000	0	43	0	0	0
Aroclor-1221	ug/kg	.000	0	43	0	0	0
Aroclor-1232	ug/kg	.000	0	43	0	0	0
Aroclor-1242	ug/kg	.000	0	43	0	0	0
Aroclor-1248	ug/kg	.000	0	43	0	0	0

TABLE 4-50
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Aroclor-1254	ug/kg	.000	12	43	41	430	12
Aroclor-1260	ug/kg	.000	1	43	89	89	1
Dieldrin	ug/kg	.000	1	43	16	16	1
Endosulfan II	ug/kg	.000	0	43	0	0	0
Endosulfan sulfate	ug/kg	.000	0	43	0	0	0
Endosulfan-I	ug/kg	.000	0	43	0	0	0
Endrin	ug/kg	.000	0	43	0	0	0
Endrin aldehyde	ug/kg	.000	0	43	0	0	0
Endrin ketone	ug/kg	.000	1	43	5.3	5.3	1
Heptachlor	ug/kg	.000	0	43	0	0	0
Heptachlor epoxide	ug/kg	.000	0	43	0	0	0
Methoxychlor	ug/kg	.000	0	43	0	0	0
Toxaphene	ug/kg	.000	0	43	0	0	0
alpha-BHC	ug/kg	.000	0	43	0	0	0
alpha-Chlordane	ug/kg	.000	1	43	8	8	1
beta-BHC	ug/kg	.000	0	43	0	0	0
delta-BHC	ug/kg	.000	0	43	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	43	0	0	0
gamma-Chlordane	ug/kg	.000	1	43	7.2	7.2	1

Phase I and Phase II subsurface soil data were compared to CIS and ES data (Tables F-7 and F-8). Analytes detected in these preliminary studies were also detected in Phase I and Phase II and within the same order of magnitude.

Attenuation of total uranium concentrations with depth in disturbed materials appears to be less than that observed in native till. This is indicated by concentrations detected in samples collected from multiple depths in borings in the south part of the South Field. Samples of total uranium (in μg/g) that show little attenuation with depth are seen in Boring No. 1968 (14.9 μg/g at 6.5 feet, 12.2 μg/g at 16.5 feet), Boring No. 1966 (13.9 μg/g at 6.5 feet, 12.6 μg/g at 25 feet) and Boring No. 1967 (15.3 μg/g at 7.5 feet, 9.17 μg/g at 31 feet). Samples from these borings are characteristic of the areas having the deepest fill, and suggest that 1) disturbed fill materials attenuate uranium less than the undisturbed native material or 2) the fill material had higher levels then background soil when they were deposited.

Six shallow trenches were excavated less than five feet deep during Phase I, and 18 samples were collected for full analytical testing from locations 1455 through 1472 (Figure 4-19, See Volume 2, Oversized Figures). Analytical data are presented in Appendix F, Table F-2B. Elevated (greater than five times background) concentrations of cadmium, lead, and silver were detected in samples that also had elevated concentrations of total uranium. Ten trenches were excavated 10 to 12 feet deep during Phase II to investigate anomalous electromagnetic readings and soil samples were collected from three of these trenches (Figure 4-19, see Volume 2, Oversized Figures). A summary of data obtained from the Phase II trenching activities was provided in Table 4-46 and show data from two samples collected from Trench 2 and Trench 4 for laboratory analyses. A sample from 6 feet deep in Trench 2 (sample 113724) detected 34 mg/kg total uranium and 3540 mg/kg total thorium. This is the most elevated concentration of total thorium detected in a South Field sample. Extensive field screening with other parts of Trench 2 did not detect radioactivity levels as high as those in sample 113724, indicating that the high hit of thorium is localized. The total mass of thorium in Trench 2 was on the order of grams. Concentrations in a sample collected from 0-3 feet deep in Trench 4 (sample 113722) included: total uranium 1170 μg/g; total thorium 55.8 μg/g; copper 436 mg/kg; lead 385 mg/kg; vanadium 30.4 μg/g; and zinc at 508 μg/g. These data indicate that the waste material originated in the production facility and that some of the construction debris in these trenches are probably contaminated as a result of process spillage and leakage prior to deposition in the South

Field. The contaminated materials within these trenches are potential sources of radionuclide contamination to percolating water.

Organic compounds detected in subsurface soil samples from the South Field are presented on Figure 4-20 (see Volume II, Oversized Figures). Highest concentrations of organic compounds were detected in samples collected from the north border of the South Field, and correspond to samples detecting the highest radionuclide concentrations. Semivolatile compounds detected in South Field samples are similar to chemicals detected in samples collected from the Solid Waste Landfill; however, concentrations detected in samples from the Solid Waste Landfill are 100 fold greater than those detected in South Field samples. This suggests that mixtures of waste chemical stocks were sent to the landfill but that much less chemically contaminated materials were sent to the South Field. The distribution of organic compounds indicates that they are pervasive in the surface (Figure 4-20) but that the number of compounds is greatly reduced within the upper four feet of the soil The following table presents some data from Figure 4-18 and Figure 4-20:

Boring No.	Depth (ft)	Number of Organic Compounds	Total Organic Concentrations* (μg/kg)
11188	0-0.5	15	2416
	5-6	2	45
	10-11	3	59
1977	0-0.5	16	7852
	8.5-10	2	10
	16.5-18.5	3	47
1972	0-0.5	14	69039
	0.5-1	16	12083
	2.5-4	2	17
	7.5-9	1	3
1795	1-1.5	12	2777
	3-4	2	8.6
1968	0-1	10	397
	4.5-6.5	3	71
	15.5-16.5	1	3

*Includes VOCs, SVOCs, and Pesticides/PCBs.

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These data indicate that in some areas, for example near to Boring No. 1972, the distribution is consistent with surface deposition of a liquid mixture of semivolatile/oily waste.

Uranium-238 data from subsurface data were kriged and the output processed to provide a model of constituent distribution in the South Field and Inactive Flyash Pile. The kriged parameters used are presented below:

Geological Layers	Fill	Till	Great Miami Aquifer
Kriging Method	Point	Block	Block
Variogram Range (ft)	275	750	250
Variogram Sill	226,000	12,400	1.3
Anisotropy detected?	No	No	No
Kriging Search			
X	250	750	250
Y	250	750	250
Z	20	20	20
Number of Samples	136	55	10

Note: Search radius of 50 feet x 50 feet x 10 feet was used in vicinity of sample 67046 (in South Field Great Miami Aquifer)

A drawing of a conceptual model for contamination located in three geological cross sections of the South Field is presented as Figure 4-21 (see Volume 2, Oversized Figures). Cross section B-B' cuts through the highest area of contamination detected in the Inactive Flyash and north South Field. The modeling indicates that break-through into the Great Miami Aquifer has been detected by soil samples collected beneath the Inactive Flyash Pile but not beneath the South Field. Modeled breakthrough of uranium-238 into the Great Miami Aquifer is primarily based upon data from Boring No. 1710 (Sample 67046 of 191 pCi/g at 28.5 feet deep). High activities of uranium-238 at this depth correspond to an area where there is no till material overlying the Great Miami Aquifer.

Cross section C-C' shows the relationship between deep soil contamination at the northwest edge of the South Field and the till surface beneath the fill. Contaminated material rests upon a depression which is interpreted to be a pre-construction streambed. The streambed has eroded the glacial overburden, which means contaminated material is in contact with the regional aquifer material.

4.5.3 Surface Water and Sediment

There are no perennial sources of surface water in the South Field subunit. Samples were collected after rain events occurred and when flow was available in a drainage. Chemical and radiological analytical results for surface water were not compared against background concentrations since there are no surface water background data. A table of detected constituent concentrations is provided in

Appendix F, Table F-2D while detected analytes above background are shown on Table 4-51. Sample locations are shown on Figure 4-22. No surface water or sediment samples were collected during Phase I in the South Field CIS or ES. Seven metals and uranium were detected in two surface water samples collected during Phase II from the South Field; no organic compounds were detected.

Surface water drainage originating at the northeast corner of the South Field and flowing south along the east boundary of the South Field was observed for extended periods after rain events finished, and two seeps were observed upstream of location SF-SW-01. Total uranium in the drainage is therefore believed to be representative of shallow interflow and potential perched groundwater discharge. Concentrations of total uranium and isotopic uranium in surface water samples collected from the South Field drainages after rain events are presented in Table 4-52. Concentrations of uranium in drainage water ranged from 110 μg/L at the upstream location (SF-SW-07) to 540 μg/L collected from standing water at the farthest downstream location (SF-SW-02) at the southeast corner of the South Field. These values are in approximate agreement with groundwater samples collected from the glacial till monitoring Well 1941 (388 μg/L to 547 μg/L) and Well 1942 (320 μg/L) completed at the east side of the South Field. This indicates that the observed drainage is representative of perched groundwater at the east side of the subunit, and that the South Field has an impact upon drainage water.

Sediment samples were collected from the drainages during Phase II, and analytical data were compared to background soil data. A summary table of analytes exceeding background concentrations is provided in Appendix F, Table F-2E. A summary of the number of detected analytes is presented on Table 4-53. Twenty-two metals, isotopes of six elements, and 15 organic compounds 4-162 exceeded the expected background concentrations for surface soil. A comparison with metals detected in the South Field shows that arsenic, beryllium, copper, lead, silver, and zinc are common to the sediment and soils of the South Field. This means that the source for the sediment may be the South Field; however, all of the metal concentrations are close to background concentrations for flyash.

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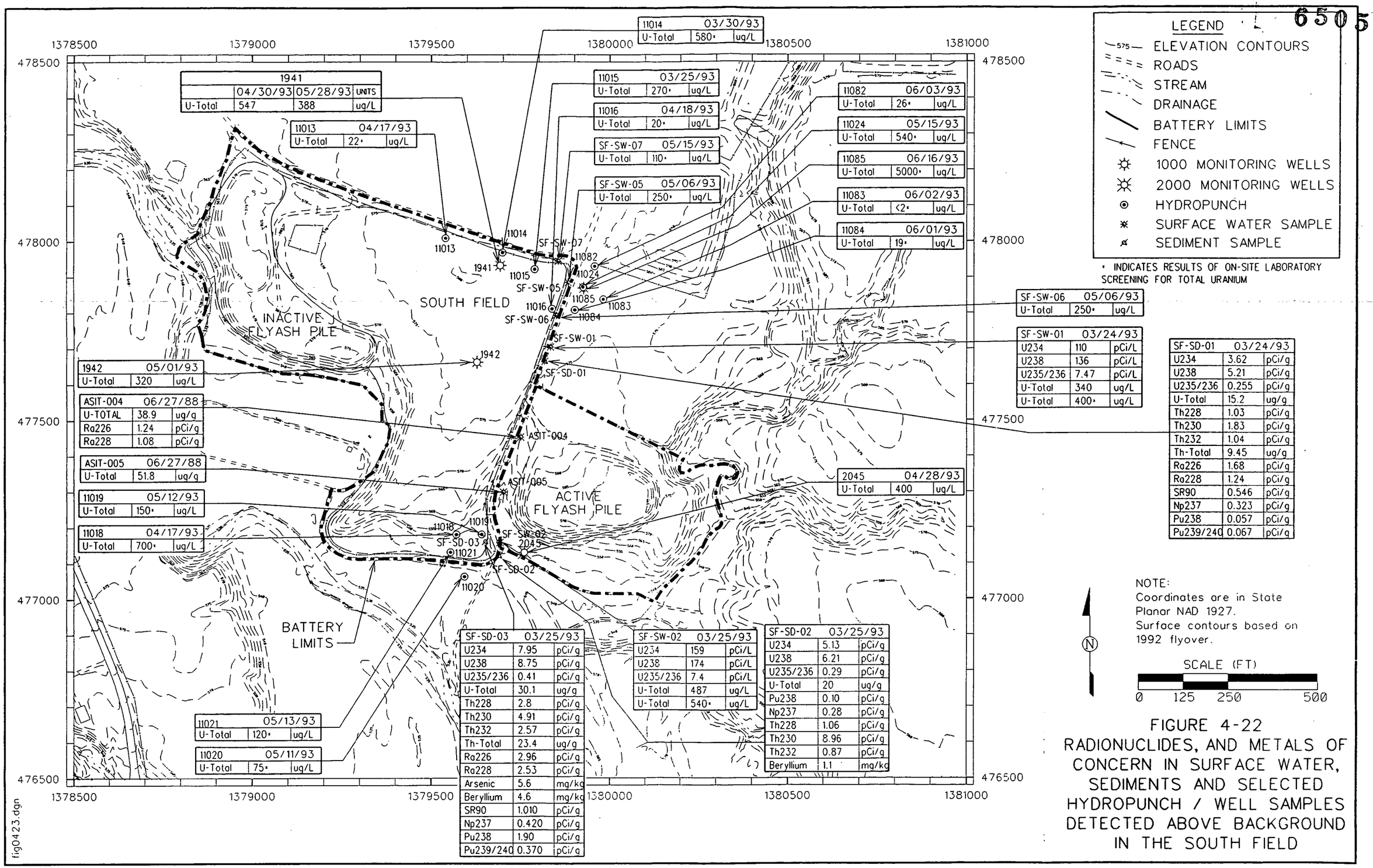

1941	04/30/93	05/28/93	UNITS
U-Total	547	388	ug/L

11013	04/17/93	
U-Total	22*	ug/L

11014	03/30/93	
U-Total	580*	ug/L

11015	03/25/93	
U-Total	270*	ug/L

11016	04/18/93	
U-Total	20*	ug/L

SF-SW-07	05/15/93	
U-Total	110*	ug/L

SF-SW-05	05/06/93	
U-Total	250*	ug/L

11082	06/03/93	
U-Total	26*	ug/L

11024	05/15/93	
U-Total	540*	ug/L

11085	06/16/93	
U-Total	5000*	ug/L

11083	06/02/93	
U-Total	<2*	ug/L

11084	06/01/93	
U-Total	19*	ug/L

SF-SW-06	05/06/93	
U-Total	250*	ug/L

SF-SW-01	03/24/93	
U234	110	pCi/L
U238	136	pCi/L
U235/236	7.47	pCi/L
U-Total	340	ug/L
U-Total	400*	ug/L

SF-SD-01	03/24/93	
U234	3.62	pCi/g
U238	5.21	pCi/g
U235/236	0.255	pCi/g
U-Total	15.2	ug/g
Th228	1.03	pCi/g
Th230	1.83	pCi/g
Th232	1.04	pCi/g
Th-Total	9.45	ug/g
Ra226	1.68	pCi/g
Ra228	1.24	pCi/g
SR90	0.546	pCi/g
Np237	0.323	pCi/g
Pu238	0.057	pCi/g
Pu239/240	0.067	pCi/g

1942	05/01/93	
U-Total	320	ug/L

ASIT-004	06/27/88	
U-TOTAL	38.9	ug/g
Ra226	1.24	pCi/g
Ra228	1.08	pCi/g

ASIT-005	06/27/88	
U-Total	51.8	ug/g

11019	05/12/93	
U-Total	150*	ug/L

11018	04/17/93	
U-Total	700*	ug/L

2045	04/28/93	
U-Total	400	ug/L

SF-SD-03	03/25/93	
U234	7.95	pCi/g
U238	8.75	pCi/g
U235/236	0.41	pCi/g
U-Total	30.1	ug/g
Th228	2.8	pCi/g
Th230	4.91	pCi/g
Th232	2.57	pCi/g
Th-Total	23.4	ug/g
Ra226	2.96	pCi/g
Ra228	2.53	pCi/g
Arsenic	5.6	mg/kg
Beryllium	4.6	mg/kg
SR90	1.010	pCi/g
Np237	0.420	pCi/g
Pu238	1.90	pCi/g
Pu239/240	0.370	pCi/g

SF-SW-02	03/25/93	
U234	159	pCi/L
U238	174	pCi/L
U235/236	7.4	pCi/L
U-Total	487	ug/L
U-Total	540*	ug/L

SF-SD-02	03/25/93	
U234	5.13	pCi/g
U238	6.21	pCi/g
U235/236	0.29	pCi/g
U-Total	20	ug/g
Pu238	0.10	pCi/g
Np237	0.28	pCi/g
Th228	1.06	pCi/g
Th230	8.96	pCi/g
Th232	0.87	pCi/g
Beryllium	1.1	mg/kg

11021	05/13/93	
U-Total	120*	ug/L

11020	05/11/93	
U-Total	75*	ug/L

FIGURE 4-22
RADIONUCLIDES, AND METALS OF CONCERN IN SURFACE WATER, SEDIMENTS AND SELECTED HYDROPUNCH / WELL SAMPLES DETECTED ABOVE BACKGROUND IN THE SOUTH FIELD

TABLE 4-51

SOUTH FIELD
SURFACE WATER[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	2	2	.178	.183	2
Antimony		mg/L	.000	0	2	0	0	0
Arsenic		mg/L	.000	0	2	0	0	0
Barium		mg/L	.000	2	2	.0497	.0544	2
Beryllium		mg/L	.000	0	2	0	0	0
Cadmium		mg/L	.000	0	2	0	0	0
Calcium		mg/L	.000	2	2	103	109	2
Chromium		mg/L	.000	0	2	0	0	0
Cobalt		mg/L	.000	0	2	0	0	0
Copper		mg/L	.000	0	2	0	0	0
Cyanide		mg/L	.000	0	2	0	0	0
Iron		mg/L	.000	0	2	0	0	0
Lead		mg/L	.000	0	2	0	0	0
Magnesium		mg/L	.000	2	2	30	38.2	2
Manganese		mg/L	.000	0	2	0	0	0
Mercury		mg/L	.000	0	2	0	0	0
Molybdenum		mg/L	.000	0	2	0	0	0
Nickel		mg/L	.000	0	2	0	0	0
Potassium		mg/L	.000	2	2	1.05	1.27	2
Selenium		mg/L	.000	0	2	0	0	0
Silicon		mg/L	.000	2	2	4.22	5.84	2
Silver		mg/L	.000	0	2	0	0	0
Sodium		mg/L	.000	2	2	4.26	5.05	2
Thallium		mg/L	.000	0	2	0	0	0
Vanadium		mg/L	.000	0	2	0	0	0
Zinc		mg/L	.000	0	2	0	0	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	2	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	2	2	205	224	2
GROSS BETA	UNFL	pCi/L	.000	2	2	97	119	2
NP-237	UNFL	pCi/L	.000	0	2	0	0	0
PU-238	UNFL	pCi/L	.000	0	2	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-51
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-226	UNFL	pCi/L	.000	0	2	0	0	0
RA-228	UNFL	pCi/L	.000	0	2	0	0	0
RU-106	UNFL	pCi/L	.000	0	2	0	0	0
SR-90	UNFL	pCi/L	.000	0	2	0	0	0
TC-99	UNFL	pCi/L	.000	0	2	0	0	0
TH-228	UNFL	pCi/L	.000	0	2	0	0	0
TH-230	UNFL	pCi/L	.000	0	2	0	0	0
TH-232	UNFL	pCi/L	.000	0	2	0	0	0
TH-TOTAL	UNFL	ug/L	.000	0	2	0	0	0
U-234	UNFL	pCi/L	.000	2	2	110	159	2
U-235/236	UNFL	pCi/L	.000	2	2	7.4	7.47	2
U-238	UNFL	pCi/L	.000	2	2	136	174	2
U-TOTAL	UNFL	ug/L	.000	2	2	340	487	2
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	2	0	0	0
2-Butanone	UNFL	ug/L	.000	0	2	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	2	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	2	0	0	0
Acetone	UNFL	ug/L	.000	0	2	0	0	0
Benzene	UNFL	ug/L	.000	0	2	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	2	0	0	0
Bromoform	UNFL	ug/L	.000	0	2	0	0	0
Bromomethane	UNFL	ug/L	.000	0	2	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	2	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	2	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
Chloroethane	UNFL	ug/L	.000	0	2	0	0	0
Chloroform	UNFL	ug/L	.000	0	2	0	0	0
Chloromethane	UNFL	ug/L	.000	0	2	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	2	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

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TABLE 4-51
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Methylene chloride	UNFL	ug/L	.000	0	2	0	0	0
Styrene	UNFL	ug/L	.000	0	2	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	2	0	0	0
Toluene	UNFL	ug/L	.000	0	2	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	2	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	2	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	2	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	2	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Diphenylhydrazine	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	2	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	2	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	2	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	2	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	2	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	2	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	2	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	2	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	2	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	2	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-51
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
4-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	2	0	0	0
Anthracene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	2	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	2	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Carbazole	UNFL	ug/L	.000	0	2	0	0	0
Chrysene	UNFL	ug/L	.000	0	2	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	2	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	2	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	2	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	2	0	0	0
Fluorene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	2	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	2	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	2	0	0	0
Isophorone	UNFL	ug/L	.000	0	2	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	2	0	0	0
Naphthalene	UNFL	ug/L	.000	0	2	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	2	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	2	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	2	0	0	0
Phenol	UNFL	ug/L	.000	0	2	0	0	0
Pyrene	UNFL	ug/L	.000	0	2	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

TABLE 4-51
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	2	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	2	0	0	0
PESTICIDES/PCBs								
4,4'-DDD	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	2	0	0	0
Aldrin	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	2	0	0	0
Dieldrin	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	2	0	0	0
Endrin	UNFL	ug/L	.000	0	2	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	2	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	2	0	0	0
Heptachlor	UNFL	ug/L	.000	0	2	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	2	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	2	0	0	0
Toxaphene	UNFL	ug/L	.000	0	2	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	2	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	2	0	0	0
beta-BHC	UNFL	ug/L	.000	0	2	0	0	0
delta-BHC	UNFL	ug/L	.000	0	2	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	2	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	2	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	1	1	355.3	355.3	0
Ammonia	UNFL	mg/L	.000	0	1	0	0	0
Chloride	UNFL	mg/L	.000	1	1	4.4	4.4	1
Fluoride	UNFL	mg/L	.000	1	1	.36	.36	1

See footnote at end of table

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TABLE 4-51
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Phenols	UNFL	mg/L	.000	0	1	0	0	0
Sulfate	UNFL	mg/L	.000	1	1	87.61	87.61	1
Sulfide	UNFL	mg/L	.000	0	1	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	1	1	.22	.22	1
Total Organic Carbon	UNFL	mg/L	.000	1	1	2.44	2.44	1
Total Organic Halides	UNFL	mg/L	.000	0	1	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.000	1	1	.22	.22	1
Total Phosphorous	UNFL	mg/L	.000	1	1	.05	.05	0

[a]Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available.

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TABLE 4-52

SUMMARY OF RADIOISOTOPE CONCENTRATION IN SURFACE DRAINAGE IN THE SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Sample	Data Collected	Activity or Concentration
SF-SW-07 farthest upstream	Sample 113666 collected 5/15/93 On-site analysis:	Total U = 110 μg/L
SF-SW-05 downstream of SW-07	Sample 113489 collected 5/6/93 On-site analysis:	Total U = 160 μg/L
SF-SW-06 downstream of SF-05	Sample 113490 collected 5/6/93 On-site analysis:	Total U = 250 μg/L
SF-SW-01 approximately midway along east side of South Field, downstream of SW-06	Sample 110422* and Sample 110424 collected 3/24/93 On-site analysis: Off-site analysis:	Total U = 400 μg/L U-234 = 110 pCi/L U-235/236 = 7.47 pCi/L U-238 = 136 pCi/L Total U = 340 μg/L
SF-SW-02 at southeast corner of South Field and most downstream of locations SW-07 to SW-01	Sample 110432* and Sample 110434 collected 3/25/93 On-site analysis: Off-site analysis:	Total U = 540 μg/L U-234 = 159 pCi/L U-235/236 = 7.4 pCi/L U-238 = 174 pCi/L Total U = 487 μg/L
11018 standing water at southeast corner of South Field after period of heavy rain. Sample is representative of accumulated surface drainage from South Field.	Sample 112633 collected 4/17/93 On-site analysis:	Total U = 560 μg/L

*Analyzed off site for full HSL, Rad.

TABLE 4-53

SOUTH FIELD
SEDIMENT[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	3	3	5750	12000	1
Antimony	mg/kg	.000	0	3	0	0	0
Arsenic	mg/kg	8.200	3	3	7.7	75.6	1
Barium	mg/kg	94.100	3	3	52.9	212	2
Beryllium	mg/kg	.600	2	3	1.1	4.6	2
Cadmium	mg/kg	.870	0	3	0	0	0
Calcium	mg/kg	4339.170	3	3	19300	83500	3
Chromium	mg/kg	15.500	3	3	6.8	19.2	2
Cobalt	mg/kg	14.160	3	3	3.7	19.4	1
Copper	mg/kg	14.070	3	3	8	122	2
Cyanide	mg/kg	.270	2	3	.18	.54	1
Iron	mg/kg	21728.170	3	3	10100	22300	1
Lead	mg/kg	26.400	3	3	27	91.5	3
Magnesium	mg/kg	2776.970	3	3	4510	20200	3
Manganese	mg/kg	1348.040	3	3	236	896	0
Mercury	mg/kg	.120	1	3	.19	.19	1
Molybdenum	mg/kg	.000	1	3	6.3	6.3	1
Nickel	mg/kg	20.870	3	3	7.1	36.4	2
Potassium	mg/kg	1231.340	3	3	597	1920	2
Selenium	mg/kg	.720	2	3	.86	5.9	2
Silicon	mg/kg	1797.030	3	3	640	1670	0
Silver	mg/kg	.000	2	3	2.9	6.5	2
Sodium	mg/kg	51.100	3	3	67.1	237	3
Thallium	mg/kg	.580	1	3	4.4	4.4	1
Vanadium	mg/kg	30.370	3	3	15.3	53.6	2
Zinc	mg/kg	59.610	3	3	24.9	118	2
RADIONUCLIDES							
CS-137	pCi/g	.710	2	3	.258	.4	0
GROSS ALPHA	pCi/g	.000	3	3	29.1	61.4	3
GROSS BETA	pCi/g	.000	3	3	32.6	58.2	3
NP-237	pCi/g	.000	3	3	.28	.42	3
PU-238	pCi/g	.000	3	3	.057	1.9	3
PU-239/240	pCi/g	.000	2	3	.067	.37	2
RA-226	pCi/g	1.420	3	3	1.57	2.96	3

See footnote at end of table

TABLE 4-53
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RA-228	pCi/g	1.250	3	3	.93	2.53	1
RU-106	pCi/g	.000	0	3	0	0	0
SR-90	pCi/g	.000	2	3	.546	1.01	2
TC-99	pCi/g	.000	0	3	0	0	0
TH-228	pCi/g	1.430	3	3	1.03	2.8	1
TH-230	pCi/g	1.970	3	3	1.83	8.96	2
TH-232	pCi/g	1.360	3	3	.87	2.57	1
TH-TOTAL	mg/kg	10.700	3	3	7.93	23.4	1
U-234	pCi/g	1.240	3	3	3.62	7.95	3
U-235/236	pCi/g	.150	3	3	.255	.41	3
U-238	pCi/g	1.220	3	3	5.21	8.75	3
U-TOTAL	mg/kg	3.700	3	3	15.2	30.1	3
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	3	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	3	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	3	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	3	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	3	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	3	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	3	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	3	0	0	0
2-Butanone	ug/kg	.000	0	3	0	0	0
2-Hexanone	ug/kg	.000	0	3	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	3	0	0	0
Acetone	ug/kg	.000	0	3	0	0	0
Benzene	ug/kg	.000	0	3	0	0	0
Bromodichloromethane	ug/kg	.000	0	3	0	0	0
Bromoform	ug/kg	.000	0	3	0	0	0
Bromomethane	ug/kg	.000	0	3	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	3	0	0	0
Carbon disulfide	ug/kg	.000	0	3	0	0	0
Chlorobenzene	ug/kg	.000	0	3	0	0	0
Chloroethane	ug/kg	.000	0	3	0	0	0
Chloroform	ug/kg	.000	0	3	0	0	0
Chloromethane	ug/kg	.000	0	3	0	0	0
Dibromochloromethane	ug/kg	.000	0	3	0	0	0
Ethylbenzene	ug/kg	.000	0	3	0	0	0
Methylene chloride	ug/kg	.000	0	3	0	0	0
Styrene	ug/kg	.000	0	3	0	0	0

See footnote at end of table

TABLE 4-53
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Tetrachloroethene	ug/kg	.000	0	3	0	0	0
Toluene	ug/kg	.000	1	3	8	8	1
Trichloroethene	ug/kg	.000	0	3	0	0	0
Vinyl Acetate	ug/kg	.000	0	3	0	0	0
Vinyl chloride	ug/kg	.000	0	3	0	0	0
Xylenes, Total	ug/kg	.000	0	3	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	3	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	3	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	3	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	3	0	0	0
1,2-Diphenylhydrazine	ug/kg	.000	0	3	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	3	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	3	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	3	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	3	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	3	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	3	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	1	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	3	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	3	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	3	0	0	0
2-Chlorophenol	ug/kg	.000	0	3	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	3	0	0	0
2-Methylphenol	ug/kg	.000	0	3	0	0	0
2-Nitroaniline	ug/kg	.000	0	3	0	0	0
2-Nitrophenol	ug/kg	.000	0	3	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	3	0	0	0
3-Nitroaniline	ug/kg	.000	0	3	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	3	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	3	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	3	0	0	0
4-Methylphenol	ug/kg	.000	0	3	0	0	0
4-Nitroaniline	ug/kg	.000	0	3	0	0	0
4-Nitrophenol	ug/kg	.000	0	3	0	0	0
Acenaphthene	ug/kg	.000	0	3	0	0	0
Acenaphthylene	ug/kg	.000	0	3	0	0	0
Anthracene	ug/kg	.000	0	3	0	0	0
Benzo(a)anthracene	ug/kg	.000	1	3	66	66	1

See footnote at end of table

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TABLE 4-53
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Benzo(a)pyrene	ug/kg	.000	1	2	110	110	1
Benzo(b)fluoranthene	ug/kg	.000	1	2	110	110	1
Benzo(g,h,i)perylene	ug/kg	.000	1	2	120	120	1
Benzo(k)fluoranthene	ug/kg	.000	2	2	74	120	2
Benzoic acid	ug/kg	.000	2	3	99	160	2
Benzyl alcohol	ug/kg	.000	0	3	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	3	0	0	0
Carbazole	ug/kg	.000	0	3	0	0	0
Chrysene	ug/kg	.000	3	3	67	110	3
Di-n-butyl phthalate	ug/kg	.000	0	3	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	2	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	2	0	0	0
Dibenzofuran	ug/kg	.000	0	3	0	0	0
Diethyl phthalate	ug/kg	.000	0	3	0	0	0
Dimethyl phthalate	ug/kg	.000	0	3	0	0	0
Fluoranthene	ug/kg	.000	3	3	74	130	3
Fluorene	ug/kg	.000	0	3	0	0	0
Hexachlorobenzene	ug/kg	.000	0	3	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	3	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	3	0	0	0
Hexachloroethane	ug/kg	.000	0	3	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	1	2	99	99	1
Isophorone	ug/kg	.000	0	3	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	3	0	0	0
Naphthalene	ug/kg	.000	0	3	0	0	0
Nitrobenzene	ug/kg	.000	0	3	0	0	0
Pentachlorophenol	ug/kg	.000	0	3	0	0	0
Phenanthrene	ug/kg	.000	1	3	63	63	1
Phenol	ug/kg	.000	1	3	56	56	1
Pyrene	ug/kg	.000	3	3	71	110	3
Tributyl phosphate	ug/kg	.000	0	3	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	3	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	3	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	3	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	3	3	74	130	3
p-Chloroaniline	ug/kg	.000	0	3	0	0	0

See footnote at end of table

TABLE 4-53
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	3	0	0	0
4,4'-DDE	ug/kg	.000	0	3	0	0	0
4,4'-DDT	ug/kg	.000	0	3	0	0	0
Aldrin	ug/kg	.000	0	3	0	0	0
Aroclor-1016	ug/kg	.000	0	3	0	0	0
Aroclor-1221	ug/kg	.000	0	3	0	0	0
Aroclor-1232	ug/kg	.000	0	3	0	0	0
Aroclor-1242	ug/kg	.000	0	3	0	0	0
Aroclor-1248	ug/kg	.000	0	3	0	0	0
Aroclor-1254	ug/kg	.000	1	3	96	96	1
Aroclor-1260	ug/kg	.000	0	3	0	0	0
Dieldrin	ug/kg	.000	0	3	0	0	0
Endosulfan II	ug/kg	.000	0	3	0	0	0
Endosulfan sulfate	ug/kg	.000	0	3	0	0	0
Endosulfan-I	ug/kg	.000	0	3	0	0	0
Endrin	ug/kg	.000	0	3	0	0	0
Endrin aldehyde	ug/kg	.000	0	3	0	0	0
Endrin ketone	ug/kg	.000	0	3	0	0	0
Heptachlor	ug/kg	.000	0	3	0	0	0
Heptachlor epoxide	ug/kg	.000	0	3	0	0	0
Methoxychlor	ug/kg	.000	0	3	0	0	0
Toxaphene	ug/kg	.000	0	3	0	0	0
alpha-BHC	ug/kg	.000	0	3	0	0	0
alpha-Chlordane	ug/kg	.000	0	3	0	0	0
beta-BHC	ug/kg	.000	0	3	0	0	0
delta-BHC	ug/kg	.000	0	3	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	3	0	0	0
gamma-Chlordane	ug/kg	.000	0	3	0	0	0

[a]Sediment results are compared to surface soil background values.

A comparison of sediment and surface water concentrations for selected constituents detected above background is shown in Table 4-54. Soluble constituents like chloride and fluoride were detected in water samples but not in the sediment. This suggests that the drainage water (water seeping in the South Field) is rainwater that has percolated downward through the contaminated material and leached the contaminants; i.e., chloride, fluoride, and uranium. Also, these data support the belief that drainage water samples containing elevated uranium are representative of perched groundwater.

Organic compounds are detected in sediment but not in drainage water, and it may be due to the erosion of surface soil into the drainage. This is because concentrations of organic compounds and metals found in sediment are similar to concentrations found in samples of surface soil at the South Field. Historical aerial photographs of early road construction show material similar in color to surface soil being used to construct roads and drainages.

4.5.4 Groundwater

Groundwater analytical data from the 1000-series wells in the South Field were compared to perched groundwater background concentrations developed for the site. A summary of the analytes detected above background is provided in Appendix F, Table F-2F and Table F-2G. A summary of the number of detected analytes is presented in Table 4-55 and Table 4-56. One upgradient well in the perched aquifer (1046) was sampled during Phase I. Other perched zone wells were sampled during Phase I but these were not within the perched system in the South Field. Three of the wells [21191 (1516), 21192 (1517), and 21193 (1518)] monitor the regional aquifer. Phase I sampling detected seven metals and isotopes for two elements that exceeded the background concentrations; no organic compounds were detected that exceeded background concentrations. Five additional monitoring wells were installed during Phase II and twelve Hydropunch™ samples were collected in order to define groundwater conditions in the perched aquifer in the South Field. During Phase II, 22 metals (Aluminum, Antimony, Barium, Beryllium, Chromium, Cobalt, Cyanide, Iron, Lead, Molybdenum, Nickel, Silver, Vanadium, and Zinc were not detected above background during Phase I), isotopes of six elements (neptunium-237, plutonium-238, plutonium-239/240, Strontium-90, thorium-230, thorium-232, and thorium-total were not detected above background during Phase I), and four organic compounds exceeded background concentrations. Hydropunch™ results are provided in Figure 4-23. There were 22 metals detected in the 1000-series wells that exceeded background (Table 4-56). Of these, beryllium and chromium were the surface soil COCs detected above background. Generally, the maximum detected concentrations were close to background except for antimony and silicon which

had background concentrations of 0.00 mg/L. Comparing these concentrations to the metal concentrations for the subsurface soil indicates a minimal impact, if any, of metals from the soil on perched groundwater.

Radioisotopes detected in groundwater samples collected from the 1000-series wells during Phase I and Phase II are presented on Figure 4-23A. Groundwater in the perched zone is believed to be a continuous unit. Therefore, concentrations of uranium detected in wells located in the perched zone display a concentration gradient in a downstream direction from higher to lower concentrations. Concentration contours of total uranium concentrations detected in samples collected during Phase II are presented on Figure 4-24. Upgradient Well 1047 and Well 1046 detected low concentrations of total uranium, while downgradient Wells 1954, 1942, and 1048 detected elevated concentrations. The distribution of uranium in perched groundwater is controlled by elevated concentrations of uranium in shallow soil samples, by a sand layer identified in South Field soil borings, and by groundwater flow patterns discussed in Section 3.0. Two regions of perched groundwater containing greater than 100 μg/L total uranium are shown on Figure 4-24. One area is at the west side of the subunit near Well 1433 and may originate as leachate from buried waste (Figure 4-21). Waste materials were also encountered while drilling Well 1433 during Phase I at the approximate center of the elevated groundwater concentrations. The second area of elevated total uranium concentration is in groundwater at the northeast corner of the subunit. The source for perched groundwater uranium contamination in this area is believed to be waste materials buried or placed on the surface and corresponds to an area of waste piles identified by historical aerial photographs.

Organic compounds detected above background included the following: acetone (6 μg/L), diethyl phthalate (1 μg/L), and tributyl phosphate (1 μg/L) in Well 11032 located north and upgradient of the South Field. Acetone was detected at 6 μg/L in Well 1046 located along the north edge, also upgradient of the South Field. These data do not indicate an impact of organic compounds from the South Field soil on groundwater in the perched aquifer since they are either common laboratory contaminants and/or detected at trace levels.

Groundwater analytical data from the 2000-series wells in the South Field were compared to background data from the regional aquifer, and the data are provided in Appendix F in Table F-2F and Table F-2G. The number of detected analytes above background is presented in Table 4-57 and Table 4-58. Nine locations surrounding the South Field had 2000-series wells installed during Phase

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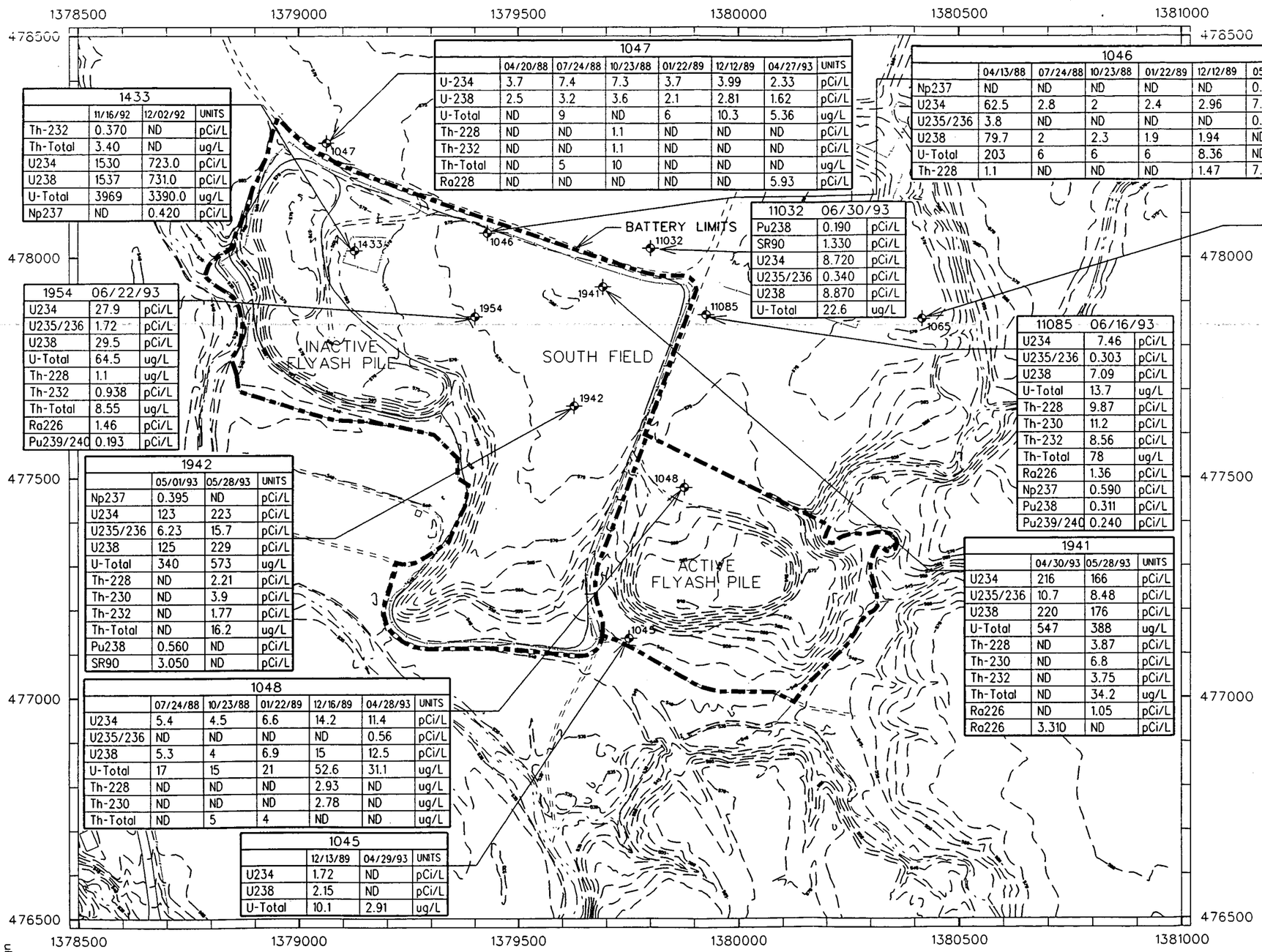

1047	04/20/88	07/24/88	10/23/88	01/22/89	12/12/89	04/27/93	UNITS
U-234	3.7	7.4	7.3	3.7	3.99	2.33	pCi/L
U-238	2.5	3.2	3.6	2.1	2.81	1.62	pCi/L
U-Total	ND	9	ND	6	10.3	5.36	ug/L
Th-228	ND	ND	1.1	ND	ND	ND	pCi/L
Th-232	ND	ND	1.1	ND	ND	ND	pCi/L
Th-Total	ND	5	10	ND	ND	ND	ug/L
Ra228	ND	ND	ND	ND	ND	5.93	pCi/L

1046	04/13/88	07/24/88	10/23/88	01/22/89	12/12/89	05/11/93	UNITS
Np237	ND	ND	ND	ND	ND	0.48	pCi/L
U234	62.5	2.8	2	2.4	2.96	7.83	pCi/L
U235/236	3.8	ND	ND	ND	ND	0.479	pCi/L
U238	79.7	2	2.3	1.9	1.94	ND	pCi/L
U-Total	203	6	6	6	8.36	ND	ug/L
Th-228	1.1	ND	ND	ND	1.47	7.91	pCi/L

1433	11/16/92	12/02/92	UNITS
Th-232	0.370	ND	pCi/L
Th-Total	3.40	ND	ug/L
U234	1530	723.0	pCi/L
U238	1537	731.0	pCi/L
U-Total	3969	3390.0	ug/L
Np237	ND	0.420	pCi/L

11032	06/30/93	
Pu238	0.190	pCi/L
SR90	1.330	pCi/L
U234	8.720	pCi/L
U235/236	0.340	pCi/L
U238	8.870	pCi/L
U-Total	22.6	ug/L

1065	01/22/89	12/13/89	04/05/93	05/04/93	UNITS
Np237	ND	ND	ND	0.22	pCi/L
U234	ND	ND	20.3	ND	pCi/L
U-Total	2	5.33	ND	1.36	ug/L
Th-Total	11	ND	ND	ND	ug/L

1954	06/22/93	
U234	27.9	pCi/L
U235/236	1.72	pCi/L
U238	29.5	pCi/L
U-Total	64.5	ug/L
Th-228	1.1	ug/L
Th-232	0.938	pCi/L
Th-Total	8.55	ug/L
Ra226	1.46	pCi/L
Pu239/240	0.193	pCi/L

11085	06/16/93	
U234	7.46	pCi/L
U235/236	0.303	pCi/L
U238	7.09	pCi/L
U-Total	13.7	ug/L
Th-228	9.87	pCi/L
Th-230	11.2	pCi/L
Th-232	8.56	pCi/L
Th-Total	78	ug/L
Ra226	1.36	pCi/L
Np237	0.590	pCi/L
Pu238	0.311	pCi/L
Pu239/240	0.240	pCi/L

1942	05/01/93	05/28/93	UNITS
Np237	0.395	ND	pCi/L
U234	123	223	pCi/L
U235/236	6.23	15.7	pCi/L
U238	125	229	pCi/L
U-Total	340	573	ug/L
Th-228	ND	2.21	pCi/L
Th-230	ND	3.9	pCi/L
Th-232	ND	1.77	pCi/L
Th-Total	ND	16.2	ug/L
Pu238	0.560	ND	pCi/L
SR90	3.050	ND	pCi/L

1941	04/30/93	05/28/93	UNITS
U234	216	166	pCi/L
U235/236	10.7	8.48	pCi/L
U238	220	176	pCi/L
U-Total	547	388	ug/L
Th-228	ND	3.87	pCi/L
Th-230	ND	6.8	pCi/L
Th-232	ND	3.75	pCi/L
Th-Total	ND	34.2	ug/L
Ra226	ND	1.05	pCi/L
Ra226	3.310	ND	pCi/L

1048	07/24/88	10/23/88	01/22/89	12/16/89	04/28/93	UNITS
U234	5.4	4.5	6.6	14.2	11.4	pCi/L
U235/236	ND	ND	ND	ND	0.56	pCi/L
U238	5.3	4	6.9	15	12.5	pCi/L
U-Total	17	15	21	52.6	31.1	ug/L
Th-228	ND	ND	ND	2.93	ND	ug/L
Th-230	ND	ND	ND	2.78	ND	ug/L
Th-Total	ND	5	4	ND	ND	ug/L

1045	12/13/89	04/29/93	UNITS
U234	1.72	ND	pCi/L
U238	2.15	ND	pCi/L
U-Total	10.1	2.91	ug/L

LEGEND

- ELEVATION CONTOURS (575)
- ROADS
- STREAM
- DRAINAGE
- BATTERY LIMITS
- FENCE
- RAILROAD
- 1000 MONITORING WELLS

ND = NOT DETECTED ABOVE BACKGROUND CONCENTRATIONS

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 125 250 500

FIGURE 4-23a
RADIONUCLIDES IN 1000-SERIES WELLS DETECTED ABOVE BACKGROUND IN THE SOUTH FIELD AND FLYASH PILES

fig0425.dgn

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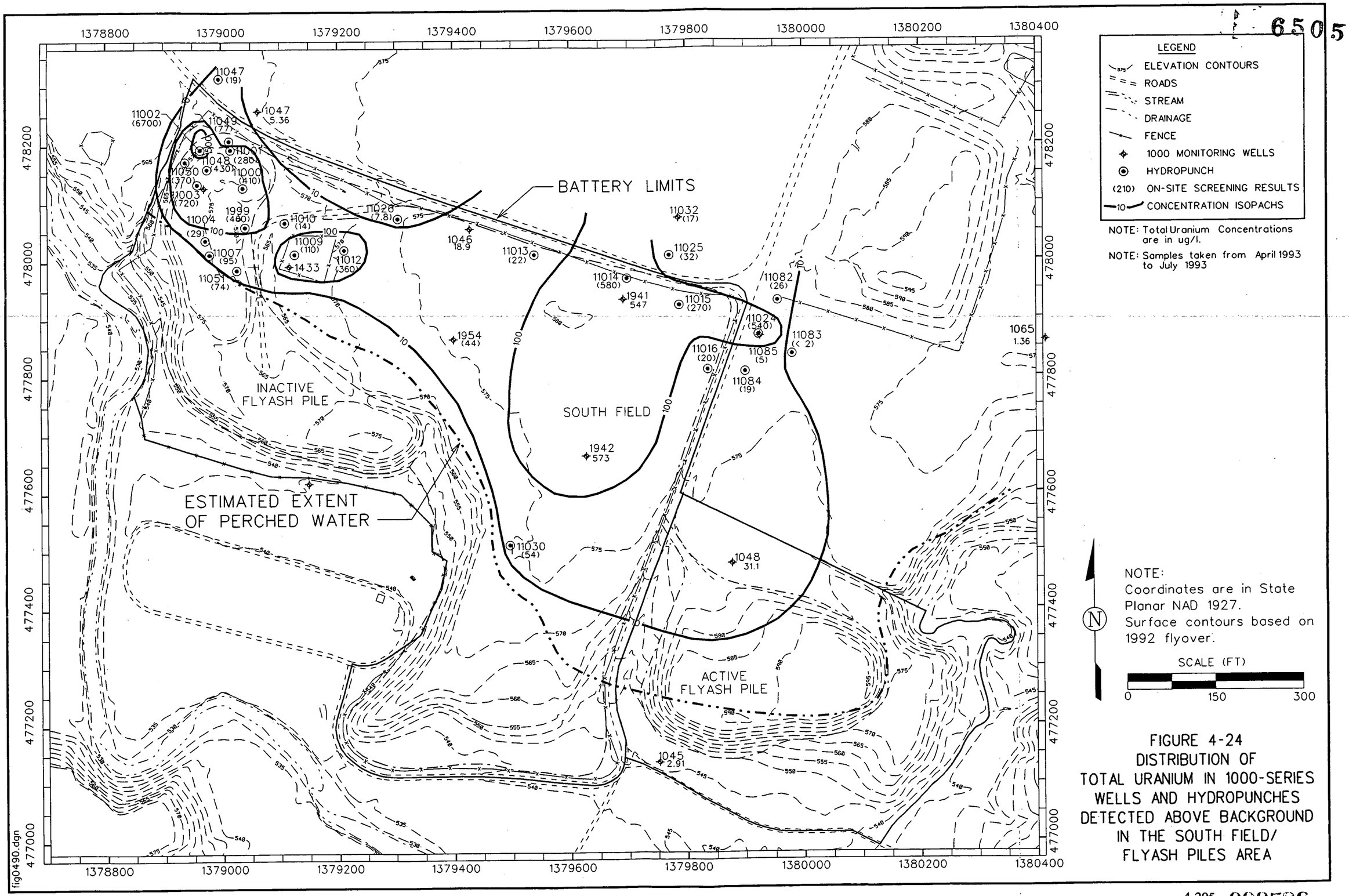

FIGURE 4-24
DISTRIBUTION OF
TOTAL URANIUM IN 1000-SERIES
WELLS AND HYDROPUNCHES
DETECTED ABOVE BACKGROUND
IN THE SOUTH FIELD/
FLYASH PILES AREA

TABLE 4-54

SOUTH FIELD
COMPARISON OF CONCENTRATION OF SELECTED CONSTITUENTS IN SEDIMENT AND SURFACE WATER
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Sample	Sample No.	Constituent	Concentration in Surface Water	Concentration in Sediment	Comment
SF-SW-01 SF-SD-01	110422 110425	Chloride Fluoride Total U	3.7 mg/L 0.4 μg/L 340 μg/L	ND ND 15.2 μg/g	Comparison indicates a source in water other than sediment or rainwater. This suggests that the drainage water originates as perched groundwater.
SF-SW-02 SF-SD-02	110432 110430	Chloride Fluoride Total U	4.4 mg/L 0.36 μg/L 340 μg/L	ND ND 20 μg/g	
SF-SW-01 SF-SD-01	110422 110425	Fluoranthene Phenanthrene Pyrene Total Th Zinc	ND ND ND ND ND	130 μg/kg 63 μg/kg 110 μg/kg 9.45 μg/kg 24.9	Comparison indicates a source in sediment other than surface water. This suggests the sediment was contaminated prior to being deposited in the drainage channel.
SF-SW-02 SF-SD-02	110432 1104360	Benzo(a)anthracene Chrysene Fluorenthene Phenol Pyrene Total Th	ND ND ND ND ND ND	66 μg/kg 110 μg/kg 120 μg/kg 56 μg/kg 110 μg/kg 7.93 μg/kg	

Note: ND = Not Detected

SF-SW-01 and SF-SD-01 were collected on March 24, 1993.
SF-SW-02 and SF-SD-02 were collected on March 25, 1993.

TABLE 4-55

SOUTH FIELD
GROUNDWATER[a] - 1000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	0	2	0	0	0
Antimony		mg/L	.000	0	2	0	0	0
Arsenic		mg/L	.050	0	8	0	0	0
Barium		mg/L	.450	6	7	.034	.102	0
Beryllium		mg/L	.002	0	2	0	0	0
Cadmium		mg/L	.005	2	8	.006	.008	2
Calcium		mg/L	123.837	8	8	89	129	2
Chromium		mg/L	.035	2	8	.023	.027	0
Cobalt		mg/L	.000	0	2	0	0	0
Copper		mg/L	.030	4	8	.013	.0306	1
Cyanide		mg/L	.000	0	2	0	0	0
Iron		mg/L	3.440	2	8	.051	.064	0
Lead		mg/L	.015	1	8	.003	.003	0
Magnesium		mg/L	48.546	8	8	29.5	48.6	1
Manganese		mg/L	.050	7	8	.007	.167	5
Mercury		mg/L	.000	0	8	0	0	0
Molybdenum		mg/L	.025	0	8	0	0	0
Nickel		mg/L	.026	1	8	.024	.024	0
Potassium		mg/L	26.976	8	8	.891	10	0
Selenium		mg/L	.000	1	8	.002	.002	1
Silicon		mg/L	.000	2	2	10.2	10.5	2
Silver		mg/L	.040	1	8	.04	.04	0
Sodium		mg/L	47.982	8	8	5.71	11	0
Thallium		mg/L	.000	0	2	0	0	0
Vanadium		mg/L	.020	0	2	0	0	0
Zinc		mg/L	.032	2	2	.0084	.01	0
RADIONUCLIDES								
GROSS ALPHA	UNFL	pCi/L	.000	1	1	372	372	1
GROSS BETA	UNFL	pCi/L	.000	1	1	129	129	1
NP-237	UNFL	pCi/L	.000	0	6	0	0	0
PU-238	UNFL	pCi/L	.000	0	6	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	6	0	0	0
RA-226	UNFL	pCi/L	1.000	0	4	0	0	0

See footnote at end of table

FE[illegible]U2RI\TDO\TAB4-55\January 16, 1995 6:59pm

TABLE 4-55
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	5.200	0	4	0	0	0
SR-90	UNFL	pCi/L	.000	0	6	0	0	0
TC-99	UNFL	pCi/L	.000	0	6	0	0	0
TH-228	UNFL	pCi/L	1.040	1	6	1.1	1.1	1
TH-230	UNFL	pCi/L	2.000	1	6	1	1	0
TH-232	UNFL	pCi/L	.000	0	6	0	0	0
TH-TOTAL	UNFL	ug/L	3.000	0	4	0	0	0
U-234	UNFL	pCi/L	1.900	4	6	2	62.5	4
U-235/236	UNFL	pCi/L	.000	1	6	3.8	3.8	1
U-238	UNFL	pCi/L	1.070	4	6	1.9	79.7	4
U-TOTAL	UNFL	ug/L	4.000	6	6	1	203	4
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Benzene	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroethane	UNFL	ug/L	.000	0	1	0	0	0
Chloroform	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	1	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	1	0	0	0
Styrene	UNFL	ug/L	.000	0	1	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	1	0	0	0
Toluene	UNFL	ug/L	.000	0	1	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-55
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Vinyl Acetate	UNFL	ug/L	.000	0	1	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	4.340	1	8	.126	.126	0
Chloride	UNFL	mg/L	46.100	6	8	2.7	21	0
Fluoride	UNFL	mg/L	1.298	8	8	.3	1.42	1
Nitrate	UNFL	mg/L	.462	4	6	.06	.31	0
Phenols	UNFL	mg/L	.000	3	8	.02	.02	0
Phosphorus	UNFL	mg/L	.206	5	8	.1	.88	4
Sulfate	UNFL	mg/L	138.192	7	8	10	120	0
Sulfide	UNFL	mg/L	.000	0	2	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	1	3	.2	.2	0
Total Organic Carbon	UNFL	mg/L	.000	2	2	3.58	4.4	2
Total Organic Halides	UNFL	mg/L	.000	1	7	.01405	.01405	1
Total Organic Nitrogen	UNFL	mg/L	.000	5	7	.1	.5	5

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available.

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TABLE 4-56

SOUTH FIELD
GROUNDWATER[a] - 1000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	10	13	.0695	184	8
Antimony		mg/L	.000	6	13	.0057	.0141	6
Arsenic		mg/L	.050	5	13	.0053	.0104	0
Barium		mg/L	.450	13	13	.0475	1.14	3
Beryllium		mg/L	.002	3	13	.0037	.0096	3
Cadmium		mg/L	.005	2	13	.0056	.034	2
Calcium		mg/L	123.837	13	13	87.3	1360	7
Chromium		mg/L	.035	7	12	.0046	.196	5
Cobalt		mg/L	.000	5	13	.0246	.116	5
Copper		mg/L	.030	5	13	.0622	.332	5
Cyanide		mg/L	.000	2	6	.0016	.0024	2
Iron		mg/L	3.440	9	13	.0246	370	6
Lead		mg/L	.015	7	13	.0016	.0992	5
Magnesium		mg/L	48.546	13	13	35.5	413	10
Manganese		mg/L	.050	12	13	.0115	6.49	10
Mercury		mg/L	.000	2	13	.00024	.0004	0
Molybdenum		mg/L	.025	5	13	.0309	.108	5
Nickel		mg/L	.026	8	13	.0072	.339	6
Potassium		mg/L	26.976	11	13	.718	27.4	1
Selenium		mg/L	.000	2	13	.0036	.0037	2
Silicon		mg/L	.000	13	13	5.67	102	13
Silver		mg/L	.040	5	13	.018	.0889	2
Sodium		mg/L	47.982	13	13	8.04	16.6	0
Thallium		mg/L	.000	0	13	0	0	0
Vanadium		mg/L	.020	5	12	.103	.376	5
Zinc		mg/L	.032	9	13	.0075	.94	7
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	10	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	6	9	38	1080	6
GROSS BETA	UNFL	pCi/L	.000	8	9	8.81	638	8
NP-237	UNFL	pCi/L	.000	4	8	.22	.48	4
PU-238	UNFL	pCi/L	.000	4	10	.09	.56	4
PU-239/240	UNFL	pCi/L	.000	2	10	.12	.193	2
RA-226	UNFL	pCi/L	1.000	3	7	1.05	1.46	3

See footnote at end of table

TABLE 4-56
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	5.200	0	8	0	0	0
RU-106	UNFL	pCi/L	.000	0	10	0	0	0
SR-90	UNFL	pCi/L	.000	2	10	3.05	3.31	2
TC-99	UNFL	pCi/L	.000	0	10	0	0	0
TH-228	UNFL	pCi/L	1.040	4	9	1.1	9.87	4
TH-230	UNFL	pCi/L	2.000	8	9	.11	11.2	3
TH-232	UNFL	pCi/L	.000	4	9	.938	8.56	4
TH-TOTAL	UNFL	ug/L	3.000	4	9	8.55	78	4
U-234	UNFL	pCi/L	1.900	10	10	.54	223	9
U-235/236	UNFL	pCi/L	.000	8	10	.303	15.7	8
U-238	UNFL	pCi/L	1.070	10	10	.47	229	8
U-TOTAL	UNFL	ug/L	4.000	10	10	1.1	573	8
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	7	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	7	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	7	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	7	0	0	0
2-Butanone	UNFL	ug/L	.000	0	7	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	6	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	6	0	0	0
Acetone	UNFL	ug/L	.000	1	5	6	6	1
Benzene	UNFL	ug/L	.000	0	7	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	7	0	0	0
Bromoform	UNFL	ug/L	.000	0	7	0	0	0
Bromomethane	UNFL	ug/L	.000	0	7	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	7	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	6	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
Chloroethane	UNFL	ug/L	.000	0	7	0	0	0
Chloroform	UNFL	ug/L	.000	0	7	0	0	0
Chloromethane	UNFL	ug/L	.000	0	6	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	7	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	7	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	7	0	0	0

See footnote at end of table

TABLE 4-56
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Styrene	UNFL	ug/L	.000	0	7	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	7	0	0	0
Toluene	UNFL	ug/L	.000	0	7	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	7	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	4	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	7	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	7	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	7	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	7	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	7	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	7	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	7	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	7	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	3	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	7	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	7	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	3	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	7	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	7	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	7	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	7	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	7	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	7	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	7	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	7	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	7	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	7	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	7	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	7	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	6	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	5	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	7	0	0	0

See footnote at end of table

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TABLE 4-56
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Acenaphthylene	UNFL	ug/L	.000	0	7	0	0	0
Anthracene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	7	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	7	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	4	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	7	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	7	0	0	0
Carbazole	UNFL	ug/L	.000	0	7	0	0	0
Chrysene	UNFL	ug/L	.000	0	7	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	1	7	4	4	1
Di-n-octyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	7	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	7	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	1	7	1	1	1
Dimethyl phthalate	UNFL	ug/L	.000	0	7	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	7	0	0	0
Fluorene	UNFL	ug/L	.000	0	7	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	7	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	7	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	7	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	7	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	7	0	0	0
Isophorone	UNFL	ug/L	.000	0	7	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	7	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	3	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	7	0	0	0
Naphthalene	UNFL	ug/L	.000	0	7	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	7	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	7	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	7	0	0	0
Phenol	UNFL	ug/L	.000	0	7	0	0	0
Pyrene	UNFL	ug/L	.000	0	7	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	1	2	1	1	1
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	7	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	7	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	7	0	0	0

See footnote at end of table

TABLE 4-56
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	7	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	7	0	0	0
PESTICIDES/PCBS								
4,4'-DDD		UG/L	.000	0	7	0	0	0
4,4'-DDE		UG/L	.000	0	7	0	0	0
4,4'-DDT		ug/L	.000	0	7	0	0	0
Aldrin		ug/L	.000	0	7	0	0	0
Aroclor-1016		ug/L	.000	0	7	0	0	0
Aroclor-1221		ug/L	.000	0	7	0	0	0
Aroclor-1232		ug/L	.000	0	7	0	0	0
Aroclor-1242		ug/L	.000	0	7	0	0	0
Aroclor-1248		ug/L	.000	0	7	0	0	0
Aroclor-1254		ug/L	.000	0	7	0	0	0
Aroclor-1260		ug/L	.000	0	7	0	0	0
Dieldrin		ug/L	.000	0	7	0	0	0
Endosulfan II		ug/L	.000	0	7	0	0	0
Endosulfan sulfate		ug/L	.000	0	7	0	0	0
Endosulfan-I		ug/L	.000	0	7	0	0	0
Endrin		ug/L	.000	0	7	0	0	0
Endrin aldehyde		ug/L	.000	0	7	0	0	0
Endrin ketone		ug/L	.000	0	7	0	0	0
Heptachlor		ug/L	.000	0	7	0	0	0
Heptachlor epoxide		ug/L	.000	0	7	0	0	0
Methoxychlor		ug/L	.000	0	7	0	0	0
Toxaphene		ug/L	.000	0	7	0	0	0
alpha-BHC		ug/L	.000	0	7	0	0	0
alpha-Chlordane		ug/L	.000	0	7	0	0	0
beta-BHC		ug/L	.000	0	7	0	0	0
delta-BHC		ug/L	.000	0	7	0	0	0
gamma-BHC (Lindane)		ug/L	.000	0	7	0	0	0
gamma-Chlordane		ug/L	.000	0	7	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	7	7	349	560	0
Ammonia	UNFL	mg/L	4.340	5	7	.11	.56	0
Chloride	UNFL	mg/L	46.100	7	7	2.5	8.89	0
Fluoride	UNFL	mg/L	1.298	7	7	.23	.64	0
Nitrate	UNFL	mg/L	.462	3	3	.26	.52	1
Phenols	UNFL	mg/L	.000	0	7	0	0	0

See footnote at end of table

TABLE 4-56
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Sulfate	UNFL	mg/L	138.192	7	7	57.72	203.7	2
Sulfide	UNFL	mg/L	.000	0	7	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	6	6	.34	8.43	2
Total Organic Carbon	UNFL	mg/L	.000	7	7	1.1	3.38	7
Total Organic Halides	UNFL	mg/L	.000	3	7	.0118	.0206	3
Total Organic Nitrogen	UNFL	mg/L	.000	7	7	.19	8.02	7
Total Phosphorous	UNFL	mg/L	.000	7	8	.08	12.11	0

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available.

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TABLE 4-57

SOUTH FIELD
GROUNDWATER[a] - 2000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	12	13	.0428	.755	3
Antimony		mg/L	.006	0	2	0	0	0
Arsenic		mg/L	.050	0	22	0	0	0
Barium		mg/L	.436	19	21	.02	.0886	0
Beryllium		mg/L	.002	0	2	0	0	0
Cadmium		mg/L	.005	13	22	.0021	.009	9
Calcium		mg/L	134.783	22	22	81	185	9
Chromium		mg/L	.041	13	20	.0141	.0516	2
Cobalt		mg/L	.000	0	2	0	0	0
Copper		mg/L	.120	8	21	.0102	.026	0
Cyanide		mg/L	.000	0	1	0	0	0
Iron		mg/L	4.000	15	22	.04	1.6	0
Lead		mg/L	.015	7	21	.0034	.009	0
Magnesium		mg/L	37.961	22	22	17.7	58.2	9
Manganese		mg/L	.050	20	22	.002	.517	9
Mercury		mg/L	.001	2	22	.0003	.0004	0
Molybdenum		mg/L	.025	3	21	.008	.049	1
Nickel		mg/L	.024	6	21	.02	.084	3
Potassium		mg/L	3.077	18	21	1.82	4.07	5
Selenium		mg/L	.004	3	22	.003	.006	1
Silicon		mg/L	6.140	11	11	3.12	6.01	0
Silver		mg/L	.014	6	21	.01	.026	4
Sodium		mg/L	51.267	21	22	6.65	16.1	0
Thallium		mg/L	.000	0	2	0	0	0
Vanadium		mg/L	.025	9	13	.0111	.0305	2
Zinc		mg/L	.095	1	2	.034	.034	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	4	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0	0	0	0	0
GROSS BETA	UNFL	pCi/L	.000	0	0	0	0	0
NP-237	UNFL	pCi/L	.000	0	18	0	0	0
PU-238	UNFL	pCi/L	.000	0	17	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	17	0	0	0
RA-226	UNFL	pCi/L	1.200	2	16	1.2	1.4	1

See footnote at end of table

TABLE 4-57
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	4.000	0	18	0	0	0
RU-106	UNFL	pCi/L	.000	0	4	0	0	0
SR-90	UNFL	pCi/L	.000	0	16	0	0	0
TC-99	UNFL	pCi/L	36.000	0	18	0	0	0
TH-228	UNFL	pCi/L	1.400	1	18	1.16	1.16	0
TH-230	UNFL	pCi/L	1.700	3	18	1.2	1.78	1
TH-232	UNFL	pCi/L	.000	1	18	1.49	1.49	1
TH-TOTAL	UNFL	ug/L	2.000	1	16	13.5	13.5	1
U-234	UNFL	pCi/L	1.200	17	19	2.6	219	17
U-235/236	UNFL	pCi/L	.000	7	19	1.6	11.5	7
U-238	UNFL	pCi/L	.900	17	19	2.6	231	17
U-TOTAL	UNFL	ug/L	2.000	17	19	3	907	17
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	1	3	5	5	1
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	3	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	3	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	1	3	9	9	1
1,1-Dichloroethene	UNFL	ug/L	.000	0	3	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	3	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	1	3	5	5	1
1,2-Dichloropropane	UNFL	ug/L	.000	0	3	0	0	0
2-Butanone	UNFL	ug/L	.000	0	2	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	3	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	3	0	0	0
Acetone	UNFL	ug/L	.000	2	3	2	5	2
Benzene	UNFL	ug/L	.000	0	3	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	3	0	0	0
Bromoform	UNFL	ug/L	.000	0	3	0	0	0
Bromomethane	UNFL	ug/L	.000	0	3	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	3	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	3	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	3	0	0	0
Chloroethane	UNFL	ug/L	.000	0	3	0	0	0
Chloroform	UNFL	ug/L	.000	0	3	0	0	0
Chloromethane	UNFL	ug/L	.000	0	3	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	3	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	3	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	3	0	0	0

See footnote at end of table

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TABLE 4-57
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Styrene	UNFL	ug/L	.000	0	3	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	3	0	0	0
Toluene	UNFL	ug/L	.000	0	3	0	0	0
Trichloroethene	UNFL	ug/L	.000	1	3	7	7	1
Vinyl Acetate	UNFL	ug/L	.000	0	3	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	3	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	3	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	3	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	3	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	3	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	3	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	3	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	3	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	3	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	3	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	3	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	3	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	3	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	3	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	3	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	3	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	3	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	3	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	3	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	3	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	3	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	3	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	3	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	3	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	3	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	3	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	3	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	3	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	3	0	0	0
Anthracene	UNFL	ug/L	.000	0	3	0	0	0

See footnote at end of table

TABLE 4-57
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(a)anthracene	UNFL	ug/L	.000	0	3	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	3	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	3	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	3	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	3	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	3	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	3	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	3	0	0	0
Chrysene	UNFL	ug/L	.000	0	3	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	3	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	3	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	3	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	3	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	1	3	20	20	1
Dimethyl phthalate	UNFL	ug/L	.000	0	3	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	3	0	0	0
Fluorene	UNFL	ug/L	.000	0	3	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	3	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	3	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	3	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	3	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	3	0	0	0
Isophorone	UNFL	ug/L	.000	0	3	0	0	0
Methyl parathion	UNFL	ug/L	.000	0	2	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	3	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	3	0	0	0
Naphthalene	UNFL	ug/L	.000	0	3	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	3	0	0	0
Parathion	UNFL	ug/L	.000	0	2	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	3	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	3	0	0	0
Phenol	UNFL	ug/L	.000	0	3	0	0	0
Pyrene	UNFL	ug/L	.000	0	3	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	2	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	3	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	3	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	1	3	2	2	1
p-Chloroaniline	UNFL	ug/L	.000	0	3	0	0	0

See footnote at end of table

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TABLE 4-57
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS								
4,4'-DDD	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	2	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	2	0	0	0
Aldrin	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	2	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	2	0	0	0
Dieldrin	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	2	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	2	0	0	0
Endrin	UNFL	ug/L	.000	0	2	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor	UNFL	ug/L	.000	0	2	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	2	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	2	0	0	0
Toxaphene	UNFL	ug/L	.000	0	2	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	2	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	2	0	0	0
beta-BHC	UNFL	ug/L	.000	0	2	0	0	0
delta-BHC	UNFL	ug/L	.000	0	2	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	2	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	2	0	0	0
Azinphosmethyl	UNFL	ug/L	.000	0	2	0	0	0
Demeton	UNFL	ug/L	.000	0	2	0	0	0
Diazinon	UNFL	ug/L	.000	0	2	0	0	0
Disulfoton	UNFL	ug/L	.000	0	2	0	0	0
Ethion	UNFL	ug/L	.000	0	2	0	0	0
Malathion	UNFL	ug/L	.000	0	2	0	0	0
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	3.240	2	22	.145	.2	0
Chloride	UNFL	mg/L	120.000	18	20	3	27	0
Fluoride	UNFL	mg/L	.929	14	18	.098	.6	0
Hexavalent Chromium	UNFL	mg/L	.000	0	1	0	0	0
Nitrate	UNFL	mg/L	10.000	20	23	.1	3.59	0

See footnote at end of table

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TABLE 4-57
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Phenols	UNFL	mg/L	.000	7	20	.01	.03	0
Phosphate	UNFL	mg/L	.000	1	1	.3	.3	0
Phosphorus	UNFL	mg/L	.679	14	18	.08	1.291	3
Sulfate	UNFL	mg/L	352.992	20	21	49.3	281	0
Sulfide	UNFL	mg/L	30.400	3	12	3.52	37.8	1
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	9	11	.1	1.07	0
Total Organic Carbon	UNFL	mg/L	3.764	7	11	2.83	62	3
Total Organic Halides	UNFL	mg/L	.021	4	13	.01	1.7	2
Total Organic Nitrogen	UNFL	mg/L	.652	14	22	.1	1.07	2

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available

TABLE 4-58

SOUTH FIELD
GROUNDWATER[a] - 2000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	8	14	.0805	5.11	5
Antimony		mg/L	.006	1	14	.0051	.0051	0
Arsenic		mg/L	.050	5	14	.0012	.0039	0
Barium		mg/L	.436	14	14	.0329	.0961	0
Beryllium		mg/L	.002	1	14	.002	.002	0
Cadmium		mg/L	.005	0	14	0	0	0
Calcium		mg/L	134.783	14	14	83.5	198	7
Chromium		mg/L	.041	2	13	.0052	.0237	0
Cobalt		mg/L	.000	0	14	0	0	0
Copper		mg/L	.120	1	14	.0296	.0296	0
Cyanide		mg/L	.000	0	9	0	0	0
Iron		mg/L	4.000	9	14	.0329	15.1	1
Lead		mg/L	.015	4	14	.0015	.016	1
Magnesium		mg/L	37.961	14	14	20.6	60.2	4
Manganese		mg/L	.050	14	14	.004	.44	10
Mercury		mg/L	.001	0	14	0	0	0
Molybdenum		mg/L	.025	0	14	0	0	0
Nickel		mg/L	.024	2	14	.0042	.0072	0
Potassium		mg/L	3.077	14	14	1.68	4.4	7
Selenium		mg/L	.004	4	14	.0014	.0033	0
Silicon		mg/L	6.140	14	14	3.07	12.8	3
Silver		mg/L	.014	0	14	0	0	0
Sodium		mg/L	51.267	14	14	4.09	12.7	0
Thallium		mg/L	.000	0	14	0	0	0
Vanadium		mg/L	.025	1	13	.0185	.0185	0
Zinc		mg/L	.095	7	14	.0051	.0801	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	11	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	5	11	49.7	1410	5
GROSS BETA	UNFL	pCi/L	.000	7	11	6.92	520	7
NP-237	UNFL	pCi/L	.000	6	9	.15	.962	6
PU-238	UNFL	pCi/L	.000	4	10	.075	.637	4
PU-239/240	UNFL	pCi/L	.000	0	10	0	0	0
RA-226	UNFL	pCi/L	1.200	7	11	.13	.536	0

See footnote at end of table

TABLE 4-58
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	4.000	0	11	0	0	0
RU-106	UNFL	pCi/L	.000	0	11	0	0	0
SR-90	UNFL	pCi/L	.000	0	11	0	0	0
TC-99	UNFL	pCi/L	36.000	0	11	0	0	0
TH-228	UNFL	pCi/L	1.400	0	10	0	0	0
TH-230	UNFL	pCi/L	1.700	8	10	.186	2.06	1
TH-232	UNFL	pCi/L	.000	1	10	.044	.044	1
TH-TOTAL	UNFL	ug/L	2.000	1	9	.398	.398	0
U-234	UNFL	pCi/L	1.200	10	10	.83	662	8
U-235/236	UNFL	pCi/L	.000	8	10	.22	31.7	8
U-238	UNFL	pCi/L	.900	10	10	.76	707	9
U-TOTAL	UNFL	ug/L	2.000	10	10	1.67	2070	9
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	1	9	1	1	1
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	9	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	9	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	9	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	9	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	9	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	9	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	9	0	0	0
2-Butanone	UNFL	ug/L	.000	0	9	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	9	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	9	0	0	0
Acetone	UNFL	ug/L	.000	2	8	3	10	2
Benzene	UNFL	ug/L	.000	0	9	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	9	0	0	0
Bromoform	UNFL	ug/L	.000	0	9	0	0	0
Bromomethane	UNFL	ug/L	.000	0	9	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	9	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	9	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	9	0	0	0
Chloroethane	UNFL	ug/L	.000	0	9	0	0	0
Chloroform	UNFL	ug/L	.000	0	9	0	0	0
Chloromethane	UNFL	ug/L	.000	0	8	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	9	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	9	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	10	0	0	0
Styrene	UNFL	ug/L	.000	0	9	0	0	0

See footnote at end of table

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TABLE 4-58
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Tetrachloroethene	UNFL	ug/L	.000	0	9	0	0	0
Toluene	UNFL	ug/L	.000	0	9	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	9	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	7	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	9	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	9	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	9	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	9	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	9	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	9	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	9	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	9	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	9	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	9	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	9	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	9	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	8	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	9	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	9	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	2	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	9	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	9	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	9	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	9	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	9	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	9	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	9	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	9	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	6	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	9	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	9	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	9	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	9	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	6	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	7	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	9	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	9	0	0	0
Anthracene	UNFL	ug/L	.000	0	9	0	0	0

See footnote at end of table

TABLE 4-58
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(a)anthracene	UNFL	ug/L	.000	0	9	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	9	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	9	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	9	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	9	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	7	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	8	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	2	9	1	2	2
Carbazole	UNFL	ug/L	.000	0	9	0	0	0
Chrysene	UNFL	ug/L	.000	0	9	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	2	9	4	5	2
Di-n-octyl phthalate	UNFL	ug/L	.000	0	8	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	9	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	9	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	9	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	9	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	9	0	0	0
Fluorene	UNFL	ug/L	.000	0	9	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	9	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	9	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	9	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	9	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	9	0	0	0
Isophorone	UNFL	ug/L	.000	0	9	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	9	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	2	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	9	0	0	0
Naphthalene	UNFL	ug/L	.000	0	9	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	9	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	9	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	9	0	0	0
Phenol	UNFL	ug/L	.000	0	9	0	0	0
Pyrene	UNFL	ug/L	.000	0	9	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	9	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	9	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	9	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	3	9	2	6	3
p-Chloroaniline	UNFL	ug/L	.000	0	8	0	0	0

See footnote at end of table

TABLE 4-58
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBS								
4,4'-DDD		ug/L	.000	0	9	0	0	0
4,4'-DDE		ug/L	.000	0	9	0	0	0
4,4'-DDT		ug/L	.000	0	9	0	0	0
Aldrin		ug/L	.000	0	9	0	0	0
Aroclor-1016		ug/L	.000	0	9	0	0	0
Aroclor-1221		ug/L	.000	0	9	0	0	0
Aroclor-1232		ug/L	.000	0	9	0	0	0
Aroclor-1242		ug/L	.000	0	9	0	0	0
Aroclor-1248		ug/L	.000	0	9	0	0	0
Aroclor-1254		ug/L	.000	0	9	0	0	0
Aroclor-1260		ug/L	.000	0	9	0	0	0
Dieldrin		ug/L	.000	0	9	0	0	0
Endosulfan II		ug/L	.000	0	9	0	0	0
Endosulfan sulfate		ug/L	.000	0	9	0	0	0
Endosulfan-I		ug/L	.000	0	9	0	0	0
Endrin		ug/L	.000	0	9	0	0	0
Endrin aldehyde		ug/L	.000	0	9	0	0	0
Endrin ketone		ug/L	.000	0	9	0	0	0
Heptachlor		ug/L	.000	0	9	0	0	0
Heptachlor epoxide		ug/L	.000	0	9	0	0	0
Methoxychlor		ug/L	.000	0	9	0	0	0
Toxaphene		ug/L	.000	0	9	0	0	0
alpha-BHC		ug/L	.000	0	9	0	0	0
alpha-Chlordane		ug/L	.000	0	9	0	0	0
beta-BHC		ug/L	.000	0	9	0	0	0
delta-BHC		ug/L	.000	0	9	0	0	0
gamma-BHC (Lindane)		ug/L	.000	0	9	0	0	0
gamma-Chlordane		ug/L	.000	0	9	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	7	7	240	455	0
Alkalinity as CaCO3	UNFL	mg/L	.000	1	1	370	370	0
Ammonia	UNFL	mg/L	3.240	1	7	.12	.12	0
Chloride	UNFL	mg/L	120.000	8	8	4.62	22.89	0
Fluoride	UNFL	mg/L	.929	8	8	.09	.51	0
Nitrate	UNFL	mg/L	10.000	7	7	.15	2.04	0
Phenols	UNFL	mg/L	.000	0	8	0	0	0
Phosphorus	UNFL	mg/L	.679	2	2	.06	.46	0
Sulfate	UNFL	mg/L	352.992	8	8	18.6	95.4	0
Sulfide	UNFL	mg/L	30.400	0	8	0	0	0

See footnote at end of table

FER\CRU2RI\TDO\TAB4-58\January16, 1995 7:00pm

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TABLE 4-58
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	7	8	.1	.32	0
Total Organic Carbon	UNFL	mg/L	3.764	2	8	1.07	1.41	0
Total Organic Halides	UNFL	mg/L	.021	1	6	.0144	.0144	0
Total Organic Nitrogen	UNFL	mg/L	.652	6	8	.11	.32	0
Total Phosphorous	UNFL	mg/L	.000	4	6	.04	.98	0

[a]Filtered radionuclides, organics, and general chemistry are not included because background concentrations were not available.

See footnote at end of table

I. Phase I sampling detected 12 metals, uranium, radium, thorium, and seven organic compounds that exceeded background. The concentration of uranium in downgradient wells was elevated with respect to some upgradient wells, but the relationship between possible source areas and regional aquifer wells was not clear. To complete the sampling network, four additional 2000-series wells and eight Hydropunch™ wells were completed in the South Field. Sample data for the 2000-series wells is shown on Figure 4-25 (see Volume 2, Oversized Figures), and the Hydropunch™ data is presented on Figure 4-23.

Phase II sampling detected eight metals (Silicon was not detected above background during Phase I; Cadmium, Chromium, Molybdenum, Nickel, Selenium, and Vanadium were detected above background for Phase I but not Phase II), isotopes of four elements (neptunium-237 and plutonium-238 were not detected above background for Phase I; radium-226 and thorium-total were detected above background for Phase I but not Phase II), and five organic compounds (Butyl benzyl phthalate and Di-n-butyl phthalate were not detected above background during Phase I; 1,1-Dichloroethane, and Diethyl phthalate were detected above background during Phase I but not Phase II). Groundwater samples were collected downgradient of the former Firing Range and analyzed for lead. Results are shown below and the sample locations are shown on Figure 4-25.

Location	Sample ID	Lead			Groundwater Unit	Sample Type
		Detected Value (mg/L)		Background (mg/L)		
11022	113058	unfiltered	0.0179	0.015	Great Miami Aquifer	Hydropunch™
11023	113062	unfiltered	0.0047	0.015	Great Miami Aquifer	Hydropunch™
11028	113242	unfiltered	0.0351	0.015	Great Miami Aquifer	Hydropunch™
11030	116361	unfiltered	0.030	0.015	Great Miami Aquifer	Hydropunch™
11030	116362	unfiltered	0.0262	0.015	Great Miami Aquifer	Hydropunch™
2944	113866	filtered unfiltered	0.002 0.016	0.015	Great Miami Aquifer	2000-Series Well
2943	113315	unfiltered	0.002	0.015	Great Miami Aquifer	2000-Series Well

Groundwater data indicate concentrations of lead above background in water samples collected downgradient of the former Firing Range and, therefore, the Firing range appears to impact groundwater.

Historical data indicate that Well 2045 (see Appendix G, Table G-2K) has detected total uranium concentrations ranging from 265 μg/L to 462 μg/L since the first sample was analyzed in May 1989. This means that impacts from the South Field are at least four years old. Contours of total uranium

concentrations detected in 2000-series wells during Phase II are plotted on Figure 4-26. Several sources potentially exist for the total uranium observed in 2000-series wells. Elevated concentrations detected in 2000-series wells on the west boundary may be related to recharge that occurs beneath the Inactive Flyash Pile and flows to the east beneath the South Field. Recharge mechanisms were discussed in Section 4.3. A plume of total uranium flows downgradient from the Inactive Flyash Pile beneath the South Field and intersects Well 2046 (423 μg/L) before flowing to Well 2385 (98.7 μg/L). The same plume flows from Well 2945 (1820 μg/L), past Well 2954 (1167 μg/L), to Well 2385 (98.7 μg/L).

Uranium contamination detected in Hydropunch™ and well groundwater samples at the southeast part of the South Field (Hydropunch™ 11018, 11019, and 11021, and Well 2045) indicate that the Great Miami Aquifer may receive contaminated groundwater recharge from at least two sources: perched groundwater recharge from the area north of Hydropunch™ location 11028 and contaminated recharge of surface water at the southeast corner of the subunit. Possible contaminated surface water recharge was detected by surface water samples and was discussed in Section 4.4.3. The plume at the southeast corner of the South Field appears to be separated from the plume to the north by a zone of less contaminated groundwater that extends from Well 2016 (17 μg/L) to Well 2944 (1.5 μg/L) and Well 2048 (1.3 μg/L). The southeast part of the total uranium plume appears to flow past Well 2045 (364 μg/L), Well 2049 (111 μg/L) and possibly Well 21033 (43.2 μg/L).

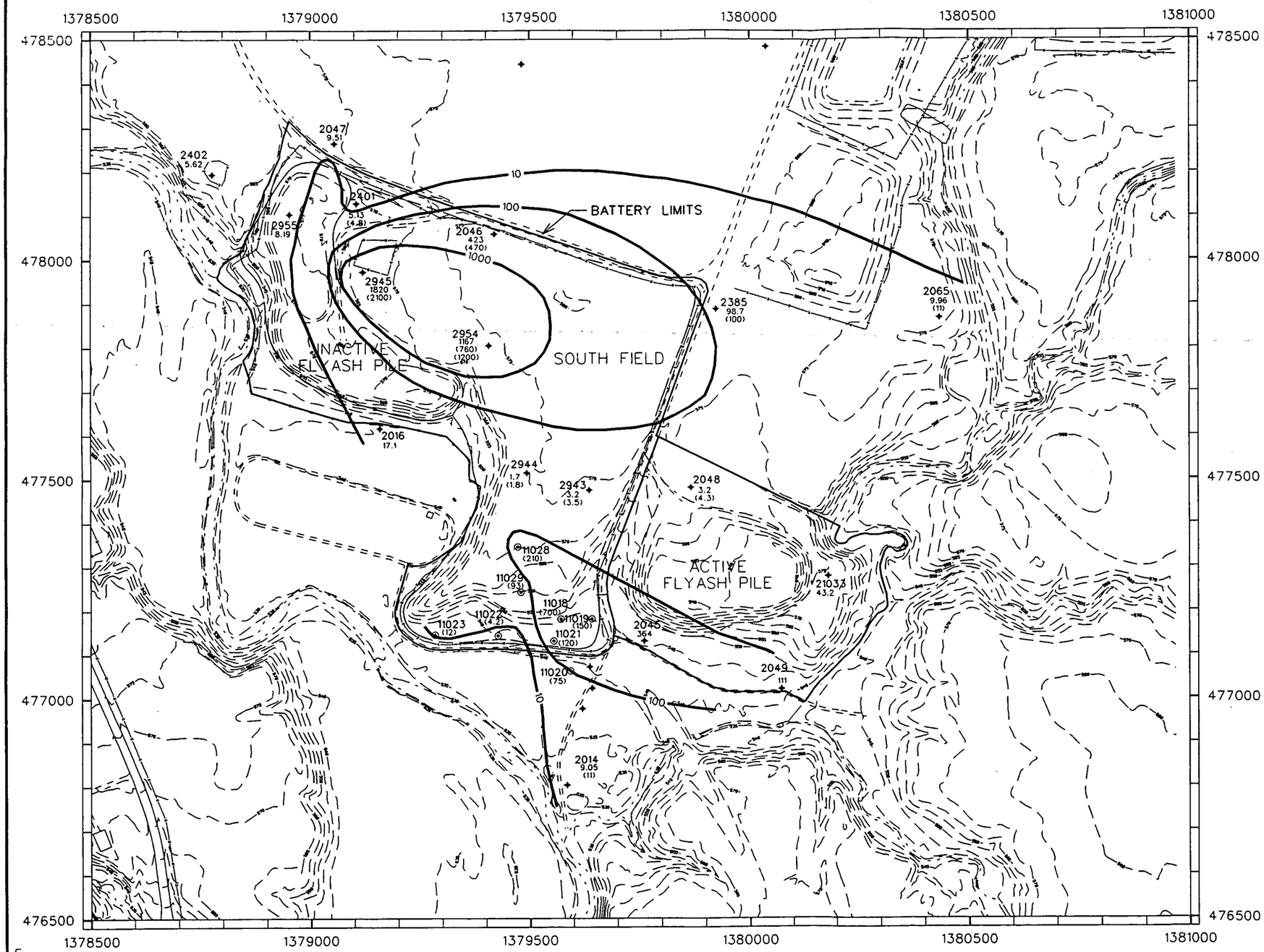
4.5.5 Biota

The ecological impacts from material left after remediation will be addressed in the Site-Wide Ecological Risk Assessment that will be prepared as part of the Operable Unit 5 RI/FS.

4.5.6 Summary

The following conclusions are possible concerning the South Field:

- Twenty-six organic compounds, mostly semivolatile, were detected in surface soil samples. These compounds are similar to those detected at the Solid Waste Landfill and are distributed over the surface of the subunit. Samples taken at depth indicate the compounds are also detected within the subsurface, but concentrations decrease with depth. Of the organic compounds detected, Aroclor-1254, Aroclor-1260, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, dieldrin, and indeno(1,2,3-cd)pyrene were the surface soil COCs detected above background.



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- DRAINAGE
- FENCE
- 2000 MONITORING WELLS
- HYDROPUNCH
- (210) ON-SITE SCREENING RESULTS

NOTE: Total Uranium Concentrations are in ug/l.

NOTE: Data from May 1993.

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 125 250 500

FIGURE 4-26
DISTRIBUTION OF TOTAL URANIUM IN 2000-SERIES WELLS DETECTED ABOVE BACKGROUND IN THE SOUTH FIELD/ FLYASH PILES AREA

fig0488.dgn

- Isotopes of eight elements were detected in soil samples. Elevated concentrations of radionuclides are associated with waste material disposed of in the South Field. The concentrations of radionuclides decrease with depth through the fill and glacial till. The radionuclide surface soil COCs detected above background were cesium, neptunium, radium, thorium, and uranium (also a cross-media groundwater COC). Other radionuclides detected above background were plutonium, strontium, and technetium.

- The surface soil COC metals detected above background in the soil were arsenic, beryllium, and chromium.

- Seven organics were detected in the 2000-series groundwater wells for Phase I and seven organics for Phase II. The organic constituents detected in Phase I included diethyl phthalate at 20 ppb, 1,1-dichloroethane at 9 ppb, trichloroethene at 7 ppb, 1,1,1-trichloroethane, 1,2-dichloroethene, and acetone at 5 ppb, and bis(2-ethylhexyl)phthalate at 2 ppb. Phase II detections included acetone at 10 ppb, bis(2-ethylhexyl)phthalate at 6 ppb, di-n-butyl phthalate at 5 ppb, butyl benzyl phthalate at 2 ppb, and 1,1,1-trichloroethane at 1 ppb. Some of these contaminants are common laboratory contaminants, and this is confirmed by the inconsistencies in the number of analytes detected from Phase I to Phase II. However, 1,1,1-trichloroethane and 1,1-dichloroethane may be present due to placement of wastes from maintenance activities, or other activities where solvents were used.

- Uranium contamination detected in Hydropunch™ and well samples in the southeastern portion of the South Field indicate that the Great Miami Aquifer may receive contaminated groundwater recharge from the perched groundwater north of the southeast corner and surface water at the southeast corner of the subunit.

- Trenching activities uncovered a variety of waste materials including concrete, steel pipe, sheet steel, wood, and clay tile. Surface wipe samples from some of these materials had a maximum reading of 150,000 disintegrations per minute (dpm) suggesting that the contamination is removable, so the materials are potential leaching sources of radionuclides to groundwater.

- Water samples from the drainage northeast and east of the South Field detected elevated uranium concentrations, which was the only surface soil COC detected in surface water in the South Field. The levels of concentrations for these samples were of the same order of magnitude as the Hydropunch™ samples from the northeastern portion of the South Field. This would indicate that the drainage is possibly impacted by the seepage of perched groundwater from the northeastern portion.

- The surface soil COCs in the sediment detected above background were arsenic, beryllium, neptunium-237, radium-226, radium-228, , thorium-228, thorium-230, thorium-232, uranium-234, uranium-235/236, uranium-238, total uranium, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and Aroclor-1254. Other radionuclides detected above background were plutonium and strontium. This indicates the possible migration of surface soil contamination from the South Field.

- The surface soil COCs detected above background for perched groundwater were beryllium, chromium, neptunium-237, radium-226, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235/236, uranium-238, and total uranium. Other radionuclides detected were plutonium and strontium. Additionally, total uranium was detected in all perched groundwater wells, which indicates an impact from the South Field.

- For the 2000-series wells, the surface soil COCs detected above background were neptunium, radium-226, thorium-230, thorium-232, and uranium-234, uranium-235/236, uranium-238, and total uranium. Well 2945 and downgradient Well 2045 had elevated concentrations of uranium, which indicates the possibility of the South Field impacting the groundwater of the Great Miami Aquifer.

- Samples from wells downgradient from the Firing Range detected lead in concentrations above background. It appears that the Firing Range material is impacting the Great Miami Aquifer.

4.6 ACTIVE FLYASH PILE

Analytical results for samples collected from the Active Flyash Pile are presented in Appendix G. Sample analyses that detected analytes at concentrations above background (defined in Table 4-1A) will be discussed in this section. Geology and hydrogeology of the Active Flyash Pile referred to in this section were discussed in more detail in Section 3.5.

4.6.1 Volume and Physical Characteristics of Waste Material

The volume of flyash was estimated by means of digitized topographic maps, boring log data, and interpolation by using Intergraph Corporation Microstation PC software. Volume calculations are summarized in Figure 4-27. The volume of flyash in the Active Flyash Pile is calculated to be approximately 64,581 cubic yards

Flyash was generated at the boiler plant by burning coal and was deposited as surface dumping by dump trucks. Aerial photographs indicate that the flyash was deposited upon the original ground surface and thereafter worked by bulldozers into lifts. Samples of flyash collected from borings into the Active Flyash Pile indicate that it contains alternating loose (blow counts ranging from 2 to 10 per 6 inches) to medium dense (blow counts ranging from 11 to 16 per 6 inches) layers.

Samples of flyash collected from borings detected dry to moist conditions but never detected water saturated samples. Very moist to wet conditions were detected at the interface of the Active Flyash Pile and the native till surface. Soil samples collected from soil borings drilled in the flyash detected other waste materials consisting of concrete and construction rubble in the vicinity of Well 1048 north

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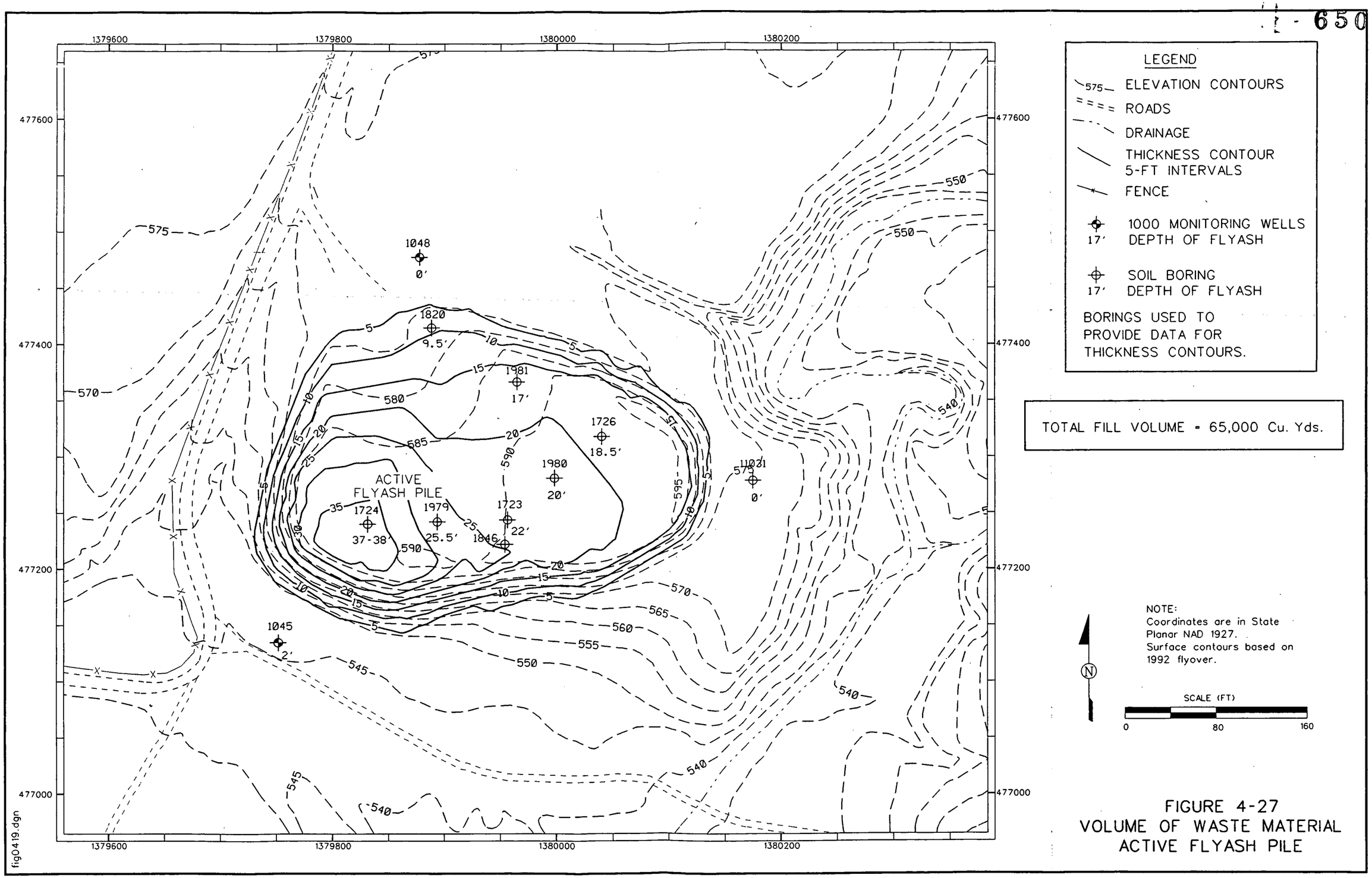

FIGURE 4-27
VOLUME OF WASTE MATERIAL
ACTIVE FLYASH PILE

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of the flyash pile. Flyash was the only material detected in all other subsurface samples collected from the flyash pile.

4.6.2 Surface and Subsurface Media

Analytical results for flyash (presented in Appendix G, Table G-2) were compared against background flyash concentrations, and soil background concentrations. The summaries of these comparisons are presented in Tables 4-59A through 65.

No surface soil samples were collected during Phase I. During Phase II surface soil samples were collected from 14 locations at the Active flyash pile. These results were compared with background flyash and are summarized in Table 4-59A. Arsenic was the only metal detected above background (one out of 14 samples analyzed), and no radionuclides were detected above background. Since organic background flyash results were not available, a comparison could not be made. Surface results compared to soil background are summarized in Table 4-59B. Twenty metals, isotopes of seven elements, and nineteen organics were detected above background. Radionuclides, metals of concern, and organics in surface samples detected above soil background are shown on Figure 4-28 (see Volume 2, Oversized Figures).Phase II surface soil data was compared to CIS and ES data (Tables G-4 and G-5). Analytes detected in these preliminary studies were also detected is Phase II within the same order of magnitude.

During Phase I subsurface flyash was collected from four locations and the comparison of the results with background flyash is summarized in Table 4-60A. No metals were detected above background flyash, and isotopes of three elements (radium-226, radium-228, thorium-232, uranium-238, and uranium-total) were detected above background during Phase I. During Phase II subsurface ash was collected from three locations and a comparison of the results with background flyash is summarized in Table 4-60B. No metals were above background flyash concentrations, and one uranium isotope was detected above background (uranium-238 maximum was 7.12 pCi/g; total uranium had a maximum concentration of 22.1 mg/kg). A comparison for organics could not be made since background flyash results for organics did not exist.

A comparison of subsurface ash results to background concentrations for subsurface soil was made for both Phase I and Phase II. The results are summarized in Tables 4-61A and 4-61B. For Phase I seventeen metals, isotopes of five elements, and eighteen organics were detected

TABLE 4-59A

ACTIVE FLYASH PILE
SURFACE SOIL[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
Metals							
Aluminum	mg/kg	140000.000	14	14	3430	11100	0
Antimony	mg/kg	18.370	7	14	1.5	3.2	0
Arsenic	mg/kg	140.970	14	14	10.4	145	1
Barium	mg/kg	4920.000	14	14	75	349	0
Beryllium	mg/kg	19.890	14	14	1.5	6.4	0
Cadmium	mg/kg	20.640	4	14	.56	.74	0
Calcium	mg/kg	134687.460	14	14	1900	59800	0
Chromium	mg/kg	218.000	14	14	6.9	15.4	0
Cobalt	mg/kg	199.350	14	14	8.9	24.9	0
Copper	mg/kg	382.160	14	14	19.9	94	0
Iron	mg/kg	148364.370	14	14	3940	16500	0
Lead	mg/kg	193.980	14	14	21.6	77.4	0
Magnesium	mg/kg	40000.000	14	14	376	16600	0
Manganese	mg/kg	1610.700	14	14	15.6	463	0
Mercury	mg/kg	.720	6	14	.14	.26	0
Molybdenum	mg/kg	269.590	14	14	1.7	12.5	0
Nickel	mg/kg	215.590	14	14	15.3	54.2	0
Selenium	mg/kg	73.000	11	14	1.9	10.3	0
Silver	mg/kg	14.000	2	14	3.4	4.7	0
Vanadium	mg/kg	390.000	14	14	23	66.3	0
Zinc	mg/kg	677.250	14	14	39.6	94.5	0
Radionuclides							
RA-226	pCi/g	5.250	14	14	1.3	4.61	0
TH-232	pCi/g	4.330	14	14	.931	3.74	0
TH-TOTAL	mg/kg	330.000	14	14	8.57	34.1	0
U-238	pCi/g	6.070	14	14	2.88	4.39	0
U-TOTAL	mg/kg	19.000	14	14	7.86	14.8	0

[a]Surface source soil results are compared to flyash background concentrations.

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TABLE 4-59B

ACTIVE FLYASH PILE
SURFACE SOIL[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
Metals							
Aluminum	mg/kg	11880.190	14	14	3430	11100	0
Antimony	mg/kg	.000	7	14	1.5	3.2	7
Arsenic	mg/kg	8.200	14	14	10.4	145	14
Barium	mg/kg	94.100	14	14	75	349	12
Beryllium	mg/kg	.600	14	14	1.5	6.4	14
Cadmium	mg/kg	.870	4	14	.56	.74	0
Calcium	mg/kg	4339.170	14	14	1900	59800	7
Chromium	mg/kg	15.500	14	14	6.9	15.4	0
Cobalt	mg/kg	14.160	14	14	8.9	24.9	10
Copper	mg/kg	14.070	14	14	19.9	94	14
Iron	mg/kg	21728.170	14	14	3940	16500	0
Lead	mg/kg	26.400	14	14	21.6	77.4	11
Magnesium	mg/kg	2776.970	14	14	376	16600	2
Manganese	mg/kg	1348.040	14	14	15.6	463	0
Mercury	mg/kg	.120	6	14	.14	.26	6
Molybdenum	mg/kg	.000	14	14	1.7	12.5	14
Nickel	mg/kg	20.870	14	14	15.3	54.2	10
Potassium	mg/kg	1231.340	14	14	671	1760	4
Selenium	mg/kg	.720	11	14	1.9	10.3	11
Silicon	mg/kg	1797.030	14	14	318	1250	0
Silver	mg/kg	.000	2	14	3.4	4.7	2
Sodium	mg/kg	51.100	14	14	92.1	302	14
Thallium	mg/kg	.580	14	14	.24	4.4	12
Vanadium	mg/kg	30.370	14	14	23	66.3	10
Zinc	mg/kg	59.610	14	14	39.6	94.5	8
CYANIDE							
Cyanide	mg/kg	.270	8	9	.19	.47	5
RADIONUCLIDES							
CS-137	pCi/g	.710	4	14	.0721	.919	1
GROSS ALPHA	pCi/g	.000	14	14	17.9	53.9	14
GROSS BETA	pCi/g	.000	14	14	25.6	47.8	14

See footnote at end of table

TABLE 4-59B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
NP-237	pCi/g	.000	6	6	.057	.3	6
PU-238	pCi/g	.000	12	13	.0317	1.29	12
PU-239/240	pCi/g	.000	8	13	.011	.12	8
RA-226	pCi/g	1.420	14	14	1.3	4.61	12
RA-228	pCi/g	1.250	14	14	1.01	3.17	13
RU-106	pCi/g	.000	0	14	0	0	0
SR-90	pCi/g	.000	7	14	.214	4.47	7
TC-99	pCi/g	.000	0	14	0	0	0
TH-228	pCi/g	1.430	14	14	.805	3.81	11
TH-230	pCi/g	1.970	14	14	1.5	6.74	11
TH-232	pCi/g	1.360	14	14	.931	3.74	12
TH-TOTAL	mg/kg	10.700	14	14	8.57	34.1	13
U-234	pCi/g	1.240	14	14	2.37	4.43	14
U-235/236	pCi/g	.150	13	14	.082	.199	9
U-238	pCi/g	1.220	14	14	2.88	4.39	14
U-TOTAL	mg/kg	3.700	14	14	7.86	14.8	14
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	1	7	8	8	1
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	5	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	6	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	13	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	13	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	13	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	13	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	6	0	0	0
2-Butanone	ug/kg	.000	0	6	0	0	0
2-Hexanone	ug/kg	.000	0	5	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	5	0	0	0
Acetone	ug/kg	.000	0	9	0	0	0
Benzene	ug/kg	.000	0	6	0	0	0
Bromodichloromethane	ug/kg	.000	0	6	0	0	0
Bromoform	ug/kg	.000	0	6	0	0	0
Bromomethane	ug/kg	.000	0	13	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	6	0	0	0
Carbon disulfide	ug/kg	.000	0	13	0	0	0
Chlorobenzene	ug/kg	.000	0	5	0	0	0
Chloroethane	ug/kg	.000	0	13	0	0	0
Chloroform	ug/kg	.000	0	13	0	0	0

See footnote at end of table

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TABLE 4-59B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Chloromethane	ug/kg	.000	0	13	0	0	0
Dibromochloromethane	ug/kg	.000	0	6	0	0	0
Ethylbenzene	ug/kg	.000	0	5	0	0	0
Methylene chloride	ug/kg	.000	5	13	5	110	5
Styrene	ug/kg	.000	0	5	0	0	0
Tetrachloroethene	ug/kg	.000	1	5	2	2	1
Toluene	ug/kg	.000	8	11	4	160	8
Trichloroethene	ug/kg	.000	0	6	0	0	0
Vinyl Acetate	ug/kg	.000	0	2	0	0	0
Vinyl chloride	ug/kg	.000	0	13	0	0	0
Xylenes, Total	ug/kg	.000	0	5	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	6	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	6	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	13	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	13	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	13	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	13	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	14	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	14	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	14	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	14	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	14	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	13	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	13	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	1	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	13	0	0	0
2-Chlorophenol	ug/kg	.000	0	14	0	0	0
2-Methylnaphthalene	ug/kg	.000	2	13	55	56	2
2-Methylphenol	ug/kg	.000	0	14	0	0	0
2-Nitroaniline	ug/kg	.000	0	13	0	0	0
2-Nitrophenol	ug/kg	.000	0	14	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	13	0	0	0
3-Nitroaniline	ug/kg	.000	0	13	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	14	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	13	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	14	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	13	0	0	0

See footnote at end of table

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TABLE 4-59B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
4-Methylphenol	ug/kg	.000	0	14	0	0	0
4-Nitroaniline	ug/kg	.000	0	13	0	0	0
4-Nitrophenol	ug/kg	.000	0	14	0	0	0
Acenaphthene	ug/kg	.000	0	13	0	0	0
Acenaphthylene	ug/kg	.000	0	13	0	0	0
Anthracene	ug/kg	.000	0	13	0	0	0
Benzo(a)anthracene	ug/kg	.000	2	13	53	110	2
Benzo(a)pyrene	ug/kg	.000	2	13	70	120	2
Benzo(b)fluoranthene	ug/kg	.000	3	13	100	180	3
Benzo(g,h,i)perylene	ug/kg	.000	0	13	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	2	13	54	73	2
Benzoic acid	ug/kg	.000	3	7	76	120	3
Benzyl alcohol	ug/kg	.000	0	6	0	0	0
Butyl benzyl phthalate	ug/kg	.000	1	13	180	180	1
Carbazole	ug/kg	.000	0	13	0	0	0
Chrysene	ug/kg	.000	3	13	69	150	3
Di-n-butyl phthalate	ug/kg	.000	3	13	58	130	3
Di-n-octyl phthalate	ug/kg	.000	0	13	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	13	0	0	0
Dibenzofuran	ug/kg	.000	0	13	0	0	0
Diethyl phthalate	ug/kg	.000	0	13	0	0	0
Dimethyl phthalate	ug/kg	.000	0	13	0	0	0
Fluoranthene	ug/kg	.000	4	13	130	390	4
Fluorene	ug/kg	.000	0	13	0	0	0
Hexachlorobenzene	ug/kg	.000	0	13	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	13	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	13	0	0	0
Hexachloroethane	ug/kg	.000	0	13	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	1	13	74	74	1
Isophorone	ug/kg	.000	0	13	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	13	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	1	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	13	0	0	0
Naphthalene	ug/kg	.000	1	13	51	51	1
Nitrobenzene	ug/kg	.000	0	13	0	0	0
Pentachlorophenol	ug/kg	.000	0	14	0	0	0
Phenanthrene	ug/kg	.000	5	13	47	210	5
Phenol	ug/kg	.000	0	14	0	0	0
Pyrene	ug/kg	.000	4	13	100	230	4
Tributyl phosphate	ug/kg	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-59B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
bis(2-Chloroethoxy)methane	ug/kg	.000	0	13	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	13	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	13	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	3	13	45	1400	3
p-Chloroaniline	ug/kg	.000	0	13	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	14	0	0	0
4,4'-DDE	ug/kg	.000	0	14	0	0	0
4,4'-DDT	ug/kg	.000	0	14	0	0	0
Aldrin	ug/kg	.000	0	14	0	0	0
Aroclor-1016	ug/kg	.000	0	14	0	0	0
Aroclor-1221	ug/kg	.000	0	14	0	0	0
Aroclor-1232	ug/kg	.000	0	14	0	0	0
Aroclor-1242	ug/kg	.000	0	14	0	0	0
Aroclor-1248	ug/kg	.000	0	14	0	0	0
Aroclor-1254	ug/kg	.000	0	14	0	0	0
Aroclor-1260	ug/kg	.000	0	14	0	0	0
Dieldrin	ug/kg	.000	0	14	0	0	0
Endosulfan II	ug/kg	.000	0	14	0	0	0
Endosulfan sulfate	ug/kg	.000	0	14	0	0	0
Endosulfan-I	ug/kg	.000	0	14	0	0	0
Endrin	ug/kg	.000	0	14	0	0	0
Endrin aldehyde	ug/kg	.000	0	14	0	0	0
Endrin ketone	ug/kg	.000	0	14	0	0	0
Heptachlor	ug/kg	.000	0	14	0	0	0
Heptachlor epoxide	ug/kg	.000	0	14	0	0	0
Methoxychlor	ug/kg	.000	0	14	0	0	0
Toxaphene	ug/kg	.000	0	14	0	0	0
alpha-BHC	ug/kg	.000	0	14	0	0	0
alpha-Chlordane	ug/kg	.000	0	14	0	0	0
beta-BHC	ug/kg	.000	0	14	0	0	0
delta-BHC	ug/kg	.000	0	14	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	14	0	0	0
gamma-Chlordane	ug/kg	.000	0	14	0	0	0

[a]Surface source soil results are compared to surface soil background concentrations.

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TABLE 4-60A

ACTIVE FLYASH PILE
SUBSOIL[a] SOURCE (FLYASH)
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	140000.000	8	8	1570	17900	0
Antimony	mg/kg	18.370	0		0	0	0
Arsenic	mg/kg	140.970	8	8	9.1	66.5	0
Barium	mg/kg	4920.000	8	8	56.6	508	0
Beryllium	mg/kg	19.890	8	8	.65	4.6	0
Cadmium	mg/kg	20.640	0	8	0	0	0
Calcium	mg/kg	134687.460	8	8	826	4000	0
Chromium	mg/kg	218.000	8	8	4.4	25.8	0
Cobalt	mg/kg	199.350	7	8	5	18.8	0
Copper	mg/kg	382.160	8	8	24	66.1	0
Iron	mg/kg	148364.370	8	8	2260	31100	0
Lead	mg/kg	193.980	8	8	19.7	61.7	0
Magnesium	mg/kg	40000.000	8	8	150	4380	0
Manganese	mg/kg	1610.700	8	8	8.2	340	0
Mercury	mg/kg	.720	1	8	.16	.16	0
Molybdenum	mg/kg	269.590	8	8	4.3	18.8	0
Nickel	mg/kg	215.590	8	8	6.2	45.7	0
Selenium	mg/kg	73.000	7	8	.85	10.2	0
Silver	mg/kg	14.000	0	8	0	0	0
Vanadium	mg/kg	390.000	8	8	15	40.3	0
Zinc	mg/kg	677.250	8	8	18.9	117	0
Radionuclides							
PB-210	pCi/g	12.500	2	2	1.52	1.63	0
RA-226	pCi/g	5.250	10	10	2.53	6.22	1
RA-228	pCi/g	.000	10	10	2.23	5.32	10
RU-106	pCi/g	.000	0	10	0	0	0
TH-232	pCi/g	4.330	10	10	1.89	5.08	1
TH-TOTAL	mg/kg	330.000	10	10	17	45.8	0
U-238	pCi/g	6.070	12	12	3.15	12.6	7
U-TOTAL	mg/kg	19.000	10	10	9.08	31.3	5

[a]Subsoil source results are compared to flyash background concentrations.

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TABLE 4-60B

ACTIVE FLYASH PILE
SUBSOIL[a] SOURCE (FLYASH)
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Number of Concentration	Number of Detects	Range of Detects Analyses	Minimum	Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	140000.000	6	6	3570	7090	0
Antimony	mg/kg	18.370	1	6	2	2	0
Arsenic	mg/kg	140.970	6	6	16.9	87.8	0
Barium	mg/kg	4920.000	6	6	106	385	0
Beryllium	mg/kg	19.890	6	6	2.3	3.9	0
Cadmium	mg/kg	20.640	1	6	.79	.79	0
Calcium	mg/kg	134687.460	6	6	2230	6680	0
Chromium	mg/kg	218.000	6	6	8.4	15.1	0
Cobalt	mg/kg	199.350	6	6	10.7	21.8	0
Copper	mg/kg	382.160	6	6	40	59.8	0
Iron	mg/kg	148364.370	6	6	2480	5310	0
Lead	mg/kg	193.980	6	6	30.3	68.2	0
Magnesium	mg/kg	40000.000	6	6	335	1730	0
Manganese	mg/kg	1610.700	6	6	16.5	107	0
Mercury	mg/kg	.720	1	6	.19	.19	0
Molybdenum	mg/kg	269.590	3	6	5.2	9.7	0
Nickel	mg/kg	215.590	6	6	18.8	34.6	0
Selenium	mg/kg	73.000	5	6	2.5	11.4	0
Silver	mg/kg	14.000	0	6	0	0	0
Vanadium	mg/kg	390.000	6	6	30.5	42.6	0
Zinc	mg/kg	677.250	6	6	23.4	120	0
Radionuclides							
RA-226	pCi/g	5.250	6	6	2.96	4.02	0
TH-232	pCi/g	4.330	6	6	2.05	3.14	0
TH-TOTAL	mg/kg	330.000	6	6	18.9	28.9	0
U-238	pCi/g	6.070	6	6	3.27	7.12	1
U-TOTAL	mg/kg	19.000	6	6	9.34	22.1	1

[a]Subsoil source results are compared to flyash background concentrations.

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TABLE 4-61A

ACTIVE FLYASH PILE
SUBSURFACE SOIL[a] SOURCE
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	8	8	1570	17900	1
Arsenic	mg/kg	9.570	8	8	9.1	66.5	7
Barium	mg/kg	119.170	8	8	56.6	508	6
Beryllium	mg/kg	.620	8	8	.65	4.6	8
Cadmium	mg/kg	.910	0	8	0	0	0
Calcium	mg/kg	150000.000	8	8	826	4000	0
Chromium	mg/kg	20.680	8	8	4.4	25.8	1
Cobalt	mg/kg	15.750	7	8	5	18.8	2
Copper	mg/kg	20.030	8	8	24	66.1	8
Cyanide	mg/kg	.130	6	8	.17	.69	6
Iron	mg/kg	30700.000	8	8	2260	31100	1
Lead	mg/kg	15.580	8	8	19.7	61.7	8
Magnesium	mg/kg	42648.210	8	8	150	4380	0
Manganese	mg/kg	1300.000	8	8	8.2	340	0
Mercury	mg/kg	.290	1	8	.16	.16	0
Molybdenum	mg/kg	2.700	8	8	4.3	18.8	8
Nickel	mg/kg	34.350	8	8	6.2	45.7	1
Potassium	mg/kg	1979.990	8	8	326	1230	0
Selenium	mg/kg	.000	7	8	.85	10.2	7
Silver	mg/kg	.000	0	8	0	0	0
Sodium	mg/kg	285.000	8	8	92.7	312	1
Thallium	mg/kg	.490	6	8	.96	2.1	6
Vanadium	mg/kg	37.800	8	8	15	40.3	2
Zinc	mg/kg	72.580	8	8	18.9	117	4
RADIONUCLIDES							
CS-137	pCi/g	.000	0	10	0	0	0
NP-237	pCi/g	.000	0	6	0	0	0
PB-210	pCi/g	.810	2	2	1.52	1.63	2
PU-238	pCi/g	.000	0	10	0	0	0
PU-239/240	pCi/g	.000	0	4	0	0	0
RA-224	pCi/g	1.010	2	2	3.44	3.74	2
RA-226	pCi/g	1.470	10	10	2.53	6.22	10

See footnote at end of table

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TABLE 4-61A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RA-228	pCi/g	1.310	10	10	2.23	5.32	10
RU-106	pCi/g	.000	0	10	0	0	0
SR-90	pCi/g	.560	7	10	1.01	1.53	7
TC-99	pCi/g	.000	0	8	0	0	0
TH-228	pCi/g	1.330	10	10	2.91	5.79	10
TH-230	pCi/g	1.880	10	10	3	6.08	10
TH-232	pCi/g	1.260	10	10	1.89	5.08	10
TH-TOTAL	mg/kg	9.470	10	10	17	45.8	10
U-234	pCi/g	1.040	10	10	3.08	17.3	10
U-235/236	pCi/g	.150	2	10	3.42	4.12	2
U-238	pCi/g	1.120	12	12	3.15	12.6	12
U-TOTAL	mg/kg	3.400	10	10	9.08	31.3	10
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	8	9	28	1300	8
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	1	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	1	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	4	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	4	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	4	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	3	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	1	0	0	0
2-Butanone	ug/kg	.000	1	2	4	4	1
2-Hexanone	ug/kg	.000	0	1	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	2	3	11	25	2
Acetone	ug/kg	.000	0	4	0	0	0
Benzene	ug/kg	.000	1	2	2	2	1
Bromodichloromethane	ug/kg	.000	0	1	0	0	0
Bromoform	ug/kg	.000	0	1	0	0	0
Bromomethane	ug/kg	.000	0	4	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	1	0	0	0
Carbon disulfide	ug/kg	.000	1	5	7	7	1
Chlorobenzene	ug/kg	.000	0	1	0	0	0
Chloroethane	ug/kg	.000	0	4	0	0	0
Chloroform	ug/kg	.000	0	4	0	0	0
Chloromethane	ug/kg	.000	0	4	0	0	0
Dibromochloromethane	ug/kg	.000	0	1	0	0	0
Ethylbenzene	ug/kg	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-61A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Methylene chloride	ug/kg	.000	4	6	34	73	4
Styrene	ug/kg	.000	0	1	0	0	0
Tetrachloroethene	ug/kg	.000	0	1	0	0	0
Toluene	ug/kg	.000	5	6	13	130	5
Trichloroethene	ug/kg	.000	0	1	0	0	0
Vinyl Acetate	ug/kg	.000	0	1	0	0	0
Vinyl chloride	ug/kg	.000	0	4	0	0	0
Xylenes, Total	ug/kg	.000	0	1	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	10	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	10	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	10	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	10	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	10	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	10	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	10	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	10	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	10	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	10	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	10	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	10	0	0	0
2-Chlorophenol	ug/kg	.000	1	10	48	48	1
2-Methylnaphthalene	ug/kg	.000	3	10	49	160	3
2-Methylphenol	ug/kg	.000	0	10	0	0	0
2-Nitroaniline	ug/kg	.000	0	10	0	0	0
2-Nitrophenol	ug/kg	.000	0	10	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	10	0	0	0
3-Nitroaniline	ug/kg	.000	0	8	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	10	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	10	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	1	10	58	58	1
4-Chlorophenylphenyl ether	ug/kg	.000	0	10	0	0	0
4-Methylphenol	ug/kg	.000	0	10	0	0	0
4-Nitroaniline	ug/kg	.000	0	10	0	0	0
4-Nitrophenol	ug/kg	.000	1	10	48	48	1
Acenaphthene	ug/kg	.000	0	10	0	0	0
Acenaphthylene	ug/kg	.000	0	10	0	0	0

See footnote at end of table

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TABLE 4-61A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Anthracene	ug/kg	.000	0	10	0	0	0
Benzo(a)anthracene	ug/kg	.000	0	10	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	10	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	10	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	10	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	10	0	0	0
Benzoic acid	ug/kg	.000	4	10	52	73	4
Benzyl alcohol	ug/kg	.000	0	10	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	10	0	0	0
Carbazole	ug/kg	.000	0		0	0	0
Chrysene	ug/kg	.000	0	10	0	0	0
Di-n-butyl phthalate	ug/kg	.000	3	10	47	69	3
Di-n-octyl phthalate	ug/kg	.000	1	10	3000	3000	1
Dibenzo(a,h)anthracene	ug/kg	.000	0	10	0	0	0
Dibenzofuran	ug/kg	.000	0	10	0	0	0
Diethyl phthalate	ug/kg	.000	0	10	0	0	0
Dimethyl phthalate	ug/kg	.000	0	10	0	0	0
Fluoranthene	ug/kg	.000	0	10	0	0	0
Fluorene	ug/kg	.000	0	10	0	0	0
Hexachlorobenzene	ug/kg	.000	0	10	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	10	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	10	0	0	0
Hexachloroethane	ug/kg	.000	0	10	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	10	0	0	0
Isophorone	ug/kg	.000	0	10	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	10	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	10	0	0	0
Naphthalene	ug/kg	.000	2	10	52	82	2
Nitrobenzene	ug/kg	.000	0	10	0	0	0
Pentachlorophenol	ug/kg	.000	0	10	0	0	0
Phenanthrene	ug/kg	.000	3	10	43	72	3
Phenol	ug/kg	.000	1	10	58	58	1
Pyrene	ug/kg	.000	0	10	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	10	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	10	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	10	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	3	10	120	2700	3
p-Chloroaniline	ug/kg	.000	0	10	0	0	0

See footnote at end of table

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TABLE 4-61A
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	8	0	0	0
4,4'-DDE	ug/kg	.000	0	8	0	0	0
4,4'-DDT	ug/kg	.000	0	8	0	0	0
Aldrin	ug/kg	.000	0	8	0	0	0
Aroclor-1016	ug/kg	.000	0	8	0	0	0
Aroclor-1221	ug/kg	.000	0	8	0	0	0
Aroclor-1232	ug/kg	.000	0	8	0	0	0
Aroclor-1242	ug/kg	.000	0	8	0	0	0
Aroclor-1248	ug/kg	.000	0	8	0	0	0
Aroclor-1254	ug/kg	.000	0	8	0	0	0
Aroclor-1260	ug/kg	.000	0	8	0	0	0
Dieldrin	ug/kg	.000	0	8	0	0	0
Endosulfan II	ug/kg	.000	0	8	0	0	0
Endosulfan sulfate	ug/kg	.000	0	8	0	0	0
Endosulfan-I	ug/kg	.000	0	8	0	0	0
Endrin	ug/kg	.000	0	8	0	0	0
Endrin ketone	ug/kg	.000	0	8	0	0	0
Heptachlor	ug/kg	.000	0	8	0	0	0
Heptachlor epoxide	ug/kg	.000	0	8	0	0	0
Methoxychlor	ug/kg	.000	0	8	0	0	0
Toxaphene	ug/kg	.000	0	8	0	0	0
alpha-BHC	ug/kg	.000	0	8	0	0	0
alpha-Chlordane	ug/kg	.000	0	8	0	0	0
beta-BHC	ug/kg	.000	0	8	0	0	0
delta-BHC	ug/kg	.000	0	8	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	8	0	0	0
gamma-Chlordane	ug/kg	.000	0	8	0	0	0
GENERAL CHEMISTRY							
Total Organic Carbon	mg/kg	.000	4	4	63907	420620	4

[a]Flyash subsurface source results are compared to subsurface background concentrations.

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TABLE 4-61B

ACTIVE FLYASH PILE
SUBSURFACE SOIL[a] SOURCE
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	6	6	3570	7090	0
Antimony	mg/kg	.000	1	6	2	2	1
Arsenic	mg/kg	9.570	6	6	16.9	87.8	6
Barium	mg/kg	119.170	6	6	106	385	5
Beryllium	mg/kg	.620	6	6	2.3	3.9	6
Cadmium	mg/kg	.910	1	6	.79	.79	0
Calcium	mg/kg	150000.000	6	6	2230	6680	0
Chromium	mg/kg	20.680	6	6	8.4	15.1	0
Cobalt	mg/kg	15.750	6	6	10.7	21.8	2
Copper	mg/kg	20.030	6	6	40	59.8	6
Cyanide	mg/kg	.130	2	4	.33	.34	2
Iron	mg/kg	30700.000	6	6	2480	5310	0
Lead	mg/kg	15.580	6	6	30.3	68.2	6
Magnesium	mg/kg	42648.210	6	6	335	1730	0
Manganese	mg/kg	1300.000	6	6	16.5	107	0
Mercury	mg/kg	.290	1	6	.19	.19	0
Molybdenum	mg/kg	2.700	3	6	5.2	9.7	3
Nickel	mg/kg	34.350	6	6	18.8	34.6	1
Potassium	mg/kg	1979.990	6	6	601	1230	0
Selenium	mg/kg	.000	5	6	2.5	11.4	5
Silicon	mg/kg	1593.080	6	6	302	964	0
Silver	mg/kg	.000	0	6	0	0	0
Sodium	mg/kg	285.000	6	6	132	231	0
Thallium	mg/kg	.490	6	6	.75	3.1	6
Vanadium	mg/kg	37.800	6	6	30.5	42.6	3
Zinc	mg/kg	72.580	6	6	23.4	120	2
RADIONUCLIDES							
CS-137	pCi/g	.000	0	6	0	0	0
GROSS ALPHA	pCi/g	.000	6	6	35.7	62	6
GROSS BETA	pCi/g	.000	6	6	30.1	45.6	6
NP-237	pCi/g	.000	5	5	.059	.45	5
PU-238	pCi/g	.000	6	6	.062	.47	6
PU-239/240	pCi/g	.000	4	6	.017	.86	4
RA-226	pCi/g	1.470	6	6	2.96	4.02	6

See footnote at end of table

FER\CRU2RI\TDO\TAB4-61B.NEW\January16, 1995 7:34pm

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TABLE 4-61B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RA-228	pCi/g	1.310	6	6	2.23	3.69	6
RU-106	pCi/g	.000	0	6	0	0	0
SR-90	pCi/g	.560	2	6	.65	.705	2
TC-99	pCi/g	.000	0	6	0	0	0
TH-228	pCi/g	1.330	6	6	1.8	3.27	6
TH-230	pCi/g	1.880	6	6	2.4	5.52	6
TH-232	pCi/g	1.260	6	6	2.05	3.14	6
TH-TOTAL	mg/kg	9.470	6	6	18.9	28.9	6
U-234	pCi/g	1.040	6	6	3.04	5.02	6
U-235/236	pCi/g	.150	6	6	.12	.326	4
U-238	pCi/g	1.120	6	6	3.27	7.12	6
U-TOTAL	mg/kg	3.400	6	6	9.34	22.1	6
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	3	6	12	740	3
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	2	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	3	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	6	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	6	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	5	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	6	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	3	0	0	0
2-Butanone	ug/kg	.000	0	5	0	0	0
2-Hexanone	ug/kg	.000	1	4	10	10	1
4-Methyl-2-pentanone	ug/kg	.000	0	3	0	0	0
Acetone	ug/kg	.000	1	5	37	37	1
Benzene	ug/kg	.000	0	3	0	0	0
Bromodichloromethane	ug/kg	.000	0	3	0	0	0
Bromoform	ug/kg	.000	0	3	0	0	0
Bromomethane	ug/kg	.000	0	6	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	3	0	0	0
Carbon disulfide	ug/kg	.000	0	6	0	0	0
Chlorobenzene	ug/kg	.000	0	3	0	0	0
Chloroethane	ug/kg	.000	0	6	0	0	0
Chloroform	ug/kg	.000	0	5	0	0	0
Chloromethane	ug/kg	.000	0	6	0	0	0
Dibromochloromethane	ug/kg	.000	0	3	0	0	0
Ethylbenzene	ug/kg	.000	0	3	0	0	0
Methylene chloride	ug/kg	.000	0	6	0	0	0
Styrene	ug/kg	.000	0	3	0	0	0

See footnote at end of table

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TABLE 4-61B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Tetrachloroethene	ug/kg	.000	0	3	0	0	0
Toluene	ug/kg	.000	5	6	12	440	5
Trichloroethene	ug/kg	.000	0	3	0	0	0
Vinyl Acetate	ug/kg	.000	0	2	0	0	0
Vinyl chloride	ug/kg	.000	0	6	0	0	0
Xylenes, Total	ug/kg	.000	1	3	53	53	1
cis-1,3-Dichloropropene	ug/kg	.000	0	3	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	3	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	6	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	6	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	6	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	6	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	6	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	6	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	6	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	6	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	2	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	6	0	0	0
2-Chlorophenol	ug/kg	.000	0	6	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	6	0	0	0
2-Methylphenol	ug/kg	.000	0	6	0	0	0
2-Nitroaniline	ug/kg	.000	0	6	0	0	0
2-Nitrophenol	ug/kg	.000	0	6	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	6	0	0	0
3-Nitroaniline	ug/kg	.000	0	6	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	6	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	6	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	6	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	6	0	0	0
4-Methylphenol	ug/kg	.000	0	6	0	0	0
4-Nitroaniline	ug/kg	.000	0	6	0	0	0
4-Nitrophenol	ug/kg	.000	0	6	0	0	0
Acenaphthene	ug/kg	.000	0	6	0	0	0
Acenaphthylene	ug/kg	.000	0	6	0	0	0
Anthracene	ug/kg	.000	0	6	0	0	0

See footnote at end of table

TABLE 4-61B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Benzo(a)anthracene	ug/kg	.000	0	6	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	6	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	6	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	6	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	6	0	0	0
Benzoic acid	ug/kg	.000	3	6	2	100	3
Benzyl alcohol	ug/kg	.000	0	4	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	6	0	0	0
Carbazole	ug/kg	.000	0	6	0	0	0
Chrysene	ug/kg	.000	0	6	0	0	0
Di-n-butyl phthalate	ug/kg	.000	1	6	86	86	1
Di-n-octyl phthalate	ug/kg	.000	0	6	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	6	0	0	0
Dibenzofuran	ug/kg	.000	0	6	0	0	0
Diethyl phthalate	ug/kg	.000	0	6	0	0	0
Dimethyl phthalate	ug/kg	.000	0	6	0	0	0
Fluoranthene	ug/kg	.000	0	6	0	0	0
Fluorene	ug/kg	.000	0	6	0	0	0
Hexachlorobenzene	ug/kg	.000	0	6	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	6	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	6	0	0	0
Hexachloroethane	ug/kg	.000	0	6	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	6	0	0	0
Isophorone	ug/kg	.000	0	6	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	6	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	6	0	0	0
Naphthalene	ug/kg	.000	0	6	0	0	0
Nitrobenzene	ug/kg	.000	0	6	0	0	0
Pentachlorophenol	ug/kg	.000	1	6	56	56	1
Phenanthrene	ug/kg	.000	0	6	0	0	0
Phenol	ug/kg	.000	0	6	0	0	0
Pyrene	ug/kg	.000	0	6	0	0	0
Tributyl phosphate	ug/kg	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	6	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	6	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	6	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	3	6	48	780	3
p-Chloroaniline	ug/kg	.000	0	6	0	0	0

See footnote at end of table

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TABLE 4-61B
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	6	0	0	0
4,4'-DDE	ug/kg	.000	0	6	0	0	0
4,4'-DDT	ug/kg	.000	0	6	0	0	0
Aldrin	ug/kg	.000	0	6	0	0	0
Aroclor-1016	ug/kg	.000	0	6	0	0	0
Aroclor-1221	ug/kg	.000	0	6	0	0	0
Aroclor-1232	ug/kg	.000	0	6	0	0	0
Aroclor-1242	ug/kg	.000	0	6	0	0	0
Aroclor-1248	ug/kg	.000	0	6	0	0	0
Aroclor-1254	ug/kg	.000	0	6	0	0	0
Aroclor-1260	ug/kg	.000	0	6	0	0	0
Dieldrin	ug/kg	.000	0	6	0	0	0
Endosulfan II	ug/kg	.000	0	6	0	0	0
Endosulfan sulfate	ug/kg	.000	0	6	0	0	0
Endosulfan-I	ug/kg	.000	0	6	0	0	0
Endrin	ug/kg	.000	0	6	0	0	0
Endrin aldehyde	ug/kg	.000	0	6	0	0	0
Endrin ketone	ug/kg	.000	0	6	0	0	0
Heptachlor	ug/kg	.000	0	6	0	0	0
Heptachlor epoxide	ug/kg	.000	0	6	0	0	0
Methoxychlor	ug/kg	.000	0	6	0	0	0
Toxaphene	ug/kg	.000	0	6	0	0	0
alpha-BHC	ug/kg	.000	0	6	0	0	0
alpha-Chlordane	ug/kg	.000	0	6	0	0	0
beta-BHC	ug/kg	.000	0	6	0	0	0
delta-BHC	ug/kg	.000	0	6	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	6	0	0	0
gamma-Chlordane	ug/kg	.000	0	6	0	0	0

[a]Flyah subsurface source results are compared to subsurface background concentrations.

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TABLE 4-62

ACTIVE FLYASH PILE
SUBSURFACE SOIL NONSOURCE
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	3	3	2440	6360	0
Antimony	mg/kg	.000	3	3	9	31.1	3
Arsenic	mg/kg	9.570	3	3	4.6	9.1	0
Barium	mg/kg	119.170	3	3	16.7	63.6	0
Beryllium	mg/kg	.620	3	3	.47	.75	2
Cadmium	mg/kg	.910	3	3	1.3	5.2	3
Calcium	mg/kg	150000.000	3	3	26200	155000	1
Chromium	mg/kg	20.680	3	3	17.4	26.8	1
Cobalt	mg/kg	15.750	3	3	6.1	10.2	0
Copper	mg/kg	20.030	3	3	14.3	21.3	1
Cyanide	mg/kg	.130	0	3	0	0	0
Iron	mg/kg	30700.000	3	3	9840	16700	0
Lead	mg/kg	15.580	3	3	5.8	11.3	0
Magnesium	mg/kg	42648.210	3	3	9600	37200	0
Manganese	mg/kg	1300.000	3	3	223	523	0
Mercury	mg/kg	.290	0	3	0	0	0
Molybdenum	mg/kg	2.700	3	3	8.7	13.2	3
Nickel	mg/kg	34.350	3	3	13.9	25.7	0
Potassium	mg/kg	1979.990	3	3	242	1220	0
Selenium	mg/kg	.000	1	3	2.3	2.3	1
Silver	mg/kg	.000	3	3	6.6	18.5	3
Sodium	mg/kg	285.000	3	3	119	247	0
Thallium	mg/kg	.490	0	3	0	0	0
Vanadium	mg/kg	37.800	3	3	16.8	24	0
Zinc	mg/kg	72.580	3	3	25.3	43	0
RADIONUCLIDES							
CS-137	pCi/g	.000	0	8	0	0	0
NP-237	pCi/g	.000	0	6	0	0	0
PU-238	pCi/g	.000	0	9	0	0	0
PU-239/240	pCi/g	.000	0	7	0	0	0
RA-226	pCi/g	1.470	7	8	.4	1.45	0
RA-228	pCi/g	1.310	6	7	.537	1.2	0
RU-106	pCi/g	.000	0	8	0	0	0
SR-90	pCi/g	.560	5	7	.5	3.61	4
TC-99	pCi/g	.000	0	6	0	0	0
TH-228	pCi/g	1.330	7	9	.813	2.09	3
TH-230	pCi/g	1.880	9	9	.7	1.97	2

TABLE 4-62
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
TH-232	pCi/g	1.260	7	9	.52	1.2	0
TH-TOTAL	mg/kg	9.470	5	5	3.38	8.71	0
U-234	pCi/g	1.040	7	9	.92	1.27	1
U-235/236	pCi/g	.150	0	9	0	0	0
U-238	pCi/g	1.120	7	9	.754	2.4	2
U-TOTAL	mg/kg	3.400	11	12	2	8	7
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	1	3	25	25	1
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	3	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	3	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	3	0	0	0
1,1-Dichloroethene	ug/kg	.000	1	3	2	2	1
1,2-Dichloroethane	ug/kg	.000	0	3	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	3	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	3	0	0	0
2-Butanone	ug/kg	.000	1	3	3	3	1
2-Hexanone	ug/kg	.000	0	3	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	3	0	0	0
Acetone	ug/kg	.000	0	3	0	0	0
Benzene	ug/kg	.000	0	3	0	0	0
Bromodichloromethane	ug/kg	.000	0	3	0	0	0
Bromoform	ug/kg	.000	0	3	0	0	0
Bromomethane	ug/kg	.000	0	3	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	3	0	0	0
Carbon disulfide	ug/kg	.000	0	3	0	0	0
Chlorobenzene	ug/kg	.000	0	3	0	0	0
Chloroethane	ug/kg	.000	0	3	0	0	0
Chloroform	ug/kg	.000	0	3	0	0	0
Chloromethane	ug/kg	.000	0	3	0	0	0
Dibromochloromethane	ug/kg	.000	0	3	0	0	0
Ethylbenzene	ug/kg	.000	0	3	0	0	0
Methylene chloride	ug/kg	.000	0	3	0	0	0
Styrene	ug/kg	.000	0	3	0	0	0
Tetrachloroethene	ug/kg	.000	0	3	0	0	0
Toluene	ug/kg	.000	0	3	0	0	0
Trichloroethene	ug/kg	.000	0	3	0	0	0
Vinyl Acetate	ug/kg	.000	0	3	0	0	0
Vinyl chloride	ug/kg	.000	0	3	0	0	0
Xylenes, Total	ug/kg	.000	0	3	0	0	0

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TABLE 4-62
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
cis-1,3-Dichloropropene	ug/kg	.000	0	3	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	3	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	3	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	3	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	3	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	3	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	3	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	3	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	3	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	3	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	3	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	3	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	3	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	3	0	0	0
2-Chlorophenol	ug/kg	.000	0	3	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	3	0	0	0
2-Methylphenol	ug/kg	.000	0	3	0	0	0
2-Nitroaniline	ug/kg	.000	0	3	0	0	0
2-Nitrophenol	ug/kg	.000	0	3	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	3	0	0	0
3-Nitroaniline	ug/kg	.000	0	2	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	3	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	3	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	3	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	3	0	0	0
4-Methylphenol	ug/kg	.000	0	3	0	0	0
4-Nitroaniline	ug/kg	.000	0	2	0	0	0
4-Nitrophenol	ug/kg	.000	0	3	0	0	0
Acenaphthene	ug/kg	.000	0	3	0	0	0
Acenaphthylene	ug/kg	.000	0	3	0	0	0
Anthracene	ug/kg	.000	0	3	0	0	0
Benzo(a)anthracene	ug/kg	.000	0	3	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	3	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	3	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	3	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	3	0	0	0
Benzoic acid	ug/kg	.000	0	3	0	0	0
Benzyl alcohol	ug/kg	.000	0	3	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	3	0	0	0
Chrysene	ug/kg	.000	0	3	0	0	0

000646

TABLE 4-62
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Di-n-butyl phthalate	ug/kg	.000	0	3	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	3	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	3	0	0	0
Dibenzofuran	ug/kg	.000	0	3	0	0	0
Diethyl phthalate	ug/kg	.000	0	3	0	0	0
Dimethyl phthalate	ug/kg	.000	0	3	0	0	0
Fluoranthene	ug/kg	.000	0	3	0	0	0
Fluorene	ug/kg	.000	0	3	0	0	0
Hexachlorobenzene	ug/kg	.000	0	3	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	3	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	3	0	0	0
Hexachloroethane	ug/kg	.000	0	3	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	3	0	0	0
Isophorone	ug/kg	.000	0	3	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	3	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	3	0	0	0
Naphthalene	ug/kg	.000	0	3	0	0	0
Nitrobenzene	ug/kg	.000	0	3	0	0	0
Pentachlorophenol	ug/kg	.000	0	3	0	0	0
Phenanthrene	ug/kg	.000	0	3	0	0	0
Phenol	ug/kg	.000	0	3	0	0	0
Pyrene	ug/kg	.000	0	3	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	3	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	3	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	3	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	1	3	42	42	1
p-Chloroaniline	ug/kg	.000	0	3	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	3	0	0	0
4,4'-DDE	ug/kg	.000	0	3	0	0	0
4,4'-DDT	ug/kg	.000	0	3	0	0	0
Aldrin	ug/kg	.000	0	3	0	0	0
Aroclor-1016	ug/kg	.000	0	3	0	0	0
Aroclor-1221	ug/kg	.000	0	3	0	0	0
Aroclor-1232	ug/kg	.000	0	3	0	0	0
Aroclor-1242	ug/kg	.000	0	3	0	0	0
Aroclor-1248	ug/kg	.000	0	3	0	0	0
Aroclor-1254	ug/kg	.000	0	3	0	0	0
Aroclor-1260	ug/kg	.000	0	3	0	0	0
Dieldrin	ug/kg	.000	0	3	0	0	0
Endosulfan II	ug/kg	.000	0	3	0	0	0

000672

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TABLE 4-62
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Endosulfan sulfate	ug/kg	.000	0	3	0	0	0
Endosulfan-I	ug/kg	.000	0	3	0	0	0
Endrin	ug/kg	.000	0	3	0	0	0
Endrin ketone	ug/kg	.000	0	3	0	0	0
Heptachlor	ug/kg	.000	0	3	0	0	0
Heptachlor epoxide	ug/kg	.000	0	3	0	0	0
Methoxychlor	ug/kg	.000	0	3	0	0	0
Toxaphene	ug/kg	.000	0	3	0	0	0
alpha-BHC	ug/kg	.000	0	3	0	0	0
alpha-Chlordane	ug/kg	.000	0	3	0	0	0
beta-BHC	ug/kg	.000	0	3	0	0	0
delta-BHC	ug/kg	.000	0	3	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	3	0	0	0
gamma-Chlordane	ug/kg	.000	0	3	0	0	0
GENERAL CHEMISTRY							
Total Organic Carbon	mg/kg	.000	1	1	12331	12331	1

TABLE 4-63

ACTIVE FLYASH PILE
SUBSURFACE SOIL NONSOURCE
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	16063.970	6	6	7610	25500	2
Antimony	mg/kg	.000	0	6	0	0	0
Arsenic	mg/kg	9.570	6	6	4.1	18.7	4
Barium	mg/kg	119.170	6	6	62.1	195	2
Beryllium	mg/kg	.620	6	6	.55	1.4	5
Cadmium	mg/kg	.910	4	6	.8	1.2	3
Calcium	mg/kg	150000.000	6	6	5870	106000	0
Chromium	mg/kg	20.680	6	6	11	26.1	2
Cobalt	mg/kg	15.750	6	6	7	13.7	0
Copper	mg/kg	20.030	6	6	14.9	32.3	3
Cyanide	mg/kg	.130	0	4	0	0	0
Iron	mg/kg	30700.000	6	6	15500	44800	2
Lead	mg/kg	15.580	6	6	8.6	31.1	3
Magnesium	mg/kg	42648.210	6	6	4190	25400	0
Manganese	mg/kg	1300.000	6	6	258	1900	1
Mercury	mg/kg	.290	0	6	0	0	0
Molybdenum	mg/kg	2.700	4	6	1.3	13.5	2
Nickel	mg/kg	34.350	6	6	16.8	36.7	1
Potassium	mg/kg	1979.990	6	6	935	2380	3
Selenium	mg/kg	.000	1	6	3.7	3.7	1
Silicon	mg/kg	1593.080	6	6	609	1210	0
Silver	mg/kg	.000	2	6	10.7	14.1	2
Sodium	mg/kg	285.000	6	6	128	227	0
Thallium	mg/kg	.490	3	6	.28	.47	0
Vanadium	mg/kg	37.800	6	6	18	64.5	2
Zinc	mg/kg	72.580	6	6	42.7	89.9	1
RADIONUCLIDES							
CS-137	pCi/g	.000	0	6	0	0	0
GROSS ALPHA	pCi/g	.000	6	6	9.43	20.3	6
GROSS BETA	pCi/g	.000	6	6	20.7	33.5	6
NP-237	pCi/g	.000	6	6	.052	.4	6
PU-238	pCi/g	.000	3	6	.031	.085	3
PU-239/240	pCi/g	.000	2	6	.027	.06	2
RA-226	pCi/g	1.470	6	6	.912	1.73	1
RA-228	pCi/g	1.310	6	6	.748	1.33	1

TABLE 4-63
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RU-106	pCi/g	.000	0	6	0	0	0
SR-90	pCi/g	.560	0	6	0	0	0
TC-99	pCi/g	.000	0	6	0	0	0
TH-228	pCi/g	1.330	6	6	.628	1.37	1
TH-230	pCi/g	1.880	6	6	1.01	3.6	2
TH-232	pCi/g	1.260	6	6	.677	1.35	1
TH-TOTAL	mg/kg	9.470	6	6	6.23	12.4	1
U-234	pCi/g	1.040	6	6	.772	1.01	0
U-235/236	pCi/g	.150	6	6	.03	.069	0
U-238	pCi/g	1.120	6	6	.8	1.21	3
U-TOTAL	mg/kg	3.400	6	6	3.3	4.534	4
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	2	6	4	5600	2
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	5	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	6	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	6	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	6	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	6	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	6	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	6	0	0	0
2-Butanone	ug/kg	.000	0	5	0	0	0
2-Hexanone	ug/kg	.000	0	6	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	6	0	0	0
Acetone	ug/kg	.000	0	4	0	0	0
Benzene	ug/kg	.000	0	6	0	0	0
Bromodichloromethane	ug/kg	.000	0	6	0	0	0
Bromoform	ug/kg	.000	0	6	0	0	0
Bromomethane	ug/kg	.000	0	6	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	6	0	0	0
Carbon disulfide	ug/kg	.000	0	6	0	0	0
Chlorobenzene	ug/kg	.000	0	6	0	0	0
Chloroethane	ug/kg	.000	0	6	0	0	0
Chloroform	ug/kg	.000	0	6	0	0	0
Chloromethane	ug/kg	.000	0	6	0	0	0
Dibromochloromethane	ug/kg	.000	0	6	0	0	0
Ethylbenzene	ug/kg	.000	0	6	0	0	0
Methylene chloride	ug/kg	.000	1	6	25	25	1
Styrene	ug/kg	.000	0	6	0	0	0
Tetrachloroethene	ug/kg	.000	0	6	0	0	0
Toluene	ug/kg	.000	1	6	2	2	1
Trichloroethene	ug/kg	.000	0	6	0	0	0

TABLE 4-63
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Vinyl Acetate	ug/kg	.000	0	4	0	0	0
Vinyl chloride	ug/kg	.000	0	6	0	0	0
Xylenes, Total	ug/kg	.000	0	6	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	6	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	6	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	6	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	6	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	6	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	6	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	6	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	6	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	6	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	6	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	6	0	0	0
2-Benzyl-4-chlorophenol	ug/kg	.000	0	2	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	6	0	0	0
2-Chlorophenol	ug/kg	.000	0	6	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	6	0	0	0
2-Methylphenol	ug/kg	.000	0	6	0	0	0
2-Nitroaniline	ug/kg	.000	0	6	0	0	0
2-Nitrophenol	ug/kg	.000	0	6	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	6	0	0	0
3-Nitroaniline	ug/kg	.000	0	6	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	6	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	6	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	6	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	6	0	0	0
4-Methylphenol	ug/kg	.000	0	6	0	0	0
4-Nitroaniline	ug/kg	.000	0	6	0	0	0
4-Nitrophenol	ug/kg	.000	0	6	0	0	0
Acenaphthene	ug/kg	.000	0	6	0	0	0
Acenaphthylene	ug/kg	.000	0	6	0	0	0
Anthracene	ug/kg	.000	0	6	0	0	0
Benzo(a)anthracene	ug/kg	.000	0	6	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	6	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	6	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	6	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	6	0	0	0
Benzoic acid	ug/kg	.000	1	6	56	56	1

TABLE 4-63
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Benzyl alcohol	ug/kg	.000	0	4	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	6	0	0	0
Carbazole	ug/kg	.000	0	6	0	0	0
Chrysene	ug/kg	.000	0	6	0	0	0
Di-n-butyl phthalate	ug/kg	.000	0	6	0	0	0
Di-n-octyl phthalate	ug/kg	.000	1	6	46	46	1
Dibenzo(a,h)anthracene	ug/kg	.000	0	6	0	0	0
Dibenzofuran	ug/kg	.000	0	6	0	0	0
Diethyl phthalate	ug/kg	.000	0	6	0	0	0
Dimethyl phthalate	ug/kg	.000	0	6	0	0	0
Fluoranthene	ug/kg	.000	0	6	0	0	0
Fluorene	ug/kg	.000	0	6	0	0	0
Hexachlorobenzene	ug/kg	.000	0	6	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	6	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	6	0	0	0
Hexachloroethane	ug/kg	.000	0	6	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	6	0	0	0
Isophorone	ug/kg	.000	0	6	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	6	0	0	0
N-Nitrosodimethylamine	ug/kg	.000	0	2	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	6	0	0	0
Naphthalene	ug/kg	.000	0	6	0	0	0
Nitrobenzene	ug/kg	.000	0	6	0	0	0
Pentachlorophenol	ug/kg	.000	0	6	0	0	0
Phenanthrene	ug/kg	.000	0	6	0	0	0
Phenol	ug/kg	.000	0	6	0	0	0
Pyrene	ug/kg	.000	0	6	0	0	0
Tributyl phosphate	ug/kg	.000	0	2	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	6	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	6	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	6	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	2	6	98	4200	2
p-Chloroaniline	ug/kg	.000	0	6	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	6	0	0	0
4,4'-DDE	ug/kg	.000	0	6	0	0	0
4,4'-DDT	ug/kg	.000	0	6	0	0	0
Aldrin	ug/kg	.000	0	6	0	0	0
Aroclor-1016	ug/kg	.000	0	6	0	0	0
Aroclor-1221	ug/kg	.000	0	6	0	0	0
Aroclor-1232	ug/kg	.000	0	6	0	0	0
Aroclor-1242	ug/kg	.000	0	6	0	0	0

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TABLE 4-63
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Aroclor-1248	ug/kg	.000	0	6	0	0	0
Aroclor-1254	ug/kg	.000	0	6	0	0	0
Aroclor-1260	ug/kg	.000	0	6	0	0	0
Dieldrin	ug/kg	.000	0	6	0	0	0
Endosulfan II	ug/kg	.000	0	6	0	0	0
Endosulfan sulfate	ug/kg	.000	0	6	0	0	0
Endosulfan-I	ug/kg	.000	0	6	0	0	0
Endrin	ug/kg	.000	0	6	0	0	0
Endrin aldehyde	ug/kg	.000	0	6	0	0	0
Endrin ketone	ug/kg	.000	0	6	0	0	0
Heptachlor	ug/kg	.000	0	6	0	0	0
Heptachlor epoxide	ug/kg	.000	0	6	0	0	0
Methoxychlor	ug/kg	.000	0	6	0	0	0
Toxaphene	ug/kg	.000	0	6	0	0	0
alpha-BHC	ug/kg	.000	0	6	0	0	0
alpha-Chlordane	ug/kg	.000	0	6	0	0	0
beta-BHC	ug/kg	.000	0	6	0	0	0
delta-BHC	ug/kg	.000	0	6	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	6	0	0	0
gamma-Chlordane	ug/kg	.000	0	6	0	0	0

000653

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TABLE 4-64

ACTIVE FLYASH PILE TCLP RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard[a] (mg/L)	Location/Sample Number and Result (mg/L)			
			1979	1980	1980	1981
			112093	112131	112146	112168
1,1-Dichloroethene	0.7		<0.005	<0.005	<0.005	<0.005
1,2-Dichloroethane	0.5		<0.005	<0.005	<0.005	<0.005
1,4-Dichlorobenzene	7.5		<0.05	<0.05	<0.05	<0.02
2,4-D	10.0		<0.12	<0.12	<0.12	<0.01
2,4-Dinitrotoluene	0.13		<0.05	<0.05	<0.05	<0.02
2,4,5-TP (Silvex)	1.0		<0.017	<0.017	<0.017	<0.0018
2,4,5-Trichlorophenol	400.0		<0.05	<0.05	<0.05	<0.01
2,4,6-Trichlorophenol	2.0		<0.05	<0.05	<0.05	<0.02
Arsenic	5.0	1.5	rejected[b]	<0.098	<0.0705	<0.05
Barium	100.0	30.0	1.25	0.563	<0.0456	0.299
Benzene	0.5		<0.005	<0.005	<0.005	<0.005
Cadmium	1.0	0.3	<0.0021	<0.0021	<0.0021	<0.005
Carbon Tetrachloride	0.5		<0.005	<0.005	<0.005	<0.005
Chlordane	0.03		<0.0014	<0.0014	<0.0014	<0.0005
Chlorobenzene	100.0		<0.005	<0.005	<0.005	<0.005
Chloroform	6.0		<0.005	<0.005	<0.005	<0.005
Chromium	5.0	1.5	<0.0031	<0.0031	<0.0031	<0.01
Copper			<0.0103	<0.0212	<0.0017	<0.001
Endrin	0.02		<0.0006	<0.0006	<0.0006	<0.0001
Heptachlor	0.008		<0.0003	<0.0003	<0.0003	<0.0001
Heptachlor epoxide	0.008		<0.0083	<0.0083	<0.0083	<0.0001

See footnote at end of table

TABLE 4-64
(Continued)

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard[a] (mg/L)	Location/Sample Number and Result (mg/L)			
			1979	1980	1980	1981
			112093	112131	112146	112168
Hexachlorobenzene	0.13		<0.05	<0.05	<0.05	<0.02
Hexachlorobutadiene	0.5		<0.05	<0.05	<0.05	<0.02
Hexachloroethane	3.0		<0.05	<0.05	<0.05	<0.02
Iron			<0.0019	<0.0514	<0.0255	<0.0557
Lead	5.0	1.5	rejected	<0.0155	<0.0155	<0.04
Lindane	0.4		<0.0004	<0.0004	<0.0004	<0.0001
Manganese			0.0195	0.0688	0.263	0.0131
Mercury	0.2	0.06	<0.0002	<0.0002	<0.0002	<0.0002
Methoxychlor	10.0		<0.018	<0.018	<0.018	<0.0005
Nitrobenzene	2.0		<0.05	<0.05	<0.05	<0.02
Pentachlorophenol	100.0		<0.25	<0.25	<0.25	<0.1
Pyridine	5.0		<0.25	<0.25	<0.25	<0.2
Selenium	1.0	0.3	rejected	<0.0296	<0.0296	<0.08
Silver	5.0		<0.0022	<0.0022	<0.0022	rejected
Tetrachloroethene	0.7		<0.005	<0.005	<0.005	<0.005
Toxaphene	0.5		<0.024	<0.024	<0.024	<0.001
Trichloroethene	0.5		<0.005	<0.005	<0.005	<0.005
Vinyl chloride	0.2		<0.01	<0.01	<0.01	<0.01
Zinc			rejected	1.33	rejected	0.184

Notes: A box surrounding a number indicates a result or detection limit that is above an EPA or OEPA standard.
[a]These standards are from OEPA Policy 4.07 "Design Criteria: Disposal of Non-Toxic Flyash, Bottom Ash, Foundry Sand, and other Exempted Solid Wastes."
[b]"Rejected" means that the sample could not be validated.

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TABLE 4-65

ACTIVE FLYASH PILE
SURFACE WATER[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Arsenic		mg/L	.000	1	2	.0455	.0455	1
Barium		mg/L	.000	2	2	.0426	.0633	2
Cadmium		mg/L	.000	0	2	0	0	0
Calcium		mg/L	.000	2	2	73	80.8	2
Chromium		mg/L	.000	2	2	.0155	.0224	2
Copper		mg/L	.000	0	2	0	0	0
Iron		mg/L	.000	2	2	.0475	.262	2
Lead		mg/L	.000	1	2	.0362	.0362	1
Magnesium		mg/L	.000	2	2	155	268	2
Manganese		mg/L	.000	2	2	.0023	.158	2
Mercury		mg/L	.000	2	2	.00022	.00099	2
Molybdenum		mg/L	.000	2	2	.0062	.0183	2
Nickel		mg/L	.000	2	2	.0122	.0149	2
Potassium		mg/L	.000	2	2	2.42	2.42	2
Selenium		mg/L	.000	0	0	0	0	0
Silver		mg/L	.000	0	2	0	0	0
Sodium		mg/L	.000	2	2	69.4	87.8	2
RADIONUCLIDES								
GROSS ALPHA	UNFL	pCi/L	.000	0		0	0	0
GROSS BETA	UNFL	pCi/L	.000	0		0	0	0
RA-226	UNFL	pCi/L	.000	0	2	0	0	0
RA-228	UNFL	pCi/L	.000	0	2	0	0	0
U-TOTAL	UNFL	ug/L	.000	2	2	14	24	2
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	.000	2	2	.152	.188	2
Chloride	UNFL	mg/L	.000	2	2	8	15	2
Fluoride	UNFL	mg/L	.000	2	2	.68	.8	2
Nitrate	UNFL	mg/L	.000	2	2	.12	.44	2
Phenols	UNFL	mg/L	.000	0	2	0	0	0
Phosphorus	UNFL	mg/L	.000	2	2	.827	1.1	2
Sulfate	UNFL	mg/L	.000	2	2	253	327	2
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	2	2	1.91	2.03	2
Total Organic Halides	UNFL	mg/L	.000	0	2	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.000	2	2	1.72	1.88	2

[a]Filtered radionuclides, orangics, general chemistry, etc. are not included because background concentrations were not available.

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above background soil concentrations. For Phase II fourteen metals (Antimony was not detected during Phase I; Aluminum, Chromium, Nickel, and Silver were detected for Phase I but not Phase II), isotopes of six elements (neptunium-237, plutonium-238, and plutonium-239/240 were not detected during Phase I; radium-224 and radium-228 were detected during Phase I but not Phase II), and nine organic compounds (2-hexanone, total xylenes, and pentachlorophenol were not detected during Phase I; 2-Butanone, Benzene, Carbon Disulfide, Methylene Chloride, 2-Chlorophenol, 2-methylnapthalene, 4-chloro-3-methylphenol, 4-nitrophenol, di-n-octyl phthalate, and phenanthrene were detected above background during Phase I but not Phase II) were detected above soil background.

Subsurface soil samples were collected around and below the flyash pile for Phase I and Phase II. The results were compared to background soil results and are summarized in Tables 4-62 and 4-63. During Phase I nine metals, isotopes of three elements, and four organic compounds [bis(2-Ethylhexyl) phthalate, 1,1,1-Trichloroethane, 1,1-Dichloroethene, and 2-Butanone] were detected above background. During Phase II seventeen metals, isotopes of five elements, and six organic compounds [1,1,1-Trichloroethane, Methylene chloride, Toluene, benzoic acid, Di-n-Octylphalate, and bis(2-Ethylhexyl) phthalate] were detected above background.

A comparison between surface (flyash) source samples and subsurface flyash and soil samples indicates the following:

- Pyrene, chrysene, benzo (anthracene, pyrene, fluoranthene), and fluoranthene were common to surface samples but were not detected in subsurface samples.
- Benzoic acid, toluene, naphthalene, 1,1,1-trichlorethane, and bis(2-Ethylhexyl)phthalate were detected in surface and subsurface samples.
- 1,1-dichloroethane, chloro-phenols, and xylene were detected in subsurface samples but not in surface samples.
- The concentration of all organics decrease below the flyash/soil interface, from approximately 10 to 17 feet deep Organics appear to be present throughout the flyash from the surface to about 10 feet deep.

The distribution suggests that the organics were not deposited at a single location with horizontal and vertical migration. A more fitting scenario is deposition of organics in dilute mixtures at several times during construction.

Phase I and Phase II subsurface soil data were compared to CIS and ES data (Table G-7 and G-8). Analytes detected in these preliminary studies were also detected in Phase I and Phase II within the same order of magnitude.

Results of radionuclide concentrations above background are presented on Figure 4-29 (see Volume 2, Oversized Figures). Concentrations of radionuclides are similar between flyash samples collected within the pile and are elevated with respect to soil concentrations. A comparison between the concentration of total uranium in flyash and the concentration in native soil indicates that impacts of the flyash on the soil have been slight if at all. For example, total uranium in Boring No. 1726 flyash (28.1 μg/g at 18.5 feet) is greater than the native soil concentration (3.08 μg/g at 21 feet deep), and flyash in Boring No. 1979 (22.1 μg/g at 22 feet deep) contrasts with the native soil concentration (4.49 μg/g at 27.5 feet deep). Background uranium for subsurface soil is 2.54 μg/g.

Four samples were collected for hazardous waste determination by TCLP analyses. Data from these analyses are provided in Appendix G-12 and are summarized in Table 4-64. Zinc was detected twice (Sample 112168 and Sample 112093), barium was detected three times (all but Sample 112146), and manganese was detected in all four samples. None of the concentrations of detected analytes exceeded the RCRA standard defining hazardous waste. Heptachlor epoxide detection limits exceeded the regulatory limit, but this compound was not detected in samples that were analyzed for total concentrations.

4.6.3 Surface Water and Sediment

There are no perennial sources of surface water within the battery limits of the Active Flyash Pile, and sampling was completed on an as-possible basis when flow was observed. The drainage system within the battery limits of the Active Flyash Pile was altered by to improve drainage during the interval between the Phase I and Phase II sampling events. Present day surface water drainage from the Active Flyash Pile is rapid after rain events, and there was one surface water available for sampling at location (AFP-SW-02) during the Phase II field sampling program. Surface water data are presented on Figure 4-28 (see Volume 2, Oversized Figures).

Analytical results for surface water were not compared against background concentrations since there is no background concentration determined for surface water. Tables of detected constituent concentrations are provided in Appendix G in Table G-2H and Table G-2I. A summary of analytes in

surface water samples is presented on Table 4-65 and Table 4-66 and shown on Figure 4-28. Two surface water sampling locations were identified for off-site analyses during Phase I adjacent to the road at the west edge of the Active Flyash Pile. Total uranium was detected in both samples above background, and concentrations fluctuated widely in multiple samples collected over six months as shown below.

Total Uranium in Phase I Surface Water Samples			
Location	Date	Filtered	Total Uranium μg/L
ASIT-004 Upstream	March 21, 1989	Yes	318
		Unknown	1692
	November 7, 1989	Unknown	107
		Unknown	98
ASIT-005 Downstream	March 21, 1989	Yes*	1829
		Unknown	499
	November 27, 1989	Unknown	274
		Duplicate	260

*Possibly mislabeled and is actually unfiltered

These data indicate an impact at both the upstream and downstream locations. The origin for the discharge may be the South Field due to the fact that the South Field surface water drained into the ditch where these samples were collected. Concentrations of total uranium are similar in South Field discharge samples from Phase II. The drainage where the Phase I samples were collected has been filled in and a rock-lined channel was constructed beside it at the toe of the Active Flyash Pile.

Nine metals and the isotopes of four elements were detected in one Phase II surface water sample; no organic compounds were detected. These data suggest that organic compounds and metals detected in surface media and sediments are not present in surface water draining the subunit. Surface water data from Phase I and Phase II can not be compared because samples were collected from different drainages. It is believed that concentrations of total uranium in the South Field surface water samples are comparable to Phase I samples collected from a drainage ditch that received surface water from both the South Field and Active Flyash Pile. One Phase II surface water sample detected 4.18 μg/L total uranium, which did not indicate an impact from the Active Flyash Pile.

Two sediment samples were collected during Phase I at the same location nine months earlier. Sample ASIT-004 detected 38.9 mg/kg total uranium and ASIT-005 detected 51.8 mg/kg total

TABLE 4-66

ACTIVE FLYASH PILE
SURFACE WATER[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.000	0	1	0	0	0
Antimony		mg/L	.000	0	1	0	0	0
Arsenic		mg/L	.000	1	1	.0054	.0054	1
Barium		mg/L	.000	1	1	.0273	.0273	1
Beryllium		mg/L	.000	0	1	0	0	0
Cadmium		mg/L	.000	0	1	0	0	0
Calcium		mg/L	.000	1	1	43.3	43.3	1
Chromium		mg/L	.000	0	1	0	0	0
Cobalt		mg/L	.000	0	1	0	0	0
Copper		mg/L	.000	0	1	0	0	0
Cyanide		mg/L	.000	0	0	0	0	0
Iron		mg/L	.000	1	1	.0824	.0824	1
Lead		mg/L	.000	0	1	0	0	0
Magnesium		mg/L	.000	1	1	6.91	6.91	1
Manganese		mg/L	.000	1	1	.0053	.0053	1
Mercury		mg/L	.000	0	1	0	0	0
Molybdenum		mg/L	.000	0	1	0	0	0
Nickel		mg/L	.000	0	1	0	0	0
Potassium		mg/L	.000	1	1	4.65	4.65	1
Selenium		mg/L	.000	1	1	.001	.001	1
Silicon		mg/L	.000	1	1	4.12	4.12	1
Silver		mg/L	.000	0	1	0	0	0
Sodium		mg/L	.000	1	1	.795	.795	1
Thallium		mg/L	.000	0	1	0	0	0
Vanadium		mg/L	.000	0	1	0	0	0
Zinc		mg/L	.000	0	1	0	0	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	1	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	1	1	3.9	3.9	1
GROSS BETA	UNFL	pCi/L	.000	1	1	6.22	6.22	1
NP-237	UNFL	pCi/L	.000	1	1	.264	.264	1
PU-238	UNFL	pCi/L	.000	1	1	.108	.108	1
PU-239/240	UNFL	pCi/L	.000	0	1	0	0	0
RA-226	UNFL	pCi/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-66
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-228	UNFL	pCi/L	.000	1	1	1.7	1.7	1
RU-106	UNFL	pCi/L	.000	0	1	0	0	0
SR-90	UNFL	pCi/L	.000	0	1	0	0	0
TC-99	UNFL	pCi/L	.000	0	1	0	0	0
TH-228	UNFL	pCi/L	.000	0	1	0	0	0
TH-230	UNFL	pCi/L	.000	0	1	0	0	0
TH-232	UNFL	pCi/L	.000	0	1	0	0	0
TH-TOTAL	UNFL	ug/L	.000	0	1	0	0	0
U-234	UNFL	pCi/L	.000	1	1	1.5	1.5	1
U-235/236	UNFL	pCi/L	.000	1	1	.102	.102	1
U-238	UNFL	pCi/L	.000	1	1	1.69	1.69	1
U-TOTAL	UNFL	ug/L	.000	1	1	4.18	4.18	1
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	1	0	0	0
2-Butanone	UNFL	ug/L	.000	0	1	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	1	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	1	0	0	0
Acetone	UNFL	ug/L	.000	0		0	0	0
Benzene	UNFL	ug/L	.000	0	1	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	1	0	0	0
Bromoform	UNFL	ug/L	.000	0	1	0	0	0
Bromomethane	UNFL	ug/L	.000	0	1	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	1	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	1	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Chloroethane	UNFL	ug/L	.000	0	1	0	0	0
Chloroform	UNFL	ug/L	.000	0	1	0	0	0
Chloromethane	UNFL	ug/L	.000	0	1	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	1	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	1	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	1	0	0	0
Styrene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

FER\CRU2RI\TDO\TAB4-66\January 17, 1995 4:33pm

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TABLE 4-66
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Tetrachloroethene	UNFL	ug/L	.000	0	1	0	0	0
Toluene	UNFL	ug/L	.000	0	1	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	1	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	1	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	1	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	1	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0		0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0		0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	1	0	0	0
Acenaphthylene	UNFL	ug/L	.000	0	1	0	0	0
Anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-66
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Carbazole	UNFL	ug/L	.000	0	1	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Fluorene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Isophorone	UNFL	ug/L	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	1	0	0	0
Naphthalene	UNFL	ug/L	.000	0	1	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	1	0	0	0
Phenol	UNFL	ug/L	.000	0	1	0	0	0
Pyrene	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	1	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDD	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	1	0	0	0
Aldrin	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-66
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)								
Aroclor-1221	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	1	0	0	0
Dieldrin	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	1	0	0	0
Endrin	UNFL	ug/L	.000	0	1	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	1	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	1	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	1	0	0	0
Toxaphene	UNFL	ug/L	.000	0	1	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	1	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
beta-BHC	UNFL	ug/L	.000	0	1	0	0	0
delta-BHC	UNFL	ug/L	.000	0	1	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	1	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	1	1	114	114	0
Ammonia	UNFL	mg/L	.000	1	1	.15	.15	1
Chloride	UNFL	mg/L	.000	1	1	1.5	1.5	1
Fluoride	UNFL	mg/L	.000	1	1	.2	.2	1
Nitrate	UNFL	mg/L	.000	0		0	0	0
Phenols	UNFL	mg/L	.000	1	1	.01	.01	0
Sulfate	UNFL	mg/L	.000	1	1	30.4	30.4	1
Sulfide	UNFL	mg/L	.000	1	1	1	1	0
Total Kjeldahl Nitrogen	UNFL	mg/L	.000	1	1	.5	.5	1
Total Organic Carbon	UNFL	mg/L	.000	1	1	9.06	9.06	1
Total Organic Halides	UNFL	mg/L	.000	1	1	.021	.021	1
Total Organic Nitrogen	UNFL	mg/L	.000	1	1	.85	.85	1
Total Phosphorous	UNFL	mg/L	.000	1	1	.2	.2	0

[a] Filtered radionuclides, organics, general chemistry, etc. are not included because background concentrations were not available.

uranium at the downstream location. No other constituents were detected above background in Phase I samples. It is believed that these sediment results have been impacted by the South Field because South Field surface water drained through the same ditch during Phase I sampling.

During Phase II field activities, six sediment samples were designated to be sampled. After sampling of the six locations occurred, only one location (AFP-SD-06) was considered a sediment sample. The remaining five locations appeared to be surface soil samples and were combined with Phase II surface soil data discussed in Section 4.6.2. The five sediment locations were changed to surface soil locations because field observations of the topography determined that the soils were not deposited as the result of surface water movement around the Active Flyash Pile. Seven metals, isotopes of three elements, and four semivolatile organic compounds were detected above background sediment samples during Phase II sampling. No volatile organics or pesticides/PCBs were detected. A summary of analytes in sediment samples are shown on Table 4-67 and Table 4-68. Detection above background in sediment samples are similar to those for surface and subsurface flyash, indicating that sediments have been impacted by the Active Flyash Pile. Radionuclide measurements in sediments are similar to those measured in surface samples and subsurface samples and suggest that there was no additional source for radionuclides in the drainages besides the flyash material.

4.6.4 Groundwater

Groundwater analytical data from the 1000-series wells were compared to background data developed for perched groundwater. Analytical data are provided in Appendix G as Table G-2L and Table G-2O. The number of detected analytes are provided in Table 4-69 and Table 4-70 and were shown on Figure 4-23a. Groundwater within the perched groundwater system is believed to flow within a sand lens in the glacial overburden, as discussed in Section 3.0 and shown on Figure 3-46. Based upon data generated during Phase II, it is believed that the sand lens thins out beneath the Active Flyash Pile. Thus, the groundwater flow system is continuous from the South Field to the Active Flyash Pile, but it does not exist at the west edge of the pile.

Phase I sampling detected four metals, and isotopes of uranium and total thorium that exceeded the background concentrations. During Phase II six metals (Aluminum, Calcium, Selenium, and Silicon were not detected above background for Phase I; lead was detected above background for Phase I but not Phase II), isotopes of five elements (neptunium-237, plutonium-238, plutonium-239/240, strontium-90, thorium-232, and uranium-235/236 were not detected above background for

TABLE 4-67

ACTIVE FLYASH PILE
SEDIMENT[a]
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	0	0	0	0	0
Antimony	mg/kg	.000	0	1	0	0	0
Arsenic	mg/kg	8.200	0	0	0	0	0
Barium	mg/kg	94.100	0	0	0	0	0
Beryllium	mg/kg	.600	0	0	0	0	0
Cadmium	mg/kg	.870	0	1	0	0	0
Calcium	mg/kg	4339.170	0	0	0	0	0
Chromium	mg/kg	15.500	0	0	0	0	0
Cobalt	mg/kg	14.160	0	0	0	0	0
Copper	mg/kg	14.070	0	0	0	0	0
Cyanide	mg/kg	.270	0	1	0	0	0
Iron	mg/kg	21728.170	0	0	0	0	0
Lead	mg/kg	26.400	1	1	12	12	0
Magnesium	mg/kg	2776.970	0	0	0	0	0
Manganese	mg/kg	1348.040	0	0	0	0	0
Mercury	mg/kg	.120	0	0	0	0	0
Molybdenum	mg/kg	.000	0	1	0	0	0
Nickel	mg/kg	20.870	0	0	0	0	0
Potassium	mg/kg	1231.340	1	1	871	871	0
Selenium	mg/kg	.720	0	1	0	0	0
Silver	mg/kg	.000	0	0	0	0	0
Sodium	mg/kg	51.100	0	0	0	0	0
Thallium	mg/kg	.580	0	1	0	0	0
Vanadium	mg/kg	30.370	0	0	0	0	0
Zinc	mg/kg	59.610	0	0	0	0	0
RADIONUCLIDES							
GROSS ALPHA	pCi/g	.000	0	0	0	0	0
GROSS BETA	pCi/g	.000	0	0	0	0	0
RA-226	pCi/g	1.420	2	2	.637	1.24	0
RA-228	pCi/g	1.250	2	2	.703	1.08	0
U-TOTAL	mg/kg	3.700	4	4	4.53	51.8	4

See footnote at end of table

TABLE 4-67
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	1	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	1	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	1	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	1	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	1	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	1	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	1	0	0	0
2-Butanone	ug/kg	.000	0	1	0	0	0
2-Hexanone	ug/kg	.000	0	1	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	1	0	0	0
Acetone	ug/kg	.000	0	1	0	0	0
Benzene	ug/kg	.000	0	1	0	0	0
Bromodichloromethane	ug/kg	.000	0	1	0	0	0
Bromoform	ug/kg	.000	0	1	0	0	0
Bromomethane	ug/kg	.000	0	1	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	1	0	0	0
Carbon disulfide	ug/kg	.000	0	1	0	0	0
Chlorobenzene	ug/kg	.000	0	1	0	0	0
Chloroethane	ug/kg	.000	0	1	0	0	0
Chloroform	ug/kg	.000	0	1	0	0	0
Chloromethane	ug/kg	.000	0	1	0	0	0
Dibromochloromethane	ug/kg	.000	0	1	0	0	0
Ethylbenzene	ug/kg	.000	0	1	0	0	0
Methylene chloride	ug/kg	.000	0	1	0	0	0
Styrene	ug/kg	.000	0	1	0	0	0
Tetrachloroethene	ug/kg	.000	0	1	0	0	0
Toluene	ug/kg	.000	0	1	0	0	0
Trichloroethene	ug/kg	.000	0	1	0	0	0
Vinyl Acetate	ug/kg	.000	0	1	0	0	0
Vinyl chloride	ug/kg	.000	0	1	0	0	0
Xylenes, Total	ug/kg	.000	0	1	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	1	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	1	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	1	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-67
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
2,4,5-Trichlorophenol	ug/kg	.000	0	1	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	1	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	1	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	1	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	1	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	1	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	1	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	1	0	0	0
2-Chlorophenol	ug/kg	.000	0	1	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	1	0	0	0
2-Methylphenol	ug/kg	.000	0	1	0	0	0
2-Nitroaniline	ug/kg	.000	0	1	0	0	0
2-Nitrophenol	ug/kg	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	1	0	0	0
3-Nitroaniline	ug/kg	.000	0	1	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	1	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	1	0	0	0
4-Methylphenol	ug/kg	.000	0	1	0	0	0
4-Nitroaniline	ug/kg	.000	0	1	0	0	0
4-Nitrophenol	ug/kg	.000	0	1	0	0	0
Acenaphthene	ug/kg	.000	0	1	0	0	0
Acenaphthylene	ug/kg	.000	0	1	0	0	0
Anthracene	ug/kg	.000	0	1	0	0	0
Benzo(a)anthracene	ug/kg	.000	0	1	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	1	0	0	0
Benzo(b)fluoranthene	ug/kg	.000	0	1	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	1	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	1	0	0	0
Benzoic acid	ug/kg	.000	0	1	0	0	0
Benzyl alcohol	ug/kg	.000	0	1	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	1	0	0	0
Chrysene	ug/kg	.000	0	1	0	0	0
Di-n-butyl phthalate	ug/kg	.000	0	1	0	0	0
Di-n-octyl phthalate	ug/kg	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	1	0	0	0
Dibenzofuran	ug/kg	.000	0	1	0	0	0
Diethyl phthalate	ug/kg	.000	0	1	0	0	0
Dimethyl phthalate	ug/kg	.000	0	1	0	0	0

See footnote at end of table

000888

TABLE 4-67
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Fluoranthene	ug/kg	.000	0	1	0	0	0
Fluorene	ug/kg	.000	0	1	0	0	0
Hexachlorobenzene	ug/kg	.000	0	1	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	1	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	1	0	0	0
Hexachloroethane	ug/kg	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	1	0	0	0
Isophorone	ug/kg	.000	0	1	0	0	0
Methyl parathion	ug/kg	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	1	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	1	0	0	0
Naphthalene	ug/kg	.000	0	1	0	0	0
Nitrobenzene	ug/kg	.000	0	1	0	0	0
Parathion	ug/kg	.000	0	1	0	0	0
Pentachlorophenol	ug/kg	.000	0	1	0	0	0
Phenanthrene	ug/kg	.000	0	1	0	0	0
Phenol	ug/kg	.000	0	1	0	0	0
Pyrene	ug/kg	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	0	1	0	0	0
p-Chloroaniline	ug/kg	.000	0	1	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	1	0	0	0
4,4'-DDE	ug/kg	.000	0	1	0	0	0
4,4'-DDT	ug/kg	.000	0	1	0	0	0
Aldrin	ug/kg	.000	0	1	0	0	0
Aroclor-1016	ug/kg	.000	0	1	0	0	0
Aroclor-1221	ug/kg	.000	0	1	0	0	0
Aroclor-1232	ug/kg	.000	0	1	0	0	0
Aroclor-1242	ug/kg	.000	0	1	0	0	0
Aroclor-1248	ug/kg	.000	0	1	0	0	0
Aroclor-1254	ug/kg	.000	0	1	0	0	0
Aroclor-1260	ug/kg	.000	0	1	0	0	0
Dieldrin	ug/kg	.000	0	1	0	0	0
Endosulfan II	ug/kg	.000	0	1	0	0	0
Endosulfan sulfate	ug/kg	.000	0	1	0	0	0
Endosulfan-I	ug/kg	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-67
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Endrin	ug/kg	.000	0	1	0	0	0
Endrin ketone	ug/kg	.000	0	1	0	0	0
Heptachlor	ug/kg	.000	0	1	0	0	0
Heptachlor epoxide	ug/kg	.000	0	1	0	0	0
Methoxychlor	ug/kg	.000	0	1	0	0	0
Toxaphene	ug/kg	.000	0	1	0	0	0
alpha-BHC	ug/kg	.000	0	1	0	0	0
alpha-Chlordane	ug/kg	.000	0	1	0	0	0
beta-BHC	ug/kg	.000	0	1	0	0	0
delta-BHC	ug/kg	.000	0	1	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	1	0	0	0
gamma-Chlordane	ug/kg	.000	0	1	0	0	0
Azinphosmethyl	ug/kg	.000	0	1	0	0	0
Demeton	ug/kg	.000	0	1	0	0	0
Diazinon	ug/kg	.000	0	1	0	0	0
Disulfoton	ug/kg	.000	0	1	0	0	0
Ethion	ug/kg	.000	0	1	0	0	0
Malathion	ug/kg	.000	0	1	0	0	0
GENERAL CHEMISTRY							
Ammonia	mg/kg	.000	1	1	50.4	50.4	1
Chloride	mg/kg	.000	1	1	230	230	1
Fluoride	mg/kg	.000	1	1	7.58	7.58	1
Nitrate	mg/kg	.000	1	1	2.76	2.76	1
Phosphorus	mg/kg	.000	1	1	37.4	37.4	1
Sulfate	mg/kg	.000	1	1	697	697	1
Total Organic Nitrogen	mg/kg	.000	1	1	355	355	1

[a]Sediment results are compared to surface soil background values.

TABLE 4-68

ACTIVE FLYASH PILE
SEDIMENT[a]
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS							
Aluminum	mg/kg	11880.190	1	1	7630	7630	0
Antimony	mg/kg	.000	0	1	0	0	0
Arsenic	mg/kg	8.200	1	1	10.9	10.9	1
Barium	mg/kg	94.100	1	1	71.1	71.1	0
Beryllium	mg/kg	.600	1	1	1.4	1.4	1
Cadmium	mg/kg	.870	1	1	.75	.75	0
Calcium	mg/kg	4339.170	1	1	49200	49200	1
Chromium	mg/kg	15.500	1	1	11.6	11.6	0
Cobalt	mg/kg	14.160	1	1	9.7	9.7	0
Copper	mg/kg	14.070	1	1	22.2	22.2	1
Cyanide	mg/kg	.270	0		0	0	0
Iron	mg/kg	21728.170	1	1	15600	15600	0
Lead	mg/kg	26.400	1	1	15.7	15.7	0
Magnesium	mg/kg	2776.970	1	1	16100	16100	1
Manganese	mg/kg	1348.040	1	1	433	433	0
Mercury	mg/kg	.120	0	1	0	0	0
Molybdenum	mg/kg	.000	1	1	1.7	1.7	1
Nickel	mg/kg	20.870	1	1	18.4	18.4	0
Potassium	mg/kg	1231.340	1	1	1120	1120	0
Selenium	mg/kg	.720	0	1	0	0	0
Silicon	mg/kg	1797.030	1	1	1090	1090	0
Silver	mg/kg	.000	0	1	0	0	0
Sodium	mg/kg	51.100	1	1	140	140	1
Thallium	mg/kg	.580	1	1	.32	.32	0
Vanadium	mg/kg	30.370	1	1	21.5	21.5	0
Zinc	mg/kg	59.610	1	1	53.1	53.1	0
RADIONUCLIDES							
CS-137	pCi/g	.710	1	1	.086	.086	0
GROSS ALPHA	pCi/g	.000	1	1	20.7	20.7	1
GROSS BETA	pCi/g	.000	1	1	31.5	31.5	1
NP-237	pCi/g	.000	1	1	.038	.038	1
PU-238	pCi/g	.000	1	1	.0243	.0243	1
PU-239/240	pCi/g	.000	1	1	.049	.049	1
RA-226	pCi/g	1.420	1	1	1.32	1.32	0

See footnote at end of table

000571

1-6505

TABLE 4-68
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)							
RA-228	pCi/g	1.250	1	1	.908	.908	0
RU-106	pCi/g	.000	0	1	0	0	0
SR-90	pCi/g	.000	0	1	0	0	0
TC-99	pCi/g	.000	0	1	0	0	0
TH-228	pCi/g	1.430	1	1	.824	.824	0
TH-230	pCi/g	1.970	1	1	1.47	1.47	0
TH-232	pCi/g	1.360	1	1	.883	.883	0
TH-TOTAL	mg/kg	10.700	1	1	8.04	8.04	0
U-234	pCi/g	1.240	1	1	2.77	2.77	1
U-235/236	pCi/g	.150	1	1	.163	.163	1
U-238	pCi/g	1.220	1	1	2.9	2.9	1
U-TOTAL	mg/kg	3.700	1	1	11.3	11.3	1
VOLATILE ORGANICS							
1,1,1-Trichloroethane	ug/kg	.000	0	1	0	0	0
1,1,2,2-Tetrachloroethane	ug/kg	.000	0	1	0	0	0
1,1,2-Trichloroethane	ug/kg	.000	0	1	0	0	0
1,1-Dichloroethane	ug/kg	.000	0	1	0	0	0
1,1-Dichloroethene	ug/kg	.000	0	1	0	0	0
1,2-Dichloroethane	ug/kg	.000	0	1	0	0	0
1,2-Dichloroethene	ug/kg	.000	0	1	0	0	0
1,2-Dichloropropane	ug/kg	.000	0	1	0	0	0
2-Butanone	ug/kg	.000	0		0	0	0
2-Hexanone	ug/kg	.000	0	1	0	0	0
4-Methyl-2-pentanone	ug/kg	.000	0	1	0	0	0
Acetone	ug/kg	.000	0		0	0	0
Benzene	ug/kg	.000	0	1	0	0	0
Bromodichloromethane	ug/kg	.000	0	1	0	0	0
Bromoform	ug/kg	.000	0	1	0	0	0
Bromomethane	ug/kg	.000	0	1	0	0	0
Carbon Tetrachloride	ug/kg	.000	0	1	0	0	0
Carbon disulfide	ug/kg	.000	0	1	0	0	0
Chlorobenzene	ug/kg	.000	0	1	0	0	0
Chloroethane	ug/kg	.000	0	1	0	0	0
Chloroform	ug/kg	.000	0	1	0	0	0
Chloromethane	ug/kg	.000	0	1	0	0	0
Dibromochloromethane	ug/kg	.000	0	1	0	0	0
Ethylbenzene	ug/kg	.000	0	1	0	0	0
Methylene chloride	ug/kg	.000	0	1	0	0	0
Styrene	ug/kg	.000	0	1	0	0	0

See footnote at end of table

000072

TABLE 4-68
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)							
Tetrachloroethene	ug/kg	.000	0	1	0	0	0
Toluene	ug/kg	.000	0	1	0	0	0
Trichloroethene	ug/kg	.000	0	1	0	0	0
Vinyl chloride	ug/kg	.000	0	1	0	0	0
Xylenes, Total	ug/kg	.000	0	1	0	0	0
cis-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
trans-1,3-Dichloropropene	ug/kg	.000	0	1	0	0	0
SEMIVOLATILE ORGANICS							
1,2,4-Trichlorobenzene	ug/kg	.000	0	1	0	0	0
1,2-Dichlorobenzene	ug/kg	.000	0	1	0	0	0
1,3-Dichlorobenzene	ug/kg	.000	0	1	0	0	0
1,4-Dichlorobenzene	ug/kg	.000	0	1	0	0	0
2,4,5-Trichlorophenol	ug/kg	.000	0	1	0	0	0
2,4,6-Trichlorophenol	ug/kg	.000	0	1	0	0	0
2,4-Dichlorophenol	ug/kg	.000	0	1	0	0	0
2,4-Dimethylphenol	ug/kg	.000	0	1	0	0	0
2,4-Dinitrophenol	ug/kg	.000	0	1	0	0	0
2,4-Dinitrotoluene	ug/kg	.000	0	1	0	0	0
2,6-Dinitrotoluene	ug/kg	.000	0	1	0	0	0
2-Chloronaphthalene	ug/kg	.000	0	1	0	0	0
2-Chlorophenol	ug/kg	.000	0	1	0	0	0
2-Methylnaphthalene	ug/kg	.000	0	1	0	0	0
2-Methylphenol	ug/kg	.000	0	1	0	0	0
2-Nitroaniline	ug/kg	.000	0	1	0	0	0
2-Nitrophenol	ug/kg	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	ug/kg	.000	0	1	0	0	0
3-Nitroaniline	ug/kg	.000	0	1	0	0	0
4,6-Dinitro-2-methylphenol	ug/kg	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	ug/kg	.000	0	1	0	0	0
4-Chloro-3-methylphenol	ug/kg	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	ug/kg	.000	0	1	0	0	0
4-Methylphenol	ug/kg	.000	1	1	1700	1700	1
4-Nitroaniline	ug/kg	.000	0	1	0	0	0
4-Nitrophenol	ug/kg	.000	0	1	0	0	0
Acenaphthene	ug/kg	.000	0	1	0	0	0
Acenaphthylene	ug/kg	.000	0	1	0	0	0
Anthracene	ug/kg	.000	0	1	0	0	0
Benzo(a)anthracene	ug/kg	.000	0	1	0	0	0
Benzo(a)pyrene	ug/kg	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-68
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)							
Benzo(b)fluoranthene	ug/kg	.000	0	1	0	0	0
Benzo(g,h,i)perylene	ug/kg	.000	0	1	0	0	0
Benzo(k)fluoranthene	ug/kg	.000	0	1	0	0	0
Benzoic acid	ug/kg	.000	1	1	680	680	1
Benzyl alcohol	ug/kg	.000	0	1	0	0	0
Butyl benzyl phthalate	ug/kg	.000	0	1	0	0	0
Carbazole	ug/kg	.000	0	1	0	0	0
Chrysene	ug/kg	.000	0	1	0	0	0
Di-n-butyl phthalate	ug/kg	.000	1	1	64	64	1
Di-n-octyl phthalate	ug/kg	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	ug/kg	.000	0	1	0	0	0
Dibenzofuran	ug/kg	.000	0	1	0	0	0
Diethyl phthalate	ug/kg	.000	0	1	0	0	0
Dimethyl phthalate	ug/kg	.000	0	1	0	0	0
Fluoranthene	ug/kg	.000	0	1	0	0	0
Fluorene	ug/kg	.000	0	1	0	0	0
Hexachlorobenzene	ug/kg	.000	0	1	0	0	0
Hexachlorobutadiene	ug/kg	.000	0	1	0	0	0
Hexachlorocyclopentadiene	ug/kg	.000	0	1	0	0	0
Hexachloroethane	ug/kg	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	ug/kg	.000	0	1	0	0	0
Isophorone	ug/kg	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	ug/kg	.000	0	1	0	0	0
N-Nitrosodiphenylamine	ug/kg	.000	0	1	0	0	0
Naphthalene	ug/kg	.000	0	1	0	0	0
Nitrobenzene	ug/kg	.000	0	1	0	0	0
Pentachlorophenol	ug/kg	.000	0	1	0	0	0
Phenanthrene	ug/kg	.000	0	1	0	0	0
Phenol	ug/kg	.000	1	1	230	230	1
Pyrene	ug/kg	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	ug/kg	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	ug/kg	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	ug/kg	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	ug/kg	.000	0	1	0	0	0
p-Chloroaniline	ug/kg	.000	0	1	0	0	0
PESTICIDES/PCBs							
4,4'-DDD	ug/kg	.000	0	1	0	0	0
4,4'-DDE	ug/kg	.000	0	1	0	0	0
4,4'-DDT	ug/kg	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-68
(Continued)

Parameter	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs (Continued)							
Aldrin	ug/kg	.000	0	1	0	0	0
Aroclor-1016	ug/kg	.000	0	1	0	0	0
Aroclor-1221	ug/kg	.000	0	1	0	0	0
Aroclor-1232	ug/kg	.000	0	1	0	0	0
Aroclor-1242	ug/kg	.000	0	1	0	0	0
Aroclor-1248	ug/kg	.000	0	1	0	0	0
Aroclor-1254	ug/kg	.000	0	1	0	0	0
Aroclor-1260	ug/kg	.000	0	1	0	0	0
Dieldrin	ug/kg	.000	0	1	0	0	0
Endosulfan II	ug/kg	.000	0	1	0	0	0
Endosulfan sulfate	ug/kg	.000	0	1	0	0	0
Endosulfan-I	ug/kg	.000	0	1	0	0	0
Endrin	ug/kg	.000	0	1	0	0	0
Endrin aldehyde	ug/kg	.000	0	1	0	0	0
Endrin ketone	ug/kg	.000	0	1	0	0	0
Heptachlor	ug/kg	.000	0	1	0	0	0
Heptachlor epoxide	ug/kg	.000	0	1	0	0	0
Methoxychlor	ug/kg	.000	0	1	0	0	0
Toxaphene	ug/kg	.000	0	1	0	0	0
alpha-BHC	ug/kg	.000	0	1	0	0	0
alpha-Chlordane	ug/kg	.000	0	1	0	0	0
beta-BHC	ug/kg	.000	0	1	0	0	0
delta-BHC	ug/kg	.000	0	1	0	0	0
gamma-BHC (Lindane)	ug/kg	.000	0	1	0	0	0
gamma-Chlordane	ug/kg	.000	0	1	0	0	0

[a]Sediment results are compared to surface soil background values.

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TABLE 4-69

ACTIVE FLYASH PILE
GROUNDWATER[a] - 1000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Arsenic		mg/L	.050	0	4	0	0	0
Barium		mg/L	.450	3	4	.071	.112	0
Cadmium		mg/L	.005	2	4	.003	.0069	1
Calcium		mg/L	123.837	4	4	51.8	114	0
Chromium		mg/L	.035	1	4	.015	.015	0
Copper		mg/L	.030	1	4	.011	.011	0
Iron		mg/L	3.440	2	4	.061	.153	0
Lead		mg/L	.015	2	4	.004	.06	1
Magnesium		mg/L	48.546	4	4	15.4	80.2	2
Manganese		mg/L	.050	4	4	.003	.187	1
Mercury		mg/L	.000	0	4	0	0	0
Molybdenum		mg/L	.025	0	4	0	0	0
Nickel		mg/L	.026	0	4	0	0	0
Potassium		mg/L	26.976	4	4	1.68	5.43	0
Selenium		mg/L	.000	0	4	0	0	0
Silver		mg/L	.040	0	4	0	0	0
Sodium		mg/L	47.982	4	4	9.85	31	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0		0	0	0
NP-237	UNFL	pCi/L	.000	0	2	0	0	0
PU-238	UNFL	pCi/L	.000	0	2	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	2	0	0	0
RA-226	UNFL	pCi/L	1.000	0	2	0	0	0
RA-228	UNFL	pCi/L	5.200	0	2	0	0	0
RU-106	UNFL	pCi/L	.000	0	0	0	0	0
SR-90	UNFL	pCi/L	.000	0	2	0	0	0
TC-99	UNFL	pCi/L	.000	0	2	0	0	0
TH-228	UNFL	pCi/L	1.040	0	2	0	0	0
TH-230	UNFL	pCi/L	2.000	0	2	0	0	0
TH-232	UNFL	pCi/L	.000	0	2	0	0	0
TH-TOTAL	UNFL	ug/L	3.000	1	2	5	5	1
U-234	UNFL	pCi/L	1.900	2	2	4.5	5.4	2

See footnote at end of table

TABLE 4-69
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
U-235/236	UNFL	pCi/L	.000	0	2	0	0	0
U-238	UNFL	pCi/L	1.070	2	2	4	5.3	2
U-TOTAL	UNFL	ug/L	4.000	2	2	15	17	2
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	4.340	0	4	0	0	0
Chloride	UNFL	mg/L	46.100	3	4	12.5	45.6	0
Fluoride	UNFL	mg/L	1.298	4	4	.19	.5	0
Nitrate	UNFL	mg/L	.462	3	3	.14	.41	0
Phenols	UNFL	mg/L	.000	0	4	0	0	0
Phosphorus	UNFL	mg/L	.206	4	4	.21	.6	4
Sulfate	UNFL	mg/L	138.192	4	4	59	99	0
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	1	2	.5	.5	0
Total Organic Halides	UNFL	mg/L	.000	0	3	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.000	2	2	.1	.5	2

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

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TABLE 4-70

ACTIVE FLYASH PILE
GROUNDWATER[a] - 1000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.123	3	3	.0556	.543	2
Antimony		mg/L	.000	0	3	0	0	0
Arsenic		mg/L	.050	2	3	.0034	.0034	0
Barium		mg/L	.450	3	3	.0481	.201	0
Beryllium		mg/L	.002	0	3	0	0	0
Cadmium		mg/L	.005	0	3	0	0	0
Calcium		mg/L	123.837	3	3	53.4	153	1
Chromium		mg/L	.035	0	3	0	0	0
Cobalt		mg/L	.000	0	3	0	0	0
Copper		mg/L	.030	0	3	0	0	0
Cyanide		mg/L	.000	0	2	0	0	0
Iron		mg/L	3.440	1	3	.958	.958	0
Lead		mg/L	.015	1	3	.0021	.0021	0
Magnesium		mg/L	48.546	3	3	16.3	139	1
Manganese		mg/L	.050	3	3	.0041	.378	1
Mercury		mg/L	.000	0	3	0	0	0
Molybdenum		mg/L	.025	1	3	.0045	.0045	0
Nickel		mg/L	.026	2	3	.0054	.0102	0
Potassium		mg/L	26.976	3	3	1.4	5.98	0
Selenium		mg/L	.000	2	3	.0182	.0195	2
Silicon		mg/L	.000	3	3	10.7	10.8	3
Silver		mg/L	.040	0	3	0	0	0
Sodium		mg/L	47.982	3	3	14.9	28.3	0
Thallium		mg/L	.000	0	3	0	0	0
Vanadium		mg/L	.020	1	3	.0169	.0169	0
Zinc		mg/L	.032	1	3	.0045	.0045	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	2	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	0	2	0	0	0
GROSS BETA	UNFL	pCi/L	.000	2	2	7.35	14.1	2
NP-237	UNFL	pCi/L	.000	1	2	.48	.48	1
PU-238	UNFL	pCi/L	.000	2	2	.122	.17	2
PU-239/240	UNFL	pCi/L	.000	1	2	.2	.2	1

See footnote at end of table

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TABLE 4-70
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-226	UNFL	pCi/L	1.000	0	2	0	0	0
RA-228	UNFL	pCi/L	5.200	0	2	0	0	0
RU-106	UNFL	pCi/L	.000	0	2	0	0	0
SR-90	UNFL	pCi/L	.000	1	2	1.19	1.19	1
TC-99	UNFL	pCi/L	.000	0	2	0	0	0
TH-228	UNFL	pCi/L	1.040	1	2	.13	.13	0
TH-230	UNFL	pCi/L	2.000	1	2	.24	.24	0
TH-232	UNFL	pCi/L	.000	1	2	.032	.032	1
TH-TOTAL	UNFL	ug/L	3.000	1	2	.29	.29	0
U-234	UNFL	pCi/L	1.900	2	2	1.16	11.4	1
U-235/236	UNFL	pCi/L	.000	1	2	.56	.56	1
U-238	UNFL	pCi/L	1.070	2	2	1.19	12.5	2
U-TOTAL	UNFL	ug/L	4.000	2	2	2.91	31.1	1
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	2	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	2	0	0	0
2-Butanone	UNFL	ug/L	.000	1	2	1	1	1
2-Hexanone	UNFL	ug/L	.000	0	2	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	2	0	0	0
Acetone	UNFL	ug/L	.000	0	2	0	0	0
Benzene	UNFL	ug/L	.000	0	2	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	2	0	0	0
Bromoform	UNFL	ug/L	.000	0	2	0	0	0
Bromomethane	UNFL	ug/L	.000	0	2	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	2	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	2	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	2	0	0	0
Chloroethane	UNFL	ug/L	.000	0	2	0	0	0
Chloroform	UNFL	ug/L	.000	0	2	0	0	0
Chloromethane	UNFL	ug/L	.000	0	2	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	2	0	0	0

See footnote at end of table

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TABLE 4-70
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Ethylbenzene	UNFL	ug/L	.000	0	2	0	0	0
Methylene chloride	UNFL	ug/L	.000	0	2	0	0	0
Styrene	UNFL	ug/L	.000	0	2	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	2	0	0	0
Toluene	UNFL	ug/L	.000	0	2	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	2	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	2	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	2	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	2	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	2	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	1	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	1	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	1	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	1	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	1	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	1	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	0	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	0	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	1	0	0	0

See footnote at end of table

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TABLE 4-70
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Acenaphthylene	UNFL	ug/L	.000	0	1	0	0	0
Anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	1	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	1	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	1	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Carbazole	UNFL	ug/L	.000	0	1	0	0	0
Chrysene	UNFL	ug/L	.000	0	1	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Di-n-octyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	1	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	1	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	1	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	1	0	0	0
Fluorene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	1	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	1	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	1	0	0	0
Isophorone	UNFL	ug/L	.000	0	1	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	1	0	0	0
Naphthalene	UNFL	ug/L	.000	0	1	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	1	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	1	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	1	0	0	0
Phenol	UNFL	ug/L	.000	0	1	0	0	0
Pyrene	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	1	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	0	0	0	0

See footnote at end of table

TABLE 4-70
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
PESTICIDES/PCBs								
4,4'-DDD	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	1	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	1	0	0	0
Aldrin	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	1	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	1	0	0	0
Dieldrin	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	1	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	1	0	0	0
Endrin	UNFL	ug/L	.000	0	1	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	1	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor	UNFL	ug/L	.000	0	1	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	1	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	1	0	0	0
Toxaphene	UNFL	ug/L	.000	0	1	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	1	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
beta-BHC	UNFL	ug/L	.000	0	1	0	0	0
delta-BHC	UNFL	ug/L	.000	0	1	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	1	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	1	0	0	0
GENERAL CHEMISTRY								
Alkalinity as CaCO3	UNFL	mg/L	.000	1	1	790	790	0
Ammonia	UNFL	mg/L	4.340	0	1	0	0	0
Chloride	UNFL	mg/L	46.100	1	1	7.31	7.31	0
Fluoride	UNFL	mg/L	1.298	1	1	.35	.35	0
Nitrate	UNFL	mg/L	.462	0		0	0	0
Phenols	UNFL	mg/L	.000	0	1	0	0	0
Phosphorus	UNFL	mg/L	.206	1	1	.08	.08	0
Sulfate	UNFL	mg/L	138.192	1	1	110.4	110.4	0
Sulfide	UNFL	mg/L	.000	0	1	0	0	0

See footnote at end of table

TABLE 4-70
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Total Kjeldahl Nitrogen	UNFL	mg/L	4.340	1	1	.23	.23	0
Total Organic Carbon	UNFL	mg/L	.000	1	1	2.94	2.94	1
Total Organic Halides	UNFL	mg/L	.000	1	1	62.3	62.3	1
Total Organic Nitrogen	UNFL	mg/L	.000	1	1	.23	.23	1

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

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Phase I), and one organic (2-butanone at 1 μg/L) exceeded background concentrations. Based upon the conceptual model of flow and constituent transport shown on Figure 2-24, groundwater quality near the Active Flyash Pile appears to be impacted by waste disposal activities in the South Field.

Due to the location of the Active Flyash Pile relative to the glacial overburden (see Figure 3-53), a perched groundwater well could not be installed downgradient of the pile except for where Boring 11031 was located, which was as far downgradient as safe accessibility allowed. The borehole was advanced to a depth that should have encountered perched groundwater, but the hole was dry; and therefore, a well was not installed. Since the Active Flyash Pile is located over the slope which is the terminal edge of the till (glacial overburden), and no free-flowing groundwater was encountered in Boring 11031 (potentially downgradient), it may be assumed that the potential impact to perched groundwater would be minimal.

Groundwater in the regional aquifer flows toward the east from the South Field to the Active Flyash Pile. Upgradient wells are located west of the Active Flyash Pile (Well 2943), and Well 21033 (constructed during Phase II) is located downgradient. Groundwater analytical data from the 2000-series wells were compared to background data from the regional aquifer and is presented in Tables 4-71 and 4-72. Phase I sampling detected six metals and isotopes of two elements that exceeded background; no organic compounds were analyzed for in Phase I samples. Phase II sampling detected above background five metals (Calcium, Magnesium, and Manganese were not detected above background during Phase I; Chromium was detected above background for Phase I but not Phase II), isotopes of two elements (plutonium-238 was not detected above background during Phase I; thorium-232 and thorium-total were detected above background during Phase I but not Phase II), and two organic compounds (Acetone and Di-n-Butyl phthalate). Available historical uranium isotope and total thorium data are summarized and presented in Table 4-73 for the groundwater wells in the Active Flyash Pile area. Available uranium and thorium concentration data from samples collected since 1988 indicate that these constituents have remained within the same concentration ranges in all wells except Well 2049. The concentration of total uranium in this well has ranged from 2 μg/L to 175 μg/L in eight samples collected from 1988 to 1993. This suggests that there may be an influence from the Storm Sewer Outfall Ditch, which flows approximately 50 feet to the east, on Well 2049 due to the recharge of water containing low uranium concentrations to groundwater. Concentrations of total uranium in Well 2045 ranged from 265.5 μg/L to 461.0 μg/L in samples collected from 1988 to 1993. These concentrations are believed to be related to recharge originating upgradient at the south

TABLE 4-71

ACTIVE FLYASH PILE
GROUNDWATER[a] - 2000 SERIES
PHASE I FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	8	8	.119	.219	1
Arsenic		mg/L	.050	0	15	0	0	0
Barium		mg/L	.436	12	14	.025	.046	0
Cadmium		mg/L	.005	11	15	.0028	.006	3
Calcium		mg/L	134.783	15	15	96.2	124	0
Chromium		mg/L	.041	11	15	.0141	.044	1
Copper		mg/L	.120	7	15	.0102	.017	0
Iron		mg/L	4.000	7	15	.032	.115	0
Lead		mg/L	.015	3	14	.003	.0115	0
Magnesium		mg/L	37.961	15	15	19.77	33.9	0
Manganese		mg/L	.050	12	15	.005	.0145	0
Mercury		mg/L	.001	3	15	.0003	.0006	1
Molybdenum		mg/L	.025	1	15	.008	.008	0
Nickel		mg/L	.024	2	15	.02	.02	0
Potassium		mg/L	3.077	14	15	1.52	3.45	1
Selenium		mg/L	.004	4	14	.002	.005	1
Silicon		mg/L	6.140	8	8	4.46	5.53	0
Silver		mg/L	.014	7	15	.01	.013	0
Sodium		mg/L	51.267	15	15	4.68	17.9	0
Vanadium		mg/L	.025	8	8	.0111	.022	0
RADIONCULIDES								
CS-137	UNFL	pCi/L	.000	0	2	0	0	0
NP-237	UNFL	pCi/L	.000	0	15	0	0	0
PU-238	UNFL	pCi/L	.000	0	15	0	0	0
PU-239/240	UNFL	pCi/L	.000	0	15	0	0	0
RA-226	UNFL	pCi/L	1.200	1	13	1.19	1.19	0
RA-228	UNFL	pCi/L	4.000	0	15	0	0	0
RU-106	UNFL	pCi/L	.000	0	2	0	0	0
SR-90	UNFL	pCi/L	.000	0	13	0	0	0
TC-99	UNFL	pCi/L	36.000	0	14	0	0	0
TH-228	UNFL	pCi/L	1.400	2	14	1.1	1.5	1
TH-230	UNFL	pCi/L	1.700	1	14	1.2	1.2	0

See footnote at end of table

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TABLE 4-71
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
TH-232	UNFL	pCi/L	.000	2	14	1.05	1.6	2
TH-TOTAL	UNFL	ug/L	2.000	2	13	5	9.47	2
U-234	UNFL	pCi/L	1.200	11	14	1	104	10
U-235/236	UNFL	pCi/L	.000	7	14	1.4	4.7	7
U-238	UNFL	pCi/L	.900	10	14	2.1	119	10
U-TOTAL	UNFL	ug/L	2.000	12	15	2	462	11
GENERAL CHEMISTRY								
Ammonia	UNFL	mg/L	3.240	0	14	0	0	0
Chloride	UNFL	mg/L	120.000	13	15	4.75	23.7	0
Fluoride	UNFL	mg/L	.929	15	15	.1	.91	0
Nitrate	UNFL	mg/L	10.000	11	12	.685	8.95	0
Phenols	UNFL	mg/L	.000	5	13	.013	.34	0
Phosphorus	UNFL	mg/L	.679	13	14	.1	2.71	6
Sulfate	UNFL	mg/L	352.992	15	15	43.2	70	0
Sulfide	UNFL	mg/L	30.400	1	8	37.8	37.8	1
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	7	9	.231	.725	0
Total Organic Carbon	UNFL	mg/L	3.764	6	8	1.98	2.72	0
Total Organic Halides	UNFL	mg/L	.021	1	9	.01	.01	0
Total Organic Nitrogen	UNFL	mg/L	.652	12	15	.1	1.64	2

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

TABLE 4-72

ACTIVE FLYASH PILE
GROUNDWATER[a] - 2000 SERIES
PHASE II FIELD INVESTIGATION
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
METALS								
Aluminum		mg/L	.180	2	5	.0959	.35	1
Antimony		mg/L	.006	0	5	0	0	0
Arsenic		mg/L	.050	0	5	0	0	0
Barium		mg/L	.436	5	5	.0443	.101	0
Beryllium		mg/L	.002	0	5	0	0	0
Cadmium		mg/L	.005	0	5	0	0	0
Calcium		mg/L	134.783	5	5	103	173	3
Chromium		mg/L	.041	0	5	0	0	0
Cobalt		mg/L	.000	0	5	0	0	0
Copper		mg/L	.120	0	5	0	0	0
Cyanide		mg/L	.000	0	4	0	0	0
Iron		mg/L	4.000	3	5	.128	.398	0
Lead		mg/L	.015	1	5	.002	.002	0
Magnesium		mg/L	37.961	5	5	27.4	46	2
Manganese		mg/L	.050	3	5	.012	.0827	2
Mercury		mg/L	.001	0	5	0	0	0
Molybdenum		mg/L	.025	0	5	0	0	0
Nickel		mg/L	.024	0	5	0	0	0
Potassium		mg/L	3.077	5	5	2.31	7.46	2
Selenium		mg/L	.004	3	5	.0013	.004	0
Silicon		mg/L	6.140	5	5	4.58	5.99	0
Silver		mg/L	.014	0	5	0	0	0
Sodium		mg/L	51.267	5	5	7.3	16.1	0
Thallium		mg/L	.000	0	5	0	0	0
Vanadium		mg/L	.025	0	5	0	0	0
Zinc		mg/L	.095	2	5	.0068	.0149	0
RADIONUCLIDES								
CS-137	UNFL	pCi/L	.000	0	3	0	0	0
GROSS ALPHA	UNFL	pCi/L	.000	2	3	22.8	59.9	2
GROSS BETA	UNFL	pCi/L	.000	2	3	12.1	25.8	2
NP-237	UNFL	pCi/L	.000	0	2	0	0	0
PU-238	UNFL	pCi/L	.000	1	2	.135	.135	1
PU-239/240	UNFL	pCi/L	.000	0	2	0	0	0

See footnote at end of table

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TABLE 4-72
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
RADIONUCLIDES (Continued)								
RA-226	UNFL	pCi/L	1.200	1	2	.264	.264	0
RA-228	UNFL	pCi/L	4.000	0	2	0	0	0
RU-106	UNFL	pCi/L	.000	0	2	0	0	0
SR-90	UNFL	pCi/L	.000	0	2	0	0	0
TC-99	UNFL	pCi/L	36.000	0	3	0	0	0
TH-228	UNFL	pCi/L	1.400	0	3	0	0	0
TH-230	UNFL	pCi/L	1.700	2	3	.281	1.27	0
TH-232	UNFL	pCi/L	.000	0	3	0	0	0
TH-TOTAL	UNFL	ug/L	2.000	0	3	0	0	0
U-234	UNFL	pCi/L	1.200	3	3	.682	41.5	2
U-235/236	UNFL	pCi/L	.000	2	3	.666	1.86	2
U-238	UNFL	pCi/L	.900	3	3	.338	46.4	2
U-TOTAL	UNFL	ug/L	2.000	2	3	43.2	111	2
VOLATILE ORGANICS								
1,1,1-Trichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1,2,2-Tetrachloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1,2-Trichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,1-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethane	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloroethene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichloropropane	UNFL	ug/L	.000	0	4	0	0	0
2-Butanone	UNFL	ug/L	.000	0	4	0	0	0
2-Hexanone	UNFL	ug/L	.000	0	3	0	0	0
4-Methyl-2-pentanone	UNFL	ug/L	.000	0	3	0	0	0
Acetone	UNFL	ug/L	.000	1	3	3	3	1
Benzene	UNFL	ug/L	.000	0	4	0	0	0
Bromodichloromethane	UNFL	ug/L	.000	0	4	0	0	0
Bromoform	UNFL	ug/L	.000	0	4	0	0	0
Bromomethane	UNFL	ug/L	.000	0	4	0	0	0
Carbon Tetrachloride	UNFL	ug/L	.000	0	4	0	0	0
Carbon disulfide	UNFL	ug/L	.000	0	3	0	0	0
Chlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Chloroethane	UNFL	ug/L	.000	0	4	0	0	0
Chloroform	UNFL	ug/L	.000	0	4	0	0	0
Chloromethane	UNFL	ug/L	.000	0	4	0	0	0
Dibromochloromethane	UNFL	ug/L	.000	0	4	0	0	0
Ethylbenzene	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-72
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
VOLATILE ORGANICS (Continued)								
Methylene chloride	UNFL	ug/L	.000	0	4	0	0	0
Styrene	UNFL	ug/L	.000	0	4	0	0	0
Tetrachloroethene	UNFL	ug/L	.000	0	4	0	0	0
Toluene	UNFL	ug/L	.000	0	4	0	0	0
Trichloroethene	UNFL	ug/L	.000	0	4	0	0	0
Vinyl Acetate	UNFL	ug/L	.000	0	3	0	0	0
Vinyl chloride	UNFL	ug/L	.000	0	4	0	0	0
Xylenes, Total	UNFL	ug/L	.000	0	4	0	0	0
cis-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
trans-1,3-Dichloropropene	UNFL	ug/L	.000	0	4	0	0	0
SEMIVOLATILE ORGANICS								
1,2,4-Trichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,2-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,3-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
1,4-Dichlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
2,4,5-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4,6-Trichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dichlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dimethylphenol	UNFL	ug/L	.000	0	4	0	0	0
2,4-Dinitrophenol	UNFL	ug/L	.000	0	3	0	0	0
2,4-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2,6-Dinitrotoluene	UNFL	ug/L	.000	0	4	0	0	0
2-Benzyl-4-chlorophenol	UNFL	ug/L	.000	0	1	0	0	0
2-Chloronaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Chlorophenol	UNFL	ug/L	.000	0	4	0	0	0
2-Methylnaphthalene	UNFL	ug/L	.000	0	4	0	0	0
2-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
2-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
2-Nitrophenol	UNFL	ug/L	.000	0	4	0	0	0
3,3'-Dichlorobenzidine	UNFL	ug/L	.000	0	4	0	0	0
3-Nitroaniline	UNFL	ug/L	.000	0	4	0	0	0
4,6-Dinitro-2-methylphenol	UNFL	ug/L	.000	0	3	0	0	0
4-Bromophenyl phenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Chloro-3-methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Chlorophenylphenyl ether	UNFL	ug/L	.000	0	4	0	0	0
4-Methylphenol	UNFL	ug/L	.000	0	4	0	0	0
4-Nitroaniline	UNFL	ug/L	.000	0	1	0	0	0
4-Nitrophenol	UNFL	ug/L	.000	0	2	0	0	0
Acenaphthene	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-72
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
Acenaphthylene	UNFL	ug/L	.000	0	4	0	0	0
Anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(a)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(b)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(g,h,i)perylene	UNFL	ug/L	.000	0	4	0	0	0
Benzo(k)fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Benzoic acid	UNFL	ug/L	.000	0	4	0	0	0
Benzyl alcohol	UNFL	ug/L	.000	0	4	0	0	0
Butyl benzyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Carbazole	UNFL	ug/L	.000	0	4	0	0	0
Chrysene	UNFL	ug/L	.000	0	4	0	0	0
Di-n-butyl phthalate	UNFL	ug/L	.000	1	4	19	19	1
Di-n-octyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dibenzo(a,h)anthracene	UNFL	ug/L	.000	0	4	0	0	0
Dibenzofuran	UNFL	ug/L	.000	0	4	0	0	0
Diethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Dimethyl phthalate	UNFL	ug/L	.000	0	4	0	0	0
Fluoranthene	UNFL	ug/L	.000	0	4	0	0	0
Fluorene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobenzene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorobutadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachlorocyclopentadiene	UNFL	ug/L	.000	0	4	0	0	0
Hexachloroethane	UNFL	ug/L	.000	0	4	0	0	0
Indeno(1,2,3-cd)pyrene	UNFL	ug/L	.000	0	4	0	0	0
Isophorone	UNFL	ug/L	.000	0	4	0	0	0
N-Nitroso-di-n-propylamine	UNFL	ug/L	.000	0	4	0	0	0
N-Nitrosodimethylamine	UNFL	ug/L	.000	0	1	0	0	0
N-Nitrosodiphenylamine	UNFL	ug/L	.000	0	4	0	0	0
Naphthalene	UNFL	ug/L	.000	0	4	0	0	0
Nitrobenzene	UNFL	ug/L	.000	0	4	0	0	0
Pentachlorophenol	UNFL	ug/L	.000	0	4	0	0	0
Phenanthrene	UNFL	ug/L	.000	0	4	0	0	0
Phenol	UNFL	ug/L	.000	0	4	0	0	0
Pyrene	UNFL	ug/L	.000	0	4	0	0	0
Tributyl phosphate	UNFL	ug/L	.000	0	1	0	0	0
bis(2-Chloroethoxy)methane	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Chloroethyl)ether	UNFL	ug/L	.000	0	4	0	0	0

See footnote at end of table

TABLE 4-72
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
SEMIVOLATILE ORGANICS (Continued)								
bis(2-Chloroisopropyl) ether	UNFL	ug/L	.000	0	4	0	0	0
bis(2-Ethylhexyl) phthalate	UNFL	ug/L	.000	0	4	0	0	0
p-Chloroaniline	UNFL	ug/L	.000	0	2	0	0	0
PESTICIDES/PCBs								
4,4'-DDD	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDE	UNFL	ug/L	.000	0	4	0	0	0
4,4'-DDT	UNFL	ug/L	.000	0	4	0	0	0
Aldrin	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1016	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1221	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1232	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1242	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1248	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1254	UNFL	ug/L	.000	0	4	0	0	0
Aroclor-1260	UNFL	ug/L	.000	0	4	0	0	0
Dieldrin	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan II	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan sulfate	UNFL	ug/L	.000	0	4	0	0	0
Endosulfan-I	UNFL	ug/L	.000	0	4	0	0	0
Endrin	UNFL	ug/L	.000	0	4	0	0	0
Endrin aldehyde	UNFL	ug/L	.000	0	4	0	0	0
Endrin ketone	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor	UNFL	ug/L	.000	0	4	0	0	0
Heptachlor epoxide	UNFL	ug/L	.000	0	4	0	0	0
Methoxychlor	UNFL	ug/L	.000	0	4	0	0	0
Toxaphene	UNFL	ug/L	.000	0	4	0	0	0
alpha-BHC	UNFL	ug/L	.000	0	4	0	0	0
alpha-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
beta-BHC	UNFL	ug/L	.000	0	4	0	0	0
delta-BHC	UNFL	ug/L	.000	0	4	0	0	0
gamma-BHC (Lindane)	UNFL	ug/L	.000	0	4	0	0	0
gamma-Chlordane	UNFL	ug/L	.000	0	4	0	0	0
GENERAL CHEMISTRY								
Alkalinity	UNFL	mg/L	.000	2	2	380	400	0
Alkalinity as CaCO3	UNFL	mg/L	.000	2	2	320	320	0
Ammonia	UNFL	mg/L	3.240	1	4	.12	.12	0
Chloride	UNFL	mg/L	120.000	4	4	9.23	17.2	0

See footnote at end of table

TABLE 4-72
(Continued)

Parameter	FILTER FLAG	UNITS	Background Concentration	Number of Detects	Number of Analyses	Range of Detects Minimum	Range of Detects Maximum	Number of Detects Above Background
GENERAL CHEMISTRY (Continued)								
Fluoride	UNFL	mg/L	.929	4	4	.13	.27	0
Nitrate	UNFL	mg/L	10.000	4	4	1.15	1.8	0
Phenols	UNFL	mg/L	.000	0	4	0	0	0
Phosphorus	UNFL	mg/L	.679	2	2	.05	.08	0
Sulfate	UNFL	mg/L	352.992	4	4	49.2	237.5	0
Sulfide	UNFL	mg/L	30.400	0	4	0	0	0
Total Kjeldahl Nitrogen	UNFL	mg/L	3.224	4	4	.12	.16	0
Total Organic Carbon	UNFL	mg/L	3.764	1	4	1.14	1.14	0
Total Organic Halides	UNFL	mg/L	.021	0	3	0	0	0
Total Organic Nitrogen	UNFL	mg/L	.652	3	4	.13	.16	0
Total Phosphorous	UNFL	mg/L	.000	2	2	.07	.12	0

[a]Filtered radionuclides, organics and general chemistry are not included because background concentrations were not available.

TABLE 4-73

SUMMARY OF URANIUM ISOTOPES AND TOTAL THORIUM IN MEDIA IN THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Sample Type	Boring No.	Date Sample Taken	Uranium-234[a] (pCi/L)	Uranium-238 (pCi/L)	Total Uranium (μg/L)	Total Thorium (μg/L)
1000-Series Well	1048	07/24/88	5.4 U	5.3 U	17.0 U	-
		10/23/88	4.5 U	4.0 U	15.0 U	5.0 U
		01/22/89	6.6 U	6.9 U	21.0 X	4.0 X
		12/16/89	14.2 U	15.0 X	52.6 X	-
		04/28/93	11.4 U	12.5 U	31.1 U	-
	1045	12/13/89	1.72 X	2.15 X	10.1 X	-
		04/29/93	1.16 U	1.19 U	2.91 U	0.30 U
		04/29/93	-	-	2.47 F	-
	(Soil)	10/07/87	1.0	0.90	-	-
2000-Series Well	21033	06/17/93	13.1 U	16.1 U	43.2 U	-
		06/17/93	12.8 F	15.6 F	41.2 F	-
	2049	04/08/88	50.3 U	51.4 U	130.0 U	-
		08/03/88	3.1 U	2.8 U	8.0 U	-
		12/06/88	-	1.0 U	2.0 U	-
		02/07/89	2.3 U	2.1 U	6.0 U	-
		05/10/89	42.9 U	47.5 X	175.0 U	-
		07/30/89	83.2 U	89.9 U	147.0 U	-
		04/03/90	-	-	43.3 U	-
		05/10/93	41.5 U	46.4 U	111.0 U	-
	2045	01/23/89	78.9 U	92.3 U	283.0 U	5.0 U
		05/01/89	74.7 U	85.5 U	265.0 U	-
		05/01/89(D)	77.6 U	87.5 U	291.0 U	-
		07/25/89	104.0 U	119.0 U	341.0 U	-
		04/01/90	97.0 U	104.0 U	462.0 U	-

See footnotes at the end of table

TABLE 4-73
(Continued)

Sample Type	Boring No.	Date Sample Taken	Uranium-234[a] (pCi/L)	Uranium-238 (pCi/L)	Total Uranium (μg/L)	Total Thorium (μg/L)
2000-Series Well (cont'd)		04/01/90(D)	95.3 U	103.0 U	461.0 U	9.47 U
		04/28/93	131.0 F	144.0 F	364.0 U	-
	(Soil)	12/06/88 (35-36.5)	-	-	2.0	-
	2048	04/01/90	3.4 U	3.02 U	2.07 U	-
		04/27/93	0.68 U	0.34 U	1.0 U	1.03 U
Surface Water	AFP-SW-02	05/13/93	1.50 U	1.69	4.18 U	-
			pCi/g	pCi/g	mg/kg	mg/kg
Sediment	AFP-SD-06	05/13/93	2.77	2.9	11.3	8.04
Surface Soil	AFP-SD-02	05/12/93	4.14	4.39	13.6	8.57
	AFP-SD-04	05/13/93	2.37	3.05	10.2	14.7
	AFP-SD-05	05/13/93	3.25	3.62	12.5	16.5
	AFP-SD-01	05/15/93	3.39	3.42	14.8	22.2
	AFP-SD-03	05/13/93	2.83	3.11	10.7	11.2

[a]F = Filtered
U = Unfiltered
X = Not Known
D = Duplicate

Soil samples collected from screened interval at the time of well construction.

east corner of the South Field subunit. The source of the recharge is discussed in Section 4.5, above. Upgradient Wells 2943 and 2048 detected 1 μg/L and 3 μg/L total uranium, respectively. Downgradient Well 21033 detected 4.12 μg/L total uranium, which suggests that there has been an impact from the subunit on groundwater.

4.6.5 Biota

The ecological impacts from material left after remediation will be addressed in the Site-Wide Ecological Risk Assessment that will be prepared as part of the Operable Unit 5 RI/FS.

4.6.6 Active Flyash Summary

Data from environmental samples collected from soil and water media in the Active Flyash Pile indicate the following:

- Flyash contains elevated concentrations of metals, radionuclides, and organic compounds when compared to background concentrations for soil. When compared to background for flyash, radium, thorium, and uranium exceeded background levels. However, it should be noted that the FEMP flyash contains approximately 70 percent bottom ash; therefore, analytical results may be skewed higher.

- There are no background concentrations for VOCs in flyash; however VOCs were detected in flyash samples from the Active Flyash Pile. This suggests that VOCs may have been disposed of as an additional waste material in the subunit.

- The surface soil COCs detected above background in subsurface soils, both source and nonsource, are arsenic, beryllium, lead-210, neptunium-237, radium-226, radium-228, thorium-228 and thorium-232. Other radionuclides detected above background were lead-210, strontium, and plutonium.

- Concentrations of organic compounds decrease below the flyash/soil interface, from approximately 10 to 17 feet deep. This suggests that the organic contamination is related to surface activities after the pile was approximately half-way constructed.

- Chemical and radiological constituents detected in sediment samples are similar to those detected in surface and subsurface flyash samples. This suggests that the origin for sediment in the subunit is the flyash and that there has been an impact from the subunit on sediment. The surface soil COCs detected above background in the sediment are arsenic, beryllium and neptunium. An additional radionuclide, plutonium, was also detected above background.

- Metals and organic compounds detected in flyash and soil samples were not detected in shallow groundwater. this suggests that constituents that have been detected in shallow groundwater are a result of upgradient contamination in the South Field.

- The levels of radionuclides in surface flyash, subsurface flyash and sediment appears to vary within a narrow range. This suggests that the source for the radionuclides is the flyash.

- In the perched groundwater, the surface soil COCs detected above background were neptunium-237. Other radionuclides detected above background were plutonium-238, strontium-90, uranium-234, uranium-235/236, uranium-238 and thorium-232.

- Based on the perched groundwater flow directions determined from groundwater elevation contouring in the area of the Active Flyash Pile and South Field, and contaminants detected, perched groundwater quality near the Active Flyash Pile seems to be impacted by the South Field and not the Active Flyash Pile.

- The surface soil COCs above background for the 2000-series wells in the Great Miami Aquifer are thorium-232 and thorium-228. Additional radionuclides radium-226, uranium-234, uranium-235/236, and uranium-238 were detected above background. Due to the proximity of the wells to the South Field, these contaminants are possibly due to the recharge originating in the South Field.

5.0 CONTAMINANT FATE AND TRANSPORT

This section summarizes the results of fate and transport modeling that was used to simulate constituent movement from the Operable Unit 2 subunits to potential human receptors via the surface water, groundwater, and air migration pathways. Used in conjunction with monitoring data, the models predict constituent concentrations at potential exposure locations when measured constituent concentration data, such as off-site locations and/or future scenarios, are not available. Modeling estimates constituent migration to off-property locations or future exposure predictions by extrapolating from known field data. Conservative assumptions were used to simulate "worst-case" constituent migration scenarios. The modeled future concentrations were based on the unremediated baseline case for the Operable Unit 2 waste areas. The results of the fate and transport models were used in the Operable Unit 2 baseline risk assessment (presented in Appendix B and summarized in Section 6.0) to estimate potential risks to human health.

The technical approach and the methods used to quantitatively predict constituent concentrations for use in the Operable Unit 2 baseline risk assessment are presented as follows:

- A presentation of background information on the environmental setting
- Definition of the conceptual transport models for surface water, groundwater, and air based on a reasonable and conservative depiction of the environmental setting
- Description of the screening processes used to select constituents of potential concern (CPC) for further groundwater modeling
- Overview of the modeling process and discussion of modeling results
- Comparison of modeling results with field data

Radionuclides, metals, and organic constituents found in Operable Unit 2 subunits during RI sampling activities were evaluated for use in the fate and transport modeling process. Based on the sampling analyses, the most prevalent radionuclides within Operable Unit 2 are the isotopes of uranium, radium, thorium, the transuranic radionuclides neptunium-237 and plutonium-238, and technetium-99.

CPCs were identified for each waste subunit in Operable Unit 2 as discussed in the Operable Unit 2 baseline risk assessment (Section 6.0 and Appendix B). Sections 5.1 and 5.2 present the information on migration pathways and contaminant persistence pertinent to Operable Unit 2. Sections 5.3, 5.4,

and 5.5 present modeling procedures and results for surface water, groundwater, and air pathways, respectively. Detailed descriptions of the technical approaches used for the fate and transport of constituents through the surface water, groundwater, and air pathways are presented in Appendix A.

5.1 POTENTIAL MIGRATION PATHWAYS

The fate and transport evaluation for Operable Unit 2 includes modeling of surface water, groundwater, and air pathways (Figure 5-1):

- Surface water
  - Erosion of contaminated soils and flow of contaminated surface runoff into the Storm Sewer Outfall Ditch and Paddys Run and eventually to the Great Miami River
  - Flow of contaminated seep water to Paddys Run and eventually to the Great Miami River
  - Deposition of airborne contaminated dust directly into surface water
- Groundwater transport
  - Leaching of constituents from the subunits through the vadose zone to underlying groundwater
  - Infiltration of contaminated surface water from the Storm Sewer Outfall Ditch and Paddys Run to the Great Miami Aquifer
  - Leaching of constituents from contaminated sediments in the Storm Sewer Outfall Ditch and Paddys Run to the Great Miami Aquifer
  - Percolation of perched water under the subunits through the vadose zone to the underlying Great Miami Aquifer
  - Lateral migration of perched water to an area where glacial till is not present and then vertical migration to the Great Miami Aquifer
  - Infiltration of contaminated seep water to the Great Miami Aquifer
  - Deposition of airborne contaminated dust onto land and surface water bodies and then leaching to groundwater
- Air emissions
  - Volatilization of organic compounds, wind erosion of contaminated particulate matter
  - Direct release of radon gas

6505

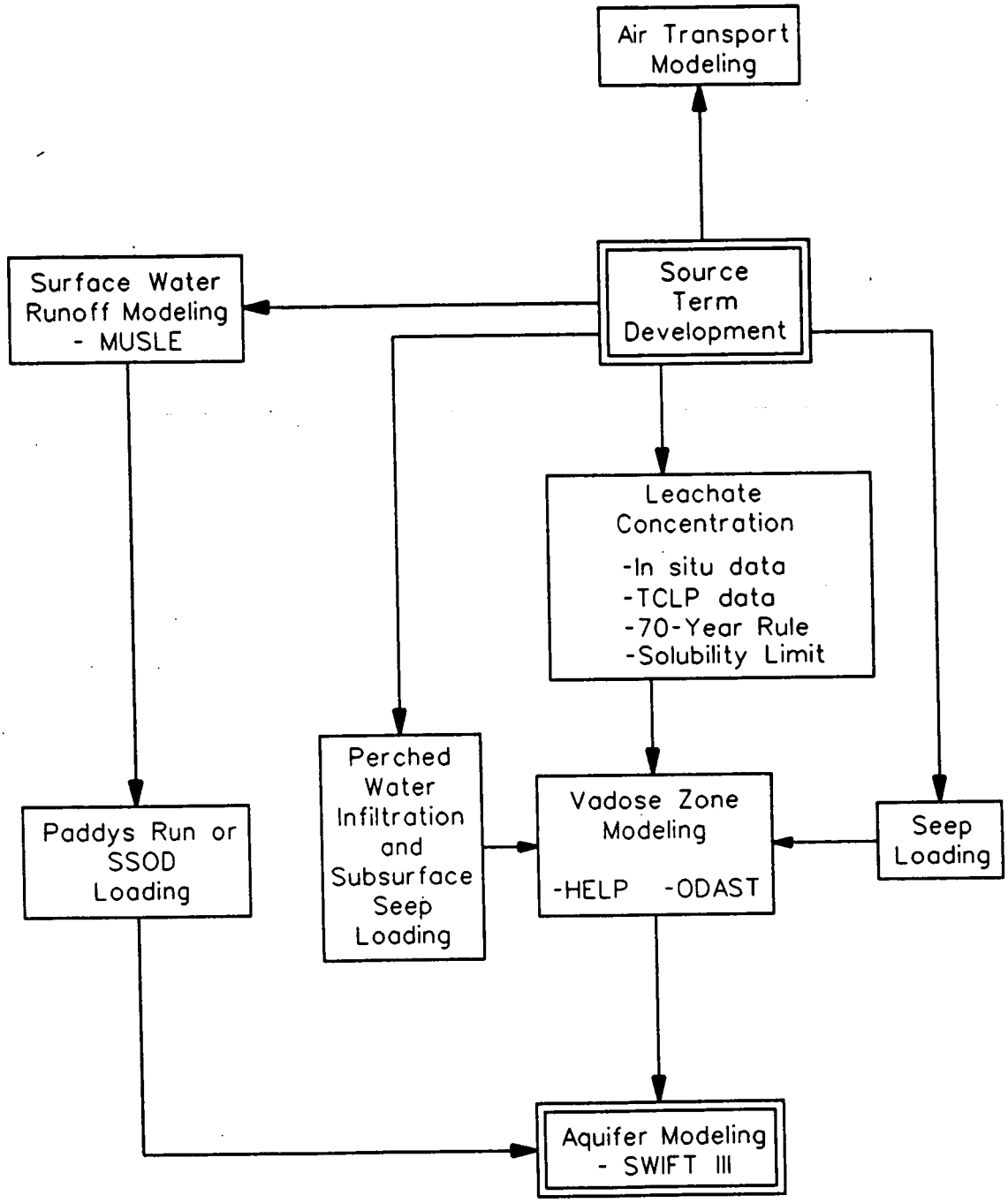

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FIGURE 5-1
OVERALL FATE AND TRANSPORT MODELING FRAMEWORK

000699

Each of these potential constituent transport pathways is discussed herein. The reader should refer to the baseline risk assessment (Section 6.0 and Appendix B) for detailed information concerning each of these pathways, the associated transport mechanisms, and the impact on environmental media or receptors. Impacts of deposition of airborne contaminated dust and subsequent leaching of constituents were not considered here. Impact of these two mechanisms will be considered under Operable Unit 5 modeling efforts.

5.1.1 Surface Water Pathway

Surface water runoff is a viable transport pathway for subunits in Operable Unit 2 except the Lime Sludge Ponds. Storm water from the Solid Waste Landfill drains to a drainageway which passes through the northern part of the subunit. Runoff flow from the slopes of the Inactive Flyash Pile and South Field drains into Paddys Run. Runoff flow from the Active Flyash Pile drains to the Storm Sewer Outfall Ditch which goes to Paddys Run. Surface water is not a viable transport pathway for the Lime Sludge Ponds since the ponds are constructed with berms, which prevent a release of contaminated runoff.

During a rainfall event, soil particles are dislodged by the impact of raindrops and the flow of runoff water across the soil surface. The amount of soil erosion depends on rainfall intensity, ground slope length, ground slope steepness, vegetative cover, and erosion control practices. Constituents adsorbed to soil particles can be desorbed and transported in the runoff water. Constituent transport in runoff water will be presented in the following two forms in Section 5.3:

- Adsorbed to the soil particles, both sediments and suspended particles
- Dissolved in the runoff water

Impact of deposition of airborne contaminated dust on surface water bodies was not considered here.

5.1.2 Groundwater Pathway

Rainfall and surface water runoff infiltrates through the surface of the waste units and percolates through the waste and soil overlying the groundwater. The FEMP is situated above the Great Miami Aquifer, which serves as a principal source of domestic, municipal, and industrial water throughout the region. The Great Miami Aquifer is considered the primary pathway by which constituents

released from Operable Unit 2 could be transported to a human receptor. The nine controlling mechanisms for this migration pathway are:

- The leaching of constituents from the soil matrix into the dissolved phase
- The percolation of the contaminated leachate to the underlying aquifer
- The infiltration of contaminated surface water from the Storm Sewer Outfall Ditch and Paddys Run to the Great Miami Aquifer
- The leaching of contaminated sediments in the Storm Sewer Outfall Ditch and Paddys Run to the Great Miami Aquifer
- Percolation (vertical migration) of contaminated water in the till under the subunits through the vadose zone to the underlying Great Miami Aquifer
- Lateral migration and infiltration of perched water to the Great Miami Aquifer
- Infiltration of contaminated seep water to the Great Miami Aquifer
- Deposition of airborne contaminated dust onto land and surface water and subsequent leaching and infiltration to the Great Miami Aquifer
- The movement of water in the Great Miami Aquifer

Impacts of deposition of airborne contaminated dust are not considered here. Impacts of this mechanism will be considered in the Operable Unit 5 modeling effort. The perched water systems under the Solid Waste Landfill and Lime Sludge Ponds are considered secondary groundwater pathways by which constituents released from Operable Unit 2 subunits could be transported to a human receptor. The three controlling mechanisms for this migration pathway are:

- The leaching of constituents from the soil matrix into the dissolved phase
- The percolation of the contaminated leachate to the underlying perched water
- The horizontal movement of water in the perched water system

The vertical migration of the contaminated perched water to the Great Miami Aquifer and then to a receptor is considered with the Great Miami Aquifer Pathway discussed above.

The constituent concentrations in leachate reaching groundwater depend on the infiltration rate, the initial concentration, contaminant mass, solubility of the CPC, degradation rate, soil textures, soil

hydraulic conductivities, depth to the groundwater, and a number of other chemical- and soil-specific factors. The predicted constituent concentrations in the Great Miami Aquifer were used as the primary basis for the assessment of human exposure by water intake and exposure pathways as discussed in the baseline risk assessment (Section 6.0 and Appendix B). The predicted constituent concentrations in the perched water under the Solid Waste Landfill and Lime Sludge Ponds were also used as the basis for the assessment of human exposure as discussed in the baseline risk assessment.

5.1.3 Air Pathway

Air emissions associated with Operable Unit 2 may involve different types of release mechanisms. During periods of turbulent wind conditions, particles of contaminated surface soil can become suspended in the air and may potentially be subject to inhalation by on- or off-site human receptors. The amount of material that may be suspended depends on wind speed and other site conditions such as soil moisture, particle size, and vegetative cover. Gaseous radon-222 will be emitted from soil and material containing radium-226. Also, if organic compounds are present within the surface soil or exposed waste materials, then volatilization of these compounds may occur. Concentrations of these airborne contaminants at on-site and off-site receptor locations form the basis for the assessment of human exposure by the air pathways, as discussed in Section 6.0.

Wind erosion of contaminated particulate matter was the principal release mechanism for organics, inorganics, and radionuclides found in Operable Unit 2, with one exception. Significant releases of radon-222 gas were estimated for most of the subunits.

5.2 PERSISTENCE OF CONSTITUENTS

The migration of constituents from Operable Unit 2 and their persistence in the environment are a function of both site characteristics and the physical/chemical properties of the constituents. Such properties include water solubility, tendency to transform or degrade (e.g., the compound's half life), and the chemical's affinity for solids or organic matter (partitioning coefficient). These properties and how they affect the constituent's behavior are described below for radionuclides, inorganics, and organics.

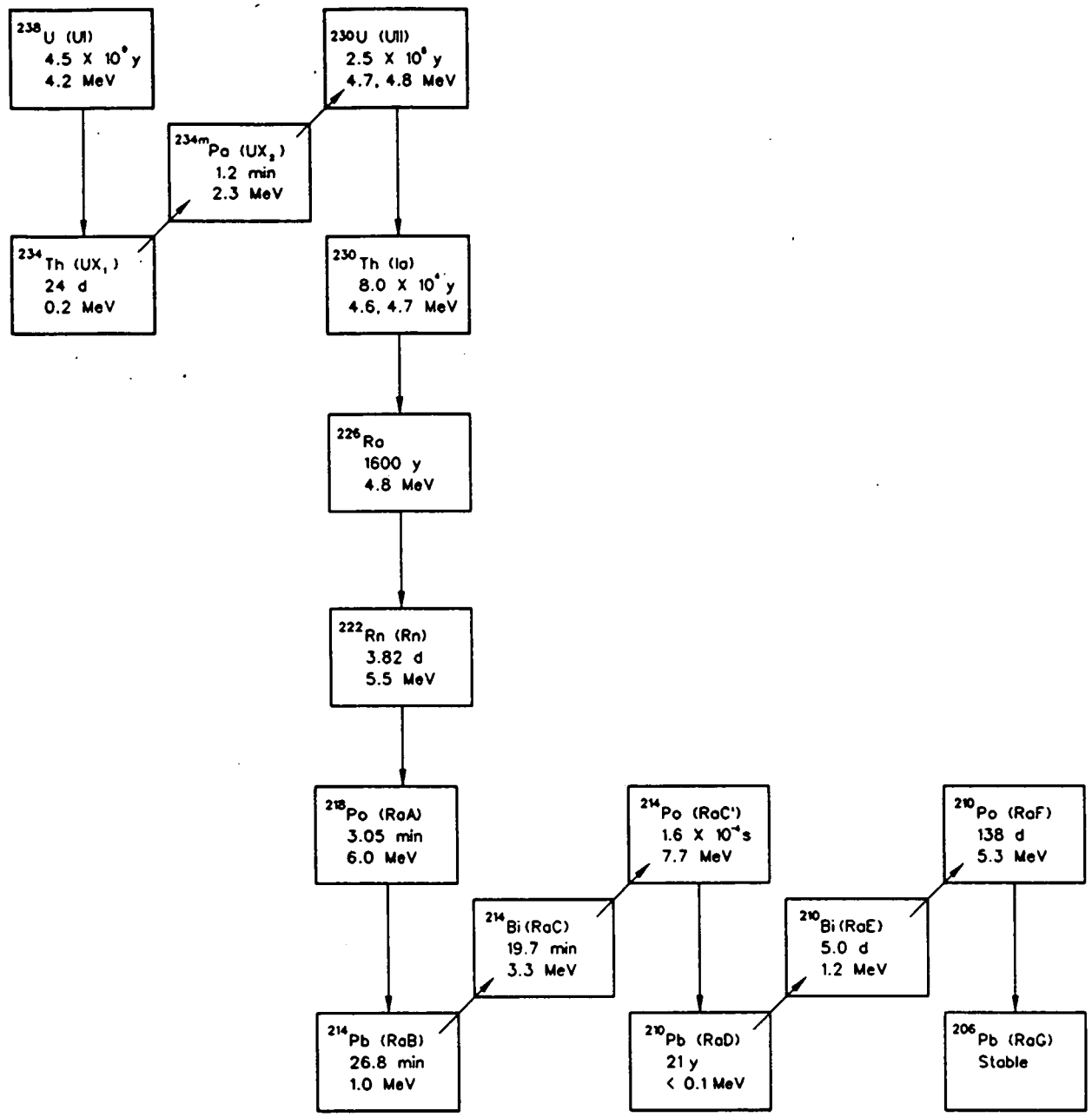
5.2.1 Radionuclides

Radionuclides undergo spontaneous transformations that involve the emission of particles and radiant energy. The resulting isotope may also be radioactive and undergo spontaneous decay or may be a

stable element that no longer decays. The succession of radioactive decays forms a decay chain, which continues until the resulting element is stable. The decay process occurs by various spontaneous mechanisms. The emissions produced by these decay modes consist of three different types of particles or photons (rays): alpha, beta, and gamma. Two of the more important decay modes are alpha decay and beta decay.

Alpha decay consists of the emission of an alpha particle from the nucleus of an atom. An alpha particle is composed of two protons and two neutrons, and consequently has a charge of +2. Following radioactive decay by alpha emission, a different element is formed (e.g., radium-226 becomes radon-222) because the number of protons in the nucleus has changed. During beta decay, a neutron is transformed into a proton and electron. The electron is then expelled from the nucleus as a beta particle. The atomic number of the resulting progeny is thus increased by one, and the number of neutrons is decreased by one (e.g. strontium-90 becomes yttrium-90). The atom may be left in an excited state; that is, the atom has excess energy that must be released. This energy can be emitted in several ways, including the formation of a gamma photon (ray) with a discrete energy.

Most of the radioactive materials present at the FEMP originated from natural sources such as pitchblende ore or ore concentrates. The radioactive elements present in these materials belong to three decay series (chain): the uranium-238 (uranium) series, the uranium-235 (actinium) series, and the thorium-232 (thorium) series as shown in Figures 5-2, 5-3, and 5-4, respectively. Stable daughter products are lead-208, lead-207, and lead-206 for uranium, actinium, and thorium series, respectively. If they are not subject to chemical or physical separation, the members of a series attain a state of radioactive equilibrium where the rate of decay of each nuclide is essentially equal to that of the nuclide that heads the series (the parent), leading to constant ratios of activity concentrations among the respective nuclides (parent and daughters or progeny). At the FEMP, radioactive equilibrium between various portions of these three decay chains does not always exist due to processing of ore concentrates prior to arrival at FEMP or as part of the uranium extraction process at FEMP. In addition to chemical processes, physical processes were used to preferentially extract certain isotopes (same element but with differing numbers of neutrons in the nucleus; such as uranium-234, uranium-235, and uranium-238) from materials prior to their use at FEMP (i.e., uranium that has been isotopically separated as part of fuel manufacturing).



NOTE:

1. SOURCE - N.C.R.P., 1987

LEGEND:

^{214}Pb (RaB) - MASS SYMBOL
26.8 min - HALF LIFE
1.0 MeV - DECAY ENERGY

Beta Decay
Alpha Decay

fig0501.dgn

FIGURE 5-2
PRINCIPAL DECAY SCHEME OF THE URANIUM SERIES

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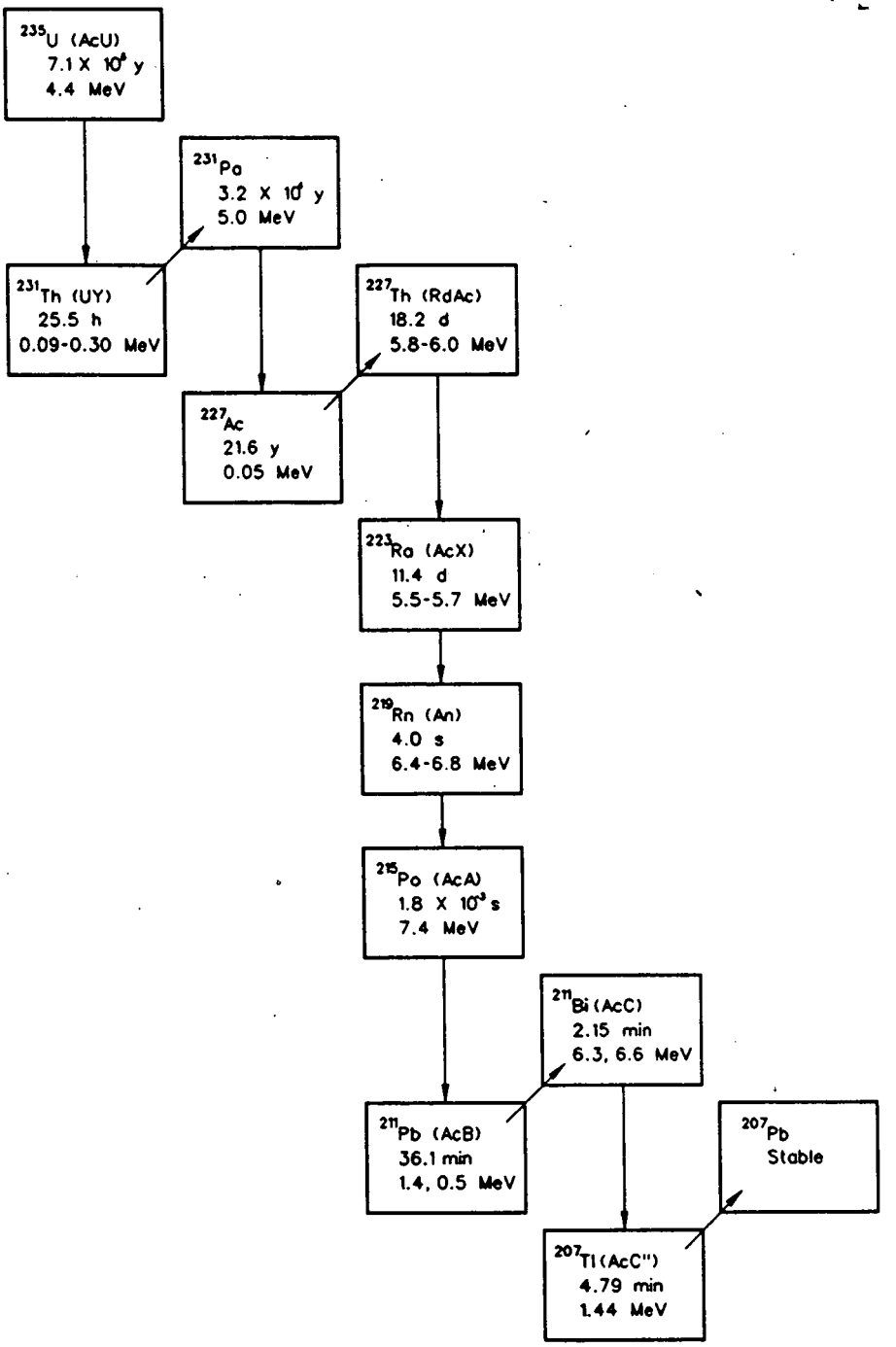
- 6505



NOTE:

1. SOURCE - N.C.R.P., 1987

LEGEND:

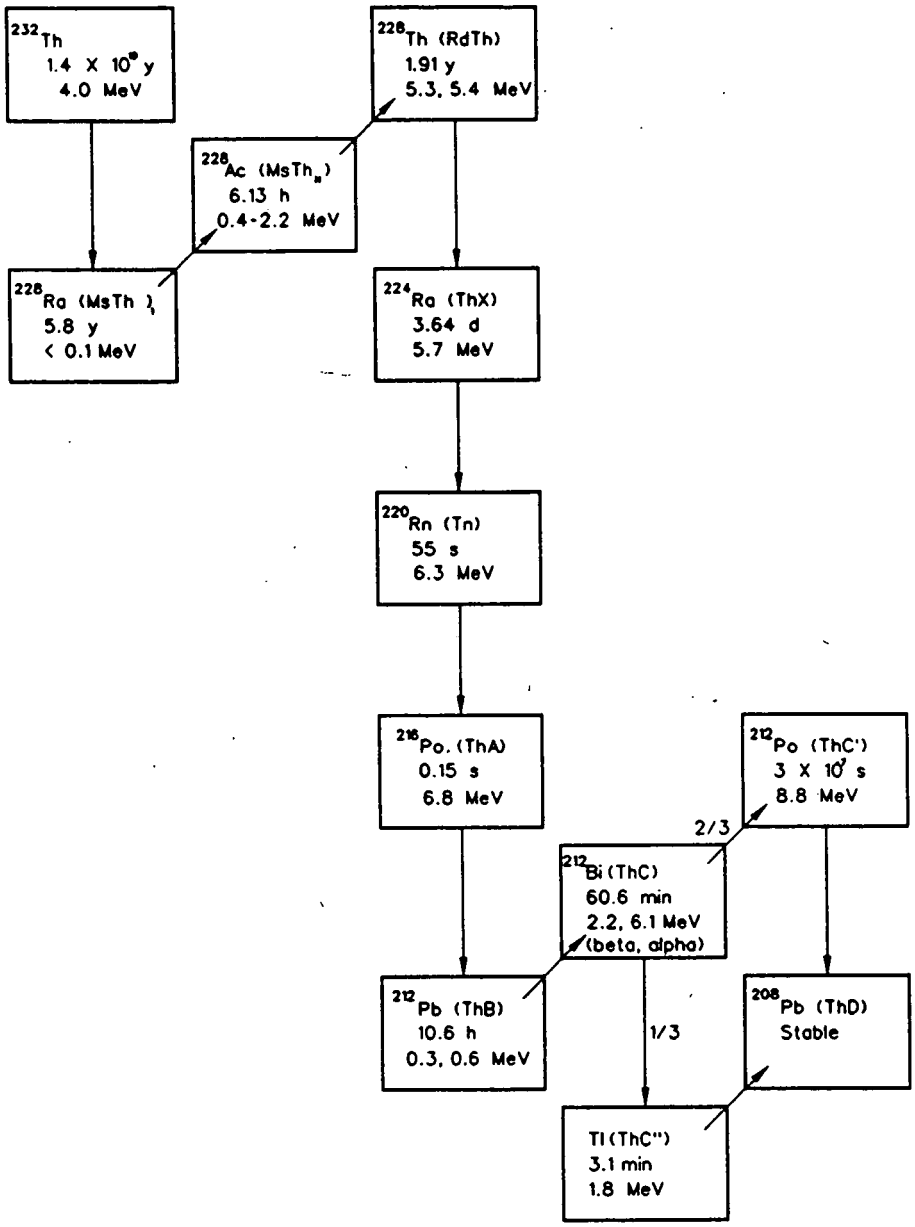
^{211}Pb (AcB) - MASS SYMBOL
36.1 min - HALF LIFE
1.4 MeV - DECAY ENERGY

Beta Decay →
Alpha Decay ↓

fig0502.dgn

FIGURE 5-3
PRINCIPAL DECAY SCHEME OF THE ACTINIUM SERIES

000705



NOTE:

1. SOURCE - N.C.R.P., 1987

LEGEND:

^{212}Pb (ThB) - MASS SYMBOL
10.6 h - HALF LIFE
0.6 MeV - DECAY ENERGY

Beta Decay
Alpha Decay

fig0503.dgn

FIGURE 5-4
PRINCIPAL DECAY SCHEME OF THE THORIUM SERIES

000706

As a result of different chemical processes in various areas of the FEMP, there is a wide variance in the presence or absence of members of the decay chain, member concentration, and isotopic content of wastes within the boundaries of Operable Unit 2. Activity ratios and parent/progeny equilibrium can be used as an indicator of contaminant source.

The half-lives of most of the radionuclides of concern at the FEMP are measured in thousands of years. Exceptions are radium-228 (with a half-life of 5.8 years), thorium-228 (with a half-life of 1.91 years), strontium-90 (with a half-life of 29 years), and cesium-137 (with a half-life of 30 years). Furthermore, many geochemical reactions occur that cause constituent movement to be retarded, which is a reduction in the velocity of the constituent movement in a medium. Radionuclide retardation in groundwater transport and their decay constants are discussed in detail in Appendix A.

5.2.2 Inorganics

Inorganics do not degrade in the environment, but they may undergo speciation, which is a change in chemical form. They may also react with soils or other solid surfaces by ion exchange, adsorption, precipitation, or complexation (combining of two compounds to form a new compound). These processes are affected by Ph, oxidation-reduction conditions, the type and amount of organic matter, clay, and hydrous oxides present. In turn, these factors are affected by the physical and biological properties of the environmental media.

Chemical speciation has a significant impact on the solubility of inorganic materials and in turn their mobility in the environment. Chemical speciation, however, is very complex and difficult to distinguish in routine laboratory analysis. Generally, the only distinction made in the analysis for inorganics is between total and filterable inorganics in water. The filterable inorganics represent the dissolved fraction, which is the more mobile and bioavailable.

5.2.3 Organics

Organic contaminants may be degraded in the environment by various processes, including hydrolysis, oxidation/reduction, photolysis, or biodegradation. Degradation rates in various media can vary from minutes to years depending on the chemical and environmental conditions.

The mobility of an organic compound is affected by its volatility, partitioning between solids and water, water solubility, and concentration. A constituent's water solubility and tendency to adsorb to

particles or organic matter correlates with its retardation in groundwater transport. Chemicals with higher water solubilities and lower adsorption coefficients are expected to remain primarily in the dissolved phase and be transported at approximately the same rate as the groundwater flow rate. Chemicals with lower water solubilities and higher adsorption coefficients are expected to remain primarily adsorbed to the surface of the soils and thus, transportation with the groundwater would be very limited and at a much slower rate. Retardation factors in groundwater transport are discussed further in Appendix A. A general overview of the relative water solubility, tendency to adsorb to solids, and constituent mobility for different categories of organic constituents is presented as follows:

- Volatile organic compounds
  - High water solubility
  - High volatility
  - Low tendency to adsorb to solids
  - Generally, transport occurs while dissolved in water or in air
  - Operable Unit 2 examples include benzene, 1,2-dichloroethene, 1,1,1-trichloroethane, and toluene
- Semivolatile organic compounds
  - Medium to low water solubility
  - Medium volatility
  - Medium to high tendency to adsorb to solids
  - Transport may occur dissolved in water, in air, or adsorbed to soil particles
  - Operable Unit 2 examples include anthracene, chlorobenzene, and di-n-butyl phthalate
- Pesticides, PCBs, and dioxins
  - Low water solubility
  - Low volatility
  - High tendency to adsorb to solids
  - Generally, transport occurs while adsorbed to soil particles
  - Operable Unit 2 examples include Aroclor-1254, heptachlorodibenzofuran, and octachlorodibenzo-p-dioxin

5.3 SURFACE WATER MODELING

The modeling approach used to estimate constituent concentrations in surface water and sediments resulting from transport by storm water runoff from Operable Unit 2 is described in this section. Details regarding the surface water modeling process, as well as modeling uncertainties, are presented in Appendix A-1. Predicting the transport of storm water runoff begins with characterizing the constituents present in the surface soil or waste and uses runoff and partitioning models to quantify the migration of constituents to stream sediments and surface water.

Constituents in surface soil from source areas can be released and transported to surface water via storm water runoff. During a rainfall event, some rainwater infiltrates the soil surface while some runs off the surface as shown in Figure 5-5. The amount of runoff increases with the increase in the clay content and moisture content of the soil, intensity and duration of rainfall, and ground slope steepness. Runoff will decrease with increased vegetative cover or greater ground slope length. Constituents in the surface soil can be transported via runoff either in the dissolved phase or adsorbed to soil particles. The less soluble a constituent is in water, the more likely it will be adsorbed to soil particles. Because the water solubility of constituents in Operable Unit 2 vary greatly, constituent transport is modeled for both dissolved-phase and adsorbed-phase.

This section also describes the use of the surface water modeling results to define source terms for groundwater modeling because the bases of Paddys Run and the Storm Sewer Outfall Ditch are in direct contact with the Great Miami Aquifer over a portion of their course.

5.3.1 Conceptual Model

Surface runoff from Operable Unit 2 that reaches the Storm Sewer Outfall Ditch and Paddys Run in response to a rainfall event is a significant potential pathway for constituent migration to surface water. However, it was assumed that once a contaminant has partitioned into the dissolved phase in the runoff water, and the adsorbed phase on the eroded soil particles at the subunit, further partitioning or dilution of contaminant adsorbed to eroded soil does not take place. Another pathway for constituent migration to surface water is storm runoff carrying contaminated seep water to the surface water before seep water can infiltrate to the Great Miami Aquifer.

Storm water runoff from the Active Flyash Pile reaches the Storm Sewer Outfall Ditch. As a conservative assumption for the impact on surface water, 44% of constituent mass reaching the Storm Sewer Outfall Ditch was assumed to reach the Paddys Run and eventually to the Great Miami River. However, for groundwater modeling purposes, all CPC mass flowing to the Storm Sewer Outfall Ditch from the Active Flyash Pile is considered to infiltrate the Great Miami Aquifer before reaching Paddys Run because flow in the Storm Sewer Outfall Ditch is very low and the base of the ditch is in direct contact with the Great Miami Aquifer. This is a conservative assumption for surface water source term to the Great Miami Aquifer, for conditions existing before the installation of the FEMP storm water retention basins.

fig0504.dgn

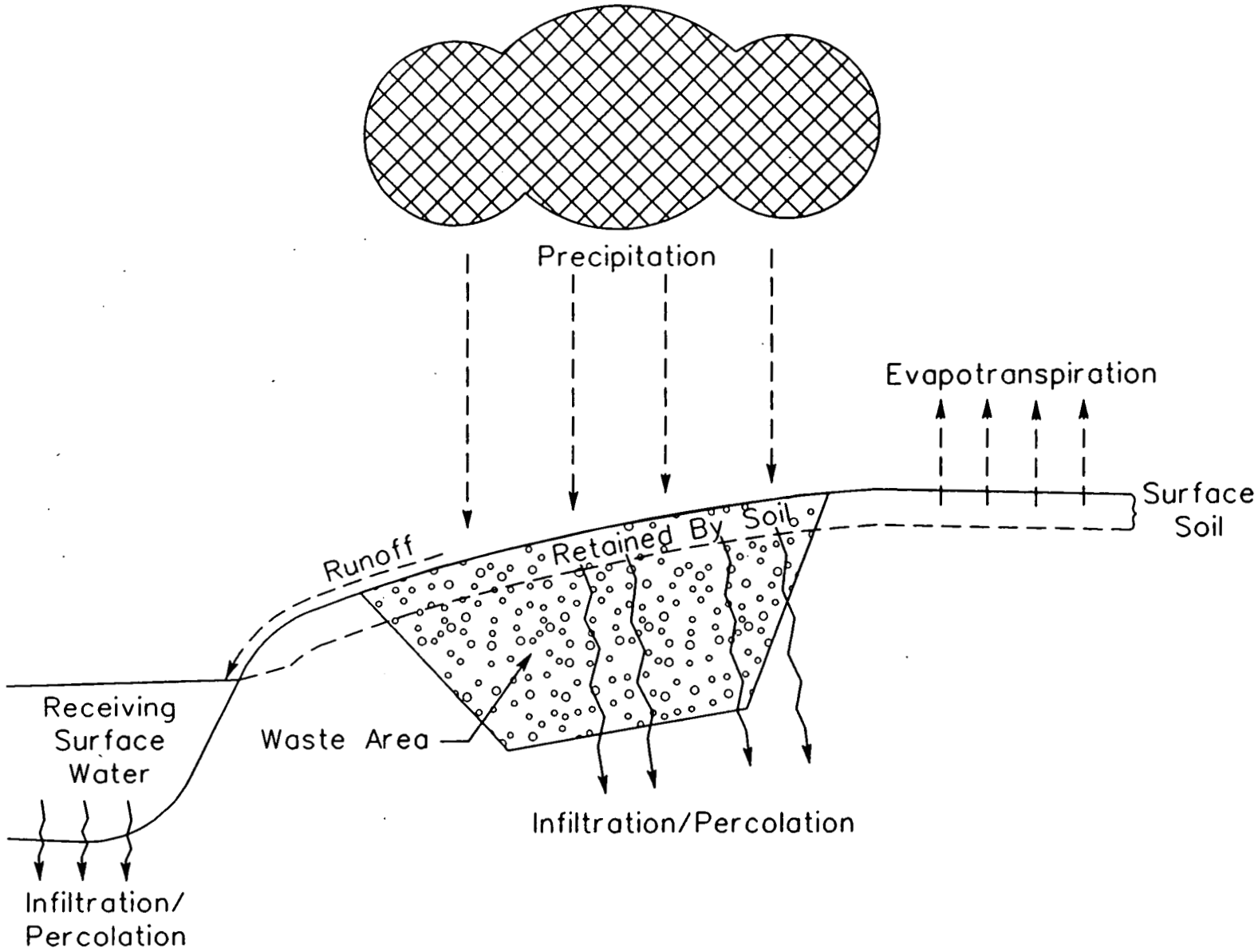


FIGURE 5-5
CONCEPTUAL MODEL OF SURFACE WATER RUNOFF

Surface water runoff from the South Field, Inactive Flyash Pile, and Solid Waste Landfill is considered to reach Paddys Run, and in turn, either discharges to the Great Miami River, or infiltrates to the Great Miami Aquifer. The Lime Sludge Ponds were not considered in surface water since berms surrounding the Lime Sludge Ponds are expected to contain the precipitation received during the storm event.

Contaminated soils in Operable Unit 2 were identified as potentially vulnerable to erosion by storm water. A uniform concentration was assigned for surface soil constituents in each subunit. The constituent concentrations used in this assessment are the upper 95 percent confidence level on the means (UCL) of the surface soil concentrations from the RI. Section 6.0 and Appendix B describe the selection of constituents of potential concern and source concentration terms for surface water modeling. Figure 5-6 shows the overall approach for surface water modeling and screening of CPCs. While determining CPCs in Section 6.0 and Appendix B, nutrients, constituents at background levels, and constituents with soil concentrations below the EPA RAGs, Part B screening values are screened out. Source term concentrations are also calculated and shown in Appendix B. Consistent with the conceptual model, runoff concentrations are then developed and screened against the EPA RAGs, Part B screening concentrations. Concentrations in Paddys Run and the Great Miami River are then calculated for the remaining CPCs. Sediment concentrations in Paddys Run and the Great Miami River are not calculated because the baseline risk assessment uses more conservative (higher) on-subunit sediment concentrations.

5.3.2 Technical Approach

The modeling approach used to estimate constituent concentrations in surface water and sediment resulting from transport by surface water runoff is described in this section.

The Modified Universal Soil Loss Equation (MUSLE) model was used to quantify soil migration as referenced in the "Superfund Exposure Assessment Manual" (EPA 1988c). This model employs event-specific runoff volume and flow rate parameters to calculate the soil loss for a single rainfall event and allows evaluation of an event-specific worst-case scenario. The MUSLE model calculates the total mass of soil transported by surface water in a single rainfall event. The volume of runoff was also estimated to determine the amount that stream flow may be increased by a storm event and dissolved contaminant loading.

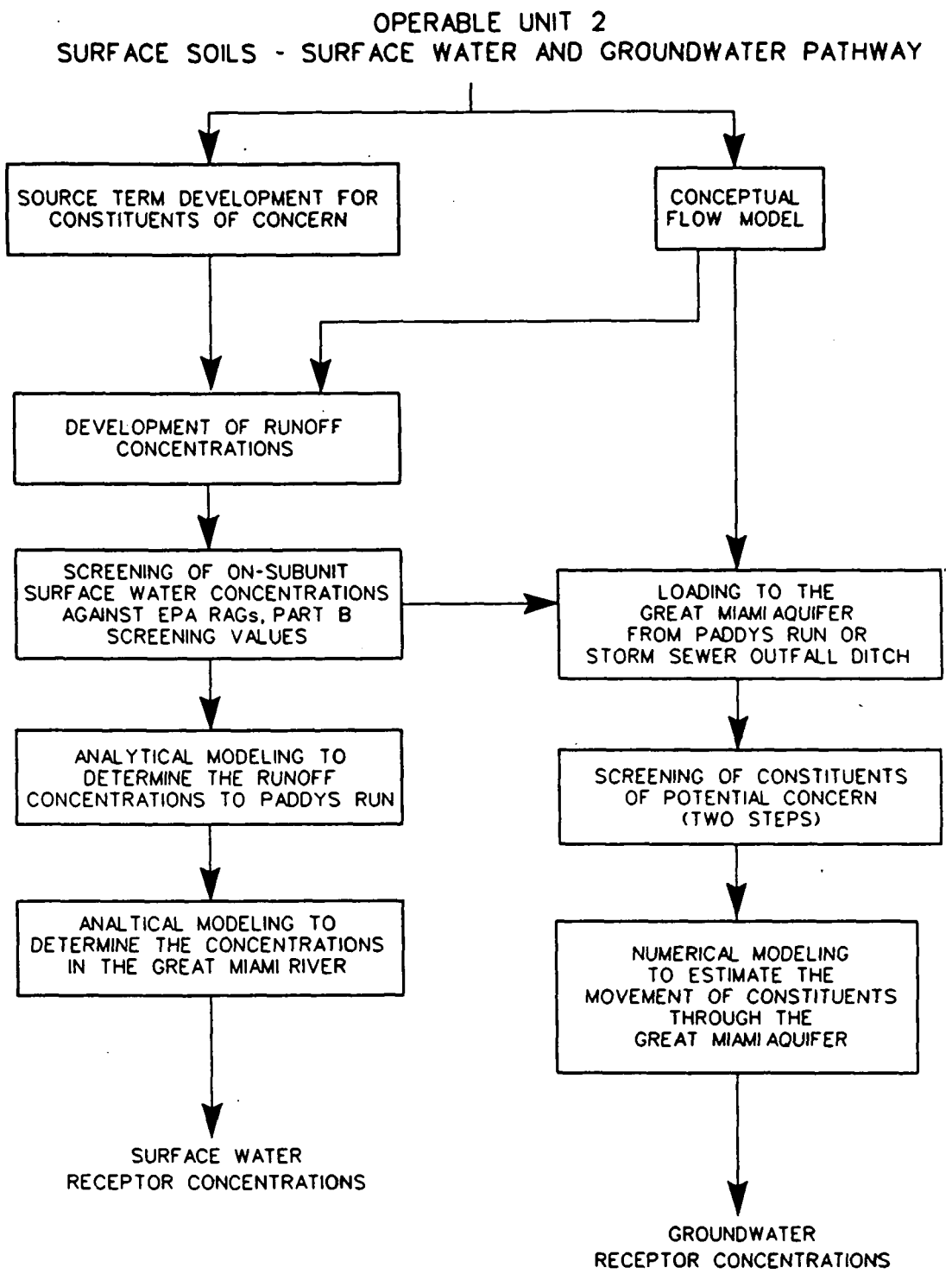


fig0531.dgn

FIGURE 5-6
SURFACE WATER TO GROUNDWATER PATHWAY TRANSPORT MODELING DIAGRAM

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Additional equations were used to approximate constituent partitioning between soil and water in the runoff flow. These partitioning equations provide an estimate of the constituent concentration dissolved in water runoff and adsorbed to the soil that is carried with the runoff and deposited in the sediment of receiving surface water bodies (Haith 1980; Mills et al. 1982; Mockus 1972).

Local meteorological data were used to obtain estimates of the amount and duration of rainfall at the site. The volume of storm water runoff flowing to Paddys Run was estimated in the surface water runoff modeling using the Soil Conservation Service (SCS) curve method. The storm runoff modeling was based on a single storm event (2.5 inches in 24 hours; Hershfield 1961) resulting in a flow rate in Paddys Run of 4 cubic feet per second (ft^3/sec) (Dames and Moore 1985a). No flow from upgradient runoff was assumed for the Storm Sewer Outfall Ditch.

Information on the soil types identified in Operable Unit 2 using the U.S. Soil Conservation Service designation is presented in detail in Section 3.0 of this RI report. The types and areal density of vegetation in Operable Unit 2 were provided by aerial photos, site reconnaissance, and interviews with personnel familiar with the Operable Unit 2 Study Area.

Maximum detected concentrations in the seeps for the subsurface soil CPCs in the Inactive Flyash Pile and South Field and the estimated seep flow rates were also used to define on-subunit surface water concentrations during a storm event and the source term for the Great Miami River and the Great Miami Aquifer. It was assumed that during the storm event, all seep water will reach Paddys Run. It was estimated that Inactive Flyash seep flow rate during storm event was two gallons per minute (gpm) and the South Field seep flow rate was 10 gpm.

Constituent concentrations in Paddys Run and the Great Miami River were calculated by diluting the dissolved concentrations in storm water runoff or seeps with the flows in the receiving streams. The results from Paddys Run were compared to observed conditions as discussed in Section 5.3.3. Constituent concentrations in the Storm Sewer Outfall Ditch were assumed to be the same as runoff concentrations to simulate a "no-flow" condition upstream of the Active Flyash Pile in the Storm Sewer Outfall Ditch.

An average flow rate of 3,300 ft^3/sec was used for the Great Miami River based on previous studies (DOE 1993a). To estimate the worst surface water conditions, it was assumed that all flow and all

constituent mass in Paddys Run (U.S. DOE 1993f) empties into the Great Miami River. To estimate the worst conditions in groundwater due to surface water as a source, it was assumed that 30 percent of constituent mass and flow in Paddys Run infiltrates to the Great Miami Aquifer. All constituent mass in the Storm Sewer Outfall Ditch, however, was assumed to infiltrate the Great Miami Aquifer. These overlapping assumptions result in assigning more than 100 percent of CPC mass in the runoff water to surface and groundwater receptors. This additional mass accounts for further leaching of CPC from the sediments as sediments are transported to Paddys Run and the Great Miami River. The equivalent of four storm runoff loading events was assumed to equal the annual loading to the stream.

5.3.3 Screening Procedure for Groundwater CPC from the Surface Water Pathway

Figure 5-6 presents the surface water to groundwater transport modeling diagram. This diagram identifies a screening step used to identify the CPCs in the Great Miami Aquifer from surface water loading. This step consists of comparing predicted constituent concentrations in the Great Miami Aquifer to screening levels. Screening levels have been determined for Operable Unit 2 constituents based on EPA RAGs, Part B guidelines (see Appendix B for the development of screening concentrations levels).

The screening step for the Great Miami Aquifer actually consists of two steps. The first two phases compare conservative estimates of Great Miami Aquifer concentrations to the screening levels. If a constituent was still of potential concern after the first two phases, more detailed modeling was performed.

The first step consists of estimating the maximum constituent concentration in the Great Miami Aquifer based on the surface water concentration and dilution in the Great Miami Aquifer resulting only from the width of the streambed (30 feet for Paddys Run and 10 feet for the Storm Sewer Outfall Ditch). Dilution was calculated by mixing runoff effluent mass with the volume of water in the Great Miami Aquifer flowing in Layer 1. Constituents were eliminated from further modeling and screening if their values were below screening levels in the first step.

The second step consists of estimating the constituent concentration in the Great Miami Aquifer by the dilution of the surface water concentration based on the Sandia Waste Isolation Flow and Transport (SWIFT) III model grid of 125 feet by 125 feet. If the predicted diluted groundwater concentrations

were below screening levels, detailed modeling was not performed. However, the predicted maximum groundwater concentration predicted in the first step (based on stream width) was reported as the maximum on-site concentrations in the Great Miami Aquifer for that constituent.

5.3.4 Results of Surface Water Modeling

This section presents the results of surface water modeling for each subunit of Operable Unit 2. The predicted maximum Great Miami Aquifer concentrations were compared to risk-based screening criteria which were derived based on EPA RAGs, Part B guidelines.

5.3.4.1 Solid Waste Landfill

Tables 5-1A and 5-1B present the results of surface water modeling for the Solid Waste Landfill based on a single storm event using the MUSLE model. Table 5-1A also shows the screening of CPCs based on comparison of on-subunit runoff concentrations against the EPA RAGs, Part B based screening concentrations for water. A total runoff of 23.2 m^3 was calculated during the 24-hour storm event. The model results show that the small mass of constituents from the Solid Waste Landfill that partition into the water, combined with dilution in the Great Miami River from a flow of 3300 ft^3/sec results in low surface water concentrations. The radionuclide concentrations in on-subunit runoff range from a minimum of 1.2×10^{-3} pCi/L for plutonium-239/240 to a maximum of 25 pCi/L for uranium-238. Note that the plutonium-239/240 runoff concentration is below the screening value. Concentrations in the Great Miami River range from a minimum of 1.4×10^{-7} pCi/L for radium-226 to a maximum of 7.1×10^{-5} pCi/L for uranium-238. Maximum inorganic concentrations were 0.8 μg/L in runoff and 2.3×10^{-6} μg/L in the Great Miami River for Arsenic. Except for phenanthrene, all organics in runoff were predicted to remain below 3.4×10^{-3} μg/L and below 9.6×10^{-9} μg/L in the Great Miami River. Phenanthrene, a CPC for which EPA RAGs, Part B screening concentration is not available, is predicted to be 55 μg/L in runoff and 1.6×10^{-4} μg/L in the Great Miami River. These concentrations remain only through the duration of the storm.

Modeled sediment concentrations resulting from a single runoff event are comparable to the source term soil concentrations for the Solid Waste Landfill. For example, the modeled sediment concentration for uranium-238 was 229.7 mg/kg compared to 230 mg/kg in the soil source term.

Table 5-2 shows predicted maximum Great Miami Aquifer concentrations due to surface water runoff. Table 5-2 also compares predicted Great Miami Aquifer concentration against the EPA RAGs, Part B

TABLE 5-1A

RUNOFF EFFLUENT AND SEDIMENT LOADING FROM THE SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern After Initial Screening	Partition Coefficient K_d (mL/g)	Waste Area Surface Soil Concentration Ci (mg/kg)	Total Annual Loading to Stream Tl (g)	Sediment Concentration Cs (mg/kg)	On-Subunit Runoff Effluent Concentration Ce (pCi/L RAD) (μg/L non-RAD)	Screening Concentration (pCi/L RAD) (μg/L non-RAD)	Final CPC For On-Subunit Runoff Water (Y/N)
INORGANICS							
Arsenic	$2.00 \times 10^{+2}$	$6.67 \times 10^{+0}$	7.52×10^{-2}	$6.67 \times 10^{+0}$	8.09×10^{-1}	1.46×10^{-4}	Yes
Berylium	$1.30 \times 10^{+3}$	6.98×10^{-1}	1.22×10^{-3}	6.98×10^{-1}	1.30×10^{-2}	2.37×10^{-4}	Yes
Lead	$3.00 \times 10^{+3}$	$1.90 \times 10^{+1}$	1.43×10^{-2}	$1.90 \times 10^{+1}$	1.54×10^{-1}	NA[a]	NA
RADIONUCLIDES							
Neptunium-237	$5.50 \times 10^{+1}$	1.69×10^{-3}	6.92×10^{-5}	1.69×10^{-3}	5.25×10^{-1}	2.16×10^{-2}	Yes
Plutonium-238	$1.70 \times 10^{+3}$	4.51×10^{-8}	6.00×10^{-11}	4.51×10^{-8}	1.10×10^{-2}	2.16×10^{-2}	No
Plutonium-239/240	$1.70 \times 10^{+3}$	1.32×10^{-6}	1.76×10^{-9}	1.32×10^{-6}	1.17×10^{-3}	2.07×10^{-2}	No
Radium-226	$6.96 \times 10^{+2}$	1.41×10^{-6}	4.60×10^{-9}	1.41×10^{-6}	4.86×10^{-2}	1.76×10^{-4}	Yes
Radium-228	$6.96 \times 10^{+2}$	6.18×10^{-9}	2.01×10^{-11}	6.18×10^{-9}	5.85×10^{-2}	4.75×10^{-2}	Yes
Strontium-90	$1.00 \times 10^{+1}$	6.97×10^{-9}	1.56×10^{-9}	6.91×10^{-9}	$2.30 \times 10^{+0}$	1.32×10^{-1}	Yes
Thorium-228	$5.80 \times 10^{+3}$	1.98×10^{-9}	7.72×10^{-13}	1.98×10^{-9}	6.79×10^{-3}	8.64×10^{-2}	No
Thorium-230	$5.80 \times 10^{+3}$	3.14×10^{-4}	1.22×10^{-7}	3.14×10^{-4}	2.71×10^{-2}	3.65×10^{-1}	No
Thorium-232	$5.80 \times 10^{+3}$	$1.37 \times 10^{+1}$	5.36×10^{-3}	$1.37 \times 10^{+1}$	6.30×10^{-3}	2.79×10^{-2}	No
Uranium-234	$7.50 \times 10^{+1}$	6.77×10^{-3}	2.04×10^{-4}	6.76×10^{-3}	$1.36 \times 10^{+1}$	2.97×10^{-1}	Yes
Uranium-235/236	$7.50 \times 10^{+1}$	$1.31 \times 10^{+0}$	3.94×10^{-2}	$1.31 \times 10^{+0}$	9.14×10^{-1}	2.97×10^{-1}	Yes
Uranium-238	$7.50 \times 10^{+1}$	$2.30 \times 10^{+2}$	$6.92 \times 10^{+0}$	$2.30 \times 10^{+2}$	$2.50 \times 10^{+1}$	1.70×10^{-1}	Yes
Uranium-Total (non-RAD)	$7.50 \times 10^{+1}$	$2.25 \times 10^{+2}$	$6.76 \times 10^{+0}$	$2.25 \times 10^{+2}$	$7.27 \times 10^{+1}$	$1.09 \times 10^{+1}$	Yes

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TABLE 5-1A
(Continued)

Constituent of Potential Concern After Initial Screening	Partition Coefficient K_d (mL/g)	Waste Area Surface Soil Concentration Ci (mg/kg)	Total Annual Loading to Stream Tl (g)	Sediment Concentration Cs (mg/kg)	On-Subunit Runoff Effluent Concentration Ce (pCi/L RAD) (μg/L non-RAD)	Screening Concentration (pCi/L RAD) (μg/L non-RAD)	Final CPC For On-Subunit Runoff Water (Y/N)
ORGANICS							
Benzo(a)anthracene	$2.63 \times 10^{+3}$	3.66×10^{-1}	3.15×10^{-4}	3.66×10^{-1}	3.38×10^{-3}	2.82×10^{-3}	Yes
Benzo(a)pyrene	$6.28 \times 10^{+3}$	3.40×10^{-1}	1.22×10^{-4}	3.40×10^{-1}	1.31×10^{-3}	2.82×10^{-4}	Yes
Benzo(b)fluoranthene	$2.45 \times 10^{+4}$	7.10×10^{-1}	6.56×10^{-5}	7.10×10^{-1}	7.03×10^{-4}	2.82×10^{-3}	No
Benzo(g,h,i)perylene	$2.13 \times 10^{+4}$	5.00×10^{-1}	5.32×10^{-5}	5.00×10^{-1}	5.69×10^{-4}	NA	NA
Dibenzo(a,h)anthracene	$6.14 \times 10^{+3}$	2.00×10^{-1}	7.36×10^{-5}	2.00×10^{-1}	7.90×10^{-4}	2.82×10^{-4}	Yes
Indeno(1,2,3,cd)pyrene	$3.01 \times 10^{+5}$	4.80×10^{-1}	3.61×10^{-6}	4.80×10^{-1}	3.87×10^{-5}	2.82×10^{-3}	No
Phenanthrene	$9.54 \times 10^{+0}$	$5.31 \times 10^{+0}$	5.14×10^{-1}	5.30×10^{-1}	$5.52 \times 10^{+1}$	NA	NA

[a]NA = EPA RAGs, Part B Screening Value could not be calculated.

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TABLE 5-1B

CONTAMINANT LOADING TO THE GREAT MIAMI RIVER FROM THE SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern for Surface Water Runoff	Runoff Effluent Concentration Ce (pCi/L RAD) (μg/L non-RAD)	Concentration in Surface Water (Paddy's Run) during Storm Event Cw (pCi/L RAD) (μg/L non-RAD)	Great Miami River Concentration Cgmr (pCi/L RAD) (μg/L non-RAD)
INORGANICS			
Arsenic	8.09×10^{-1}	1.91×10^{-3}	2.31×10^{-6}
Berylium	1.30×10^{-2}	3.08×10^{-5}	3.72×10^{-8}
Lead	1.54×10^{-1}	3.63×10^{-4}	4.38×10^{-7}
RADIONUCLIDES			
Neptunium-237	5.25×10^{-1}	1.24×10^{-3}	1.50×10^{-6}
Radium-226	4.86×10^{-2}	1.15×10^{-4}	1.39×10^{-7}
Radium-228	5.85×10^{-2}	1.38×10^{-4}	1.67×10^{-7}
Strontium-90	$2.30 \times 10^{+0}$	5.43×10^{-3}	6.55×10^{-6}
Uranium-234	$1.36 \times 10^{+1}$	3.22×10^{-2}	3.88×10^{-5}
Uranium-235/236	9.14×10^{-1}	2.16×10^{-3}	2.61×10^{-6}
Uranium-238	$2.50 \times 10^{+1}$	5.90×10^{-2}	7.12×10^{-5}
Uranium-Total (non-RAD)	$7.27 \times 10^{+1}$	1.72×10^{-1}	2.07×10^{-4}
ORGANICS			
Benzo(a)anthracene	3.38×10^{-3}	7.98×10^{-6}	9.63×10^{-9}
Benzo(a)pyrene	1.31×10^{-3}	3.10×10^{-6}	3.75×10^{-9}
Benzo(g,h,i)perylene	5.69×10^{-4}	1.35×10^{-6}	1.62×10^{-9}
Dibenzo(a,h)anthracene	7.90×10^{-4}	1.87×10^{-6}	2.25×10^{-9}
Phenanthrene	$5.52 \times 10^{+1}$	1.30×10^{-1}	1.57×10^{-4}

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TABLE 5-2

LOADING TO THE GREAT MIAMI AQUIFER FROM PADDYS RUN AND CPC SCREENING FOR GROUNDWATER MODELING, SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents	Predicted Maximum Aquifer Concentration C_{GMA} (pCi/L RAD) (μg/L non-RAD)	Screening Concentrations (pCi/L RAD) (μg/L non-RAD)	Groundwater Modeling Required
INORGANICS			
Arsenic	7.58×10^{-4}	1.46×10^{-4}	Yes[a]
Berylium	1.22×10^{-5}	2.37×10^{-4}	No
Lead	1.44×10^{-4}	NA[b]	NA
ORGANICS			
Benzo(a)anthracene	3.17×10^{-6}	2.82×10^{-3}	No
Benzo(a)pyrene	1.23×10^{-6}	2.82×10^{-4}	No
Benzo(g,h,i)perylene	5.33×10^{-6}	NA	NA
Dibenzo(a,h)anthraene	7.40×10^{-7}	2.82×10^{-4}	No
Phenanthrene	5.17×10^{-2}	NA	NA
RADIONUCLIDES			
Neptunium-237	4.92×10^{-4}	2.16×10^{-2}	No
Radium-226	4.55×10^{-5}	1.76×10^{-4}	No
Radium-228	5.48×10^{-5}	4.75×10^{-2}	No
Strontium-90	2.15×10^{-3}	1.32×10^{-1}	No
Uranium-234	1.27×10^{-2}	2.97×10^{-1}	No
Uranium-235/236	8.56×10^{-4}	2.97×10^{-1}	No
Uranium-238	2.34×10^{-2}	1.70×10^{-1}	No
Uranium-Total (non-RAD)	6.81×10^{-2}	$1.09 \times 10^{+1}$	No

[a]After mixing in the full SWIFT cell, calculated arsenic concentration is 1.82×10^{-4} μg/L, which is marginally above the screening concentration. It is expected that losses due to adsorption to soils will reduce the concentration and therefore was not considered for further modeling.

[b]NA = EPA RAGs, Part B screening value could not be calculated.

screening concentrations. As shown in Table 5-2, only arsenic concentration in the Great Miami Aquifer was above the screening concentration. However, when mixing with the full SWIFT cell was considered, predicted arsenic concentration was 1.82 x 10^{-4} μg/L, which is only marginally above the screening concentration of 1.46 x 10^{-4} μg/L. Furthermore, the predicted arsenic concentration does not consider reduction in concentration due to adsorption.

5.3.4.2 Lime Sludge Ponds

The Lime Sludge Ponds are contained within soil berms which isolate them from the surrounding soils; therefore, they were not considered a source of contaminants to the surface waters. No surface water pathway modeling was conducted.

5.3.4.3 Inactive Flyash Pile

Tables 5-3A and 5-3B present the results of surface water modeling for the Inactive Flyash Pile, based on a designated single storm event using the MUSLE model and loading from seeps in the Inactive Flyash Pile during the storm event. Table 5-3A also shows the screening of CPCs based on a comparison of on-subunit runoff concentration against the EPA RAGs, Part B based screening concentrations for water. A total runoff of 29.1 m^3 was calculated during the 24-hour storm event. For radionuclides, on-subunit surface water concentrations range from a minimum of a 8.1 x 10^{-3} pCi/L for cesium-137 (below the screening concentration for cesium-137) to a maximum of 163 pCi/L for uranium-234. For CPCs above screening concentrations, radionuclide concentrations in the Great Miami River range from a low of 2.9 x 10^{-7} pCi/L for plutonium-239/240 to a high of 8.0 x 10^{-4} pCi/L for uranium-234. All inorganics and organics were predicted to remain below 13 μg/L in on-subunit surface water and 6.4 x 10^{-5} μg/L in the Great Miami River. These concentrations remain only through the duration of the storm.

Modeled sediment concentrations resulting from a single runoff event are comparable to the source term soil concentrations for the Inactive Flyash Pile. For example, the modeled uranium-238 sediment concentration was 23.6 mg/kg compared to 26.4 mg/kg in the surface soil source term.

Loading from surface runoff to the Great Miami Aquifer from the Inactive Flyash Pile and the South Field was combined into one source term because of close proximity of the Inactive Flyash Pile to the South Field and surface runoff from both subunits arrive into Paddys Run at approximately the same

TABLE 5-3A

RUNOFF EFFLUENT AND SEDIMENT LOADING FROM THE INACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern After Initial Screening	Partition Coefficient K_d (mL/g)	Waste Area Surface Soil Concentration Ci (mg/kg)	Total Annual Loading to Stream Tl (g)	Seep Concentration (pCi/L RAD) (μg/L non-RAD)	Sediment Concentration Cs (mg/kg)	Runoff Effluent Concentration Ce (pCi/L RAD) (μg/L non-RAD)	On-Subunit Surface Water Concentration (pCi/L RAD) (μg/L non-RAD)	Screening Concentration (pCi/L RAD) (μg/L non-RAD)	Final CPC For On-Subunit Runoff Water (Y/N)
INORGANICS									
Arsenic	$2.00 \times 10^{+2}$	$3.32 \times 10^{+1}$	4.56×10^{-1}	$1.40 \times 10^{+0}$	$3.32 \times 10^{+1}$	$3.92 \times 10^{+0}$	$3.23 \times 10^{+0}$	1.46×10^{-4}	Yes
Beryllium	$2.50 \times 10^{+2}$	$2.27 \times 10^{+0}$	2.50×10^{-2}	ND[a]	$2.27 \times 10^{+0}$	2.14×10^{-1}	1.56×10^{-1}	2.37×10^{-4}	Yes
Lead	$3.80 \times 10^{+1}$	$2.39 \times 10^{+1}$	$1.72 \times 10^{+0}$	$8.30 \times 10^{+0}$	$2.38 \times 10^{+1}$	$1.48 \times 10^{+1}$	$1.30 \times 10^{+1}$	NA[b]	NA
ORGANICS									
2-Methylnaphthalene	$3.67 \times 10^{+1}$	1.6×10^{-1}	5.05×10^{-1}	ND	1.59×10^{-1}	$4.34 \times 10^{+0}$	$3.15 \times 10^{+0}$	NA	NA
Dibenzo(a,h)anthracene	$1.70 \times 10^{+3}$	$2.20 \times 10^{+0}$	3.56×10^{-3}	ND	$2.20 \times 10^{+0}$	3.06×10^{-2}	2.22×10^{-2}	2.82×10^{-4}	Yes
RADIONUCLIDES									
Cesium-137	$1.37 \times 10^{+3}$	7.41×10^{-9}	1.49×10^{-11}	ND	7.41×10^{-9}	1.11×10^{-2}	8.07×10^{-3}	1.07×10^{-1}	No
Neptunium-237	$5.00 \times 10^{+0}$	1.94×10^{-4}	1.03×10^{-4}	7.90×10^{-1}	1.87×10^{-4}	6.26×10^{-1}	6.71×10^{-1}	2.16×10^{-2}	Yes
Plutonium-238	$1.00 \times 10^{+2}$	4.74×10^{-9}	1.30×10^{-10}	$2.91 \times 10^{+0}$	4.73×10^{-9}	1.91×10^{-2}	8.08×10^{-1}	2.16×10^{-2}	Yes
Plutonium-239/240	$1.00 \times 10^{+2}$	3.38×10^{-7}	9.28×10^{-9}	2.00×10^{-1}	3.37×10^{-7}	4.95×10^{-3}	5.82×10^{-2}	2.07×10^{-2}	Yes
Radium-226	$1.06 \times 10^{+2}$	2.00×10^{-6}	5.20×10^{-8}	1.48×10^{-1}	2.00×10^{-6}	4.40×10^{-1}	3.60×10^{-1}	1.76×10^{-4}	Yes
Radium-228	$1.06 \times 10^{+2}$	8.24×10^{-9}	2.14×10^{-10}	ND	8.23×10^{-9}	4.99×10^{-1}	3.63×10^{-1}	4.75×10^{-2}	Yes
Strontium-90	$1.06 \times 10^{+2}$	6.35×10^{-9}	1.64×10^{-10}	ND	6.34×10^{-9}	1.94×10^{-1}	1.41×10^{-1}	1.32×10^{-1}	Yes
Thorium-228	$3.20 \times 10^{+3}$	3.30×10^{-9}	2.84×10^{-12}	ND	3.30×10^{-9}	2.00×10^{-2}	1.45×10^{-2}	8.64×10^{-2}	No
Thorium-230	$3.20 \times 10^{+3}$	1.34×10^{-4}	1.15×10^{-7}	6.53×10^{-1}	1.34×10^{-4}	2.04×10^{-2}	1.93×10^{-1}	3.65×10^{-1}	No
Thorium-232	$3.20 \times 10^{+3}$	$2.12 \times 10^{+1}$	1.82×10^{-2}	ND	$2.12 \times 10^{+1}$	1.72×10^{-2}	1.25×10^{-2}	2.79×10^{-2}	No

See footnotes at end of table

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TABLE 5-3A
(Continued)

Constituent of Potential Concern After Initial Screening	Partition Coefficient K_d (mL/g)	Waste Area Surface Soil Concentration Ci (mg/kg)	Total Annual Loading to Stream Tl (g)	Seep Concentration (pCi/L RAD) (μg/L non-RAD)	Sediment Concentration Cs (mg/kg)	Runoff Effluent Concentration Ce (pCi/L RAD) (μg/L non-RAD)	On-Subunit Surface Water Concentration (pCi/L RAD) (μg/L non-RAD)	Screening Concentration (pCi/L RAD) (μg/L non-RAD)	Final CPC For On-Subunit Runoff Water (Y/N)
RADIONUCLIDES (Continued)									
Uranium-234	$1.48 \times 10^{+0}$	1.39×10^{-3}	2.31×10^{-3}	$2.65 \times 10^{+2}$	1.24×10^{-3}	$1.24 \times 10^{+2}$	$1.63 \times 10^{+2}$	2.97×10^{-1}	Yes
Uranium-235/236	$1.48 \times 10^{+0}$	2.79×10^{-1}	4.64×10^{-1}	$1.40 \times 10^{+1}$	2.50×10^{-1}	$8.60 \times 10^{+0}$	$1.10 \times 10^{+1}$	2.97×10^{-1}	Yes
Uranium-238	$1.48 \times 10^{+0}$	$2.64 \times 10^{+1}$	$4.40 \times 10^{+1}$	$2.57 \times 10^{+2}$	$2.36 \times 10^{+1}$	$1.27 \times 10^{+2}$	$1.62 \times 10^{+2}$	1.70×10^{-1}	Yes
Uranium-Total (non-RAD)	$1.48 \times 10^{+0}$	$2.62 \times 10^{+1}$	$4.36 \times 10^{+1}$	$8.20 \times 10^{+2}$	$2.34 \times 10^{+1}$	$3.74 \times 10^{+2}$	$4.96 \times 10^{+2}$	$1.09 \times 10^{+1}$	Yes

[a]ND = Not detected
[b]NA = EPA RAGs, Part B screening value could not be calculated.

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TABLE 5-3B

CONTAINMENT LOADING TO THE GREAT MIAMI RIVER FROM THE INACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern For On-Subunit Runoff	On-Subunit Surface Water Concentration (pCi/L RAD) (μg/L non-RAD)	Concentration in Paddys Run during Storm Event Cw (pCi/L RAD) (μg/L non-RAD)	Great Miami River Concentration Cgmr (pCi/L Rad) (μg/L Non-Rad)
INORGANICS			
Arsenic	$3.23 \times 10^{+0}$	1.31×10^{-2}	1.59×10^{-5}
Beryllium	1.56×10^{-1}	6.32×10^{-4}	7.64×10^{-7}
Lead	$1.30 \times 10^{+1}$	5.29×10^{-2}	6.40×10^{-5}
ORGANICS			
2 - Methylnaphthalene	$3.15 \times 10^{+0}$	1.28×10^{-2}	1.54×10^{-5}
Dibenzo(a,h)anthracene	2.22×10^{-2}	9.02×10^{-5}	1.09×10^{-7}
RADIONUCLIDES			
Neptunium-237	6.71×10^{-1}	2.73×10^{-3}	3.32×10^{-6}
Plutonium-238	8.08×10^{-1}	3.30×10^{-3}	3.99×10^{-6}
Plutonium-239/240	5.82×10^{-2}	2.37×10^{-4}	2.87×10^{-7}
Radium-226	3.60×10^{-1}	1.46×10^{-3}	1.77×10^{-6}
Radium-228	3.63×10^{-1}	1.47×10^{-3}	1.78×10^{-6}
Strontium-90	1.41×10^{-1}	5.71×10^{-4}	6.90×10^{-7}
Uranium-234	$1.63 \times 10^{+2}$	6.65×10^{-1}	8.06×10^{-4}
Uranium-235/236	$1.01 \times 10^{+1}$	4.10×10^{-2}	4.96×10^{-5}
Uranium-238	$1.62 \times 10^{+2}$	6.65×10^{-1}	8.06×10^{-4}
Uranium-Total (non-RAD)	$4.96 \times 10^{+2}$	$2.02 \times 10^{+0}$	2.44×10^{-3}

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location. CPC loadings to the Great Miami Aquifer due to surface runoff from the Inactive Flyash Pile and South Field are discussed in Section 5.3.4.4.

5.3.4.4 South Field

Tables 5-4A and 5-4B present the results of surface water modeling from the South Field based on a designated single storm event using the MUSLE model. Table 5-4A also shows the screening of CPCs based on a comparison of on-subunit runoff concentrations against the EPA RAGs, Part B based screening concentrations for water. A total runoff of 192 m^3 was calculated during the 24-hour storm event. Modeling results showed that on-subunit surface water radionuclide concentrations range from a low of 6.9 x 10^{-3} pCi/L for cesium-137 to a high of 1.7 x 10^{+4} pCi/L for technetium-99. For some radionuclides, like cesium-137, predicted on-subunit surface water concentrations are below the screening concentrations. For the remaining radionuclide CPCs, concentrations in the Great Miami River ranged from 6.6 x 10^{-7} pCi/L for plutonium-238 to 0.51 pCi/L for technetium-99. Modeled uranium-238 concentrations were 151 pCi/L and 4.5 x 10^{-3} pCi/L for on-subunit surface water and the Great Miami River, respectively. All inorganics were predicted to be below 12.2 μg/L in on-subunit surface water and below 3.7 x 10^{-4} μg/L in the Great Miami River. Phenanthrene was predicted to be at 151 μg/L in on-subunit surface water and 4.7 x 10^{-3} μg/L in the Great Miami River. Other organics were predicted to be below 0.49 μg/L and 1.5 x 10^{-5} μg/L, in on-subunit surface water and the Great Miami River, respectively. These concentrations remain only through the duration of the storm.

Modeled sediment concentrations resulting from a single runoff event are comparable to the source term soil concentrations for the South Field because sediment mixing and desorption in Paddys Run were not considered. For example, the modeled uranium-238 sediment concentration was 26.1 mg/kg compared to 27.7 mg/kg in the soil source term. Sediment concentrations would be expected to decrease following the rainfall event because of dispersion through sediment transport, gradual mixing with sediment from other sources, and leaching of constituents in Paddys Run.

Loading from surface runoff to the Great Miami Aquifer from Inactive Flyash Pile and the South Field was combined into one source term because of the close proximity of the Inactive Flyash to the South Field, resulting in surface runoff from both subunits to Paddys Run at approximately the same location. The loading to the Great Miami Aquifer consists of loading due to infiltration of surface water as well as leaching of sediments. This was assumed to equal 30 percent of the runoff mass

TABLE 5-4A

RUNOFF EFFLUENT AND SEDIMENT LOADING FROM THE SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern After Initial Screening	Partition Coefficient K_d (mL/g)	Waste Area Surface Soil Concentration Ci (mg/kg)	Total Annual Loading to Stream Tl (g)	Seep Concentration (pCi/L RAD) (μg/L non-RAD)	Sediment Concentration Cs (mg/kg)	Runoff Effluent Concentration Ce (pCi/L RAD) (μg/L non-RAD)	On-Subunit Surface Water Concentration pCi/L Rad μg/L non-RAD	Screening Concentration (pCi/L RAD) (μg/L non-RAD)	Final CPC For On-Subunit Runoff Water (Y/N)
INORGANICS									
Arsenic	$2.00 \times 10^{+2}$	$7.27 \times 10^{+0}$	6.80×10^{-1}	ND[a]	$7.27 \times 10^{+0}$	8.81×10^{-1}	6.84×10^{-1}	1.46×10^{-4}	Yes
Beryllium	$2.50 \times 10^{+2}$	9.42×10^{-1}	7.04×10^{-2}	ND	9.42×10^{-1}	9.14×10^{-2}	7.09×10^{-2}	2.37×10^{-4}	Yes
Lead	$3.80 \times 10^{+1}$	$2.46 \times 10^{+1}$	$1.21 \times 10^{+1}$	ND	$2.45 \times 10^{+1}$	$1.57 \times 10^{+1}$	$1.22 \times 10^{+1}$	NA[b]	NA
ORGANICS									
Aroclor-1254	$1.95 \times 10^{+3}$	8.90×10^{-2}	8.52×10^{-4}	ND	8.90×10^{-2}	1.11×10^{-3}	8.62×10^{-4}	1.10×10^{-3}	No
Aroclor-1260	$2.35 \times 10^{+3}$	5.20×10^{-2}	4.12×10^{-4}	ND	5.20×10^{-2}	5.37×10^{-4}	4.17×10^{-4}	1.10×10^{-3}	No
Benzo(a)anthracene	$7.28 \times 10^{+2}$	$5.50 \times 10^{+0}$	1.41×10^{-1}	ND	$5.50 \times 10^{+0}$	1.83×10^{-1}	1.42×10^{-1}	2.82×10^{-3}	Yes
Benzo(a)pyrene	$1.74 \times 10^{+3}$	$9.40 \times 10^{+0}$	1.01×10^{-1}	ND	$9.40 \times 10^{+0}$	1.31×10^{-1}	1.02×10^{-1}	2.82×10^{-4}	Yes
Benzo(b)fluoranthene	$6.77 \times 10^{+3}$	$6.20 \times 10^{+0}$	1.71×10^{-2}	ND	$6.20 \times 10^{+0}$	2.22×10^{-2}	1.72×10^{-2}	2.82×10^{-3}	Yes
Benzo(k)fluoranthene	$1.26 \times 10^{+4}$	$7.30 \times 10^{+0}$	1.08×10^{-2}	ND	$7.30 \times 10^{+0}$	1.41×10^{-2}	1.09×10^{-2}	2.82×10^{-2}	No
Benzo(g,h,i)perylene	$9.88 \times 10^{+3}$	$6.2 \times 10^{+0}$	4.82×10^{-1}	ND	$6.20 \times 10^{+0}$	6.28×10^{-1}	4.87×10^{-1}	NA	NA
Dibenzo(a,h)anthracene	$1.70 \times 10^{+3}$	$1.90 \times 10^{+0}$	2.09×10^{-2}	ND	$1.90 \times 10^{+0}$	2.71×10^{-2}	2.10×10^{-2}	2.82×10^{-4}	Yes
Dieldrin	$5.75 \times 10^{+0}$	9.70×10^{-3}	3.10×10^{-2}	ND	9.55×10^{-3}	4.03×10^{-2}	3.13×10^{-2}	1.12×10^{-4}	Yes
Indeno(1,2,3-cd)pyrene	$8.32 \times 10^{+4}$	$6.00 \times 10^{+0}$	1.35×10^{-3}	ND	$6.00 \times 10^{+0}$	1.75×10^{-3}	1.36×10^{-3}	2.82×10^{-3}	No
Phenanthrene	$1.17 \times 10^{+1}$	$2.30 \times 10^{+0}$	$1.50 \times 10^{+2}$	ND	$2.30 \times 10^{+0}$	$1.95 \times 10^{+2}$	$1.51 \times 10^{+2}$	NA	NA

See footnote at end of table

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TABLE 5-4A
(Continued)

Constituent of Potential Concern After Initial Screening	Partition Coefficient K_d (mL/g)	Waste Area Surface Soil Concentration Ci (mg/kg)	Total Annual Loading to Stream Tl (g)	Seep Concentration (pCi/L RAD) (μg/L non-RAD)	Sediment Concentration Cs (mg/kg)	Runoff Effluent Concentration Ce (pCi/L RAD) (μg/L non-RAD)	On-Subunit Surface Water Concentration pCi/L Rad μg/L non-RAD	Screening Concentration (pCi/L RAD) (μg/L non-RAD)	Final CPC For On-Subunit Runoff Water (Y/N)
RADIONUCLIDES									
Cesium-137	$1.37 \times 10^{+3}$	5.77×10^{-9}	7.88×10^{-11}	ND	5.77×10^{-9}	8.84×10^{-3}	6.86×10^{-3}	1.70×10^{-1}	No
Neptunium-237	$5.00 \times 10^{+0}$	3.04×10^{-4}	1.11×10^{-3}	ND	2.98×10^{-4}	$1.03 \times 10^{+0}$	8.00×10^{-1}	2.16×10^{-2}	Yes
Plutonium-238	$1.00 \times 10^{+2}$	6.78×10^{-9}	1.27×10^{-9}	ND	6.77×10^{-9}	2.81×10^{-2}	2.18×10^{-2}	2.16×10^{-2}	Yes
Plutonium-239/240	$1.00 \times 10^{+2}$	1.22×10^{-6}	2.28×10^{-7}	ND	1.22×10^{-6}	1.84×10^{-2}	1.43×10^{-2}	2.07×10^{-2}	No
Radium-226	$1.06 \times 10^{+2}$	3.11×10^{-5}	5.48×10^{-6}	ND	3.11×10^{-5}	$7.03 \times 10^{+0}$	$5.46 \times 10^{+0}$	1.76×10^{-4}	Yes
Radium-228	$1.06 \times 10^{+2}$	1.43×10^{-8}	2.52×10^{-9}	ND	1.43×10^{-8}	8.89×10^{-1}	6.90×10^{-1}	4.75×10^{-2}	Yes
Strontium-90	$2.50 \times 10^{+0}$	1.17×10^{-9}	8.46×10^{-9}	ND	1.13×10^{-9}	$1.50 \times 10^{+0}$	$1.16 \times 10^{+0}$	1.32×10^{-1}	Yes
Technetium-99	7.00×10^{-2}	8.35×10^{-3}	9.72×10^{-1}	ND	3.64×10^{-3}	$2.15 \times 10^{+4}$	$1.67 \times 10^{+4}$	$3.65 \times 10^{+0}$	Yes
Thorium-228	$3.20 \times 10^{+3}$	5.38×10^{-9}	3.14×10^{-11}	ND	5.38×10^{-9}	3.34×10^{-2}	2.59×10^{-2}	8.64×10^{-2}	No
Thorium-230	$3.20 \times 10^{+3}$	6.70×10^{-4}	3.91×10^{-6}	ND	6.70×10^{-4}	1.05×10^{-1}	8.15×10^{-2}	3.65×10^{-1}	No
Thorium-232	$3.20 \times 10^{+3}$	$3.63 \times 10^{+1}$	2.12×10^{-1}	ND	$3.63 \times 10^{+1}$	3.03×10^{-2}	2.35×10^{-2}	2.79×10^{-2}	No
Uranium-234	$1.48 \times 10^{+0}$	1.39×10^{-3}	1.65×10^{-2}	$1.59 \times 10^{+2}$	1.31×10^{-3}	$1.34 \times 10^{+2}$	$1.40 \times 10^{+2}$	2.97×10^{-1}	Yes
Uranium-235/236	$1.48 \times 10^{+0}$	4.11×10^{-1}	$4.89 \times 10^{+0}$	$7.47 \times 10^{+0}$	3.88×10^{-1}	$1.37 \times 10^{+1}$	$1.23 \times 10^{+1}$	2.97×10^{-1}	Yes
Uranium-238	$1.48 \times 10^{+0}$	$2.77 \times 10^{+1}$	$3.30 \times 10^{+2}$	$1.74 \times 10^{+2}$	$2.61 \times 10^{+1}$	$1.44 \times 10^{+2}$	$1.51 \times 10^{+2}$	1.7×10^{-1}	Yes
Uranium-Total (non-RAD)	$1.48 \times 10^{+0}$	$2.96 \times 10^{+1}$	$3.52 \times 10^{+2}$	$4.87 \times 10^{+2}$	$2.79 \times 10^{+1}$	$4.57 \times 10^{+2}$	$4.64 \times 10^{+2}$	1.09×10^{-2}	Yes

[a]ND = Not detected
[b]NA = EPA RAGs, Part B screening values could not be calculated.

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TABLE 5-4B

CONTAMINANT LOADING TO THE GREAT MIAMI RIVER FROM THE SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern for On-Subunit Runoff	On-Subunit Surface Water Concentration (pCi/g RAD) (μg/L non-RAD)	Concentration in Paddys Run during Storm Event Cw (pCi/L RAD) (μg/L non-RAD)	Great Miami River Concentration Cgmr (pCi/L RAD (μg/L non-RAD)
INORGANICS			
Arsenic	6.84×10^{-1}	1.69×10^{-2}	2.08×10^{-5}
Beryllium	7.09×10^{-2}	1.75×10^{-3}	2.15×10^{-6}
Lead	$1.22 \times 10^{+1}$	3.01×10^{-1}	3.69×10^{-4}
ORGANICS			
Benzo(a)anthracene	1.42×10^{-1}	3.52×10^{-3}	4.32×10^{-6}
Benzo(a)pyrene	1.02×10^{-1}	2.52×10^{-3}	3.09×10^{-6}
Benzo(b)fluoranthene	1.72×10^{-2}	4.26×10^{-4}	5.24×10^{-7}
Benzo(g,h,i)perylene	4.87×10^{-1}	1.21×10^{-2}	1.48×10^{-5}
Dibenzo(a,h)anthracene	2.10×10^{-2}	5.20×10^{-4}	6.39×10^{-7}
Dieldrin	3.13×10^{-2}	7.73×10^{-4}	9.50 x 10-7
Phenantarene	$1.51 \times 10^{+2}$	$3.75 \times 10^{+0}$	4.61×10^{-3}
RADIONUCLIDES			
Neptunium-237	8.00×10^{-1}	1.96×10^{-2}	2.41×10^{-5}
Plutonium-238	2.18×10^{-2}	5.39×10^{-4}	6.63×10^{-7}
Radium-226	$5.46 \times 10^{+0}$	1.35×10^{-1}	1.66×10^{-4}
Radium-228	6.90×10^{-1}	1.71×10^{-2}	2.10×10^{-5}
Strontium-90	$1.16 \times 10^{+0}$	2.88×10^{-2}	3.54×10^{-3}
Technetium-99	$1.67 \times 10^{+4}$	$4.12 \times 10^{+2}$	5.06×10^{-1}

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TABLE 5-4B
(Continued)

Constituent of Potential Concern for On-Subunit Runoff	On-Subunit Surface Water Concentration (pCi/g RAD) (μg/L non-RAD)	Concentration in Paddys Run during Storm Event Cw (pCi/L RAD) (μg/L non-RAD)	Great Miami River Concentration Cgmr (pCi/L RAD (μg/L non-RAD)
RADIONUCLIDES (Continued)			
Uranium-234	$1.40 \times 10^{+2}$	$3.44 \times 10^{+0}$	4.17×10^{-3}
Uranium-235/236	$1.23 \times 10^{+1}$	3.03×10^{-1}	3.65×10^{-4}
Uranium-238	$1.51 \times 10^{+2}$	$3.72 \times 10^{+0}$	4.51×10^{-3}
Uranium-Total (non-RAD)	$4.64 \times 10^{+2}$	$1.15 \times 10^{+1}$	1.39×10^{-2}

reaching Paddys Run. Because the seep pathway to groundwater was considered separately, the contribution to groundwater from seeps is not considered here.

Table 5-5A shows the predicted maximum Great Miami Aquifer concentrations due to surface water runoff from Inactive Flyash Pile and South Field. Table 5-5A also compares predicted maximum Great Miami Aquifer concentrations against the screening concentrations (first screening step). As shown in Table 5-5A, a number of CPCs may reach the Great Miami Aquifer above the screening concentrations. For those CPCs having predicted maximum concentrations exceeding screening concentrations, diluted Great Miami Aquifer concentrations in the full SWIFT cell were predicted and compared against the screening concentrations (Table 5-5B). During this screening step, arsenic, beryllium, benzo(a)pyrene, dieldrin, radium-226, technetium-99, uranium-234, and uranium-238 were above the screening levels. However, beryllium, benzo(a)pyrene, dieldrin, and radium-226 concentrations only marginally exceed screening concentrations. A reduction in concentration due to adsorption was not considered during this screening step, therefore, these CPCs were not considered for further modeling. Only arsenic, technetium-99, and uranium isotopes were identified for further groundwater modeling.

5.3.4.5 Active Flyash Pile

Tables 5-6A and 5-6B present the results of surface water modeling from the Active Flyash Pile based on a single storm event using the MUSLE model. Table 5-6A also shows the screening of CPCs based on a comparison of on-subunit runoff concentrations against the EPA RAGs, Part B based screening concentrations for water. A total runoff of 285.5 m^3 was calculated during the 24-hour storm event. No dilution of runoff concentrations was assumed in the Storm Sewer Outfall Ditch. Therefore, runoff concentration and the Storm Sewer Outfall Ditch concentrations are modeled to be equal. This is a very conservative assumption since during the storm event, it is likely that runoff from the east side of the Storm Sewer Outfall Ditch and upgradient of the Active Flyash Pile will also drain into the Storm Sewer Outfall Ditch. The amount of runoff contribution to the Storm Sewer Outfall Ditch from the east side of the Storm Sewer Outfall Ditch is estimated to be the same order of magnitude as the runoff from the Active Flyash Pile. However, for modeling purposes, flow from a storm event from the east side of the Storm Sewer Outfall Ditch was assumed to be zero. Although most of the flow in the Storm Sewer Outfall Ditch infiltrates to the Great Miami Aquifer, it was assumed that 44 percent of the flow reaches Paddys Run.

TABLE 5-5A

LOADING TO THE GREAT MIAMI AQUIFER FROM PADDYS RUN AND CPC SCREENING (FIRST STEP) FOR GROUNDWATER MODELING, INACTIVE FLYASH PILE/SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents	Predicted Maximum Aquifer Concentration C_{GMA} (pCi/L RAD) (μg/L non-RAD)	Concentrations (pCi/L RAD) (μg/L non-RAD)	Groundwater Modeling Required
INORGANICS			
Arsenic	3.09×10^{-2}	1.46×10^{-4}	Yes
Beryllium	2.60×10^{-3}	2.37×10^{-4}	Yes
Lead	3.77×10^{-1}	NA[a]	NA
ORGANICS			
2-Methylnaphthalene	1.37×10^{-2}	NA	NA
Benzo(a)anthracene	3.84×10^{-3}	2.82×10^{-3}	Yes
Benzo(a)pyrene	2.75×10^{-3}	2.82×10^{-4}	Yes
Benzo(b)fluoranthene	4.66×10^{-4}	2.82×10^{-3}	No
Benzo(g,h,i)perylene	1.32×10^{-2}	NA	NA
Dibenzo(a,h)anthracene	6.66×10^{-4}	2.82×10^{-4}	Yes
Dieldrin	8.47×10^{-4}	1.12×10^{-4}	Yes
Phenanthrene	$4.10 \times 10^{+0}$	NA	NA
RADIONUCLIDES			
Neptunium-237	2.36×10^{-2}	2.16×10^{-2}	Yes
Plutonium-238	6.51×10^{-4}	2.16×10^{-2}	No
Plutonium-239/240	4.02×10^{-4}	2.16×10^{-2}	No
Radium-226	1.49×10^{-1}	1.76×10^{-2}	Yes
Radium-228	2.03×10^{-2}	4.75×10^{-2}	No
Strontium-90	3.21×10^{-2}	1.32×10^{-1}	No
Technetium-99	$4.52 \times 10^{+2}$	$3.65 \times 10^{+0}$	Yes
Uranium-234	$3.21 \times 10^{+0}$	2.97×10^{-1}	Yes
Uranium-235/236	3.15×10^{-1}	2.97×10^{-1}	Yes
Uranium-238	$3.43 \times 10^{+0}$	1.70×10^{-1}	Yes
Uranium-Total (non-RAD)	$1.08 \times 10^{+1}$	$1.09 \times 10^{+1}$	Yes

[a]EPA RAGs Screening Value could not be calculated.

TABLE 5-5B

CPC SCREENING FOR GROUNDWATER MODELING USING FULL SWIFT CELL DILUTION
INACTIVE FLYASH PILE/SOUTH FIELD
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	Runoff Concentration: Inactive Flyash Pile	Runoff Concentration: South Field	Predicted Diluted Great Miami Aquifer Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
INORGANICS						
Arsenic	µg/L	$3.92 \times 10^{+0}$	8.81×10^{-1}	7.56×10^{-3}	1.46×10^{-4}	Yes
Beryllium	µg/L	2.14×10^{-1}	9.14×10^{-2}	6.35×10^{-4}	2.37×10^{-4}	Yes[a]
Lead	µg/L	$1.48 \times 10^{+1}$	$1.57 \times 10^{+1}$	9.21×10^{-2}	NA[b]	NA
ORGANICS						
2-methylnapthalene	µg/L	$4.34 \times 10^{+0}$	-[c]	3.36×10^{-3}	NA	NA
Benzo(a)anthracene	µg/L	-	1.83×10^{-1}	9.40×10^{-4}	2.82×10^{-3}	No
Benzo(a)pyrene	µg/L	-	1.31×10^{-1}	6.73×10^{-4}	2.82×10^{-4}	Yes[a]
Benzo(g,h,i)perylene	µg/L	-	6.28×10^{-1}	3.23×10^{-3}	NA	NA
Dibenzo(a,h)anthracene	µg/L	3.06×10^{-2}	2.71×10^{-2}	1.63×10^{-4}	2.82×10^{-4}	No
Dieldrin	µg/L	-	4.03×10^{-2}	2.07×10^{-4}	1.12×10^{-4}	Yes[a]
Phenanthrene	µg/L	-	$1.95 \times 10^{+2}$	$1.00 \times 10^{+0}$	NA	NA
RADIONUCLIDES						
Neptunium-237	pCi/L	6.26×10^{-1}	$1.03 \times 10^{+0}$	5.78×10^{-3}	2.16×10^{-2}	No
Radium-226	pCi/L	4.40×10^{-1}	$7.03 \times 10^{+0}$	3.65×10^{-2}	1.76×10^{-2}	Yes[a]
Technetium-99	pCi/L	-	$2.15 \times 10^{+4}$	$1.10 \times 10^{+2}$	$3.65 \times 10^{+0}$	Yes
Uranium-234	pCi/L	$1.24 \times 10^{+2}$	$1.34 \times 10^{+2}$	7.84×10^{-1}	2.97×10^{-1}	Yes
Uranium-235/236	pCi/L	$8.06 \times 10^{+1}$	$1.37 \times 10^{+1}$	7.66×10^{-2}	2.97×10^{-1}	No

See footnote at end of table.

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TABLE 5-5B
(Continued)

Constituent of Potential Concern	Units	Runoff Concentration		Predicted Diluted Great Miami Aquifer Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
		Inactive Flyash Pile	South Field			
RADIONUCLIDES (Continued)						
Uranium-238	pCi/L	$1.27 \times 10^{+2}$	$1.44 \times 10^{+2}$	8.38×10^{-1}	1.70×10^{-1}	Yes
Uranium-Total (non-RAD)	μg/L	$3.74 \times 10^{+2}$	$4.57 \times 10^{+2}$	$2.64 \times 10^{+0}$	$1.09 \times 10^{+1}$	No

[a]Diluted Great Miami Aquifer concentration marginally exceeds screening concentration. However, it is expected that maximum concentration in the Great Miami Aquifer will be about an order of magnitude lower and, therefore, CPC's were not modeled further.

[b]NA = EPA RAGs, Part B screening value could not be calculated.

[c]Dash = not a constitutent of potential concern for this subunit for surface soils or subsurface soils. Therefore, surface water concentrations were not calculated.

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TABLE 5-6A

RUNOFF EFFLUENT AND SEDIMENT LOADING FROM THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern After Initial Screening	Partition Coefficient K_d (mL/g)	Waste Area Surface Soil Concentration Ci (mg/kg)	Total Annual Loading to Stream Tl (g)	Runoff Sediment Concentration Cs (mg/kg)	On-Subunit Runoff Effluent or Storm Sewer Outfall Ditch Concentration Ce (pCi/L RAD) (μg/L non-RAD)	Screening Concentration (pCi/L RAD) (μg/L non-RAD)	Final CPC For On-Subunit Runoff Water (Y/N)
INORGANICS							
Arsenic	$2.00 \times 10^{+2}$	$8.98 \times 10^{+1}$	$1.21 \times 10^{+1}$	$8.97 \times 10^{+1}$	$1.06 \times 10^{+1}$	1.46×10^{-4}	Yes
Beryllium	$2.50 \times 10^{+2}$	$4.67 \times 10^{+0}$	5.04×10^{-1}	$4.67 \times 10^{+0}$	4.41×10^{-1}	2.37×10^{-4}	Yes
Lead	$3.80 \times 10^{+1}$	$5.54 \times 10^{+1}$	$3.89 \times 10^{+1}$	$5.48 \times 10^{+1}$	$3.40 \times 10^{+1}$	NA[a]	NA
Thallium	$1.50 \times 10^{+3}$	$2.66 \times 10^{+0}$	4.76×10^{-2}	$2.66 \times 10^{+0}$	4.19×10^{-2}	2.55×10^{-1}	No
RADIONUCLIDES							
Neptunium-237	$5.00 \times 10^{+0}$	7.77×10^{-3}	4.08×10^{-2}	7.51×10^{-3}	$2.51 \times 10^{+1}$	2.16×10^{-2}	Yes
Plutonium-238	$1.00 \times 10^{+2}$	4.22×10^{-8}	1.14×10^{-8}	4.21×10^{-8}	1.70×10^{-1}	2.16×10^{-2}	Yes
Plutonium-239/240	$1.00 \times 10^{+2}$	5.32×10^{-6}	1.43×10^{-6}	5.31×10^{-6}	7.79×10^{-2}	2.07×10^{-2}	Yes
Radium-226	$1.06 \times 10^{+2}$	4.66×10^{-6}	1.18×10^{-6}	4.65×10^{-6}	$1.02 \times 10^{+0}$	1.76×10^{-4}	Yes
Radium-228	$1.06 \times 10^{+2}$	1.17×10^{-8}	2.98×10^{-9}	1.17×10^{-8}	7.08×10^{-1}	4.75×10^{-2}	Yes
Strontium-90	$1.06 \times 10^{+2}$	3.26×10^{-8}	8.28×10^{-9}	3.26×10^{-8}	9.94×10^{-1}	1.32×10^{-1}	Yes
Thorium-228	$3.20 \times 10^{+3}$	4.65×10^{-9}	3.92×10^{-11}	4.65×10^{-9}	2.81×10^{-2}	8.64×10^{-2}	No
Thorium-230	$3.20 \times 10^{+3}$	1.78×10^{-4}	1.50×10^{-6}	1.78×10^{-4}	2.71×10^{-2}	3.65×10^{-1}	No
Thorium-232	$3.20 \times 10^{+3}$	$2.42 \times 10^{+1}$	2.04×10^{-1}	$2.42 \times 10^{+1}$	1.97×10^{-2}	2.79×10^{-2}	No
Uranium-234	$1.48 \times 10^{+0}$	5.79×10^{-4}	9.44×10^{-3}	5.18×10^{-4}	$5.14 \times 10^{+1}$	2.97×10^{-1}	Yes
Uranium-235/236	$1.48 \times 10^{+0}$	7.42×10^{-2}	$1.21 \times 10^{+0}$	6.64×10^{-2}	$2.29 \times 10^{+0}$	2.97×10^{-1}	Yes
Uranium-238	$1.48 \times 10^{+0}$	$1.07 \times 10^{+1}$	$1.74 \times 10^{+2}$	$9.57 \times 10^{+0}$	$5.13 \times 10^{+1}$	1.70×10^{-1}	Yes
Uranium-Total (non-RAD)	$1.48 \times 10^{+0}$	$1.26 \times 10^{+1}$	$2.05 \times 10^{+2}$	$1.13 \times 10^{+1}$	$1.80 \times 10^{+2}$	$1.09 \times 10^{+1}$	Yes

[a]NA = EPA RAGs, Part B Screening Value could not be calculated.

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TABLE 5-6B

CONTAMINANT LOADING TO THE GREAT MIAMI RIVER FROM THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern for On-Subunit Runoff	On-Subunit Runoff Effluent or Storm Sewer Outfall Ditch Concentration Ce (pCi/L Rad) (ug/L non-Rad)	Paddys Run Concentration during Storm Event Cw (pCi/L RAD) (μg/L non-RAD)	Great Miami River Concentration Cgmr (pCi/L RAD) (μg/L non-RAD)
INORGANICS			
Arsenic	$1.06 \times 10^{+1}$	1.32×10^{-1}	1.60×10^{-4}
Beryllium	4.41×10^{-1}	5.40×10^{-3}	6.67×10^{-6}
Lead	$3.40 \times 10^{+1}$	4.25×10^{-1}	5.15×10^{-4}
RADIONUCLIDES			
Neptunium-237	$2.51 \times 10^{+1}$	3.13×10^{-1}	3.79×10^{-4}
Plutonium-238	1.70×10^{-1}	2.12×10^{-3}	2.57×10^{-6}
Plutonium-239/240	7.79×10^{-2}	9.74×10^{-4}	1.18×10^{-6}
Radium-226	$1.02 \times 10^{+0}$	1.28×10^{-2}	1.55×10^{-5}
Radium-228	7.08×10^{-1}	8.84×10^{-3}	1.07×10^{-5}
Strontium-90	9.94×10^{-1}	1.24×10^{-2}	1.50×10^{-5}
Uranium-234	$5.14 \times 10^{+1}$	6.43×10^{-1}	7.78×10^{-4}
Uranium-235/236	$2.29 \times 10^{+0}$	2.86×10^{-2}	3.46×10^{-5}
Uranium-238	$5.13 \times 10^{+1}$	6.41×10^{-1}	7.77×10^{-4}
Uranium-Total (non-RAD)	$1.80 \times 10^{+2}$	$2.25 \times 10^{+0}$	2.72×10^{-3}

The predicted runoff concentrations of radionuclides from the Active Flyash Pile into the Storm Sewer Outfall Ditch ranged from 2.0 x 10^{-2} pCi/L for thorium-232 to 51.4 pCi/L for uranium-234. Radionuclide concentrations in the Great Miami River were predicted to range between 1.2 x 10^{-7} pCi/L for plutonium-239/240 to 7.8 x 10^{-4} pCi/L for uranium-234 and uranium-238. For inorganic parameters, the predicted concentrations in runoff and the Storm Sewer Outfall Ditch ranged from 4.2 x 10^{-2} μg/L for thallium to 34 μg/L for lead. Inorganic concentrations in the Great Miami River were predicted to remain below 5.2 x 10^{-4} μg/L. There were no organic CPCs identified for the surface soils from the Active Flyash Pile. These concentrations remain only through the duration of the storm. When rainfall and runoff cease, no surface water is expected in the Storm Sewer Outfall Ditch.

Table 5-7 compares predicted and observed concentrations in the Storm Sewer Outfall Ditch. The modeling results are comparable to analytical results from filtered samples. However, due to a small database for the filtered surface water samples, Table A.5-7 also presents analytical results from unfiltered samples and samples whose filtered/unfiltered status is unknown. Predicted and observed concentrations for the CPCs are on the same order of magnitude, with the exception of lead and total uranium. The model predicts more than one order of magnitude higher concentrations than the observed data for these two constituents. Comparison to within an order of magnitude is considered acceptable because there are additional FEMP sources to the Storm Sewer Outfall Ditch that were not modeled and surface water samples were not taken during a storm event corresponding to the modeled condition of 2.5 inches of rainfall in 24 hours. Data corresponding to the modeled storm conditions are difficult to obtain and are not available.

Modeled sediment concentrations resulting from a single runoff event are comparable to the source term soil concentrations for the Active Flyash Pile because sediment mixing was not considered. For example, the modeled uranium-238 sediment concentration was 9.57 mg/kg, compared to 10.7 mg/kg in the soil source term. Sediment concentrations would be expected to decrease downgradient and following the rainfall event because of dispersion through sediment transport and gradual mixing with sediment from other sources.

Total loading to the Great Miami Aquifer from the Storm Sewer Outfall Ditch (from runoff water as well as sediment leaching) was assumed to equal 100% of the dissolved mass reaching the Storm Sewer Outfall Ditch. Since 44 percent of dissolved CPC mass was also assumed to reach Paddys

TABLE 5-7

COMPARISON OF MODELED RESULTS TO MEASURED SURFACE WATER CONCENTRATIONS IN THE STORM SEWER OUTFALL DITCH OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern[a]	Units	Modeled Concentrations in SSOD[b,c]	Range of Measured Concentrations in SSOD[d]		
			Filtered	Unfiltered	Unknown
RADIONUCLIDES					
Uranium-234	pCi/L	51.4	15.9	-[e]	-
Uranium-238	pCi/L	51.3	15.9	-	-
Total Uranium	μg/L	180	14-44	14-24	-
INORGANICS					
Lead	μg/L	34.0	-	-	2.2

[a]CPC listed only if measured data were available for comparison

[b]Modeled from surface soil sources in the Active Flyash Pile only

[c]SSOD - Storm Sewer Outfall Ditch

[d]Concentrations in samples from locations ASIT-002, ASIT-006, and ASIT-007

[e]Data not available or all were nondetects

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Run, the loading assumption for the Great Miami Aquifer allows up to 44 percent contribution from leaching of sediments. Table 5-8 shows the predicted maximum Great Miami Aquifer concentrations due to surface water runoff from Active Flyash Pile. Table 5-8 also compares predicted maximum Great Miami Aquifer concentrations against the screening levels (first screening step). As shown in Table 5-8, arsenic, beryllium, neptunium-237, plutonium-238, plutonium-239/240, radium-226, radium-228, strontium-90, uranium-234, uranium 235/236, uranium-238, and total uranium were predicted to be above screening concentrations. For the constituents passing the first screening step, diluted Great Miami Aquifer concentration in full SWIFT cell were predicted and compared against the screening concentrations (Table 5-9). During this screening step, predicted arsenic, beryllium, neptunium-237, radium-226, uranium-234, and uranium-238 concentrations were above the screening levels. However, the radium-226 concentration calculated without considering adsorption effects is only marginally above the screening concentration, and therefore radium-226 was not considered for further modeling. Source term loadings from the surface water runoff pathway to groundwater were developed for arsenic, beryllium, neptunium-237, uranium-234, and uranium-238.

Table 5-10 compares model predicted concentrations in the Great Miami Aquifer due to surface water pathway to concentrations observed in monitoring wells near the Storm Sewer Outfall Ditch. Observed concentration range and predicted concentrations are generally on the same order of magnitude, however, the range of concentrations for uranium isotopes is quite large. This may be reflective of up-gradient source contributions before installation of storm water retention basins.

5.3.4.6 Combined Modeling Results

Modeling results indicate that surface water runoff from the Solid Waste Landfill, Inactive Flyash Pile, South Field, and Active Flyash Pile reaches Paddys Run. The predicted constituent loading to Paddys Run and subsequent predicted loading to the Great Miami Aquifer and the Great Miami River is only from the sources within the Operable Unit 2 battery limits. These predictions were made to evaluation the Operable Unit 2 impact to these media and is not meant to imply that Operable Unit 2 is the only source of constituents to these media. Table 5-11 shows the combined effect of all Operable Unit 2 subunits on Paddys Run and the Great Miami River. Combined sediment concentrations in the Paddys Run or the Great Miami Aquifer were not calculated because these combined sediment concentrations were not needed for the baseline risk assessment. For radionuclides, total concentrations in Paddys Run range from a low of 1.2×10^{-3} pCi/L for plutonium-239/240 to a high of 412 pCi/L for technetium-99. Concentrations of radionuclides in the Great

TABLE 5-8

LOADING TO THE GREAT MIAMI AQUIFER FROM THE STORM SEWER OUTFALL DITCH AND CPC SCREENING (FIRST STEP) FOR GROUNDWATER MODELING, ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents	Predicted Maximum Aquifer Concentration C_{GMA} (pCi/L RAD) (μg/L non-RAD)	Screening Concentrations (pCi/L RAD) (μg/L non-RAD)	Groundwater Modeling Required
INORGANICS			
Arsenic	$3.50 \times 10^{+0}$	1.46×10^{-4}	Yes
Beryllium	1.46×10^{-1}	2.37×10^{-4}	Yes
Lead	$1.12 \times 10^{+1}$	NA[a]	NA[a]
RADIONUCLIDES			
Neptunium-237	$8.29 \times 10^{+0}$	2.16×10^{-2}	Yes
Plutonium-238	5.61×10^{-2}	2.16×10^{-2}	Yes
Plutonium-239/240	2.57×10^{-2}	2.07×10^{-2}	Yes
Radium-226	3.37×10^{-1}	1.76×10^{-4}	Yes
Radium-228	2.34×10^{-1}	4.75×10^{-2}	Yes
Strontium-90	3.28×10^{-1}	1.32×10^{-1}	Yes
Uranium-234	$1.70 \times 10^{+1}$	$2.97 \times 10^{+0}$	Yes
Uranium-235/236	7.56×10^{-1}	2.97×10^{-1}	Yes
Uranium-238	$1.69 \times 10^{+1}$	1.70×10^{-1}	Yes
Uranium-Total (non-RAD)	$5.94 \times 10^{+1}$	$1.09 \times 10^{+1}$	Yes

[a]EPA RAGs, Part B screening value could not be calculated.

TABLE 5-9

CPC SCREENING FOR GROUNDWATER MODELING USING FULL SWIFT CELL DILUTION, ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	Surface Water Runoff Concentration	Predicted Diluted GMA Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
RADIONUCLIDES					
Neptunium-237	pCi/L	$2.51 \times 10^{+1}$	9.52×10^{-1}	2.16×10^{-2}	Yes
Plutonium-238	pCi/L	1.70×10^{-1}	6.45×10^{-3}	2.16×10^{-2}	No
Plutonium-239/240	pCi/L	7.79×10^{-2}	2.96×10^{-3}	2.07×10^{-2}	No
Radium-226	pCi/L	$1.02 \times 10^{+0}$	3.87×10^{-2}	1.76×10^{-4}	Yes
Radium-228	pCi/L	7.08×10^{-1}	2.69×10^{-2}	4.75×10^{-2}	No
Strontium-90	pCi/L	9.94×10^{-1}	3.77×10^{-2}	1.32×10^{-1}	No
Uranium-234	pCi/L	$5.14 \times 10^{+1}$	$1.95 \times 10^{+0}$	2.97×10^{-1}	Yes
Uranium-235/236	pCi/L	$2.29 \times 10^{+0}$	8.69×10^{-2}	2.97×10^{-1}	No
Uranium-238	pCi/L	$5.13 \times 10^{+1}$	$1.95 \times 10^{+0}$	1.70×10^{-1}	Yes
INORGANICS					
Arsenic	μg/L	$1.06 \times 10^{+1}$	4.02×10^{-1}	1.46×10^{-4}	Yes
Beryllium	μg/L	4.41×10^{-1}	1.67×10^{-2}	2.37×10^{-4}	Yes
Lead	μg/L	$3.40 \times 10^{+1}$	$1.29 \times 10^{+0}$	NA[a]	NA[a]
Uranium-Total	μg/L	$1.80 \times 10^{+2}$	$6.83 \times 10^{+0}$	$1.09 \times 10^{+1}$	No

[a]NA = EPA RAGs, Part B screening value could not be calculated.

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TABLE 5-10

COMPARISON OF GREAT MIAMI AQUIFER AND MODELED RESULTS FROM SURFACE RUNOFF PATHWAY, ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern[a]	Units	GMA Wells 2014 and 2049[b]		Model Predicted GMA Concentration from SSOD Loading[c]
		Minimum	Maximum	
		RADIONUCLIDES (Unfiltered)[d]		
Neptunium-237	pCi/L	0.48	0.48	8.290
Radium-226	pCi/L	0.17	1.40	0.337
Uranium-234	pCi/L	1.00	83.20	17.000
Uranium-235/236	pCi/L	0.22	1.86	0.756
Uranium-238	pCi/L	2.10	89.90	17.000
		INORGANICS (Filtered)		
Lead	μg/L	6.00	6.00	11.2

[a]CPC listed only if measured data were available for comparison

[b]These two GMA wells are close to the SSOD

[c]Model predicted concentrations are considered equivalent to filtered samples

[d]Only unfiltered data were available for comparison for radionuclides

GMA - Great Miami Aquifer

SSOD - Storm Sewer Outfall Ditch

TABLE 5-11

IMPACT OF ALL OPERABLE UNIT 2 SUBUNITS ON PADDYS RUN AND THE GREAT MIAMI RIVER

Constituent of Potential Concern	Unit	Paddys Run Concentration From					Great Miami River Concentration
		Solid Waste Landfill	Inactive Flyash Pile	South Field	Active Flyash Pile	Total	
INORGANICS							
Arsenic	μg/L	1.91×10^{-3}	1.31×10^{-2}	1.69×10^{-2}	1.32×10^{-1}	1.64×10^{-1}	1.99×10^{-4}
Beryllium	μg/L	3.08×10^{-5}	6.32×10^{-4}	1.75×10^{-3}	5.40×10^{-3}	7.81×10^{-3}	9.46×10^{-6}
Lead	μg/L	3.63×10^{-4}	5.29×10^{-2}	3.01×10^{-1}	4.25×10^{-1}	7.79×10^{-1}	9.43×10^{-4}
ORGANICS							
Benzo(a)anthracene	μg/L	7.98×10^{-6}	-[a]	3.52×10^{-3}	-	3.52×10^{-3}	4.27×10^{-6}
Benzo(a)pyrene	μg/L	3.10×10^{-6}	-	2.52×10^{-3}	-	2.52×10^{-3}	3.05×10^{-6}
2-Methynapthalene	μg/L	-	1.28×10^{-2}	-	-	1.28×10^{-2}	1.55×10^{-5}
Benzo(b)fluoranthene	μg/L	-	-	4.26×10^{-4}	-	4.26×10^{-4}	5.16×10^{-7}
Benzo(g,h,i)peryle	μg/L	1.35×10^{-6}		1.21×10^{-2}		1.21×10^{-2}	1.46×10^{-5}
Dibenzo(a,h)anthracene	μg/L	1.87×10^{-6}	9.02×10^{-5}	5.20×10^{-4}	-	6.12×10^{-4}	7.41×10^{-7}
Dieldrin	μg/L	-	-	7.73×10^{-4}	-	7.73×10^{-4}	9.36×10^{-7}
Ideno(1,2,3-cd)pyrene	μg/L	9.14×10^{-8}	-	-	-	9.14×10^{-8}	1.11×10^{-10}
Phenanathrene	μg/L	1.30×10^{-1}	-	$3.75 \times 10^{+0}$	-	$3.88 \times 10^{+0}$	4.70×10^{-3}
RADIONUCLIDES							
Neptunium-237	pCi/L	1.24×10^{-3}	2.73×10^{-3}	1.96×10^{-2}	3.79×10^{-4}	2.39×10^{-2}	2.90×10^{-5}
Plutonium-238	pCi/L	-	3.30×10^{-3}	5.39×10^{-4}	2.12×10^{-3}	5.96×10^{-3}	7.21×10^{-6}
Plutonium-239/240	pCi/L	-	2.37×10^{-4}	-	9.74×10^{-4}	1.21×10^{-3}	1.47×10^{-6}
Radium-226	pCi/L	1.15×10^{-4}	1.46×10^{-3}	1.35×10^{-1}	1.28×10^{-2}	1.49×10^{-2}	1.81×10^{-4}
Radium-228	pCi/L	1.38×10^{-4}	1.47×10^{-3}	1.71×10^{-2}	8.84×10^{-3}	2.75×10^{-2}	3.33×10^{-5}
Strontium-90	pCi/L	5.43×10^{-3}	5.71×10^{-4}	2.88×10^{-1}	1.24×10^{-2}	3.06×10^{-1}	3.71×10^{-4}
Technetium-99	pCi/L	-	-	$4.12 \times 10^{+2}$	-	$4.12 \times 10^{+2}$	4.99×10^{-1}
Uranium-234	pCi/L	3.22×10^{-2}	6.65×10^{-1}	$3.44 \times 10^{+0}$	6.43×10^{-1}	$4.78 \times 10^{+0}$	5.78×10^{-3}
Uranium-235/236	pCi/L	2.16×10^{-3}	4.10×10^{-2}	3.03×10^{-1}	2.86×10^{-2}	3.75×10^{-1}	4.54×10^{-4}
Uranium-238	pCi/L	5.90×10^{-2}	6.65×10^{-1}	$3.72 \times 10^{+0}$	6.41×10^{-1}	$5.08 \times 10^{+0}$	6.15×10^{-3}
Total Uranium (non-RAD)	μg/L	1.30×10^{-1}	$2.02 \times 10^{+0}$	$1.15 \times 10^{+1}$	$2.25 \times 10^{+0}$	$1.59 \times 10^{+1}$	1.92×10^{-2}

[a]Dash = Not a constituent of potential concern for this subunit. Therefore, surface water concentrations were not calculated.

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Miami River ranged from 1.5 x 10^{-6} pCi/L for plutonium-239/240 to 0.5 pCi/L for technetium-99. All inorganics were predicted to be below 0.8 μg/L in Paddys Run and below 9.4 x 10^{-4} μg/L in the Great Miami River. All organics, except phenanthrene, were predicted to be below 1.3 x 10^{-2} μg/L and 1.6 x 10^{-5} μg/L, in Paddys run and the Great Miami River, respectively. Phenanthrene is predicted to be at 3.88 μg/L and 4.7 x 10^{-3} μg/L in Paddys Run and the Great Miami River, respectively.

Table 5-12 lists all the CPCs for groundwater from the surface water pathway. No CPCs from the Solid Waste Landfill were considered for further modeling, and surface water modeling for the Lime Sludge Ponds was not performed. Although 17 CPCs were identified for the surface water pathway to the Great Miami Aquifer from the Inactive Flyash Pile and South Field, only arsenic, technetium-99 and uranium isotopes were considered for detailed modeling in the Great Miami Aquifer. The Active Flyash Pile results in three inorganic and nine radionuclides as CPCs. However, only arsenic, beryllium, neptunium-237, and uranium isotopes remained CPCs after the second screening step, and were considered for detailed groundwater modeling.

5.3.5 Uncertainties in the Surface Water Model

The surface water model (like any other model) is a mathematical tool which simplifies the actual situation. Uncertainties in the output from the model are introduced from three primary sources:

- Source Term Uncertainty: Source terms for the modeling were defined based on analytical results from the surface soil samples collected during the RI/FS field investigations. It was assumed that these concentrations are representative of CPC concentrations in the past. Although CPC concentrations in the past may have exceeded the present concentrations, use of the UCL concentration may counter the uncertainties introduced by using analytical results from the RI/FS field investigation. Use of uniform CPC concentration at UCL also introduces a potential for overestimation of contaminant mass.

- Input Parameter Uncertainty: The accuracy of the model prediction is highly dependent on the accuracy of the input parameters. Input parameters such as the SCS runoff curve number, rainfall and runoff factor, soil erodibility factor, slope length and steepness factor, cover factor, etc., are approximate numbers representing the physical characteristics of a given site. The chemical-specific distribution coefficient (Kd) values used to calculate the fraction of contaminants sorbed to soil particles are another source of uncertainty.

- Modeling Uncertainty: Any mathematical model representing a physical process tends to be simplified by making approximations and assumptions. The uncertainties in model predictions will increase with increased simplification of the model. Several portions of the surface water model equations consist of empirical equations, which are approximations of actual physical processes.

TABLE 5-12

SUMMARY OF CONSTITUENTS OF CONCERN FOR GROUNDWATER FROM SURFACE WATER PATHWAY OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern (CPC)[a]	Units	Model Predicted Maximum GMA[b] Concentration
SOLID WASTE LANDFILL		
Arsenic[c]	μg/L	2.51×10^{-3}
Benzo(g,h,i)perylene[d]	μg/L	1.77×10^{-6}
Phenanthrene[d]	μg/L	5.17×10^{-2}
LIME SLUDGE PONDS		
None		
SOUTH FIELD/INACTIVE FLYASH PILE		
Arsenic	μg/L	3.09×10^{-2}
Beryllium[c]	μg/L	2.60×10^{-3}
Lead[d]	μg/L	3.77×10^{-1}
2-Methylnaphthalene[d]	μg/L	1.37×10^{-2}
Benzo(a)anthracene[e]	μg/L	3.84×10^{-3}
Benzo(a)pyrene[c]	μg/L	2.75×10^{-3}
Benzo(g,h,i)perylene[d]	μg/L	1.32×10^{-2}
Dibenzo(a,h)anthracene[e]	μg/L	6.66×10^{-4}
Dieldrin[c]	μg/L	8.47×10^{-4}
Phenanthrene[d]	μg/L	$4.10 \times 10^{+0}$
Neptunium-237[e]	pCi/L	2.36×10^{-2}
Radium-226[c]	pCi/L	1.49×10^{-1}
Technetium-99	pCi/L	$4.52 \times 10^{+2}$
Uranium-234	pCi/L	$3.21 \times 10^{+0}$
Uranium-235/236	pCi/L	3.15×10^{-1}
Uranium-238	pCi/L	$3.43 \times 10^{+0}$
Uranium-Total (Non-Rad)[e]	μg/L	$1.08 \times 10^{+1}$
ACTIVE FLYASH PILE		
Arsenic	μg/L	3.50
Beryllium	μg/L	0.15
Lead[d]	μg/L	11.20
Neptunium-237	pCi/L	8.29
Plutonium-238[e]	pCi/L	0.06
Plutonium-238/240[e]	pCi/L	0.03
Radium-226[e]	pCi/L	0.34
Radium-228[e]	pCi/L	0.23

TABLE 5-12
(Continued)

Constituents of Potential Concern (CPC)[a]	Units	Model Predicted Maximum GMA[b] Concentration
ACTIVE FLYASH PILE (Continued)		
Strontium-90[e]	pCi/L	0.33
Uranium-234	pCi/L	17.00
Uranium-235/236[e]	pCi/L	0.76
Uranium-238	pCi/L	16.90
Uranium-Total[e]	μg/L	59.4

[a]CPC listed only if above screening concentration.
[b]GMA - Great Miami Aquifer.
[c]These CPCs were not considered for detailed groundwater modeling because predicted diluted GMA concentration without adsorption effects is marginally above the screening concentration.
[d]Lead, 2-methylnaphthalene, benzo(g,h,i)perylene, and phenanthrene were not screened and further modeled because RAGs Part B screening concentrations could not be calculated.
[e]These CPCs were screened out in the second screening step which uses dilution in the full SWIFT cell.

- Scenario Uncertainty: The assumption that each subunit of Operable Unit 2 acts as a point source contamination will introduce some uncertainty in the model predictions. Wherever possible, conservative assumptions were made so that model can predict worst-case conditions.

5.4 GROUNDWATER MODELING

A summary of the fate and transport modeling for the groundwater pathway is presented in the following subsections. Modeling was performed to predict the transport of constituents and to estimate the concentrations of constituents that potential receptors may be exposed to in the future. As part of the initial modeling process, screening of all detected constituents for CPCs was performed to reduce the list of compounds to be carried forward to the detailed modeling process. The screening included comparisons of observed concentrations against various criteria including background concentrations, risk levels, etc., which is described in detail in Appendix A.2 and summarized in Subsection 5.4.2.3.

The migration of water and dissolved constituents from the waste source to the receptor involves flow through both unsaturated (vadose zone) and saturated zones (regional aquifer and perched zones). Flow and solute transport in these zones are affected by the permeability of the media, the hydraulic gradient, and the saturation conditions. Other factors considered were dispersion (mixing) in groundwater, retardation, and biological or radioactive decay. The fate and transport modeling are discussed in detail in Appendix A-2 and are summarized in the following sections.

The waste areas contained in Operable Unit 2 were assumed to remain in their existing locations and in their current conditions for the purposes of the fate and transport modeling. The extent of the waste areas is described in Section 4.0. The assumptions regarding waste area conditions were made to provide a conservative worst-case estimate of contaminant transport.

5.4.1 Conceptual Model

Based on characteristics of the material underlying the Operable Unit 2 subunits, a conceptual model was developed for the pathways between the subunit and the Great Miami Aquifer. Five pathways for CPC migration from Operable Unit 2 subunits to the Great Miami Aquifer were identified.

- VADOSE ZONE PATHWAY: Migration of CPCs from the waste unit laterally and vertically through the vadose zone to the aquifer was designated as the vadose zone pathway.

- PERCHED WATER INFILTRATION: Vertical migration of perched water through the glacial till to the Great Miami Aquifer was designated as the perched water infiltration pathway.

- PERCHED WATER SUBSURFACE SEEP PATHWAY: Lateral migration of CPCs occurs when perched water in sand and gravel layers within the glacial overburden come in contact with waste material. Perched water moves laterally in the sand layer until it is intercepted at the sand/gravel and waste interface. At that point, perched water moves along the slope of the waste and till interface until it comes in contact with the unsaturated Great Miami Aquifer. This water containing CPCs then vertically infiltrates to the aquifer.

- SEEP PATHWAY: Migration of CPCs from seeps to an area where glacial overburden is not present, and then through the unsaturated portion of the Great Miami Aquifer to the groundwater was designated as the seep pathway.

- SURFACE WATER PATHWAY: Migration of CPCs from the surface soils due to storm event runoff to Paddys Run or the Storm Sewer Outfall Ditch, and then vertically to the aquifer was designated as the surface water pathway.

Figure 5-7 shows a generalized picture of contaminant migration at the FEMP. Three primary pathways shown are: vadose zone pathway, surface water pathway, and perched water infiltration pathway. Vertical transport down through the vadose zone to the aquifer and the horizontal transport through the aquifer to the well of a potential human receptor is illustrated in Figure 5-7.

The migration of contaminants from the source to the groundwater begins with the infiltration of rainwater (Figure 5-8). As water percolates through the waste, constituents in the waste are dissolved into the water to form a leachate. Fluids and/or leachate entering from the waste areas migrate first through the unsaturated glacial overburden (if present), then through the unsaturated outwash deposits, and finally into the Great Miami Aquifer. In the South Field, Inactive Flyash Pile, and Active Flyash Pile, part of the waste material is underlain by the glacial overburden, while other parts are underlain by the unsaturated sand and gravel of the Great Miami Aquifer. At these subunits, lateral drainage may take place at the interface of waste and glacial overburden. This lateral drainage then infiltrates through the unsaturated portion of the Great Miami Aquifer where lateral drainage comes in contact with the unsaturated Great Miami Aquifer.

The vadose zone, applicable to all subunits, was modeled as two layers: the glacial overburden underlying the subunits (Layer 1) and the unsaturated portion of the underlying Great Miami Aquifer (Layer 2). Layer 1 soils consist of tills in the glacial overburden. A sequence of fine-grained till deposits interbedded with sand and gravel glaciofluvial stringers forms the glacial overburden at the

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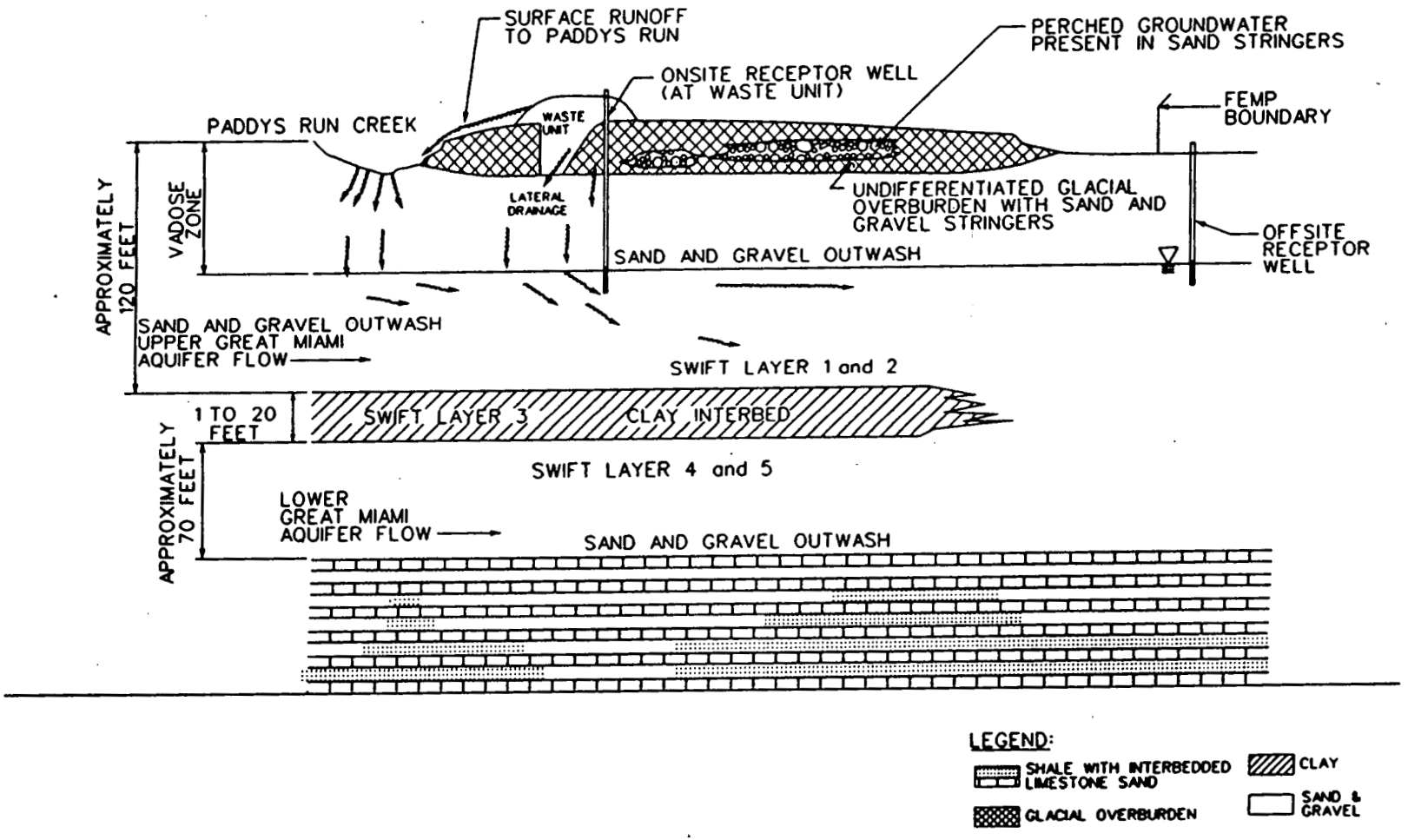

FIGURE 5-7
CONCEPTUAL MODEL OF LOADING TO THE GREAT MIAMI AQUIFER
AND CONTAMINANT TRANSPORT BY GROUNDWATER

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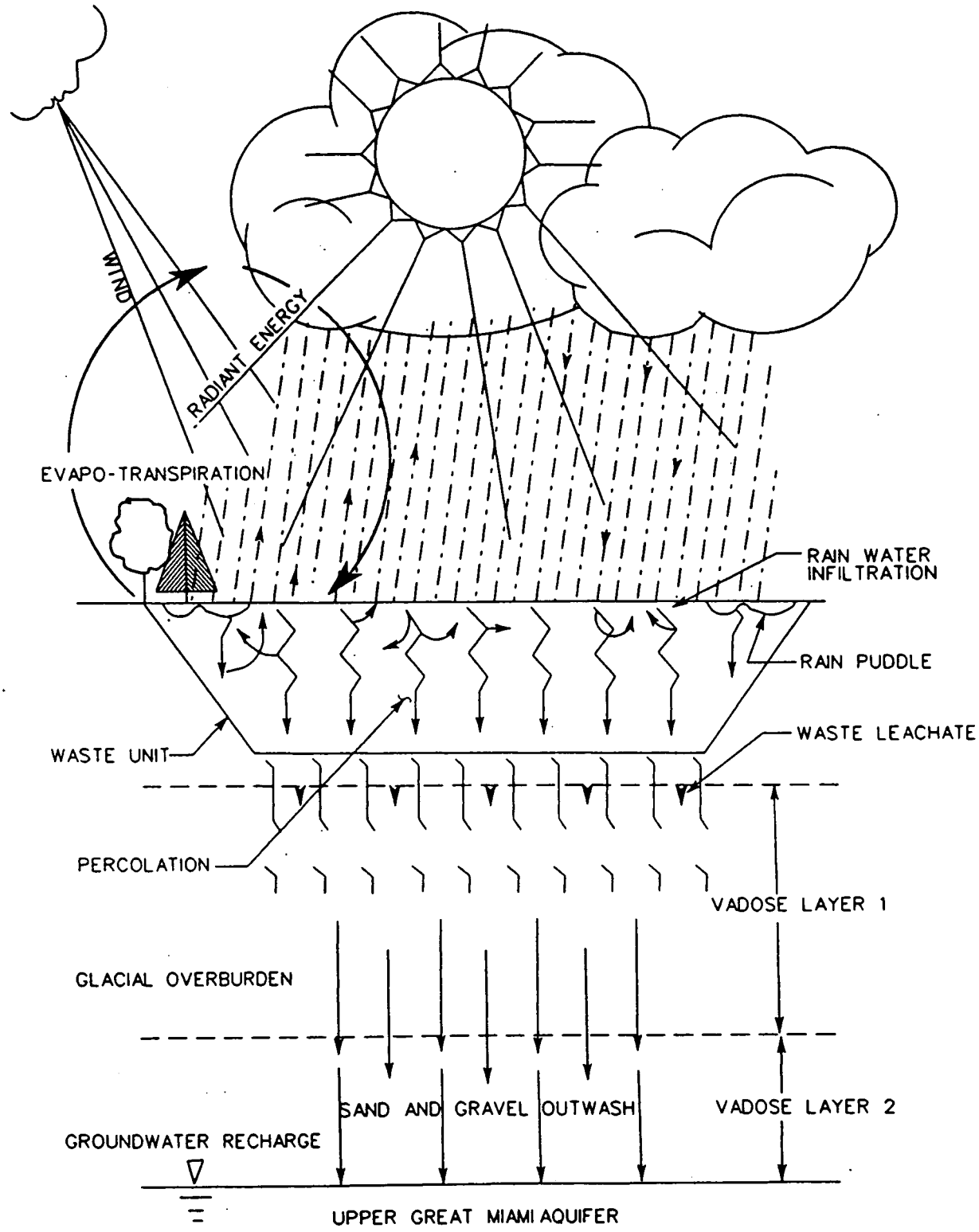

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FIGURE 5-8
CONCEPTUAL VADOSE ZONE MODEL

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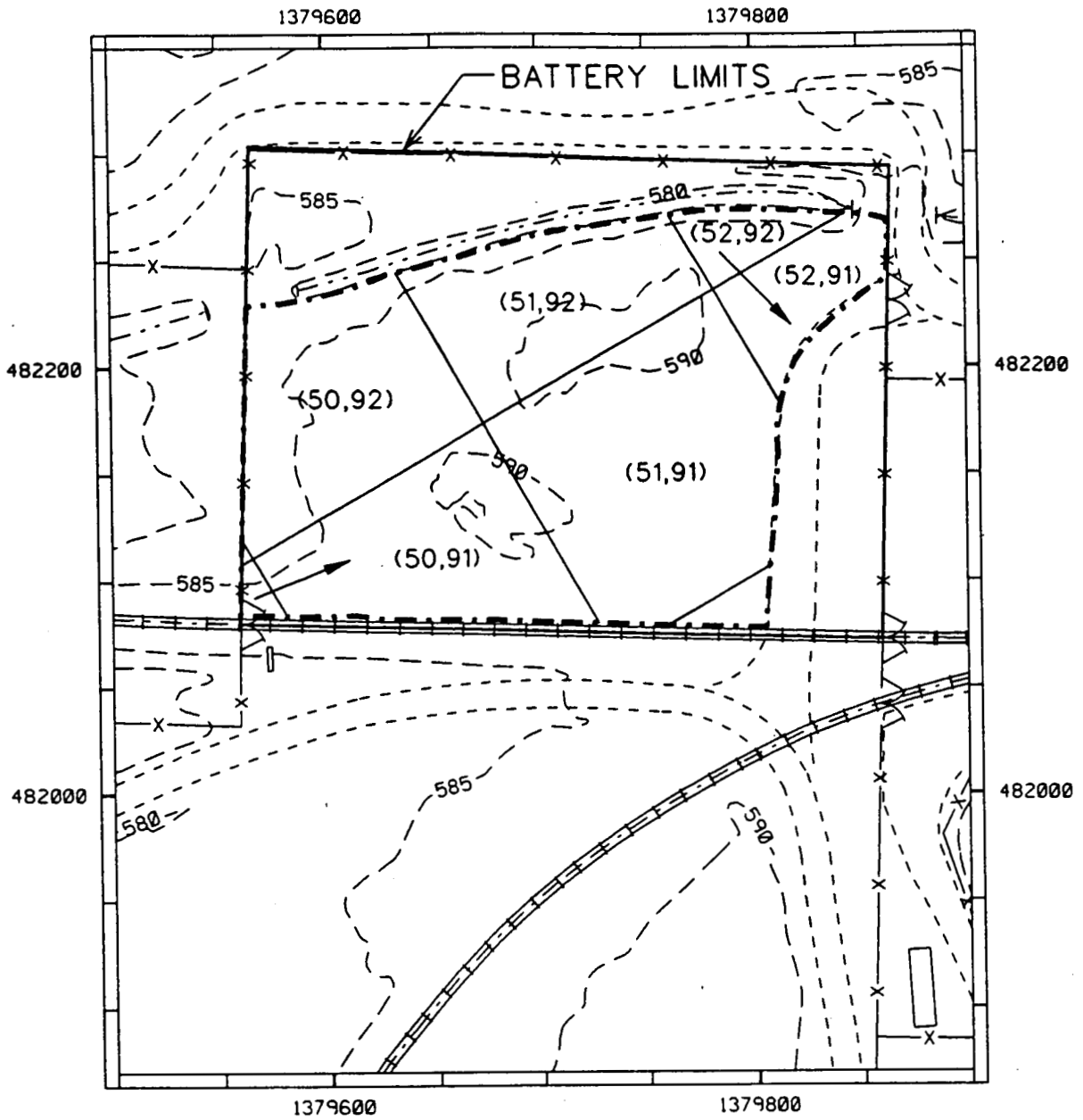
site. The sand and gravel units within the glacial overburden were not included in the vadose zone pathway modeling because this layer has much higher hydraulic conductivity and low adsorption properties. In addition, the computer model selected to evaluate flow in the vadose zone is limited to two layers. By neglecting the sand and gravel units, the model underpredicts travel time, and is therefore conservative. The thickness of till ranges between 0 and 38 feet for the subunits. Beneath the till is the unsaturated sand and gravel outwash layer (Layer 2), which is present beneath all the subunits. The thickness of Layer 2 ranges from 16 to 33 feet.

Another pathway which was applicable to all subunits was perched water infiltration. The conceptual model for the perched water infiltration pathway is similar to that of the vadose zone pathway. This pathway was modeled with two layers. Layer 1 soils consist of till below the perched water zone and Layer 2 soils consist of the unsaturated portion of the Great Miami Aquifer. The thickness of Layer 1 ranged from 2 to 22 feet, and the thickness of Layer 2 ranged from 17 to 33 feet. Constituent mass in the perched water, as well as adsorbed to the sand layer, was considered in the source term for perched water infiltration. The perched water was simulated as an additional source of constituent loading based on the concentration of constituents detected in the 1000-series wells located within the Operable Unit 2 subunits.

Based on characteristics of the material underlying each Operable Unit 2 subunits, a detailed conceptual model is developed for the pathways between each subunit and receptor locations. These more detailed models are developed to account for the variable stratigraphies of the soils of Operable Unit 2 subunits. Areas overlying each SWIFT III grid block in all subunits were modeled separately with individual stratigraphy, constituent type and concentration, and infiltration rate parameters; each constituent was simulated using retardation and decay factors taken from literature studies or site-specific data. The waste areas contained in Operable Unit 2 are assumed to remain in their existing locations for the purposes of the baseline fate and transport modeling. The detailed conceptual models are described next.

5.4.1.1 Solid Waste Landfill

Constituent migration pathways applicable to the Solid Waste Landfill were the vadose zone, surface water, and perched water infiltration pathways. Figure 5-9 shows the SWIFT III grid blocks directly beneath the waste at the Solid Waste Landfill and Table 5-13 provides the physical parameters of various layers for each of the blocks modeled. The average thickness of the waste is 8.5 feet. The



LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- EXTENT OF WASTE
- WASTE FROM CELL IS INCLUDED IN OTHER CELL
- SWIFT MODEL CELL (COLUMN, ROW)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 40 80 160

FIGURE 5-9
EXTENT OF WASTE AND MODELED SWIFT GRID CELLS, SOLID WASTE LANDFILL

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TABLE 5-13

PHYSICAL PARAMETERS FOR THE SWIFT III CELLS IMPACTED BY THE SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Row	Column	Fill or Waste Area (ft^2)	Fill or Waste Volume (ft^3)	Fill or Waste Thickness (ft)	Unsaturated GMA Thickness (ft)	Glacial Overburden Thickness (ft)	Thickness of Till Above the Sand/Gravel (ft)	Thickness of Sand/Gravel In Till (ft)	Thickness of Till Below the Sand/Gravel (ft)	Total Till Thickness (ft)
ZONE 1 - LESS THAN 2 FEET SAND										
52	91	3404	27600	8.8	23.3	35.8	21.2	0.6	14.1	35.3
51	90	652	4375	7.0	25.7	35.5	25.1	1.0	9.4	34.5
52	92	1577	11388	9.1	22.2	36.1	19.2	1.6	15.4	34.5
Zone 1 Average		1878	14454	8.3	23.7	35.8	21.8	1.1	12.9	34.8
ZONE 2 - 2-3 FEET OF SAND										
51	91	14062	121906	8.5	23.5	36.3	19.4	2.6	14.4	33.8
51	92	7906	66213	8.2	20.6	38.6	17.9	3.4	17.3	35.2
Zone 2 Average		10984	94059	8.3	22.1	37.5	18.7	3.0	15.8	34.5
ZONE 3 - MORE THAN 4 FEET OF SAND, SIGNIFICANT TILL										
50	91	8697	85163	9.7	21.7	35.9	14.8	4.8	16.3	31.1
50	92	9313	73088	7.8	19.4	38.0	16.3	5.0	16.6	32.9
Zone 3 Average		9005	79125	8.8	20.6	36.9	15.5	4.9	16.5	32.0

NOTE: GMA = Great Miami Aquifer

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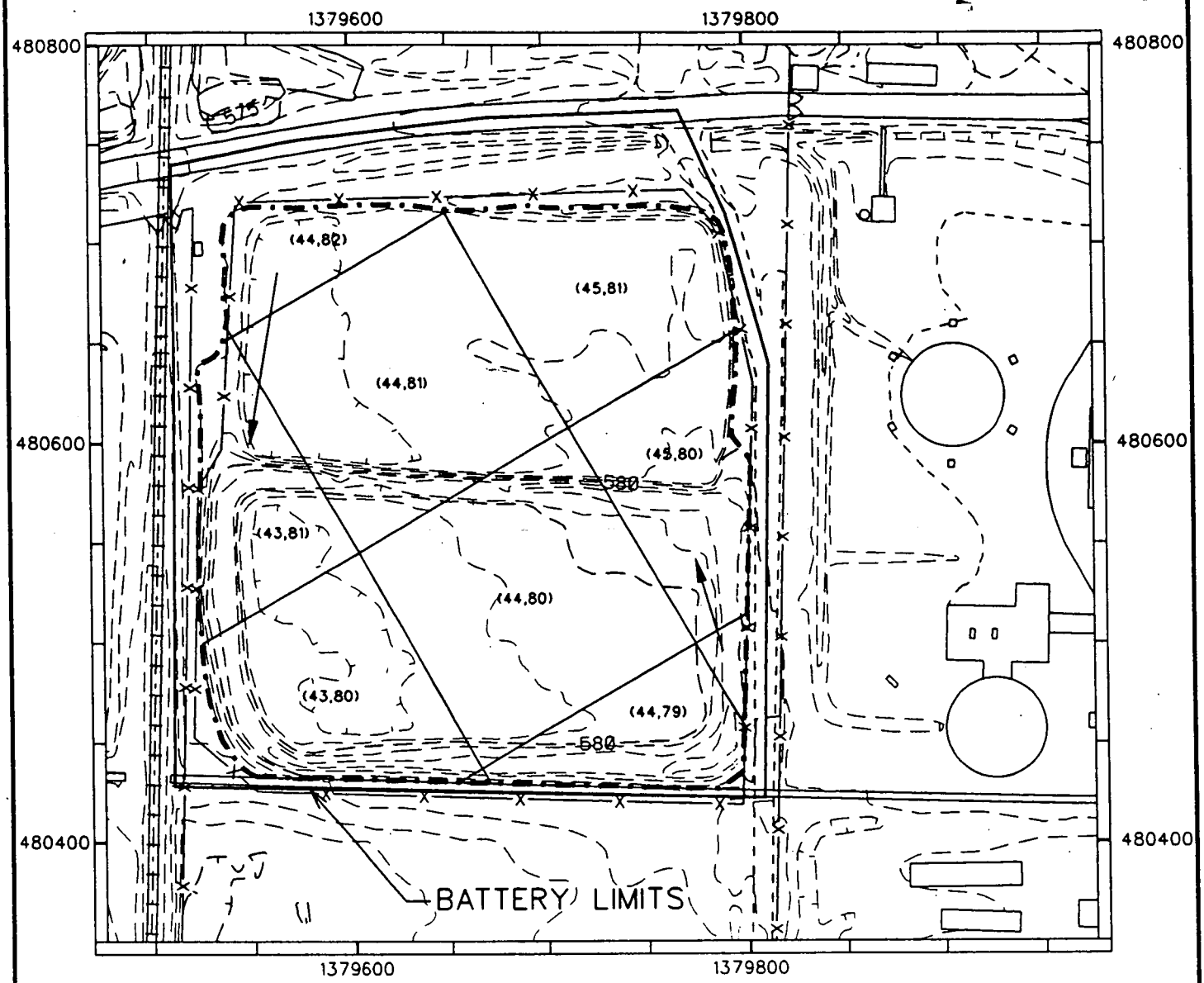
conceptual model depicting flow in the subsurface soils at the Solid Waste Landfill considers two layers. Layer 1 soils consist of tills, 31 to 38 feet thick. Interbedded sand and gravel stringers within the till, with thicknesses of 0.5 to 6 feet containing perched water, were not considered as a part of Layer 1 of the vadose zone pathway. These sand layers are underlain by 9 to 17 feet of glacial till. Beneath the till layer at the Solid Waste Landfill is the 19 to 25 feet thick unsaturated sand and gravel layer (Layer 2).

5.4.1.2 Lime Sludge Ponds

As discussed in Section 5.3, the surface water pathway was not applicable to the Lime Sludge Ponds. Borings 1956 through 1963 are located in the Lime Sludge Ponds (see Figure 2-7a). The glacial till/lime sludge interface was encountered in these bore holes at depth ranging from 3.5 to 11.5 feet. Also, glacial till was encountered in all peripheral borings/wells (2042, 1042, 1934, 1210, 2935, 2936, 1039, 2939, 1937, and 1940). This confirms that the Lime Sludge Ponds are located on glacial till. Consequently, perched water surface seep and seep pathways were also not applicable to the Lime Sludge Ponds. Figure 5-10 shows the SWIFT III grid blocks directly under the waste at the Lime Sludge Ponds. The hydrostratigraphic units beneath the Lime Sludge Ponds consists of 24 to 35 feet of till (excluding 3 to 6 feet of sand and gravel beds) forming model Layer 1 for the vadose zone pathway, and 16 to 21 feet of buried valley glaciofluvial material forming vadose model Layer 2 (Table 5-14). The base of the ponds is assumed to be located in the unweathered gray tills. Perched water has been observed in the sand and gravel layers under the Lime Sludge Ponds. The thickness of the till below the sand and gravel ranges from 11 to 22 feet (Layer 1 of the perched water vertical infiltration pathway). Only the vadose zone and perched water infiltration pathways were applicable to the Lime Sludge Ponds.

5.4.1.3 Inactive Flyash Pile and South Field

All five constituent migration pathways were applicable to the Inactive Flyash Pile and South Field. The South Field and Inactive Flyash Pile contains the most surface area of any of the Operable Unit 2 subunits (Figure 5-11). The lithology of this area is variable with the southwestern portion containing virtually no tills, while the till thicknesses increases to 22 feet towards the northeastern portion of the South Field. The thickness of the unsaturated zone in the Great Miami Aquifer (Layer 2) ranges from 17 to 33 feet (Table 5-15). When leachate from waste arrives at the interface of waste and till, a portion of leachate infiltrates through glacial overburden (till and sand/gravel stringers) and the rest is laterally drained to areas where till does not exist. Figure 5-12 shows the conceptual model for



LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- WASTE FROM CELL IS INCLUDED IN OTHER CELL
- EXTENT OF WASTE
- SWIFT MODEL CELL (COLUMN, ROW)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100

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FIGURE 5-10
EXTENT OF WASTE AND MODELED SWIFT GRID CELLS, LIME SLUDGE PONDS

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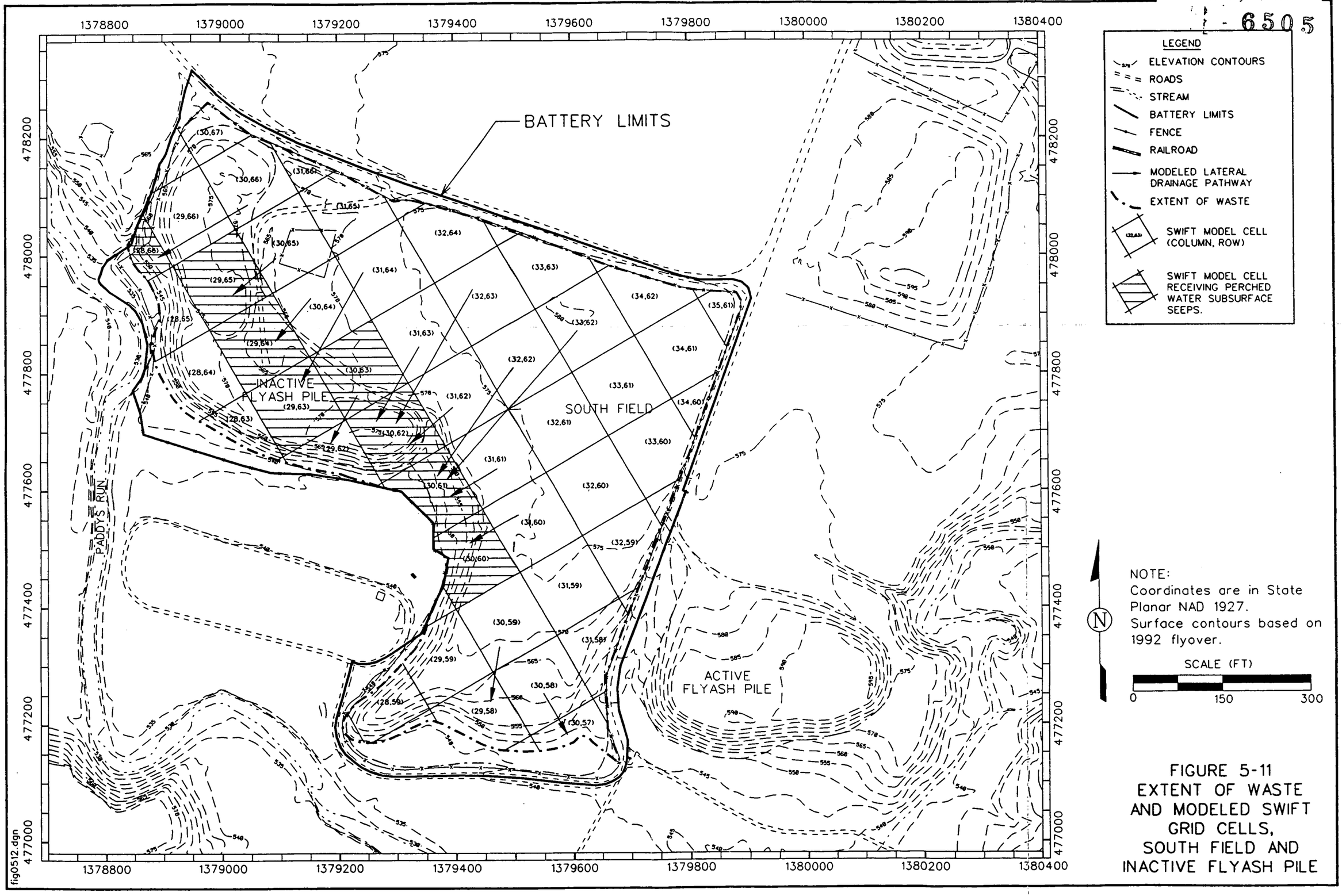
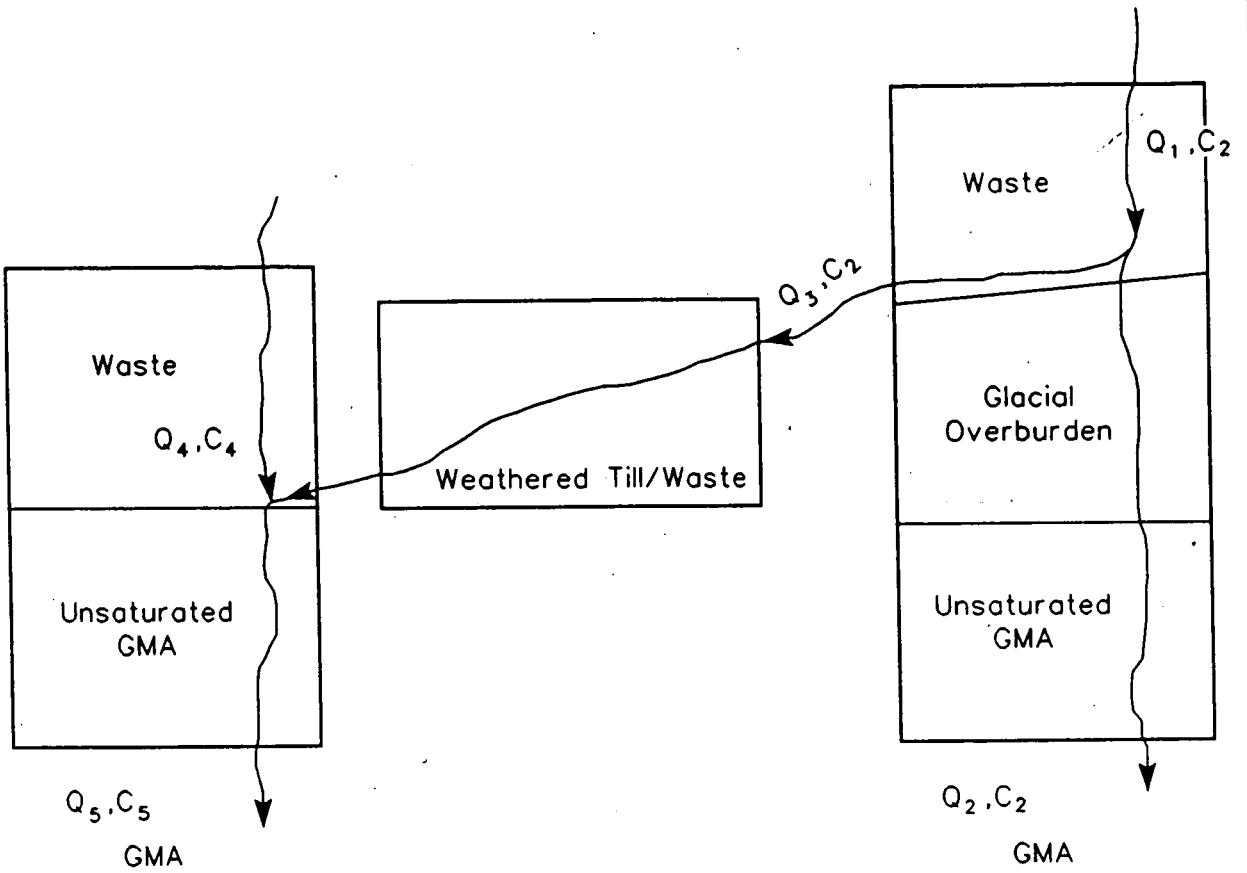


FIGURE 5-11
EXTENT OF WASTE
AND MODELED SWIFT
GRID CELLS,
SOUTH FIELD AND
INACTIVE FLYASH PILE



$$Q_1 = Q_2 + Q_3$$

$$Q_5 = Q_3 + Q_4$$

$$C_5 = \frac{Q_3 C_2 + Q_4 C_4}{Q_3 + Q_4}$$

NOTE:
C_i - CONSTITUENT CONCENTRATION
Q_i - FLOW RATE

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FIGURE 5-12
CONCEPTUAL MODEL FOR LATERAL DRAINAGE INFILTRATING TO THE UNSATURATED GREAT MIAMI AQUIFER

TABLE 5-14

PHYSICAL PARAMETERS FOR THE SWIFT III GRID CELLS IMPACTED BY THE LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Row	Column	Fill or Waste Area (ft^2)	Fill or Waste Volume (ft^3)	Fill or Waste Thickness (ft)	Unsaturated GMA Thickness (ft)	Glacial Overburden Thickness (ft)	Thickness of Till Above the Sand/Gravel (ft)	Thickness of Sand/Gravel In Till (ft)	Thickness of Till Below the Sand/Gravel (ft)	Total Till Thickness (ft)
ZONE 1 - 2 TO FOUR FEET OF FILL										
44	79	5427	15019	2.7	17.7	38.4	15.9	3.6	18.9	34.8
45	80	9163	31863	3.6	19.0	36.3	17.3	5.5	13.5	30.8
43	81	10313	36381	3.9	18.3	35.9	10.3	5.9	19.7	30.0
Zone 1 Average		8288	27754	3.4	18.3	36.8	14.5	5.0	17.4	31.8
ZONE 2 - 6.5 TO 8.5 FEET OF FILL										
44	81	15625	100156	6.4	19.7	31.7	11.3	3.8	16.6	27.9
43	80	10322	69238	6.9	16.7	34.9	7.5	5.4	22.0	29.4
45	81	11414	89781	8.5	20.5	29.6	11.9	6.1	11.6	23.6
Zone 2 Average		12454	94969	7.4	20.1	30.7	11.6	5.0	14.1	25.7
ZONE 3 - 9.4 FEET OF FILL										
44	80	15625	146931	9.4	18.2	31.3	9.1	3.6	18.6	27.6

NOTE: GMA = Great Miami Aquifer

TABLE 5-15

PHYSICAL PARAMETERS FOR THE SWIFT III GRID CELLS IMPACTED BY THE INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Row	Column	Fill or Waste Area (ft)	Fill or Waste Volume (ft^3)	Fill or Waste Thickness (ft)	Unsaturated GMA Thickness (ft)	Glacial Overburden Thickness (ft)	Thickness of Till Above the Sand/Gravel (ft)	Thickness of Sand/Gravel In Till (ft)	Thickness of Till Below the Sand/Gravel (ft)	Total Till Thickness (ft)	Slope at the Base of Fill/Waste (%)
ZONE 1 - NO SAND, NO TILL, MEDIUM FILL/WASTE											
28	59	11720	155938	15.6	16.7	0.0	0.0	0.0	0.0	0.0	
28	63	7029	104463	15.2	18.9	0.0	0.0	0.0	0.0	0.0	
28	65	8907	133369	15.2	19.6	0.0	0.0	0.0	0.0	0.0	
29	62	8869	151588	16.2	18.5	0.0	0.0	0.0	0.0	0.0	
29	64	15625	285594	18.3	25.5	0.0	0.0	0.0	0.0	0.0	
30	62	15625	292094	18.7	24.1	0.0	0.0	0.0	0.0	0.0	
Zone 1 Average		11296	187174	16.5	20.6	0.0	0.0	0.0	0.0	0.0	0.0
ZONE 2 - NO SAND, NO TILL, MAXIMUM FILL/WASTE											
28	64	13618	292531	21.3	19.7	0.0	0.0	0.0	0.0	0.0	
29	63	15625	382981	24.5	20.8	0.0	0.0	0.0	0.0	0.0	
Zone 2 Average		14622	337756	22.9	20.2	0.0	0.0	0.0	0.0	0.0	0.0
ZONE 3 - NO SAND, LESS THAN 2 FEET FILL/WASTE											
29	60	1392	1706	1.4	25.4	0.0	0.0	0.0	0.0	0.0	
30	57	8444	1006	0.1	21.3	0.0	0.0	0.0	0.0	0.0	
30	61	12342	21281	1.6	24.8	0.0	0.0	0.0	0.0	0.0	
Zone 3 Average		7393	7998	1.0	23.8	0.0	0.0	0.0	0.0	0.0	0.0

See note at end of table

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TABLE 5-15
(Continued)

Row	Column	Fill or Waste Area (ft)	Fill or Waste Volume (ft^3)	Fill or Waste Thickness (ft)	Unsaturated GMA Thickness (ft)	Glacial Overburden Thickness (ft)	Thickness of Till Above the Sand/Gravel (ft)	Thickness of Sand/Gravel In Till (ft)	Thickness of Till Below the Sand/Gravel (ft)	Total Till Thickness (ft)	Slope at the Base of Fill/Waste (%)
ZONE 4 - NO SAND, LESS THAN 10 FEET FILL/WASTE											
28	66	4480	15288	3.5	21.3	6.0	0.0	0.0	6.0	6.0	
30	60	13981	87850	6.4	29.0	7.0	0.3	0.0	6.7	7.0	
31	58	11040	56950	5.7	29.6	6.0	0.0	0.0	5.9	6.0	
31	59	15625	131675	8.4	31.4	11.8	3.2	0.1	8.6	11.8	
Zone 4 Average		11282	72941	6.0	27.8	7.7	0.0	0.0	7.7	7.7	1.5
ZONE 5 - NO SAND, LESS THAN 2 FEET TILL, MORE THAN 10 FEET FILL/WASTE											
29	58	12171	137888	11.0	18.2	0.0	0.0	0.0	0.0	0.0	
29	59	14263	297838	20.7	20.2	0.0	0.0	0.0	0.0	0.0	
29	65	15625	398850	25.5	24.8	0.0	0.0	0.0	0.0	0.0	
Zone 5 Average		14020	278192	19.1	21.1	0.0	0.0	0.0	0.0	0.0	8.5
ZONE 6 - NO SAND, MORE THAN 2 FEET SAND, MORE THAN 10 FEET FILL/WASTE											
30	58	15625	164338	10.5	21.7	7.4	0.0	0.0	7.4	7.4	
30	59	15625	231375	14.8	28.2	6.5	0.0	0.0	6.5	6.5	
30	63	15625	294731	18.9	24.8	3.3	0.0	0.0	3.3	3.3	
30	64	15625	245375	15.7	26.4	4.4	0.0	0.0	4.4	4.4	
Zone 6 Average		15625	233955	15.0	25.3	5.4	0.0	0.0	5.4	5.4	5
ZONE 7 - NORTHERN PART OF INACTIVE FLYASH PILE											
29	67	3837	13519	3.6	32.5	8.5	3.3	3.0	2.2	5.4	
30	67	6665	55444	8.9	29.7	8.4	1.7	2.7	3.9	5.7	
Zone 7 Average		5251	34481	6	31	8	2	3	3.1	5.5	0.0

See note at end of table

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TABLE 5-15
(Continued)

Row	Column	Fill or Waste Area (ft)	Fill or Waste Volume (ft^3)	Fill or Waste Thickness (ft)	Unsaturated GMA Thickness (ft)	Glacial Overburden Thickness (ft)	Thickness of Till Above the Sand/Gravel (ft)	Thickness of Sand/Gravel In Till (ft)	Thickness of Till Below the Sand/Gravel (ft)	Total Till Thickness (ft)	Slope at the Base of Fill/Waste (%)
ZONE 8											
29	66	15241	227906	15.2	32.0	4.0	0.3	1.4	2.3	2.6	0.0
ZONE 9											
30	65	15625	117675	7.5	27.3	10.1	0.4	0.4	9.2	9.7	4
ZONE 10 - LESS THAN 3 FEET OF TILL ABOVE SAND											
30	66	15429	154863	9.9	28.6	10.3	1.6	1.6	7.1	8.7	
31	61	15625	149431	9.6	30.8	10.8	2.1	1.3	7.4	9.5	
31	62	15625	134256	8.6	30.1	11.5	2.3	0.8	8.4	10.7	
31	63	15625	162263	10.4	29.5	12.2	1.8	0.7	9.7	11.5	
Zone 10 Average		15576	150203	9.6	29.8	11.2	1.9	1.1	8.2	10.1	4
ZONE 11 - LESS THAN 1 FEET OF FILL, MORE THAN 5 FEET OF TILL ABOVE SAND											
31	66	3615	4919	0.9	28.7	18.5	8.3	0.8	9.4	17.7	
34	60	3509	1269	0.3	32.7	22.7	12.8	2.1	7.8	20.6	
35	61	4123	788	0.2	32.2	23.9	12.8	2.0	9.1	21.9	
Zone 11 Average			2325	0.5	31.2	21.7	11.3	1.6	8.8	20.1	0
ZONE 12 - 2-3 FEET OFF FILL, GOOD TILL LAYER ABOVE SAND											
31	65	13612	31419	2.3	28.6	18.0	5.8	1.5	10.7	16.5	
32	64	14238	41544	3.0	29.6	22.0	10.6	1.8	9.6	20.2	
33	59	1860	3688	2.0	33.0	18.3	9.8	1.3	7.2	17.0	
33	60	14234	26344	1.8	32.7	20.4	10.7	2.0	7.7	18.4	
33	61	15625	39369	2.5	31.8	21.7	10.7	1.8	9.2	20.0	
33	63	12928	29019	2.4	30.6	23.5	12.1	1.7	9.6	21.7	

See note at end of table

TABLE 5-15
(Continued)

Row	Column	Fill or Waste Area (ft)	Fill or Waste Volume (ft^3)	Fill or Waste Thickness (ft)	Unsaturated GMA Thickness (ft)	Glacial Overburden Thickness (ft)	Thickness of Till Above the Sand/Gravel (ft)	Thickness of Sand/Gravel In Till (ft)	Thickness of Till Below the Sand/Gravel (ft)	Total Till Thickness (ft)	Slope at the Base of Fill/Waste (%)
ZONE 12 - 2-3 FEET OF FILL, GOOD TILL LAYER ABOVE SAND (Continued)											
34	61	15140	39388	2.6	32.1	22.2	11.0	2.0	9.1	20.1	
34	62	10365	26269	2.8	31.5	22.6	11.2	1.7	9.7	20.9	
Zone 12 Average		12250	29630	2.4	31.2	21.1	10.3	1.7	9.1	19.3	0
ZONE 13 - MORE THAN 4 FEET OF FILL WITH LATERAL DRAINAGE											
31	60	15625	121769	7.8	31.6	14.0	4.1	1.4	8.6	12.7	
31	64	15625	104775	6.7	29.1	15.9	4.5	0.8	10.6	15.1	
32	62	15625	96975	6.2	30.7	18.8	7.3	2.5	9.0	16.3	
32	63	15625	96025	6.2	30.1	19.7	8.4	2.1	9.3	17.6	
33	62	15625	63881	4.1	31.1	21.7	10.3	1.7	9.8	20.1	
Zone 13 Average		15625	96685	6.2	30.5	18.0	6.9	1.7	9.5	16.4	0.9
ZONE 14 - MORE THAN 4 FEET OF FILL, NO LATERAL DRAINAGE											
32	59	12620	60931	4.9	32.5	14.8	6.3	0.7	7.9	14.1	
32	60	15625	70544	4.5	32.3	17.6	7.6	2.5	7.5	15.1	
32	61	15625	66731	4.3	31.4	18.6	7.7	2.3	8.6	16.3	
Zone 14 Average		14623	66069	4.6	32.1	17.0	7.2	1.8	8.0	15.2	0

NOTE: GMA = Great Miami Aquifer

lateral drainage. The area receiving lateral drainage has increased flow. Horizontal travel time is simulated by travel through an equivalent Layer 1 using permeability of waste material. One vadose zone modeling run is used to simulate vertical infiltration. A separate one-dimensional analytical solute transport model (ODAST) run was used for simulating contribution from lateral drainage and was added to the Great Miami Aquifer before screening. Lateral drainage and infiltration through waste were added to calculate total vertical percolation rate and interstitial fluid velocity for the areas receiving lateral drainage from upgradient waste areas.

Perched water has been observed in 0 to 3 feet thick sand and gravel layers in the till. It is recognized that the glacial till is saturated. However, only the perched water in the sand and gravel layer represents a source for the Great Miami Aquifer. These sand and gravel layers are underlain by 2 to 11 feet thick till layer. Perched water not only represents a source for vertical infiltration, but it also serves as a source for perched water subsurface seeps. Figure 5-13 shows the conceptual model for the perched water subsurface seeps. Sand and gravel layer within the till (containing perched water) comes in contact with the waste in sections of the Inactive Flyash Pile and South Field. Perched water laterally moves in the sand layer until it is intercepted at the sand/gravel and waste contact. At that point, perched water moves along the slope of waste and till interface until it comes in contact with the unsaturated Great Miami Aquifer. The subsurface seep water then vertically infiltrates to the aquifer. Figure 5-11 identifies eight blocks which receive subsurface seep water.

Furthermore, two seeps have been observed adjacent to or in the area of these subunits. One seep exists on the western boundary of the Inactive Flyash Pile, while another was observed on the eastern side of the South Field. Seep water travels on the top of the till until it flows onto the unsaturated sand and gravels of the Great Miami Aquifer. At those locations, seep water infiltrates into the Great Miami Aquifer. These seeps were included as source term for the Great Miami Aquifer.

5.4.1.4 Active Flyash Pile

The constituent migration pathways applicable to the Active Flyash Pile were the vadose zone, perched water infiltration, and surface water pathways. Figure 5-14 shows the SWIFT III grid blocks directly under the waste at the Active Flyash Pile. The Active Flyash Pile overlies a variable, 0 to 22 feet thick layer of till (Layer 1) for the vadose zone pathway followed immediately by 22 to 33 feet of the unsaturated Great Miami Aquifer layer (Table 5-16). For the purposes of modeling, colluvial

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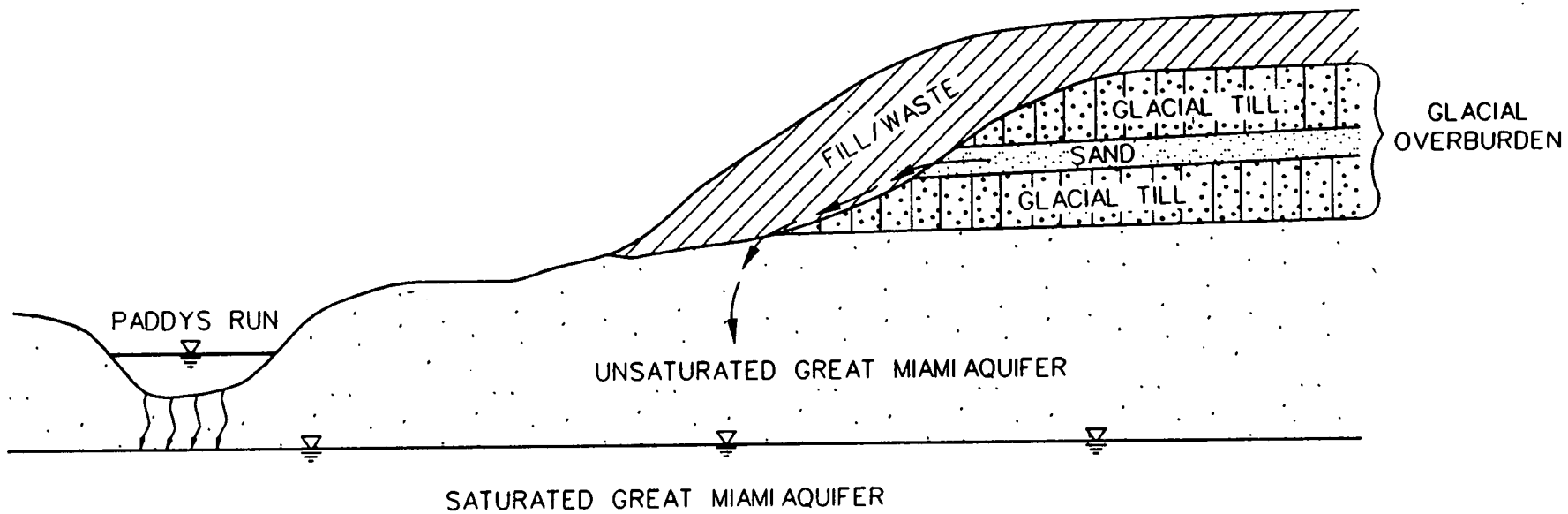

FIGURE 5-13
CONCEPTUAL MODEL FOR PERCHED WATER SUBSURFACE SEEPS

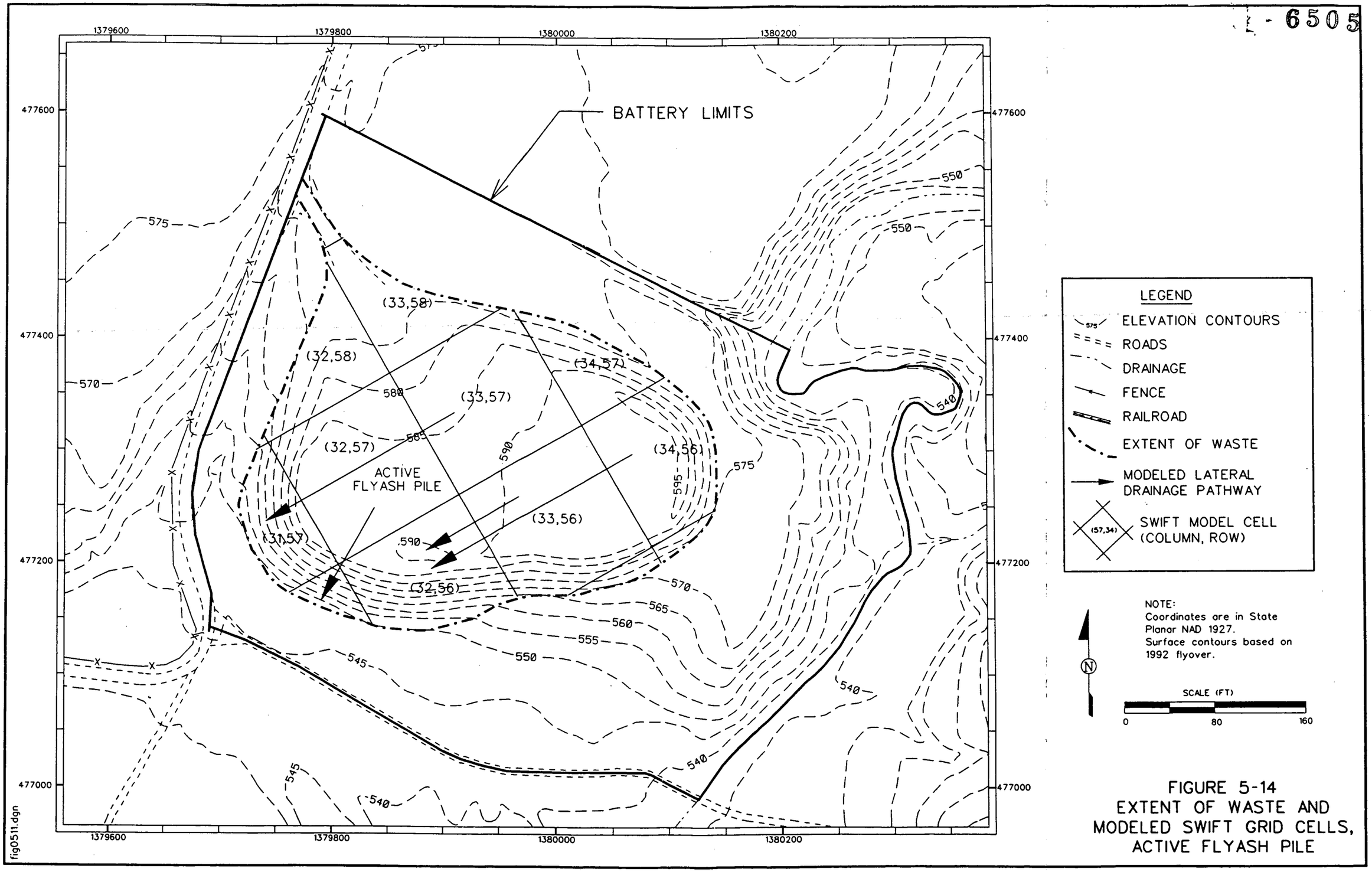

FIGURE 5-14
EXTENT OF WASTE AND
MODELED SWIFT GRID CELLS,
ACTIVE FLYASH PILE

TABLE 5-16

PHYSICAL PARAMETERS FOR THE SWIFT III GRID CELLS IMPACTED BY THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Row	Column	Fill or Waste Area (ft)	Fill or Waste Volume (ft^3)	Fill or Waste Thickness (ft)	Unsaturated GMA Thickness (ft)	Glacial Overburden Thickness (ft)	Slope at the Base of Fill/Waste (%)
ZONE 1 - CENTRAL PORTION OF THE ACTIVE FLYASH PILE							
32	57	15625	449800	28.8	30.1	5.7	
33	56	15240	319700	21.2	30.8	15.8	
33	57	15595	276300	17.7	31.6	14.9	
34	56	11205	188350	15.9	31.2	22.2	
Zone 1 Average		14416	308538	20.9	30.9	14.7	5
ZONE 2 - NORTHERN SLOPING SURFACE							
32	58	7095	55100	8.0	31.7	12.7	
33	58	7350	42250	5.6	32.6	16.6	
34	57	5885	68700	12.2	32.1	20.0	
Zone 2 Average		6777	55350	8.6	32.1	16.4	0
ZONE 3 - FLYASH DIRECTLY ON THE GREAT MIAMI AQUIFER							
31	56	1625	16100	8.6	22.1	0.0	
31	57	6240	90550	16.1	25.8	0.0	
32	56	11570	246250	20.7	28.3	0.0	
Zone 3 Average		6478	117633	15.1	25.4	0.0	0

NOTE: GMA = Great Miami Aquifer

material was assumed to have the same properties as the Great Miami Aquifer soils. Lateral drainage of infiltrated leachate was simulated as shown in Figure 5-12. Although no sand/gravel layers were identified under the Active Flyash Pile during field activities, perched water has been observed in monitoring wells installed just north of the Active Flyash Pile. Therefore, a 3-foot perched water layer in the middle of the till layer was used for perched water infiltration pathway simulation.

5.4.2 Technical Approach

This section describes the technical approach used to model groundwater.

5.4.2.1 Source Term Development for Vadose Zone and Groundwater Models

Analytical data for the waste areas were compiled and screened to identify CPCs based on the requirements of the Operable Unit 2 baseline risk assessment (Section 6.0 and Appendix B). A variety of radionuclides, inorganics, and organic compounds are included in the CPC list. Waste area constituent concentrations (as calculated in Appendix B) and their corresponding inventory are presented in Appendix A-2.

Waste constituent concentrations used in the groundwater modeling were the upper 95 percent confidence level on the means of the waste concentrations from the RI/FS subsurface soil or perched water database for Operable Unit 2. For uranium-238, the waste concentration in each block was estimated using kriging. This approach was selected for uranium, since uranium controls the risk from groundwater pathways, to simulate known hot spots identified during field investigations.

All validated uranium-238 analysis from RI/FS Phase I and Phase II field investigations for each subunit were segregated by waste/fill, glacial overburden, and sand/gravel of the Great Miami Aquifer. Uranium-238 concentrations in each 25 x 25 x 2.5 foot block were then estimated using three-dimensional kriging for each media type. Kriging for each medium used analytical results of soil samples from that medium only. Average waste concentrations in each 125 x 125 foot SWIFT III grid cells were then calculated from 25 x 25 x 2.5 foot thick blocks. These concentrations are reported in Section 5.4.3.

The source terms for seeps and perched water (infiltration and subsurface seep) pathways were estimated using the following equation:

$$\text{Mass} = (\phi\, C_w + \rho_b K_d C_w)\, Ab$$

where:

A = Area of cell (125 x 125 ft^2)
b = Average perched water zone thickness
C_w = Upper 95 percent confidence level on the means of the perched water concentrations
K_d = Distribution coefficient
ϕ = Porosity
ρ_b = Bulk (dry) density

5.4.2.2 Methods of Estimating Leachate Concentrations

Estimated leachate concentrations were used as initial CPC concentrations in the vadose zone fate and transport model to predict CPC concentrations at the top of the Great Miami Aquifer. Conservative assumptions were used in developing leachate concentrations. All CPC concentrations used as input data in the fate and transport model were constrained by (in order of preference): in situ leachate analyses (Appendix C, Section 4.0), TCLP data (Appendices C through G, Section 4.0), or the EPA 70-year rule (EPA 1988a). See Figure 5-15 for logic in estimating leachate concentrations. Geochemical modeling was not used due to lack of data or large uncertainty associated with leachate concentrations derived from geochemical modeling.

The preferred data for estimating contaminant concentrations in leachate was analyses of in situ leachate. When these data were unavailable, an approach of using the best available TCLP data was followed. When a constituent was detected in in situ leachate or TCLP, the maximum detected concentration was used as leachate concentration. If in situ leachate or TCLP analyses indicated that the compound was not detected, then the concentration of a particular CPC was conservatively estimated as the maximum detection limit value. For CPCs that lack in situ and TCLP data, the EPA 70-year rule calculation was used to estimate their leachate concentration. If the leachate concentration estimated from the EPA 70-year rule exceeds the solubility limit, then the leachate concentration was set to the solubility limit.

Uncertainties in Estimating Leachate Concentration

As waste composition in Operable Unit 2 subunits is generally heterogeneous, it is possible that in situ leachate concentration may not be a representative value of leachate concentration in each block. Uncertainty is introduced into the estimation of leachate composition whenever in situ leachate analyses are lacking. Figure 5-15 shows the procedure for estimating leachate concentrations. The logic behind using this decision hierarchy is to apply the best available site-specific data to the

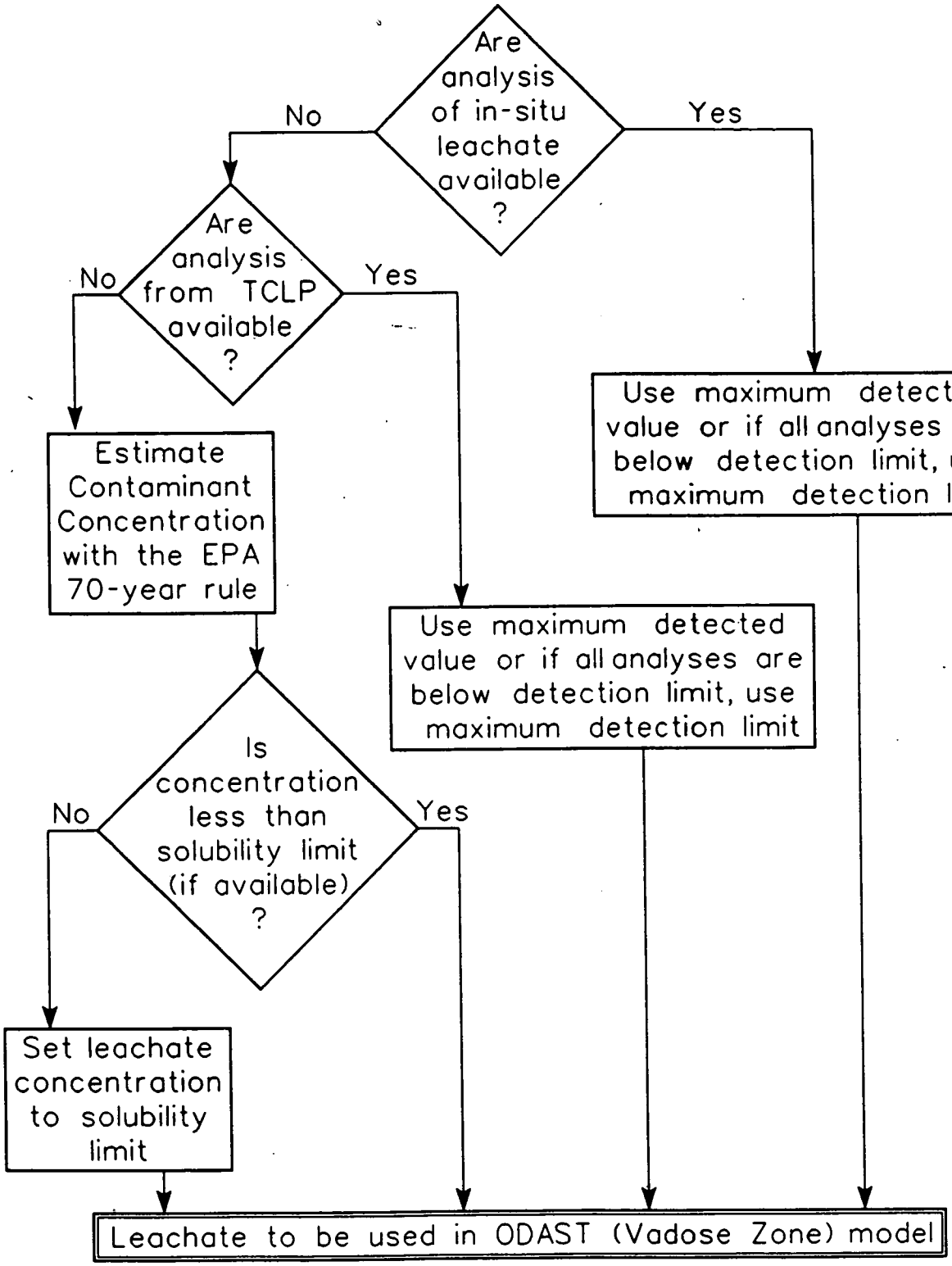

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FIGURE 5-15
PROCEDURE FOR ESTIMATING LEACHATE CONCENTRATION

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estimation of leachate compositions. Each successively lower step on this hierarchy represents a more conservative method for estimating CPC concentrations in leachate. For example, the use of TCLP data to estimate leachate composition will probably result in CPC concentrations that are greater than values expected for in situ leachate. The acetic acid leaching used in TCLP procedure results in greater concentrations for many metals in leachate because acetic acid is a more aggressive leaching agent than rainwater. Calculations carried out to estimate CPC concentrations using the EPA 70-year rule will introduce a large conservative uncertainty for all but the most soluble contaminants (e.g., bromide and cesium). The possibility exists to underestimate the contaminant concentration when the EPA 70-year rule is applied to a very soluble constituent. However, the value used for the baseline risk assessment was the maximum predicted concentration for a full 70-year average life span of humans. Even if the leaching time is underestimated by a factor of two to three, peak concentration in the Great Miami Aquifer will occur very early when the concentration of other (less soluble) CPCs is low and risk will still be below the 10^{-6} carcinogenic risk or HI of 1.0, if the very soluble CPC was screened out.

5.4.2.3 Vadose Zone Modeling

Details of the vadose zone modeling is presented in Appendix A.2. Vadose zone modeling was performed by using the leachate concentrations and results of initial screening as inputs into one-dimensional unsaturated flow models to simulate transport through the vadose zone to the Great Miami Aquifer. The ODAST model was used to simulate dispersion, retardation, and decay through unsaturated materials. The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate infiltration rates and lateral drainage.

Waste above each SWIFT III grid cell was modeled separately with individual stratigraphy, contaminant type and concentration, and infiltration rate parameters. The conceptual models for the subunits considered the following:

- The contents of waste above individual SWIFT III grid cells
- The presence or absence of standing water in the waste
- The presence/absence of perched water beneath each SWIFT III grid cells
- The average concentration of CPC in perched groundwater
- The identifiable geologic strata beneath the waste areas
- The presence/absence of sand lenses beneath the subunits
- The thickness of each layer in the vadose zone
- The vertical permeability of the layers
- The interstitial fluid velocity through each layer based on saturation

- The dispersion coefficients of each layer
- The partition coefficients for each contaminant in each layer

The vadose zone was modeled as two layers: the glacial overburden underlying the waste areas (Layer 1) and the unsaturated portion of the underlying Great Miami Aquifer (Layer 2). Layer 1 soils consist of tills in the glacial overburden. A sequence of fine-grained till deposits interbedded with sand and gravel glaciofluvial stringers forms the glacial overburden in Operable Unit 2. The sand and gravel unit within the glacial overburden was not included in the vadose zone modeling because this layer has much higher permeability and less adsorption potential compared to clay and silts in glacial overburden. The thickness of till ranges between 0 and 38 feet for Operable Unit 2 waste areas. Beneath the till is the unsaturated sand and gravel outwash layer (Layer 2), which is present beneath all the waste units. The thickness of Layer 2 ranges from 16 to 33 feet.

The vertical hydraulic conductivity values for Layer 1 were obtained from the geometric average horizontal hydraulic conductivities of 1000-series wells completed in dark gray clay or clayey silt or from maximum permeability measurements conducted on core samples. The vertical hydraulic conductivity for Layer 2 was obtained by dividing the horizontal hydraulic conductivity of the Great Miami Aquifer by 10. The factor of 10 represents a typical horizontal to vertical hydraulic conductivity ratio. The vertical hydraulic conductivity was estimated to be 1.9×10^{-6} to 1.4×10^{-7} cm/s for Layer 1. The vertical hydraulic conductivity of Layer 2 was estimated to be 1.6×10^{-2} cm/s for all of the Operable Unit 2 subunits.

Flow and solute transport through porous media are not only determined by the parameters considered in the conceptual model described above, but they are also affected by the retardation factors and decay rates. These parameters are both chemical- and media-specific. The retardation factors used for all the CPCs in the vadose zone Layers 1 and 2, the radioactive decay constants for radionuclides, and the biodegradation coefficients for the organic constituents are discussed in detail in Appendix A.2. These retardation factors and decay rates are used in the analytical modeling of the vadose zone and numeric modeling of the Great Miami Aquifer.

The retardation factor was used to account for those reversible reactions that slow the arrival of a contaminant front, but do not act as a sink. The retardation factor can be expressed as the ratio between the rate of groundwater movement and the rate of contaminant movement. The retardation

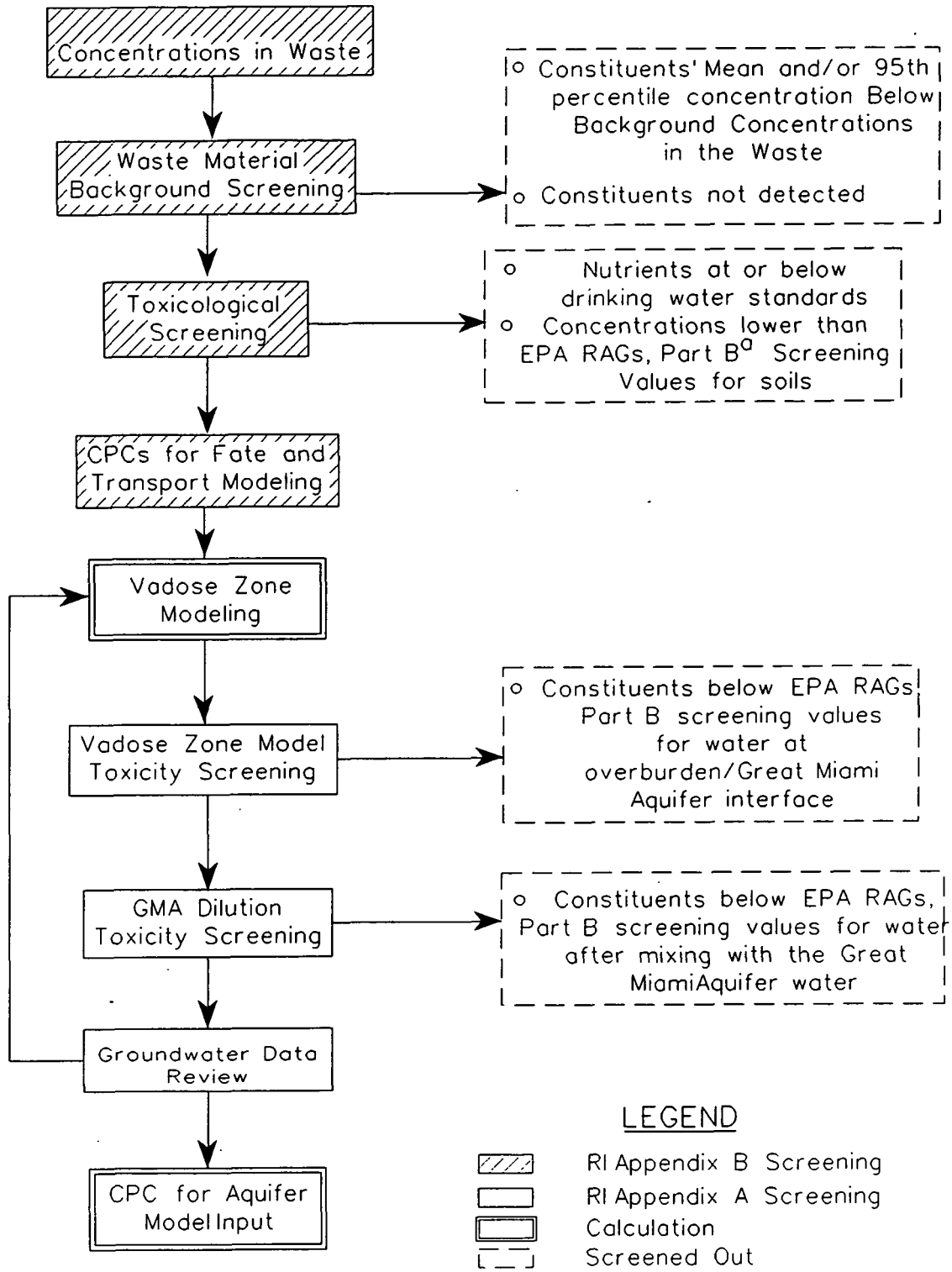
factors used have been revised from the Risk Assessment Work Plan Addendum (DOE 1992a) based on more conservative assumptions (for transport) of organic content and moisture content (see Table 5-17). The radioactive decay constants and biodegradation coefficients were estimated based on the degradation rates (Howard et al. 1991) using the formulation presented in the Risk Assessment Work Plan Addendum (DOE 1992a).

In the South Field, Inactive Flyash Pile, and Active Flyash Pile, some of the waste material is directly underlain by an unsaturated portion of the Great Miami Aquifer; other waste material is underlain by glacial overburden. When leachate from waste arrives at the interface of waste and glacial overburden, a portion of leachate infiltrates through glacial overburden; the rest of the leachate is laterally drained to areas where glacial overburden does not exist. Figure 5-12 shows the conceptual model for lateral drainage. The area receiving lateral drainage has increased flow. Horizontal travel time is simulated by travel through an equivalent Layer 1 with a permeability of waste material. A separate ODAST run was used before screening for simulating contribution from lateral drainage to the Great Miami Aquifer. Lateral drainage and infiltration through waste were added to calculate the total vertical percolation rate and interstitial fluid velocity for the areas receiving lateral drainage from upgradient waste areas (see Figure 5-12).

5.4.2.4 Screening Procedures

The list of potential CPCs was screened in several ways to eliminate constituents from further analysis that pose insignificant risk. These screening steps were performed because vadose zone and aquifer modeling requires long computational times and allows the analysis to focus on only those constituents that may potentially create significant risks. Figure 5-16 shows the different screening steps. These steps include background screening, toxicological screening (performed and presented in Section 6.0 and Appendix B), vadose zone output concentration screening, and Great Miami Aquifer dilution screening (presented in detail in Appendix A). Each subunit was treated separately in these screening analyses. These screening steps were applied only to the vadose zone modeling where each block was modeled individually.

If the modeling of a possible CPC through the vadose zone to the Great Miami Aquifer revealed that the peak concentrations of the constituent before or after dilution was below the screening concentration at the point of reaching the Great Miami Aquifer within 1,000 years, further modeling of the constituent was not considered necessary for the human health risk assessment. Screening



[a] EPA Risk Assessment Guidence, Part B **(EPA, 1991d).**

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FIGURE 5-16
POTENTIAL CONSTITUENT OF CONCERN SCREENING DIAGRAM

TABLE 5-17

MEDIA PARAMETERS FOR VADOSE ZONE MODEL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	Vadose Zone	
	Layer 1[a]	Layer 2[b]
SOLID WASTE LANDFILL		
Porosity (%)	41	39
Specific yield (%)	6	25
Bulk density (g/cc)	1.89	1.60
Field capacity (%)	37.1	4.5
Organic content (%)	1.43	0.87
Fines passing less than 200 mesh (%)	70.1	16.5
LIME SLUDGE PONDS		
Porosity (%)	41	39
Specific yield (%)	6	25
Bulk density (g/cc)	1.73	1.60
Field capacity (%)	28	14
Organic content (%)	1.65	0.87
Fines passing less than 200 mesh (%)	70.1	16.5
INACTIVE FLYASH PILE		
Porosity (%)	41	39
Specific yield (%)	6	25
Bulk density (g/cc)	1.85	1.60
Field capacity (%)	37.1	4.5
Organic content (%)	1.69	0.87
Fines passing less than 200 mesh (%)	70.9	16.5

See footnotes at end of table

TABLE 5-17
(Continued)

Parameter	Vadose Zone Layer 1[a]	Vadose Zone Layer 2[b]
SOUTH FIELD		
Porosity (%)	41	39
Specific yield (%)	6	25
Bulk density (g/cc)	1.85	1.60
Field capacity (%)	37.1	4.5
Organic content (%)	1.69	0.87
Fines passing less than 200 mesh (%)	70.9	16.5
ACTIVE FLYASH PILE		
Porosity (%)	41	39
Specific yield (%)	6	25
Bulk density (g/cc)	1.850	1.600
Field capacity (%)	37.1	4.5
Organic content (%)	1.69	0.87
Fines passing less than 200 mesh (%)	70.9	16.5

[a]Layer 1 consists of a clay-rich glacial till interbedded with glaciofluvial sand and gravel stringers. However, Layer 1 consists of only glacial till.

[b]Layer 2 consists of unsaturated well-sorted sand and gravel outwash deposits existing above the Great Miami Aquifer.

concentrations were calculated using EPA RAGs, Part B guidelines. If the predicted concentration of a given constituent equals or exceeds the respective screening level concentration after mixing the Great Miami Aquifer, the constituent was included in the aquifer modeling.

The vadose zone modeling results were compared against the Great Miami Aquifer data. If the model predictions were not in agreement with the Great Miami Aquifer data, model parameters, assumptions, and conceptual models were reviewed and modified accordingly. If the vadose zone model was refined, the vadose zone model calculations were repeated and the vadose zone model toxicity screening and the Great Miami Aquifer dilutions toxicity screening steps were repeated. This process was continued until the model predictions were in agreement with the field measured data. Detailed modeling in the Great Miami Aquifer was performed for the CPCs remaining from the Great Miami Aquifer dilution toxicity screening.

5.4.2.5 Great Miami Aquifer Modeling

The calibrated groundwater flow model for the FEMP was developed previously for use in Operable Unit 5. A detailed description of the development, calibration, and verification of the site-wide model is available in the Groundwater Modeling Report, Summary of Model Development, April 1993 (DOE 1993d). The model is based on the SWIFT III model. The modeling approach taken for Operable Unit 2 is described in detail in Appendix A-2. The Operable Unit 2 fate and transport modeling involved incorporating the vadose zone modeling results (for vadose zone, perched water infiltration, perched water subsurface seep, and seep pathways) to determine loading rates (both concentration and volume) to the Great Miami Aquifer from the subunits. In addition, surface water infiltration from the Storm Sewer Outfall Ditch or Paddys Run to the Great Miami Aquifer was used as an additional source term to the model. The model then simulated the transport of constituents away from these source areas. Figure 5-7 presents a conceptual model of fate and transport through groundwater. Dispersion, retardation, and decay were factored into the contaminant transport process. SWIFT III simulations of CPC transport in the Great Miami Aquifer were run up to 1,000 years.

One modeling run was performed for each CPC that remained after the screening processes. The loading from each grid cell impacted by the subunit was entered into the SWIFT III model as a discrete source, making multiple sources for each constituent. Due to the proximity of the Inactive Flyash Pile to the South Field, sources from the Inactive Flyash Pile and South Field were combined

into one SWIFT III run. The modeling runs produced simulations of the aggregate effects of loading from these two subunits for the CPCs.

Only uranium-238 was modeled to reduce computation time for modeling of uranium isotopes. Concentrations of uranium-234, uranium-235/236 were estimated by using site-specific activity ratios for uranium. The uranium at the FEMP is mostly uranium-238 (approximately 91 percent by mass). A discussion of the site-specific activity ratio is provided in Appendix A-2 and Section 5.4.4.

5.4.3 Results of Vadose Zone Modeling and Screening of Contaminants of Potential Concern

Loading rates to the Great Miami Aquifer were estimated for each CPC for the Operable Unit 2 subunits using ODAST. Loading rates of a constituent from ODAST to the aquifer from a given source vary over time.

5.4.3.1 Solid Waste Landfill

Figure 5-9 shows the areal extent of the waste in the Solid Waste Landfill and the SWIFT III grid blocks impacted by the direct loading from the Solid Waste Landfill. Waste overlying the SWIFT III grid block (49,91) was included with SWIFT III waste overlying grid block (50,91). Similarly, contaminant loadings for SWIFT III grid blocks (52,91) and (52,92) were combined and loaded from the grid block (52,91). Three pathways were considered for the Solid Waste Landfill fate and transport modeling. One of these pathways was the surface water pathway. However, no CPCs were identified from this pathway (see Section 5.3.3). Two other pathways were the vadose zone pathway and the perched water infiltration pathway. Table 5-18 lists the CPCs considered for the fate and transport modeling, CPC concentration in the waste, inventory in waste, predicted maximum leachate concentration, predicted maximum concentration from vadose zone Layer 2 from the vadose zone and perched water pathways, and screening concentrations for the Solid Waste Landfill. A summary of screening for CPCs for the Solid Waste Landfill is also included in Table 5-18. Only technetium-99 was found to reach the Great Miami Aquifer above the EPA RAGs, Part B screening concentrations. Great Miami Aquifer dilution screening for technetium-99 was not performed since the ODAST output concentration for technetium-99 was one order of magnitude higher than the screening concentration. The predicted increases in CPC concentrations above the background values in the Great Miami Aquifer due to the source term loading from the Solid Waste Landfill were small. Table 5-19 compares the background concentration and the field measured concentrations in the Great Miami Aquifer from 2000-series wells in the Solid Waste Landfill. For all the CPCs, observed

TABLE 5-18

SOURCE CHARACTERIZATION AND SCREENING SUMMARY FOR CONSTITUENTS OF POTENTIAL CONCERN, SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituent Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥ Screening Concentration and Requires SWIFT Modeling
RADIONUCLIDES							
Cesium-137	2.89×10^{-9}	5.84×10^{-2}	$2.00 \times 10^{+1}$	ISL	0.0[b]	1.70×10^{-1}	No
Lead-210	1.35×10^{-8}	2.72×10^{-1}	$2.79 \times 10^{+2}$	70-Year	0.0	7.20×10^{-3}	No
Neptunium-237	4.98×10^{-4}	$1.01 \times 10^{+4}$	$1.00 \times 10^{+0}$	ISL	0.0	2.16×10^{-2}	No
Plutonium-238	1.92×10^{-8}	3.87×10^{-1}	$1.00 \times 10^{+0}$	ISL	0.0	2.16×10^{-2}	No
Plutonium-239/240	1.10×10^{-5}	$2.21 \times 10^{+2}$	$1.00 \times 10^{+0}$	ISL	0.0	2.07×10^{-2}	No
Radium-224	1.35×10^{-11}	2.72×10^{-4}	$7.28 \times 10^{+2}$	70-Year	0.0	1.25×10^{-1}	No
Radium-226	1.57×10^{-6}	$3.17 \times 10^{+1}$	$1.00 \times 10^{+0}$	ISL	0.0	1.76×10^{-4}	No
Radium-228	9.41×10^{-9}	1.90×10^{-1}	$3.00 \times 10^{+0}$	ISL	0.0	4.75×10^{-2}	No
Strontium-90	1.15×10^{-8}	2.33×10^{-1}	$5.00 \times 10^{+0}$	ISL	0.0	1.32×10^{-1}	No
Technetium-99	4.44×10^{-5}	$8.96 \times 10^{+2}$	$3.00 \times 10^{+1}$	ISL	$2.85 \times 10^{+1}$	$3.65 \times 10^{+0}$	Yes
Thorium-228	4.13×10^{-9}	8.35×10^{-2}	$1.00 \times 10^{+0}$	ISL	0.0	8.64×10^{-2}	No
Thorium-230	5.97×10^{-4}	$1.21 \times 10^{+4}$	$1.00 \times 10^{+0}$	ISL	0.0	3.65×10^{-1}	No
Thorium-232	$3.26 \times 10^{+1}$	$6.59 \times 10^{+8}$	$1.00 \times 10^{+0}$	ISL	0.0	2.79×10^{-2}	No
Uranium-234	1.56×10^{-2}	$3.15 \times 10^{+5}$	$9.42 \times 10^{+2}$	ISL	0.0	2.97×10^{-1}	No
Uranium-235/236	$3.72 \times 10^{+0}$	$7.52 \times 10^{+7}$	$1.05 \times 10^{+2}$	ISL	0.0	2.97×10^{-1}	No
Uranium-238		$3.39 \times 10^{+9}$	$8.68 \times 10^{+2}$	ISL	0.0	1.70×10^{-1}	No
Grid # 52,91	$6.01 \times 10^{+1}$	$1.21 \times 10^{+8}$	$8.68 \times 10^{+2}$	ISL			
Grid # 51,90	$1.21 \times 10^{+2}$	$2.73 \times 10^{+7}$	$8.68 \times 10^{+2}$	ISL			
Grid # 51,91	$2.00 \times 10^{+2}$	$1.26 \times 10^{+9}$	$8.68 \times 10^{+2}$	ISL			
Grid # 51,92	$5.36 \times 10^{+1}$	$1.84 \times 10^{+8}$	$8.68 \times 10^{+2}$	ISL			

See footnotes at end of table

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TABLE 5-18
(Continued)

Constituent of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituent Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling
RADIONUCLIDES (Continued)							
Grid # 50,91	$3.19 \times 10^{+2}$	$1.41 \times 10^{+9}$	$8.68 \times 10^{+2}$	ISL			
Grid # 50,92	$1.02 \times 10^{+2}$	$3.86 \times 10^{+8}$	$8.68 \times 10^{+2}$	ISL			
Uranium - Total (non-RAD)	$1.77 \times 10^{+3}$	$3.58 \times 10^{+10}$	$1.61 \times 10^{+3}$	mdl-ISL	0.0	1.09×10^{-2}	No
ORGANICS							
1,4 Dioxane	$1.29 \times 10^{+1}$	$2.61 \times 10^{+8}$	$4.70 \times 10^{+1}$	mdl-ISL	0.0	NA[c]	No
2-Methylnaphthalene	1.0×10^{-1}	$2.02 \times 10^{+6}$	$7.00 \times 10^{+1}$	mdl-ISL	0.0	NA	No
Aroclor-1254	4.80×10^{-2}	$1.01 \times 10^{+6}$	2.00×10^{-0}	mdl-ISL	0.0	1.10×10^{-3}	No
Aroclor-1260	7.70×10^{-2}	$1.62 \times 10^{+6}$	2.00×10^{-0}	mdl-ISL	0.0	1.10×10^{-3}	No
Benzo(a)anthracene	$7.50 \times 10^{+0}$	$1.52 \times 10^{+8}$	$1.00 \times 10^{+1}$	mdl-ISL	0.0	2.82×10^{-3}	No
Benzo(a)pyrene	$8.20 \times 10^{+0}$	$1.66 \times 10^{+8}$	$1.00 \times 10^{+1}$	mdl-ISL	0.0	2.82×10^{-4}	No
Benzo(b)fluoranthene	$1.50 \times 10^{+0}$	$3.03 \times 10^{+7}$	$1.00 \times 10^{+1}$	mdl-ISL	0.0	2.82×10^{-3}	No
Benzo(g,h,i)perylene	4.90×10^{-1}	$9.90 \times 10^{+6}$	$1.00 \times 10^{+1}$	mdl-ISL	0.0	NA	No
Carbazole	$4.20 \times 10^{+0}$	$8.48 \times 10^{+7}$	$1.00 \times 10^{+1}$	mdl-ISL	1.45×10^{-3}	4.25×10^{-1}	No
Dibenzo(ah)anthracene	2.50×10^{-1}	$5.05 \times 10^{+6}$	$1.00 \times 10^{+1}$	mdl-ISL	0.0	2.82×10^{-4}	No
Endosulfan Sulfate	6.20×10^{-3}	$1.25 \times 10^{+5}$	2.0×10^{-1}	mdl-ISL	0.0	NA	No
Heptachlorodibenzo-p-dioxin	9.00×10^{-4}	$1.82 \times 10^{+4}$	2.40×10^{-3}	SOL	0.0	1.19×10^{-6}	No
Heptachlorodibenzofuran	2.50×10^{-4}	$5.05 \times 10^{+3}$	8.51×10^{-2}	70-Year	0.0	1.19×10^{-6}	No
Indeno(1,2,3-cd)pyrene	$5.50 \times 10^{+0}$	$1.11 \times 10^{+8}$	$1.00 \times 10^{+1}$	mdl-ISL	0.0	2.82×10^{-3}	No
Octachlorodibenzo-p-dioxin	1.37×10^{-2}	$2.63 \times 10^{+5}$	4.00×10^{-4}	SOL	0.0	1.19×10^{-5}	No
Phenanthrene	$4.80 \times 10^{+0}$	$9.70 \times 10^{+7}$	$8.9 \times 10^{+1}$	mdl-ISL	0.0	NA	No

See footnotes at end of table

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TABLE 5-18
(Continued)

Constituent of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituent Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥ Screening Concentration and Requires SWIFT Modeling
INORGANICS							
Antimony	$2.20 \times 10^{+1}$	$4.44 \times 10^{+8}$	$3.00 \times 10^{+1}$	mdl-ISL	0.0	$1.46 \times 10^{+0}$	No
Arsenic	$1.38 \times 10^{+1}$	$2.79 \times 10^{+8}$	$1.81 \times 10^{+1}$	mdl-ISL	0.0	1.46×10^{-4}	No
Beryllium	$1.08 \times 10^{+0}$	$2.17 \times 10^{+7}$	2.00×10^{-0}	mdl-ISL	0.0	2.37×10^{-4}	No
Lead	$2.83 \times 10^{+1}$	$5.72 \times 10^{+8}$	$1.95 \times 10^{+1}$	mdl-ISL	0.0	NA	No

[a]Constraint on reported concentration is by In Situ Leachate (ISL), Toxicity Characteristic Leaching Procedure (TCLP), maximum detection limit (MDL), by US EPA 70-year rule (70-Year), or by the Solubility Limit (SOL).

[b]Zero indicates that predicted concentration is at least three orders of magnitude below the screening concentrations.

[c]NA = no data available to calculate EPA RAGs, Part B screening value.

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TABLE 5-19

COMPARISON OF GREAT MIAMI AQUIFER WATER AND BACKGROUND FOR CONSTITUENTS OF POTENTIAL CONCERN IN GROUNDWATER SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent Potential of Concern	Units	Detects in 2000-Series Well Water Samples					Background		2000-Series Comparable to Background?
		Samples	Hits	Minimum	Maximum	Mean[a]	Minimum	Maximum	
RADIONUCLIDES									
NP-237	pCi/L	16	1	0.32	0.32	0.41	NA	1.10[c]	Yes
PU-238	pCi/L	19	3	0.05	0.28	0.33	NA	1.00[c]	Yes
RA-226	pCi/L	17	10	0.22	1.6	0.67	1.10	8.50	Yes
RA-228	pCi/L	17	1	4.30	4.3	1.43	3.10	5.50	Yes
SR-90	pCi/L	19	6	0.75	2.38	2.01	NA	5.00[c]	Yes
TH-228	pCi/L	19	1	0.03	0.03	0.34	1.20	2.90	Yes
TH-230	pCi/L	19	3	0.31	0.71	0.44	1.20	3.44	Yes
U-234	pCi/L	18	11	0.17	4.74	1.23	1.20	4.20	Yes
U-235/236	pCi/L	19	3	0.05	0.28	0.34	NA	1.30[c]	Yes
U-238	pCi/L	18	11	0.16	3.69	1.12	0.90	4.40	Yes
INORGANICS									
Arsenic	µg/L	7	2	2.5	2.5	1.1	2.0	550.0	Yes
Lead	µg/L	7	3	2.8	4.5	2.0	2.6	140.0	Yes

[a]Mean calculated by using half of the detection limit for non-detects.

[b]Not detected in background samples. Value reported is minimum detection limit.

[c]Not detected in background samples. Value reported is maximum detection limit.

NA - Not Available.

concentrations are comparable with the background concentration, which is consistent with the model prediction that the impact of the Solid Waste Landfill on the Great Miami is negligible.

As only technetium-99 reached the Great Miami Aquifer above the 10^{-7} risk level or 0.1 HI level, it was selected for modeling in the Great Miami Aquifer. Table 5-20 lists the constituents that survived the various screening processes and was simulated using the SWIFT III model.

In addition to predicting constituent loading to the Great Miami Aquifer, future perched water concentration increases were also predicted using the ODAST. Only one layer was considered. This layer consisted of till above the perched water zone (sand/gravel in the till). The thickness of this layer for various blocks are shown in Table 5-13. CPC waste inventory, CPC concentration in the waste, leachate concentration (all shown in Table 5-18), and physical and chemical parameters were the same as those for the vadose zone modeling to the Great Miami Aquifer.

Table 5-21 shows the predicted perched water concentrations beneath the Solid Waste Landfill and the screening summary. Only technetium-99 and carbazole are predicted to reach the perched water zone above the EPA RAGs, Part B screening concentrations. An increase in CPC concentration above background values in perched water due to source term loading from Solid Waste Landfill were small. Table 5-22 compares the background concentrations and the field measured concentrations in the perched water. Thorium-232, uranium-234, uranium-238, and uranium-total were observed above background levels. All other CPCs were detected at concentrations comparable to background concentrations. All the high hits for CPCs occur in Well 1952, located southeast of the Solid Waste Landfill and south of railroad, which may be impacted by sources other than the Solid Waste Landfill. Detected total uranium concentration in the upgradient well for perched water (Well 1035) ranged from 2 to 17 μg/L with an average value of 6 μg/L. Total uranium in Well 1950 was detected at 11 μg/L, comparable to the upgradient well. Similarly, detected total uranium concentration at Well 1038 ranged from 4 to 5 μg/L, again comparable to the upgradient well. Only one downgradient well, Well 1952, detected total uranium at concentration of 55.8 μg/L, which is higher than upgradient well (see Figure 4-5, page 4-73). Although uranium is leachable (leachate concentration of 1610 μg/L was used in modeling as shown in Table 5-21), it is believed that the Solid Waste Landfill is not responsible for the high hits for CPCs occurring in Well 1952, located southeast of the Solid Waste Landfill and south of railroad.

TABLE 5-20

SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN AND SOURCE PATHWAYS FOR THE SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Source Pathways[a]		
	Solid Waste Landfill Wastes	Perched Groundwater	Paddy's Run Loading from Surface Water Runoff
RADIONUCLIDES			
Technetium-99	Yes	NA[b]	NA

[a]Yes - Indicates concentrations were above screening concentrations from this source pathway
[b]NA - Not Applicable, not present in the perched groundwater or surface water

TABLE 5-21

PREDICTED PERCHED WATER CONCENTRATIONS AND SCREENING SUMMARY FOR CONSTITUENTS OF POTENTIAL CONCERN, SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent	Units	Maximum Leachate Concentration	Predicted Maximum Perched Water Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
RADIONUCLIDES					
Cesium-137	pCi/L	$2.00 \times 10^{+1}$	0.00[a]	1.70×10^{-1}	No
Lead-210	pCi/L	$2.79 \times 10^{+2}$	0.00	7.20×10^{-3}	No
Neptunium-237	pCi/L	$1.00 \times 10^{+0}$	1.11×10^{-5}	2.16×10^{-2}	No
Plutonium-238	pCi/L	$1.00 \times 10^{+0}$	0.00	2.16×10^{-2}	No
Plutonium-239/240	pCi/L	$1.00 \times 10^{+0}$	0.00	2.07×10^{-2}	No
Radium-224	pCi/L	$7.28 \times 10^{+2}$	0.00	1.25×10^{-1}	No
Radium-226	pCi/L	$1.00 \times 10^{+0}$	0.00	1.76×10^{-4}	No
Radium-228	pCi/L	$3.00 \times 10^{+0}$	0.00	4.75×10^{-2}	No
Strontium-90	pCi/L	$5.00 \times 10^{+0}$	1.43×10^{-3}	1.32×10^{-1}	No
Technetium-99	pCi/L	$3.00 \times 10^{+1}$	$2.89 \times 10^{+1}$	$3.65 \times 10^{+0}$	Yes
Thorium-228	pCi/L	$1.00 \times 10^{+0}$	0.00	8.64×10^{-2}	No
Thorium-230	pCi/L	$1.00 \times 10^{+0}$	0.00	3.65×10^{-1}	No
Thorium-232	pCi/L	$1.00 \times 10^{+0}$	0.00	2.79×10^{-2}	No
Uranium-234	pCi/L	$9.42 \times 10^{+2}$	0.00	2.97×10^{-1}	No
Uranium-235/236	pCi/L	$1.05 \times 10^{+2}$	0.00	2.97×10^{-1}	No
Uranium-238	pCi/L	$8.68 \times 10^{+2}$	0.00	1.70×10^{-1}	No
Uranium-Total (non-RAD)	μg/L	$1.61 \times 10^{+3}$	0.00	$1.09 \times 10^{+1}$	No

See footnotes at end of table.

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TABLE 5-21
(Continued)

Constituent	Units	Maximum Leachate Concentration	Predicted Maximum Perched Water Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
ORGANICS					
1,4-Dioxane	μg/L	$4.70 \times 10^{+1}$	0.00	NA[b]	No
2-Methylnaphthalene	μg/L	$7.00 \times 10^{+1}$	$7.00 \times 10^{+4}$ [c]	NA	NA
Aroclor-1254	μg/L	$2.00 \times 10^{+0}$	0.00	1.10×10^{-3}	No
Aroclor-1260	μg/L	$2.00 \times 10^{+0}$	0.00	1.10×10^{-3}	No
Benzo(a)anthracene	μg/L	$1.00 \times 10^{+1}$	0.00	2.82×10^{-3}	No
Benzo(a)pyrene	μg/L	$1.00 \times 10^{+1}$	0.00	2.82×10^{-4}	No
Benzo(b)fluoranthene	μg/L	$1.00 \times 10^{+1}$	0.00	2.82×10^{-3}	No
Benzo(g,h,i)perylene	μg/L	$1.00 \times 10^{+1}$	0.0	NA	No
Carbazole	μg/L	$1.00 \times 10^{+1}$	$9.61 \times 10^{+0}$	4.25×10^{-1}	Yes
Dibenzo(a,h)anthracene	μg/L	$1.00 \times 10^{+1}$	0.00	2.82×10^{-4}	No
Endosulfan Sulfate	μg/L	2.0×10^{-1}	2.00×10^{-1} [c]	NA	No
Heptachlorodibenzo-p-dioxin	μg/L	2.40×10^{-3}	0.00	1.19×10^{-6}	No
Heptachlorodibenzofuran	μg/L	8.51×10^{-2}	0.00	1.19×10^{-6}	No
Ideno(1,2,3-cd)pyrene	μg/L	$1.00 \times 10^{+1}$	0.00	2.82×10^{-3}	No
Octachlorodibenzo-p-dioxin	μg/L	4.00×10^{-4}	0.00	1.19×10^{-5}	No
Phenanthrene	μg/L	$8.9 \times 10^{+1}$	0.0	NA	No
INORGANICS					
Antimony	μg/L	$3.00 \times 10^{+1}$	0.00	$1.46 \times 10^{+0}$	No
Arsenic	μg/L	$1.81 \times 10^{+1}$	0.00	1.46×10^{-4}	No

See footnotes at end of table.

TABLE 5-21
(Continued)

Constituent	Units	Maximum Leachate Concentration	Predicted Maximum Perched Water Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
INORGANICS (Continued)					
Beryllium	μg/L	$2.00 \times 10^{+0}$	0.00	2.37×10^{-4}	No
Lead	μg/L	$1.95 \times 10^{+1}$	0.00	NA	No

[a]Zero indicates that predicted concentration is at least three orders of magnitude below the screening concentration.

[b]NA = No data available to calculate EPA RAGs, Part B screening value.

[c]Assumed to be the same as the initial leachate due to lack of data on biodegradation. These will require modeling if toxicity data becomes available at a later time.

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TABLE 5-22

COMPARISON OF PERCHED WATER AND BACKGROUND FOR CONSTITUENTS OF POTENTIAL CONCERN IN PERCHED WATER FOR THE SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	Detects in Perched Water (1000-Series Wells)					Background		Perched Water Comparable to Background?
		Samples	Hits	Minimum	Maximum	Mean[a]	Minimum	Maximum	
RADIONUCLIDES									
NP-237	pCi/L	11	2	0.3	1.94	0.54	0.50[b]	0.60[c]	Yes
PU-238	pCi/L	13	3	0.14	0.67	0.32	0.50[b]	0.50[c]	Yes
RA-226	pCi/L	13	3	0.19	5.11	0.73	1.00	1.00	Yes
RA-228	pCi/L	13	1	3.72	3.72	1.37	4.50	5.20	Yes
SR-90	pCi/L	12	2	0.90	1.35	1.41	2.50[b]	2.50[c]	Yes
TH-228	pCi/L	13	2	0.57	14	1.41	1.04	1.60	Yes
TH-230	pCi/L	13	4	0.26	13.8	1.45	2.00	2.00	Yes
TH-232	pCi/L	13	2	0.65	11.5	1.21	0.50[b]	0.60[c]	No
U-234	pCi/L	13	11	1.1	12	3.03	1.06	1.90	No
U-235/236	pCi/L	13	3	0.21	0.43	0.34	0.50[b]	0.50[c]	Yes
U-238	pCi/L	13	12	0.67	15.2	3.08	1.07	1.50	No
U-TOTAL	µg/L	13	13	2	55.8	8.37	0.8	5.3	No
INORGANICS									
Arsenic	µg/L	6	4	1.1	4.4	1.885	15.0	122.0	Yes
Beryllium	µg/L	6	1	2.2	2.2	0.84	1.0	1.8	Yes
Lead	µg/L	6	2	1	31.4	6.08	2.0	50.0	Yes

[a]Mean calculated by using half of the detection limit for non-detects.

[b]Not detected in background samples. Value reported is minimum detection limit.

[c]Not detected in background samples. Value reported is maximum detection limit.

5.4.3.2 Lime Sludge Ponds

Figure 5-10 shows the aerial extent of the waste in the Lime Sludge Ponds and the SWIFT III grid cells impacted by the direct loading from the Lime Sludge Ponds. Waste overlying the SWIFT III grid block (44,82) was included with the waste overlying the SWIFT III grid block (43,81). Similarly, constituent loadings from SWIFT III grid blocks (45,79) and (45,80) were combined and loaded from the grid block (45,80). Only vadose zone and perched water infiltration pathways were applicable to vadose zone modeling for the Lime Sludge Ponds. Table 5-23 lists the CPCs considered for the fate and transport modeling, CPC concentration in the waste, CPC inventory in the waste, predicted maximum leachate concentration, predicted maximum concentration from vadose zone Layer 2 from all pathways, and screening concentrations for the Lime Sludge Ponds. A summary of screening for constituent of concern for the Lime Sludge Ponds is also included in Table A.2-23. Only technetium-99 was found to reach the Great Miami Aquifer from the Lime Sludge Ponds above the EPA RAGs, Part B screening concentrations. Table 5-24 lists the constituents that survived the various screening processes and were simulated using the SWIFT III model.

The predicted increases in CPC concentrations above the background values in the Great Miami Aquifer due to the source term leading from the Lime Sludge Ponds were small. Table 5-25 compares the background concentration and the field measured concentrations in the Great Miami Aquifer. All constituents were detected at concentrations comparable to or below the background concentrations in the Great Miami Aquifer. Therefore, the model results were considered consistent with the observed data as model only predicts increase in concentration over the background value.

In addition to predicting constituent loading to the Great Miami Aquifer, future perched water concentration increases were also predicted using the ODAST. Only one layer consisting of till above the perched water zone was considered. Thickness of this layer for various blocks are shown in Table 5-14. CPC waste inventory, CPC concentration in the waste, leachate concentration (all shown in Table 5-23), and physical and chemical parameters are the same as those for the vadose zone modeling to the Great Miami Aquifer.

Table 5-26 shows the predicted perched water concentrations beneath the Lime Sludge Ponds and the screening summary. Neptunium-237, strontium-90, technetium-99, arsenic, and manganese are predicted to reach perched water above the EPA RAGs, Part B screening concentrations.

TABLE 5-23

SOURCE CHARACTERIZATION AND SCREENING SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN
LIME SLUDGE PONDS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituent Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
RADIONUCLIDES							
Cesium-137	1.95×10^{-9}	2.05×10^{-2}	$1.42 \times 10^{+1}$	70-Year	0.0[b]	1.70×10^{-1}	No
Neptunium-237	4.58×10^{-4}	$4.65 \times 10^{+3}$	$2.62 \times 10^{+1}$	70-Year	1.10×10^{-3}	2.16×10^{-2}	No
Plutonium-238	1.46×10^{-8}	1.23×10^{-1}	$1.67 \times 10^{+1}$	70-Year	0.0	2.16×10^{-2}	No
Plutonium-239/240	1.71×10^{-6}	$1.80 \times 10^{+1}$	$8.91 \times 10^{+0}$	70-Year	0.0	2.07×10^{-2}	No
Radium-226	1.58×10^{-6}	$1.66 \times 10^{+1}$	$1.31 \times 10^{+2}$	70-Year	0.0	1.76×10^{-4}	No
Radium-228	6.62×10^{-9}	6.97×10^{-2}	$1.51 \times 10^{+2}$	70-Year	0.0	4.75×10^{-2}	No
Strontium-90	6.14×10^{-9}	6.47×10^{-2}	$7.07 \times 10^{+1}$	70-Year	0.0	1.32×10^{-1}	No
Technetium-99	6.18×10^{-5}	$6.50 \times 10^{+2}$	$8.82 \times 10^{+1}$	70-Year	$7.64 \times 10^{+1}$	$3.65 \times 10^{+0}$	Yes
Thorium-228	1.88×10^{-9}	1.98×10^{-2}	$1.29 \times 10^{+2}$	70-Year	0.0	8.64×10^{-2}	No
Thorium-230	4.07×10^{-4}	$4.28 \times 10^{+3}$	$7.05 \times 10^{+2}$	70-Year	0.0	3.65×10^{-1}	No
Thorium-232	$9.73 \times 10^{+0}$	$1.02 \times 10^{+8}$	$9.00 \times 10^{+1}$	70-Year	0.0	2.79×10^{-2}	No
Uranium-234	9.94×10^{-4}	$1.05 \times 10^{+4}$	$5.20 \times 10^{+2}$	70-Year	0.0	2.97×10^{-1}	No
Uranium-235/236	2.01×10^{-1}	$2.12 \times 10^{+6}$	$3.66 \times 10^{+1}$	70-Year	0.0	2.97×10^{-1}	No
Uranium-238		$8.30 \times 10^{+7}$		70-Year	0.0	1.70×10^{-1}	No
Grid #44,79	$2.16 \times 10^{+1}$	$6.25 \times 10^{+6}$	$1.85 \times 10^{+2}$	70-Year			
Grid #45,80	$7.63 \times 10^{+0}$	$4.81 \times 10^{+6}$	$2.32 \times 10^{+2}$	70-Year			
Grid #43,81	$2.07 \times 10^{+1}$	$8.57 \times 10^{+6}$	$2.35 \times 10^{+2}$	70-Year			
Grid #44,81	$2.33 \times 10^{+0}$	$4.72 \times 10^{+6}$	$4.28 \times 10^{+2}$	70-Year			
Grid #43,80	$1.59 \times 10^{+1}$	$2.22 \times 10^{+7}$	$4.48 \times 10^{+2}$	70-Year			
Grid #45,81	$5.39 \times 10^{+0}$	$9.53 \times 10^{+6}$	$5.25 \times 10^{+2}$	70-Year			
Grid #44,80	$8.45 \times 10^{+0}$	$6.27 \times 10^{+7}$	$2.40 \times 10^{+2}$	70-Year			

See footnotes at end of table

TABLE 5-23
(Continued)

Constituent of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituent Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
RADIONUCLIDES (Continued)							
Uranium - Total (non-RAD)	$2.22 \times 10^{+1}$	$2.34 \times 10^{+8}$	$1.87 \times 10^{+3}$	70-Year	0.0	$1.09 \times 10^{+1}$	No
ORGANICS							
1,1,2-Trichlorotrifluoroethane	2.00×10^{-2}	$2.11 \times 10^{+5}$	1.68×10^{0}	70-Year	0.0	NA[c]	No
1,2-Diethylbenzene	4.10×10^{-2}	$4.34 \times 10^{+5}$	$3.45 \times 10^{+0}$	70-Year	0.0	NA	No
Acrylonitrile	2.00×10^{-1}	$2.11 \times 10^{+6}$	$1.68 \times 10^{+1}$	70-Year	0.0	5.93×10^{-3}	No
Aroclor-1254	4.30×10^{-2}	$4.53 \times 10^{+5}$	3.62×10^{0}	70-Year	0.0	1.10×10^{-3}	No
Benzo(g,h,i)perylene	1.70×10^{-1}	$1.80 \times 10^{+6}$	$1.43 \times 10^{+1}$	70-Year	0.0	NA	No
bis(2-Ethylhexyl) phthalate	$1.70 \times 10^{+0}$	$1.79 \times 10^{+7}$	$1.43 \times 10^{+2}$	70-Year	0.0	6.07×10^{-1}	No
Dibenzo(a,h)anthracene	1.10×10^{-1}	$1.16 \times 10^{+6}$	9.25×10^{0}	70-Year	0.0	2.82×10^{-4}	No
Indeno(1,2,3-cd)pyrene	2.10×10^{-1}	$2.21 \times 10^{+6}$	$1.77 \times 10^{+1}$	70-Year	0.0	2.82×10^{-3}	No
Phenanthrene	8.20×10^{-2}	$8.67 \times 10^{+5}$	$6.90 \times 10^{+0}$	70-Year	0.0	NA	No
INORGANICS							
Arsenic	$6.78 \times 10^{+0}$	$7.15 \times 10^{+7}$	$4.99 \times 10^{+2}$	TCLP	0.0	1.46×10^{-4}	No
Beryllium	$1.27 \times 10^{+0}$	$1.33 \times 10^{+7}$	$1.07 \times 10^{+2}$	70-Year	0.0	2.37×10^{-4}	No
Lead	$2.40 \times 10^{+2}$	$2.54 \times 10^{+9}$	$2.02 \times 10^{+4}$	70-Year	0.0	NA	No

[a]Constraint on reported concentration is by In Situ Leachate (ISL), Toxicity Characteristic Leaching Procedure (TCLP), maximum detection limit (MDL), or by US EPA 70-year rule (70-Year).

[b]Zero indicates that predicted concentration is at least three orders of magnitude below the screening concentrations.

[c]NA - No data available to calculate EPA RAGs, Part B screening value.

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TABLE 5-24

SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN AND SOURCE PATHWAYS FOR THE LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	Source Pathways[a]	
	Lime Sludge Pond Wastes	Perched Groundwater
RADIONUCLIDES		
Technetium-99	Yes	NA[b]

[a]Yes - Indicates concentrations were above screening concentrations from this source pathway
[b]NA - Not applicable, not present in the perched groundwater

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TABLE 5-25

COMPARISON OF GREAT MIAMI AQUIFER WATER AND BACKGROUND FOR CONSTITUENTS OF POTENTIAL CONCERN IN GROUNDWATER FOR THE LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	Detects in 2000-Series Well Water Samples					Background		2000-Series Comparable to Background?
		Samples	Hits	Minimum	Maximum	Mean[a]	Minimum	Maximum	
RADIONUCLIDES									
Neptunium-237	pCi/L	8	3	0.20	0.41	0.37	NA	1.10[b]	Yes
Plutonium-238	pCi/L	8	3	0.05	0.12	0.23	NA	1.00[b]	Yes
Radium-226	pCi/L	9	4	0.16	0.79	0.41	1.10	8.50	Yes
Radium-228	pCi/L	9	1	1.54	1.74	1.36	3.10	5.50	Yes
Thorium-228	pCi/L	9	2	0.10	1.60	0.40	1.20	2.90	Yes
Thorium-230	pCi/L	9	4	0.13	1.00	0.40	1.20	3.44	Yes
Uranium-234	pCi/L	8	6	1.10	1.50	1.08	1.20	4.20	Yes
Uranium-235/236	pCi/L	9	4	0.08	0.13	0.27	NA	1.30[b]	Yes
Uranium-238	pCi/L	9	6	0.58	1.62	1.01	0.90	4.40	Yes
INORGANICS									
Arsenic	µg/L	6	2	1.1	1.2	0.7	2.0	550.0	Yes
Chromium	µg/L	6	1	10.3	10.3	3.6	10.0	45.0	Yes
Manganese	µg/L	6	6	94.7	1685.0	596.8	2.0	897.0	Yes

[a]Means calculated by using half of the detection limit for non-detects.

[b]Not detected in background samples. Value reported is maximum detection limit.

NA = Not Available

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TABLE 5-26

PREDICTED PERCHED WATER CONCENTRATIONS AND SCREENING SUMMARY FOR CONSTITUENTS OF POTENTIAL CONCERN, LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent	Units	Maximum Leachate Concentration	Predicted Maximum Perched Water Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
RADIONUCLIDES					
Cesium-137	pCi/L	$1.42 \times 10^{+1}$	0.0[a]	1.70×10^{-1}	No
Neptunium-237	pCi/L	$2.62 \times 10^{+1}$	$5.06 \times 10^{+0}$	2.16×10^{-2}	Yes
Plutonium-238	pCi/L	$1.67 \times 10^{+1}$	0.0	2.16×10^{-2}	No
Plutonium-239/240	pCi/L	$8.91 \times 10^{+0}$	0.0	2.07×10^{-2}	No
Radium-226	pCi/L	$1.31 \times 10^{+2}$	0.0	1.76×10^{-4}	No
Radium-228	pCi/L	$1.51 \times 10^{+2}$	0.0	4.75×10^{-2}	No
Strontium-90	pCi/L	$7.07 \times 10^{+1}$	$1.91 \times 10^{+0}$	1.32×10^{-1}	Yes
Technetium-99	pCi/L	$8.82 \times 10^{+1}$	$8.23 \times 10^{+1}$	$3.65 \times 10^{+0}$	Yes
Thorium-228	pCi/L	$1.29 \times 10^{+2}$	0.0	8.64×10^{-2}	No
Thorium-230	pCi/L	$7.05 \times 10^{+2}$	0.0	3.65×10^{-1}	No
Thorium-232	pCi/L	$9.00 \times 10^{+1}$	0.0	2.79×10^{-2}	No
Uranium-234	pCi/L	$5.20 \times 10^{+2}$	2.01×10^{-2}	2.97×10^{-1}	No
Uranium-235/236	pCi/L	$3.66 \times 10^{+1}$	1.42×10^{-3}	2.97×10^{-1}	No
Uranium-238	pCi/L	$6.27 \times 10^{+2}$	1.64×10^{-2}	1.70×10^{-1}	No
Uranium-Total (non-RAD)	μg/L	$1.87 \times 10^{+3}$	7.24×10^{-2}	$1.09 \times 10^{+1}$	No

See footnote at end of table

TABLE 5-26
(Continued)

Constituent	Units	Maximum Leachate Concentration	Predicted Maximum Perched Water Concentration	Screening Concentration	Predicted Concentration Above Screening Concentration
ORGANICS					
1,1,2-Trichlorotrifluoroethane	μg/L	$1.68 \times 10^{+0}$	1.66×10^{-1}	NA[b]	NA
1,1-Diethylbenzene	μg/L	$3.45 \times 10^{+0}$	1.00×10^{-4}	NA	NA
Acrylonitrile	μg/L	$1.68 \times 10^{+1}$	4.12×10^{-5}	2.82×10^{-3}	No
Aroclor-1254	μg/L	$3.62 \times 10^{+0}$	0.0	1.00×10^{-3}	No
Benzo(g,h,i) Perylene	μg/L	$1.43 \times 10^{+1}$	0.0	NA	No
bis(2-Ethylhexyl)phthalate	μg/L	$1.43 \times 10^{+2}$	0.0	6.07×10^{-1}	No
Dibenzo(a,h)anthracene	μg/L	$9.25 \times 10^{+0}$	0.0	2.82×10^{-4}	No
Ideno(1,2,3-cd)pyrene	μg/L	$1.77 \times 10^{+1}$	0.0	2.82×10^{-3}	No
Phenanthrene	μg/L	$6.90 \times 10^{+0}$	0.0	NA	No
INORGANICS					
Arsenic	μg/L	$4.99 \times 10^{+2}$	1.45×10^{-2}	1.46×10^{-4}	Yes
Beryllium	μg/L	$1.07 \times 10^{+2}$	0.0	2.37×10^{-4}	No
Lead	μg/L	$2.02 \times 10^{+4}$	0.0	NA	No

[a]Zero indicates that predicted concentration is at least three order of magnitued below the screening concentrations.

[b]NA = No data available to calculate EPA RAGs, Part B screening value.

The predicted increases in CPC concentrations above background in the perched water due to the source term loading from the Lime Sludge Ponds were small. Table 5-27 compares the background concentrations and the field measured concentrations in the perched water beneath or in the vicinity of the Lime Sludge Ponds. Thorium-232, uranium-234, uranium-238, total uranium, beryllium, manganese, and bis(2-Ethylhexyl) phthalate were detected above the background concentrations. Perched water under the Lime Sludge Ponds may be affected by other FEMP sources.

5.4.3.3 Inactive Flyash Pile/South Field

Figure 5-11 shows the areal extent of the waste in the Inactive Flyash Pile/South Field and the SWIFT III grid cells impacted by direct loading from these subunits. Many SWIFT III grid blocks received lateral drainage. These grid blocks are identified in Figure 5-11. All five pathways discussed in Section 5.4.1 were applicable for these two subunits. For the vadose zone pathway, Table 5-28 shows the CPC concentration in the waste and constituent inventory in the waste. Table 5-28 shows predicted maximum leachate concentration from the vadose zone, perched water infiltration, perched water subsurface seeps, and seep pathways. Table 5-29 shows the flow rates for the seeps and perched water subsurface seeps. While seep flow rates are based on field observations, subsurface seep flow rates were estimated from the perched water hydraulic gradients and hydraulic conductivity of the perched water zone. Concentration and mass loading due to the surface water pathway are discussed in Section 5.3; perched water and seep pathways are discussed in Appendix A-2.

CPCs from these two units were screened together because of the close proximity of the subunits. A summary of screening for CPCs is also included in Table 5-28 for the vadose zone, perched water infiltration, perched water subsurface seeps, and seep pathways. CPCs passing the screening in Table 5-28 were further screened using predicted dilution in the Great Miami Aquifer. Table 5-30 shows the results of the Great Miami Aquifer dilution screening. Table 5-31 lists the constituents that survived the various screening processes and were simulated using the SWIFT III model for the Inactive Flyash Pile and South Field.

Table 5-32 compares the background concentrations and the field measured concentrations in the Great Miami Aquifer. Uranium and bis(2-Ethylhexyl) phthalate are above background levels. Uranium was simulated using the SWIFT III model. Results of uranium calibration are presented in Section 5.4.4.3. Vadose zone modeling predicted no increase in bis(2-Ethylhexyl) phthalate

TABLE 5-27

COMPARISON OF PERCHED WATER AND BACKGROUND FOR POTENTIAL CONSTITUENTS OF CONCERN IN PERCHED WATER FOR THE LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	Detects in Perched Water (1000-Series Well)					Background		Perched Water Comparable to Background?
		Samples	Hits	Minimum	Maximum	Mean[a]	Minimum	Maximum	
RADIONUCLIDES									
Neptunium-237	pCi/L	9	3	0.15	0.08	0.4	0.50[a]	0.60[b]	Yes
Radium-226	pCi/L	12	6	0.21	1.4	0.6	1.00	1.00	Yes
Radium-228	pCi/L	12	2	3.68	3.8	3.7	4.50	5.20	Yes
Strontium-90	pCi/L	12	1	3.45	3.5	3.5	2.50[a]	2.50[b]	Yes
Thorium-228	pCi/L	14	6	0.78	2.9	1.6	1.04	1.60	Yes
Thorium-230	pCi/L	14	8	0.25	6.7	2.3	2.00	2.00	Yes
Thorium-232	pCi/L	12	4	0.74	2.6	1.5	0.50[a]	0.60[b]	No
Uranium-234	pCi/L	16	15	0.39	11.0	3.1	1.06	1.90	No
Uranium-235/236	pCi/L	11	8	0.08	0.7	0.2	0.50[a]	0.50[b]	Yes
Uranium-238	pCi/L	18	17	0.30	11.8	3.5	1.07	1.50	No
Total Uranium	μg/L	22	20	1	58	12.8	0.8	5.3	No
INORGANICS									
Arsenic	μg/L	10	5	2.2	14	5.9	15.0	122.0	Yes
Beryllium	μg/L	8	2	1.9	6.8	4.4	1.0	1.8	No
Lead	μg/L	12	7	2	51.4	14.8	2.0	50.0	Yes
ORGANICS									
bis(2-Ethylhexyl)phthlate	μg/L	3	2	1	2	1.5	0.0	0.0	No

[a]Not detected in background samples. Value reported is minimum detection limit.

[b]Not detected in background samples. Value reported is maximum detection limit.

TABLE 5-28

SOURCE CHARACTERIZATION AND SCREENING SUMMARY FOR CONSTITUENTS OF POTENTIAL CONCERN FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD

Constituents of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituents Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
RADIONUCLIDES							
Cesium-137	2.74×10^{-9}	6.06×10^{-1}	$2.49 \times 10^{+2}$	70-Year	0.0[b]	1.70×10^{-1}	No
Lead-210	7.87×10^{-8}	$1.74 \times 10^{+1}$	$6.31 \times 10^{+3}$	70-Year	0.0	7.20×10^{-3}	No
Neptunium-237	4.26×10^{-4}	$9.39 \times 10^{+4}$	$3.15 \times 10^{+2}$	70-Year	$1.06 \times 10^{+2}$	2.16×10^{-2}	Yes
Plutonium-238	2.34×10^{-9}	5.17×10^{-1}	$4.21 \times 10^{+1}$	70-Year	8.53×10^{-3}	2.16×10^{-2}	No
Plutonium-239/240	3.37×10^{-7}	$7.45 \times 10^{+1}$	$2.19 \times 10^{+1}$	70-Year	0.0	2.07×10^{-2}	No
Radium-224	1.97×10^{-11}	4.35×10^{-3}	$3.29 \times 10^{+3}$	70-Year	0.0	1.25×10^{-1}	No
Radium-226	2.95×10^{-6}	$6.52 \times 10^{+2}$	$3.06 \times 10^{+3}$	70-Year	1.58×10^{-1}	1.76×10^{-4}	Yes
Radium-228	6.09×10^{-9}	$1.35 \times 10^{+0}$	$1.74 \times 10^{+3}$	70-Year	0.0	4.75×10^{-2}	No
Ruthenium-106	3.87×10^{-10}	8.55×10^{-2}	$1.36 \times 10^{+3}$	70-Year	0.0	5.00×10^{-1}	No
Strontium-90	9.93×10^{-9}	$2.19 \times 10^{+0}$	$1.43 \times 10^{+3}$	70-Year	$1.53 \times 10^{+1}$	1.32×10^{-2}	Yes
Technetium-99	5.29×10^{-5}	$1.17 \times 10^{+4}$	$9.45 \times 10^{+2}$	70-Year	$7.72 \times 10^{+2}$	3.65×10^{0}	Yes
Thorium-228	2.08×10^{-9}	4.59×10^{-1}	$1.78 \times 10^{+3}$	70-Year	0.0	8.64×10^{-2}	No
Thorium-230	2.07×10^{-4}	$4.57 \times 10^{+4}$	$4.48 \times 10^{+3}$	70-Year	0.0	3.65×10^{-1}	No
Thorium-232	$1.39 \times 10^{+1}$	$3.07 \times 10^{+9}$	$1.61 \times 10^{+3}$	70-Year	0.0	2.79×10^{-2}	No
Uranium-234	4.85×10^{-3}	$1.07 \times 10^{+6}$	$3.17 \times 10^{+4}$	70-Year	$1.10 \times 10^{+4}$	2.97×10^{-1}	Yes
Uranium-235/236	$2.67 \times 10^{+0}$	$5.89 \times 10^{+8}$	$6.06 \times 10^{+3}$	70-Year	$2.11 \times 10^{+3}$	2.97×10^{-1}	Yes
Uranium-238		$1.82 \times 10^{+10}$			$5.44 \times 10^{+5}$	1.70×10^{-1}	Yes
Grid#28,59	$1.88 \times 10^{+1}$	$1.41 \times 10^{+8}$	$4.24 \times 10^{+3}$	70-Year			
Grid#28,63	$1.62 \times 10^{+2}$	$4.13 \times 10^{+8}$	$1.72 \times 10^{+4}$	70-Year			

See footnotes at end of table

TABLE 5-28
(Continued)

Constituents of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituents Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
			RADIONUCLIDES				
Uranium-238 (Continued)							
Grid#28,65	$1.28 \times 10^{+2}$	$4.17 \times 10^{+8}$	$1.36 \times 10^{+4}$	70-Year			
Grid#29,62	$3.04 \times 10^{+1}$	$1.12 \times 10^{+8}$	$3.69 \times 10^{+3}$	70-Year			
Grid#29,64	$7.66 \times 10^{+1}$	$5.33 \times 10^{+8}$	$9.89 \times 10^{+3}$	70-Year			
Grid#30,62	$2.18 \times 10^{+1}$	$1.55 \times 10^{+8}$	$2.88 \times 10^{+3}$	70-Year			
Grid#28,64	$3.04 \times 10^{+1}$	$2.17 \times 10^{+8}$	$4.62 \times 10^{+3}$	70-Year			
Grid#29,63	$4.16 \times 10^{+1}$	$3.88 \times 10^{+8}$	$7.21 \times 10^{+3}$	70-Year			
Grid#29,60	$7.85 \times 10^{+0}$	$6.45 \times 10^{+5}$	$6.37 \times 10^{+2}$	70-Year			
Grid#30,57	$1.59 \times 10^{+1}$	$7.69 \times 10^{+5}$	$1.51 \times 10^{+2}$	70-Year			
Grid#30,61	$1.81 \times 10^{+1}$	$1.85 \times 10^{+7}$	$2.06 \times 10^{+3}$	70-Year			
Grid#28,66	$5.34 \times 10^{+2}$	$1.99 \times 10^{+8}$	$3.70 \times 10^{+4}$	70-Year			
Grid#30,60	$1.18 \times 10^{+1}$	$4.99 \times 10^{+7}$	$2.98 \times 10^{+3}$	70-Year			
Grid#31,58	$1.38 \times 10^{+1}$	$3.80 \times 10^{+7}$	$3.03 \times 10^{+3}$	70-Year			
Grid#31,59	$1.38 \times 10^{+1}$	$8.73 \times 10^{+7}$	$4.66 \times 10^{+3}$	70-Year			
Grid#29,58	$1.42 \times 10^{+1}$	$9.45 \times 10^{+7}$	$2.72 \times 10^{+3}$	70-Year			
Grid#29,59	$9.89 \times 10^{+0}$	$1.42 \times 10^{+8}$	$3.49 \times 10^{+3}$	70-Year			
Grid#29,65	$7.30 \times 10^{+2}$	$7.09 \times 10^{+9}$	$1.59 \times 10^{+5}$	70-Year			
Grid#30,58	$1.77 \times 10^{+1}$	$1.40 \times 10^{+8}$	$2.20 \times 10^{+3}$	70-Year			
Grid#30,59	$1.69 \times 10^{+1}$	$1.88 \times 10^{+8}$	$2.96 \times 10^{+3}$	70-Year			
Grid#30,63	$1.45 \times 10^{+1}$	$2.06 \times 10^{+8}$	$3.25 \times 10^{+3}$	70-Year			

See footnotes at end of table

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TABLE 5-28
(Continued)

Constituents of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituents Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
RADIONUCLIDES							
Uranium-238 (Continued)							
Grid#30,64	$4.30 \times 10^{+1}$	$5.08 \times 10^{+8}$	$8.00 \times 10^{+3}$	70-Year			
Grid#29,67	$2.10 \times 10^{+1}$	$6.92 \times 10^{+6}$	$1.27 \times 10^{+3}$	70-Year			
Grid#30,67	$1.46 \times 10^{+1}$	$1.97 \times 10^{+7}$	$2.08 \times 10^{+3}$	70-Year			
Grid#29,66	$3.29 \times 10^{+2}$	$1.83 \times 10^{+9}$	$3.48 \times 10^{+4}$	70-Year			
Grid#30,65	$4.77 \times 10^{+2}$	$2.71 \times 10^{+9}$	$6.37 \times 10^{+4}$	70-Year			
Grid#30,66	$8.25 \times 10^{+1}$	$3.11 \times 10^{+8}$	$6.16 \times 10^{+3}$	70-Year			
Grid#31,61	$2.12 \times 10^{+1}$	$1.53 \times 10^{+8}$	$2.98 \times 10^{+3}$	70-Year			
Grid#31,62	$2.07 \times 10^{+1}$	$1.34 \times 10^{+8}$	$2.62 \times 10^{+3}$	70-Year			
Grid#31,63	$2.11 \times 10^{+1}$	$1.65 \times 10^{+8}$	$3.22 \times 10^{+3}$	70-Year			
Grid#31,66	$2.61 \times 10^{+1}$	$6.19 \times 10^{+6}$	$2.81 \times 10^{+3}$	70-Year			
Grid#34,60	$6.29 \times 10^{+1}$	$3.84 \times 10^{+6}$	$1.80 \times 10^{+3}$	70-Year			
Grid#35,61	$6.29 \times 10^{+1}$	$2.39 \times 10^{+6}$	$1.01 \times 10^{+3}$	70-Year			
Grid#31,65	$2.17 \times 10^{+1}$	$3.28 \times 10^{+7}$	$2.63 \times 10^{+3}$	70-Year			
Grid#32,64	$2.34 \times 10^{+1}$	$4.67 \times 10^{+7}$	$3.92 \times 10^{+3}$	70-Year			
Grid#33,59	$1.61 \times 10^{+1}$	$2.86 \times 10^{+6}$	$1.68 \times 10^{+3}$	70-Year			
Grid#33,60	$8.10 \times 10^{+0}$	$1.03 \times 10^{+7}$	$7.90 \times 10^{+2}$	70-Year			
Grid#33,61	$3.41 \times 10^{+1}$	$6.47 \times 10^{+7}$	$4.53 \times 10^{+3}$	70-Year			
Grid#33,63	$1.01 \times 10^{+2}$	$1.41 \times 10^{+8}$	$1.31 \times 10^{+4}$	70-Year			
Grid#34,61	$6.29 \times 10^{+1}$	$1.19 \times 10^{+8}$	$8.62 \times 10^{+3}$	70-Year			

See footnotes at end of table

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TABLE 5-28
(Continued)

Constituents of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituents Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
RADIONUCLIDES							
Uranium-238 (Continued)							
Grid#34,62	$2.12 \times 10^{+2}$	$2.68 \times 10^{+8}$	$2.92 \times 10^{+4}$	70-Year			
Grid#31,60	$1.32 \times 10^{+1}$	$7.75 \times 10^{+7}$	$2.82 \times 10^{+3}$	70-Year			
Grid#31,64	$2.46 \times 10^{+1}$	$1.24 \times 10^{+8}$	$4.51 \times 10^{+3}$	70-Year			
Grid#32,60	$1.30 \times 10^{+1}$	$4.40 \times 10^{+7}$	$1.60 \times 10^{+3}$	70-Year			
Grid#32,61	$1.07 \times 10^{+1}$	$3.42 \times 10^{+7}$	$1.24 \times 10^{+3}$	70-Year			
Grid#32,62	$2.66 \times 10^{+1}$	$1.24 \times 10^{+8}$	$4.52 \times 10^{+3}$	70-Year			
Grid#32,63	$2.92 \times 10^{+1}$	$1.35 \times 10^{+8}$	$4.90 \times 10^{+3}$	70-Year			
Grid#33,62	$1.60 \times 10^{+2}$	$4.93 \times 10^{+8}$	$1.79 \times 10^{+4}$	70-Year			
Grid#32,59	$1.00 \times 10^{+1}$	$2.95 \times 10^{+7}$	$2.15 \times 10^{+3}$	70-Year			
Uranium Total (non-RAD)	$1.04 \times 10^{+2}$	$2.29 \times 10^{+10}$	$1.09 \times 10^{+5}$	70-Year	$3.79 \times 10^{+4}$	$1.09 \times 10^{+1}$	Yes
ORGANICS							
2-methylnapthalene	5.60×10^{-2}	$1.24 \times 10^{+7}$	$5.89 \times 10^{+1}$	70-Year	$1.98 \times 10^{+1}$	NA[c]	NA
Aroclor-1254	4.30×10^{-1}	$9.50 \times 10^{+7}$	$4.52 \times 10^{+2}$	70-Year	0.0	1.10×10^{-3}	No
Aroclor-1260	8.90×10^{-2}	$1.97 \times 10^{+7}$	$9.35 \times 10^{+1}$	70-Year	0.0	1.10×10^{-3}	No
Benzo(a)anthracene	1.30×10^{-1}	$2.87 \times 10^{+7}$	$1.37 \times 10^{+2}$	70-Year	0.0	2.82×10^{-3}	No
Benzo(a)pyrene	1.10×10^{-1}	$2.43 \times 10^{+7}$	$1.16 \times 10^{+2}$	70-Year	0.0	2.82×10^{-4}	No
Benzo(b)fluoranthene	1.40×10^{-1}	$3.09 \times 10^{+7}$	$1.47 \times 10^{+2}$	70-Year	0.0	2.82×10^{-3}	No
bis(2-Ethylhexyl) phthalate	8.60×10^{-1}	$1.90 \times 10^{+8}$	$9.03 \times 10^{+2}$	70-Year	0.0	6.07×10^{-1}	No
Dieldrin	1.60×10^{-2}	$3.53 \times 10^{+6}$	$1.68 \times 10^{+1}$	70-Year	0.0	1.12×10^{-4}	No

See footnotes at end of table

TABLE 5-28
(Continued)

Constituents of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituents Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
ORGANICS (Continued)							
Octachlorodibenzo-p-dioxin	3.60×10^{-3}	$7.96 \times 10^{+5}$	$3.78 \times 10^{+0}$	70-Year	0.0	1.19×10^{-5}	No
Phenanthrene	2.10×10^{-1}	$4.64 \times 10^{+7}$	$2.21 \times 10^{+2}$	70-Year	0.0	NA	No
Tetrachlorodibenzofuran	1.80×10^{-5}	$3.98 \times 10^{+3}$	1.89×10^{-2}	70-Year	0.0	1.19×10^{-7}	No
Tributyl Phosphate	2.00×10^{-1}	$4.42 \times 10^{+7}$	$2.10 \times 10^{+2}$	70-Year	$3.95 \times 10^{+1}$	NA	NA
INORGANICS							
Arsenic	$1.21 \times 10^{+1}$	$2.66 \times 10^{+9}$	$4.00 \times 10^{+2}$	TCLP	1.29×10^{-5}	1.46×10^{-4}	No
Beryllium	$1.44 \times 10^{+0}$	$3.18 \times 10^{+8}$	$1.51 \times 10^{+3}$	70-Year	0.0	2.37×10^{-4}	No
Lead	$2.81 \times 10^{+1}$	$6.20 \times 10^{+9}$	$2.00 \times 10^{+2}$	TCLP	$5.61 \times 10^{+1}$	NA	NA

[a]Constraint on reported concentration is by In Situ Leachate (ISL), Toxicity Characteristic Leaching Procedure (TCLP), maximum detection limit (MDL), or by US EPA 70-year rule (70-Year).

[b]Zero indicates that the predicted concentration is at least three orders of magnitude below the screening concentration.

[c]NA = No data available to calculate EPA RAGs, Part B screening value.

TABLE 5-29

FLOW RATES FOR SEEPS AND PERCHED WATER SUBSURFACE SEEPS INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Flow Rate	
Grid Cell	Gallons/minute	Inch/year
INACTIVE FLYASH PILE SEEP		
(28,66)	0.35	18.9
SOUTH FIELD SEEP		
(30,57)	0.26	14.0
PERCHED WATER SUBSURFACE SEEP		
(28,66)	0.44	23.6
(29,62)	0.15	8.1
(29,63)	0.45	24.4
(29,64)	0.77	41.8
(29,65)	1.73	93.6
(30,60)	0.20	10.9
(30,61)	0.40	21.7
(30,62)	0.40	21.7

TABLE 5-30

SCREENING FOR CONSTITUENTS OF POTENTIAL CONCERN AFTER DILUTION IN THE GREAT MIAMI AQUIFER FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent	Units	Concentration at the Groundwater Table	Diluted Great Miami Aquifer Concentration	Screening Concentration	Diluted Concentration Exceeds Screening Concentration
RADIONUCLIDES					
Neptunium-237	pCi/L	$1.06 \times 10^{+2}$	$3.84 \times 10^{+0}$	2.16×10^{-2}	Yes
Radium-226	pCi/L	1.58×10^{-1}	9.14×10^{-2}	1.76×10^{-4}	Yes
Strontium-90	pCi/L	$1.53 \times 10^{+1}$	$1.52 \times 10^{+0}$	1.32×10^{-1}	Yes
Technetium-99	pCi/L	$7.72 \times 10^{+2}$	$2.79 \times 10^{+1}$	$3.65 \times 10^{+0}$	Yes
Uranium-234	pCi/L	$1.10 \times 10^{+4}$	$3.98 \times 10^{+2}$	2.97×10^{-1}	Yes
Uranium-235/236	pCi/L	$2.11 \times 10^{+3}$	$1.21 \times 10^{+2}$	2.97×10^{-1}	Yes
Uranium-238	pCi/L	$5.44 \times 10^{+5}$	$2.89 \times 10^{+3}$	1.70×10^{-1}	Yes
Uranium-Total	μg/L	$3.79 \times 10^{+4}$	$1.37 \times 10^{+0}$	$1.09 \times 10^{+1}$	Yes
ORGANICS					
2-methylnapthalene	μg/L	$1.98 \times 10^{+1}$	7.17×10^{-1}	NA[a]	NA
Tributyl phosphate	μg/L	$3.95 \times 10^{+1}$	$1.43 \times 10^{+0}$	NA	NA
INORGANICS					
Lead	μg/L	$5.61 \times 10^{+1}$	$3.25 \times 10^{+1}$	NA	NA

[a]NA = No data available to calculate EPA RAGs, Part B screening value.

[b]Diluted Great Miami Aquifer concentration marginally exceeds screening concentration. However, it is expected that maximum concentration in the Great Miami Aquifer will be about an order of magnitude lower and, therefore, silver was not modeled further.

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TABLE 5-31

SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN AND SOURCE PATHWAYS FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Source Pathways[a]				
Contaminants of Potential Concern	Inactive Flyash Pile/South Field Waste[b]	Inactive Flyash Pile Seep	South Field Seep	Perched Groundwater Subsurface Seeps in Inactive Flyash Pile/South Field	Paddy's Run Loading from Inactive Flyash Pile/ South Field Runoff
RADIONUCLIDES					
Neptunium-237	Yes	Yes	No	Yes	No
Radium-226	Yes	Yes	No	Yes	Yes
Strontium-90	Yes	No	No	No	No
Technetium-99	Yes	No	No	No	Yes
Uranium-234	Yes	Yes	Yes	Yes	Yes
Uranium-235/236	Yes	Yes	Yes	Yes	No
Uranium-238	Yes	Yes	Yes	Yes	Yes
Uranium - Total (non-RAD)	Yes	Yes	Yes	Yes	No
ORGANICS					
2-methylnaphthalene[c]	NA[c]	No	No	No	NA
Benzo(a)pyrene[d]	No	No	No	No	Yes[d]
Benzo(g,h,i)perylene[c]	No	No	No	No	NA
Dieldrin[d]	No	No	No	No	Yes[d]
Phenanthrene[c]	No	No	No	No	NA
Tributyl phosphate[c]	NA	No	No	No	No
INORGANICS					
Arsenic	No	Yes	No	No	Yes
Beryllium[d]	No	No	No	No	Yes[d]

See footnotes at end of table

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TABLE 5-31
(Continued)

Contaminants of Potential Concern	Source Pathways[a]				
	Inactive Flyash Pile/South Field Waste[b]	Inactive Flyash Pile Seep	South Field Seep	Perched Groundwater Subsurface Seeps in Inactive Flyash Pile/South Field	Paddy's Run Loading from Inactive Flyash Pile/ South Field Runoff
INORGANICS (Continued)					
Lead[c]	NA[c]	NA	No	NA	NA

[a]"Yes" indicates that predicted CPC concentration was above screening concentration; "No" indicates that the predicted CPC concentration was below screening concentration.

[b]Includes loading from perched groundwater source leakage through till and unsaturated GMA, if applicable.

[c]NA = no data available to calculate EPA RAGs, Part B screening values for 2-Methylnaphthalene, benzo(g,h,i)perylene, phenanthrene and lead. These CPCs were not considered for further modeling using SWIFT.

[d]Not modeled using SWIFT because diluted GMA concentration without absorption effects is marginaly above the screening concentration. Typical concentration reduction in the GMA is approximately by a factor of 20.

000803

TABLE 5-32

COMPARISON OF GREAT MIAMI AQUIFER WATER AND BACKGROUND FOR CONSTITUENTS OF POTENTIAL CONCERN IN GROUNDWATER SOUTH FIELD, INACTIVE FLYASH PILE, AND ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents Potential of Concern	Units	Detects in 2000-Series Well Groundwater Samples				Background		2000-Series Comparable to Background?
		Samples	Hits	Minimum	Maximum	Minimum	Maximum	
RADIONUCLIDES								
NP-237	pCi/L	57	8	0.15	0.962	NA	1.10[a]	Yes
PU-238	pCi/L	59	7	0.07	0.637	NA	1.00[a]	Yes
PU-239/240	pCi/L	59	1	0.06	0.06	NA	1.00[a]	Yes
RA-226	pCi/L	52	14	0.13	1.4	1.10	8.50	Yes
TH-228	pCi/L	60	4	1.10	1.4	1.20	2.90	Yes
TH-230	pCi/L	59	18	0.21	2.06	1.20	3.44	Yes
TH-232	pCi/L	59	5	0.04	1.49	1.20	2.90	Yes
U-234	pCi/L	61	57	0.68	662	1.20	4.20	No
U-235/236	pCi/L	60	28	0.15	31.70	NA	1.30[a]	No
U-238	pCi/L	60	54	0.338	384	0.90	4.40	No
U-Total	μg/L	60	56	2.0	2070.0	NA	NA	No[b]
INORGANICS								
Arsenic	μg/L	16	6	1.2	3.9	2.0	550.0	Yes
Lead	μg/L	16	7	1.3	16.0	2.6	140.0	Yes
ORGANICS								
bis(2-Ethylhexyl) phthalate	μg/L	22	3	2.0	6.0	NA	NA	No

[a]Not detected in background samples. Value reported is maximum detection limit.
[b]Perched water concentration is lower then the Great Miami Aquifer concentration.

NA - Not available.

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concentration. However, the frequency of detection of bis(2-Ethylhexyl) phthalate in the Great Miami Aquifer was low, and it is also a common laboratory contaminant. Therefore, further calibration for bis(2-Ethylhexyl) phthalate was not considered and was not included for SWIFT III modeling.

5.4.3.4 Active Flyash Pile

Figure 5-14 shows the aerial extent of the waste in the Active Flyash Pile and the SWIFT III grid cells impacted by direct loading from this subunit. Three SWIFT III grid cells were modeled to receive lateral drainage from adjacent grid cells' waste (Figure 5-14). Three pathways of CPC migration to the Great Miami Aquifer were modeled from the Active Flyash Pile. These pathways were the vadose zone pathway, perched water infiltration pathway, and surface water pathway. For the vadose zone pathway, Table 5-33 shows CPC concentration in the waste, constituent inventory in the waste, and the maximum predicted leachate concentration. Concentration and mass for the perched water infiltration pathway are discussed in Appendix A-2. Concentration and mass loading due to surface water pathway are discussed in Section 5.3.

A summary of screening for CPCs is also included in Table 5-33 for the vadose zone and perched water infiltration pathways. CPCs passing the screening (Table 5-33) were further screened using predicted dilution in the Great Miami Aquifer. Table 5-34 shows the results of the Great Miami Aquifer dilution. Table 5-35 lists the constituents that survived various screening processes and were simulated using the SWIFT III model for the Active Flyash Pile. Predicted CPC concentrations were not compared to the field analytical results since this subunit is in close proximity and downgradient of the Inactive Flyash Pile and South Field.

5.4.4 Great Miami Aquifer Modeling Results and Discussion

The fate and transport of CPCs contained in the Operable Unit 2 subunits were evaluated to provide a basis for estimating current and future risks posed by Operable Unit 2. The groundwater fate and transport modeling results are summarized in following subsections for the Operable Unit 2's CPCs that will reach the Great Miami Aquifer within 1,000 years. The simulation time period of 1,000 years was selected based on the Risk Assessment Work Plan Addendum (DOE 1992a). Contributions to constituent concentrations from other FEMP sources and background concentrations were not included in the results presented in this section. Constituents concentrations were estimated for both on-site and off-site areas to provide a range of potential exposure scenarios.

TABLE 5-33

SOURCE CHARACTERIZATION AND SCREENING SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN
ACTIVE FLYASH PILE
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituent Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
RADIONUCLIDES							
Lead-210	2.13×10^{-8}	9.12×10^{-1}	$1.25 \times 10^{+3}$	70-Year	0.0[b]	7.20×10^{-3}	No
Neptunium-237	6.38×10^{-4}	$2.73 \times 10^{+4}$	$3.45 \times 10^{+2}$	70-Year	$3.28 \times 10^{+1}$	2.16×10^{-2}	Yes
Plutonium-238	7.19×10^{-9}	3.07×10^{-1}	$9.43 \times 10^{+1}$	70-Year	0.0	2.16×10^{-2}	No
Plutonium-239/240	1.77×10^{-6}	$7.57 \times 10^{+1}$	$8.43 \times 10^{+1}$	70-Year	0.0	2.07×10^{-2}	No
Radium-224	2.35×10^{-11}	1.01×10^{-3}	$2.87 \times 10^{+3}$	70-Year	0.0	1.25×10^{-1}	No
Radium-226	5.30×10^{-6}	$2.27 \times 10^{+2}$	$4.02 \times 10^{+3}$	70-Year	0.0	1.76×10^{-4}	No
Radium-228	1.59×10^{-8}	6.81×10^{-1}	$3.32 \times 10^{+3}$	70-Year	0.0	4.75×10^{-2}	No
Strontium-90	7.04×10^{-9}	3.01×10^{-1}	$7.39 \times 10^{+2}$	70-Year	$1.79 \times 10^{+1}$	1.32×10^{-1}	Yes
Thorium-228	7.06×10^{-9}	3.02×10^{-1}	$4.44 \times 10^{+3}$	70-Year	0.0	8.64×10^{-2}	No
Thorium-230	2.78×10^{-4}	$1.19 \times 10^{+4}$	$4.38 \times 10^{+3}$	70-Year	0.0	3.65×10^{-1}	No
Thorium-232	$3.51 \times 10^{+1}$	$1.50 \times 10^{+9}$	$2.96 \times 10^{+3}$	70-Year	0.0	2.79×10^{-2}	No
Uranium-234	1.43×10^{-3}	$6.12 \times 10^{+4}$	$6.82 \times 10^{+3}$	70-Year	$8.54 \times 10^{+2}$	2.97×10^{-1}	Yes
Uranium-235/236	$1.91 \times 10^{+0}$	$8.15 \times 10^{+7}$	$3.16 \times 10^{+3}$	70-Year	$3.95 \times 10^{+2}$	2.97×10^{-1}	Yes
Uranium-238		$6.45 \times 10^{+8}$			$4.87 \times 10^{+2}$	1.70×10^{-1}	Yes
Grid #31,56	$1.51 \times 10^{+1}$	$6.32 \times 10^{+6}$	$6.78 \times 10^{+2}$	70-Year			
Grid #31,57	$1.51 \times 10^{+1}$	$3.33 \times 10^{+7}$	$9.39 \times 10^{+2}$	70-Year			
Grid #32,56	$1.51 \times 10^{+1}$	$9.13 \times 10^{+7}$	$1.39 \times 10^{+3}$	70-Year			
Grid #32,57	$1.51 \times 10^{+1}$	$1.64 \times 10^{+8}$	$1.84 \times 10^{+3}$	70-Year			
Grid #32,58	$1.51 \times 10^{+1}$	$1.95 \times 10^{+7}$	$2.50 \times 10^{+3}$	70-Year			

See footnotes at end of table

TABLE 5-33
(Continued)

Constituents of Potential Concern	Upper 95% C.I. on Mean Concentration (mg/kg)	Constituent Inventory in the Waste (mg)	Initial Maximum Leachate Concentration (pCi/L RAD) (μg/L non-RAD)	Constraint[a]	Maximum Loading Concentration from ODAST (Vadose Layer 2) (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Concentration (pCi/L RAD) (μg/L non-RAD)	CPC ≥Screening Concentration and Requires SWIFT Modeling?
RADIONUCLIDES (Continued)							
Uranium-238 (Continued)							
Grid #33,56	$1.51 \times 10^{+1}$	$1.18 \times 10^{+8}$	$1.37 \times 10^{+3}$	70-Year			
Grid #33,57	$1.51 \times 10^{+1}$	$1.03 \times 10^{+8}$	$1.77 \times 10^{+3}$	70-Year			
Grid #33,58	$1.51 \times 10^{+1}$	$1.61 \times 10^{+7}$	$1.97 \times 10^{+3}$	70-Year			
Grid #34,56	$1.51 \times 10^{+1}$	$6.78 \times 10^{+7}$	$1.06 \times 10^{+3}$	70-Year			
Grid #34,57	$1.51 \times 10^{+1}$	$2.53 \times 10^{+7}$	$3.89 \times 10^{+3}$	70-Year			
Uranium Total (non RAD)	$3.00 \times 10^{+1}$	$1.28 \times 10^{+9}$	$2.30 \times 10^{+4}$	70-Year	$2.88 \times 10^{+3}$	$1.09 \times 10^{+1}$	Yes
ORGANICS							
2-Methylnaphthalene	1.60×10^{-1}	$6.85 \times 10^{+6}$	$1.23 \times 10^{+2}$	70-Year	$9.18 \times 10^{+0}$	NA[c]	NA
Phenanthrene	7.20×10^{-2}	$3.08 \times 10^{+6}$	$5.54 \times 10^{+1}$	70-Year	0.0	NA	No
INORGANICS							
Arsenic	$6.43 \times 10^{+1}$	$2.75 \times 10^{+9}$	$9.80 \times 10^{+1}$	TCLP	0.0	1.46×10^{-4}	No
Beryllium	$3.38 \times 10^{+0}$	$1.44 \times 10^{+8}$	$2.59 \times 10^{+3}$	70-Year	0.0	2.37×10^{-4}	No
Lead	$4.54 \times 10^{+1}$	$1.94 \times 10^{+9}$	$6.04 \times 10^{+1}$	TCLP	$2.87 \times 10^{+1}$	NA	NA
Thallium	$2.08 \times 10^{+0}$	$8.91 \times 10^{+7}$	$1.60 \times 10^{+3}$	70-Year	0.0	2.55×10^{-1}	No

[a]Constraint on reported concentration is by In Situ Leachate (ISL), Toxicity Characteristic Leaching Procedure (TCLP), maximum detection limit (mdl), or by US EPA 70-year rule (70-Year).

[b]Zero indicates that predicted concentration is at least three orders of magnitude below the screening concentration.

[c]NA = no data available to calculate EPA RAGs, Part B screening value.

000502

TABLE 5-34

SCREENING FOR CONSTITUENTS OF POTENTIAL CONCERN AFTER DILUTION IN THE GREAT MIAMI AQUIFER FOR THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent	Units	Concentration in Vadose Zone at the Groundwater Table	Diluted Great Miami Aquifer Concentration	Screening Concentration	Diluted Concentration Exceeds Screening Concentration
RADIONUCLIDES					
Neptunium-237	pCi/L	$3.28 \times 10^{+1}$	$6.98 \times 10^{+0}$	2.16×10^{-2}	Yes
Strontium-90	pCi/L	$1.79 \times 10^{+1}$	$3.80 \times 10^{+0}$	1.32×10^{-1}	Yes
Uranium-234	pCi/L	$8.54 \times 10^{+2}$	$1.28 \times 10^{+2}$	2.97×10^{-1}	Yes
Uranium-235/236	pCi/L	$3.95 \times 10^{+2}$	$5.92 \times 10^{+1}$	2.97×10^{-1}	Yes
Uranium-238	pCi/L	$4.87 \times 10^{+2}$	$7.28 \times 10^{+1}$	1.70×10^{-1}	Yes
Uranium-total(Non-RAD)	pCi/L	$2.88 \times 10^{+3}$	$4.31 \times 10^{+2}$	$1.09 \times 10^{+1}$	Yes
ORGANICS					
2-Methylnaphthalene	μg/L	$9.18 \times 10^{+0}$	$1.95 \times 10^{+0}$	NA[a]	NA
INORGANICS					
Lead	μg/L	$2.87 \times 10^{+1}$	$6.11 \times 10^{+0}$	NA	NA

[a]NA = no data available to calculate EPA, RAGs, Part B screening volume.

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TABLE 5-35

SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN AND SOURCE PATHWAYS FOR THE ACTIVE FLYASH PILE
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Contaminants of Potential Concern	Source Pathways[a]	
	Infiltration through Active Flyash Pile[b]	SSOD Loading from Active Flyash Pile Runoff
RADIONUCLIDES		
Neptunium-237	Yes	Yes
Strontium-90	Yes	No
Uranium-234	Yes	Yes
Uranium-235/236	Yes	No
Uranium-238	Yes	Yes
Uranium Total	Yes	No
ORGANICS		
2-Methylnaphthalene	NA[d]	No
INORGANICS		
Arsenic	No	Yes
Beryllium	No	Yes
Lead	NA	NA

[a]"Yes" indicates predicted CPC concentration was above screening concentration; "No" indicates that the predicted CPC concentration was below screening concentration.
[b]Includes loading from perched groundwater source leakage through till and unsaturated GMA, if applicable.
[c]Not modeled based on diluted GMA concentration less than EPA RAGs, Part B screening concentration.
[d]NA = no data available to calculate EPA, RAGs, Part B screening value.

000309

5.4.4.1 Solid Waste Landfill

The groundwater fate and transport modeling results are summarized in Table 5-36 for technetium-99, the only CPC that was predicted to reach the Great Miami Aquifer within 1,000 years from the Solid Waste Landfill. The table also presents the arrival time for the CPCs in the aquifer, the maximum loading concentration, the maximum concentrations of the CPC that would be expected in the aquifer within 1,000 years and the time required for the CPC to reach the maximum value. It also presents the predicted maximum concentration at the FEMP boundary due to loading from the Solid Waste Landfill. Screening levels have been developed based on EPA RAGs, Part B guidelines (presented in Appendix B) and provide a basis for understanding the risk to human health from the ingestion of water from the Great Miami Aquifer at the hypothetical receptor location. Maximum predicted technetium-99 concentration in the Great Miami Aquifer was 0.61 pCi/L, which is more than an order of magnitude below the screening concentration. Due to low concentrations, no contour map of technetium-99 concentration was produced.

5.4.4.2 Lime Sludge Ponds

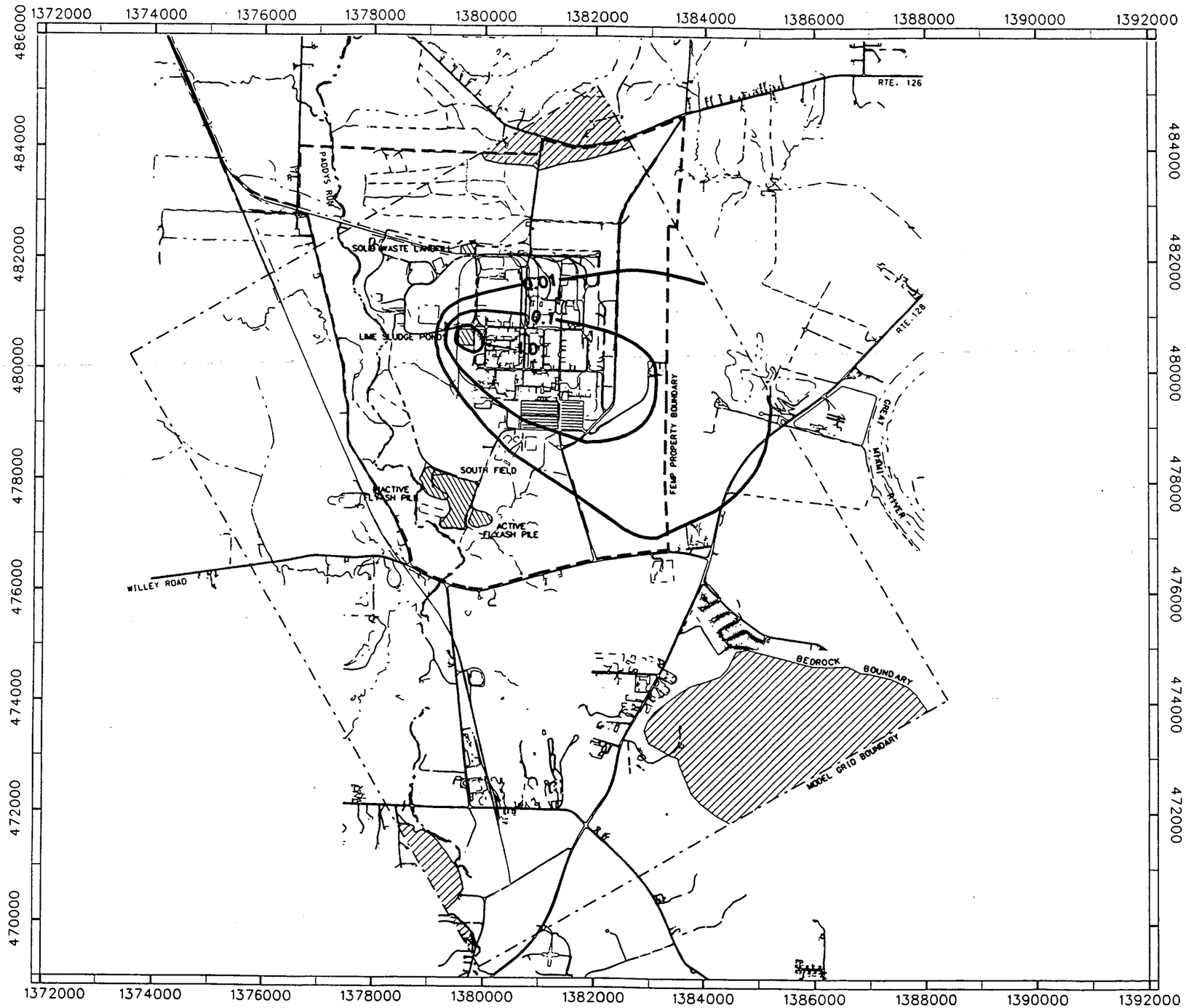
The groundwater fate and transport modeling results are summarized in Table 5-37 for technetium-99, the only CPC that was predicted to reach the Great Miami Aquifer within 1,000 years from the Lime Sludge Ponds. The table also presents the arrival time for technetium-99 in the aquifer, the maximum loading concentration, the maximum concentrations of the technetium-99 that would be expected in the aquifer within 1,000 years, and the time required for the constituents to reach the maximum value. It shows that the predicted maximum concentration at the FEMP boundary due to loading from the Lime Sludge Ponds is below the screening level (i.e., off-site impact of Lime Sludge Ponds is negligible). Screening levels have been developed based on EPA RAGs, Part B guidelines (presented in Appendix B) and provide a basis for understanding the risk to human health from the ingestion of water from the Great Miami Aquifer at the hypothetical receptor location. Contour plots for projected increases in the concentrations of technetium-99 at the time of maximum concentrations (40 years) is shown in Figure 5-18. The plot shows the profiles of future increase in concentration as predicted by the SWIFT III model. Figure 5-18 shows that plume migration from the Lime Sludge Ponds is in east-southeasterly direction. At 1,000 years, concentrations of technetium-99 were predicted to be significantly below the screening level.

5.4.4.3 Inactive Flyash Pile/South Field

The Operable Unit 2 SWIFT III model was calibrated for uranium-238. Uranium-238 was selected for calibration because of the high detection frequency, very sensitive analytic procedure, projection as a main parameter of concern for risk assessment, and for the determination and modeling of hot spots. Use of uranium at the FEMP site began in the 1950s. Current uranium-238 concentrations in the Great Miami Aquifer in the vicinity of the South Field area were detected as high as 707 pCi/L at Well 2945 in the validated unfiltered samples and validated analysis indicated that the total uranium concentration was as high as 2070 μg/L (equivalent to 570 pCi/L of uranium-238).

SWIFT III was first run using a K_d of 8.4 for uranium (Uranium Partition Coefficient Evaluation Study for Operable Unit 2, 1993) in the Great Miami Aquifer. SWIFT III model results indicated that it will take more than 200 years to reach current concentrations levels in the Great Miami Aquifer. Since uranium breakthrough for the vadose zone pathway for K_d of 8.4 ml/g does not occur until after 160 years, calibration cannot be done by increasing waste concentration alone. Through the calibration process, the K_d value in the Great Miami Aquifer (and ODAST) was reduced to 1.48 ml/g. At 40 years from placement of waste in the Inactive Flyash Pile and South Field subunits (approximately current conditions), model predicted uranium-238 concentrations in the Great Miami Aquifer to be 134 pCi/L in the grid cell containing the Well 2945 (Figure 5-19), as compared to 707 pCi/L measured at Well 2945. This is considered a good calibration of the model given the limitations that source areas smaller than 125 x 125 feet cannot be assigned. The uranium breakthrough close to the Well 2945 is due to subsurface seeps. Although subsurface seeps do not travel laterally 125 feet on the unsaturated Great Miami Aquifer, model limitations require that subsurface seep mass be loaded uniformly over the full 125 x 125 foot cell. If subsurface seeps infiltrate through a 20- to 50-foot wide area, this can easily result in underestimation of concentration by the model near subsurface seep at 40 years by a factor of 3 to 6. Since overall maximum loading is due to the vadose zone pathway (Figure 5-20), which is uniformly distributed over the full grid cell, the maximum predicted uranium-238 concentrations for the baseline risk assessment are not very sensitive to the above mentioned limitation of the model. The predicted uranium-238 plume shape at 40 years due to loading from the Inactive Flyash Pile and South Field is in general agreement with the field observations.

Figure 5-20 shows the loading of uranium-238 to the Great Miami Aquifer from the Inactive Flyash Pile and South Field. Figure 5-20 shows that uranium-238 reaches the Great Miami Aquifer very



MAXIMUM INCREASE IN CONCENTRATION = 2.51 pCi/L

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — TECHNETIUM-99 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentrations not included.

N

SCALE (FT)
0 2000 4000

FIGURE 5-18
PROJECTED INCREASE IN TECHNETIUM-99 CONCENTRATION IN GREAT MIAMI AQUIFER AT 40 YEARS DUE TO LOADING FROM THE LIME SLUDGE PONDS

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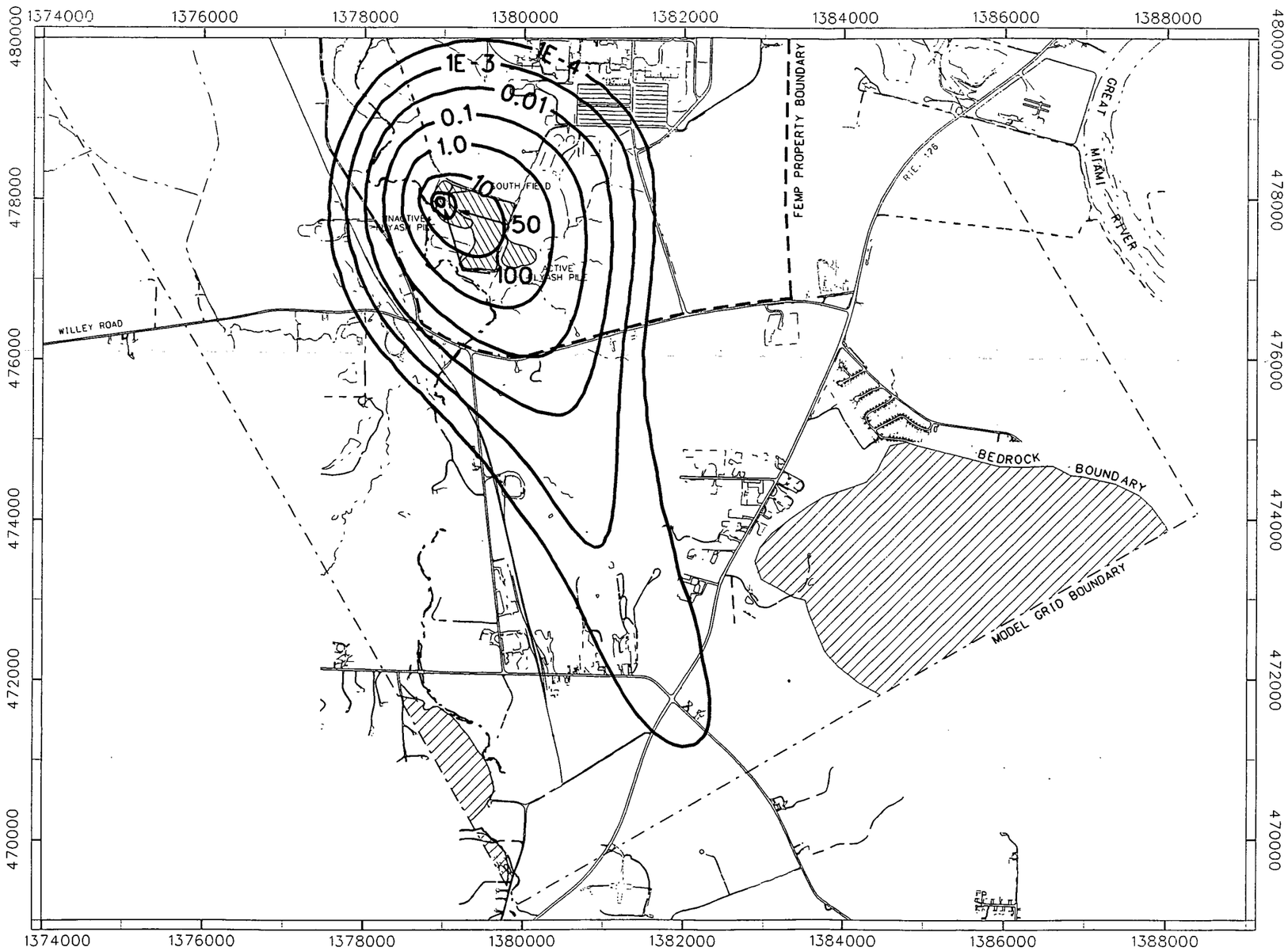


LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

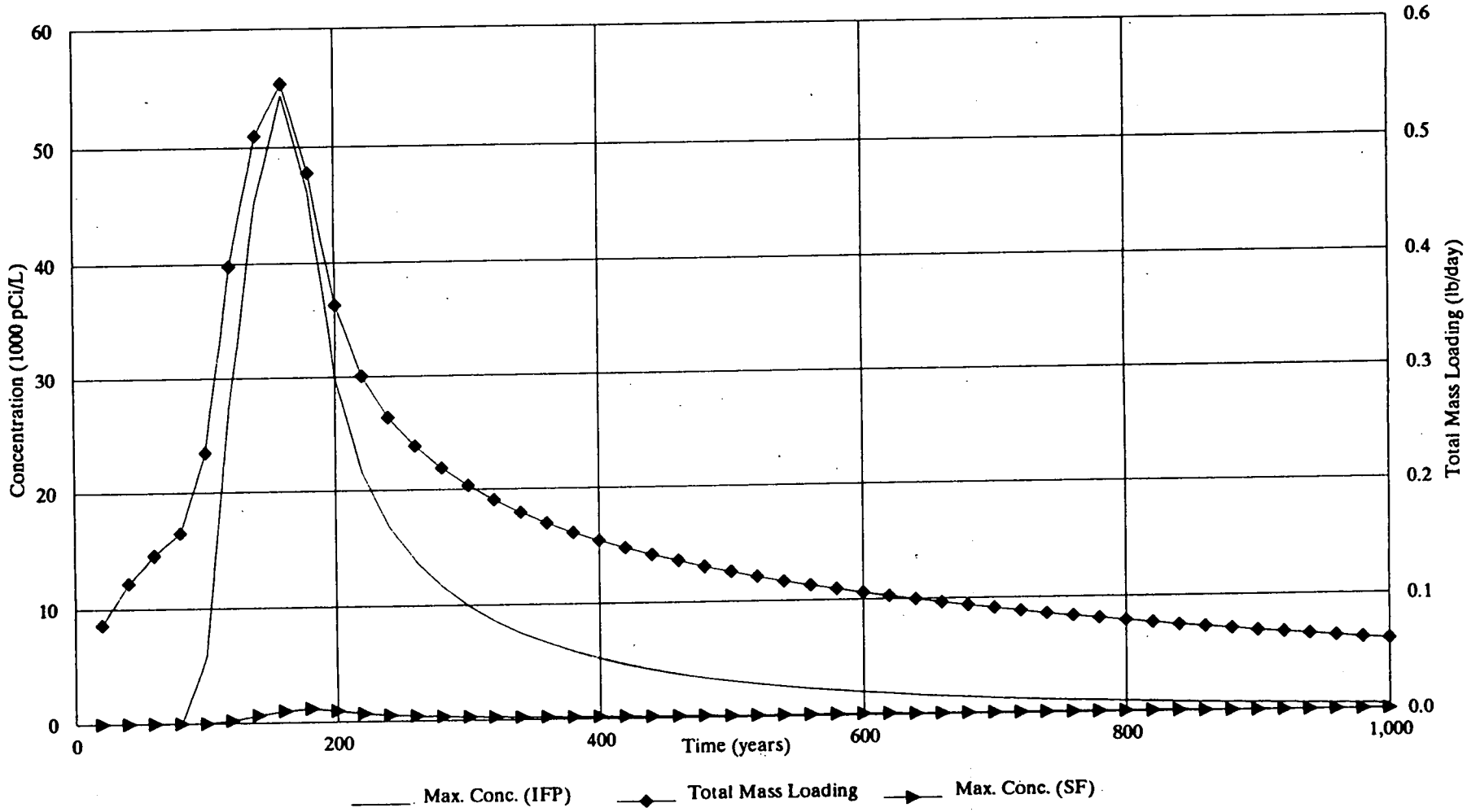
SCALE (FT)
0 1500 3000

MAXIMUM PREDICTED INCREASE IN CONCENTRATION = 134 pCi/L
MAXIMUM MEASURED CONCENTRATION = 707 pCi/L

FIGURE 5-19
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 40 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

fig0519.dgn

000813



Maximum Concentration in the Inactive Flyash Pile (54,400 pCi/L) occurs in grid block (29,65)

Maximum Concentration in South Field (1200 pCi/L) occurs in grid block (29,59)

IFP Inactive Flyash Pile

SF South Field

FIGURE 5-20. URANIUM-238 LOADING TO THE GREAT MIAMI AQUIFER FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

000814

6 5 0 5

TABLE 5-36

SUMMARY OF SWIFT MODELING RESULTS FOR THE SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L)	EPA RAGs, Part B Screening Concentration (pCi/L)
RADIONUCLIDES							
Technetium-99	28.5	10-20	60	0.61	70	0.054	3.65

000815

TABLE 5-37

SUMMARY OF SWIFT MODELING RESULTS FOR THE
LIME SLUDGE PONDS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L)	EPA RAGs, Part B Screening Levels (pCi/L)
RADIONUCLIDES							
Technetium-99	76.4	20-30	40	2.96	40	0.17	3.65

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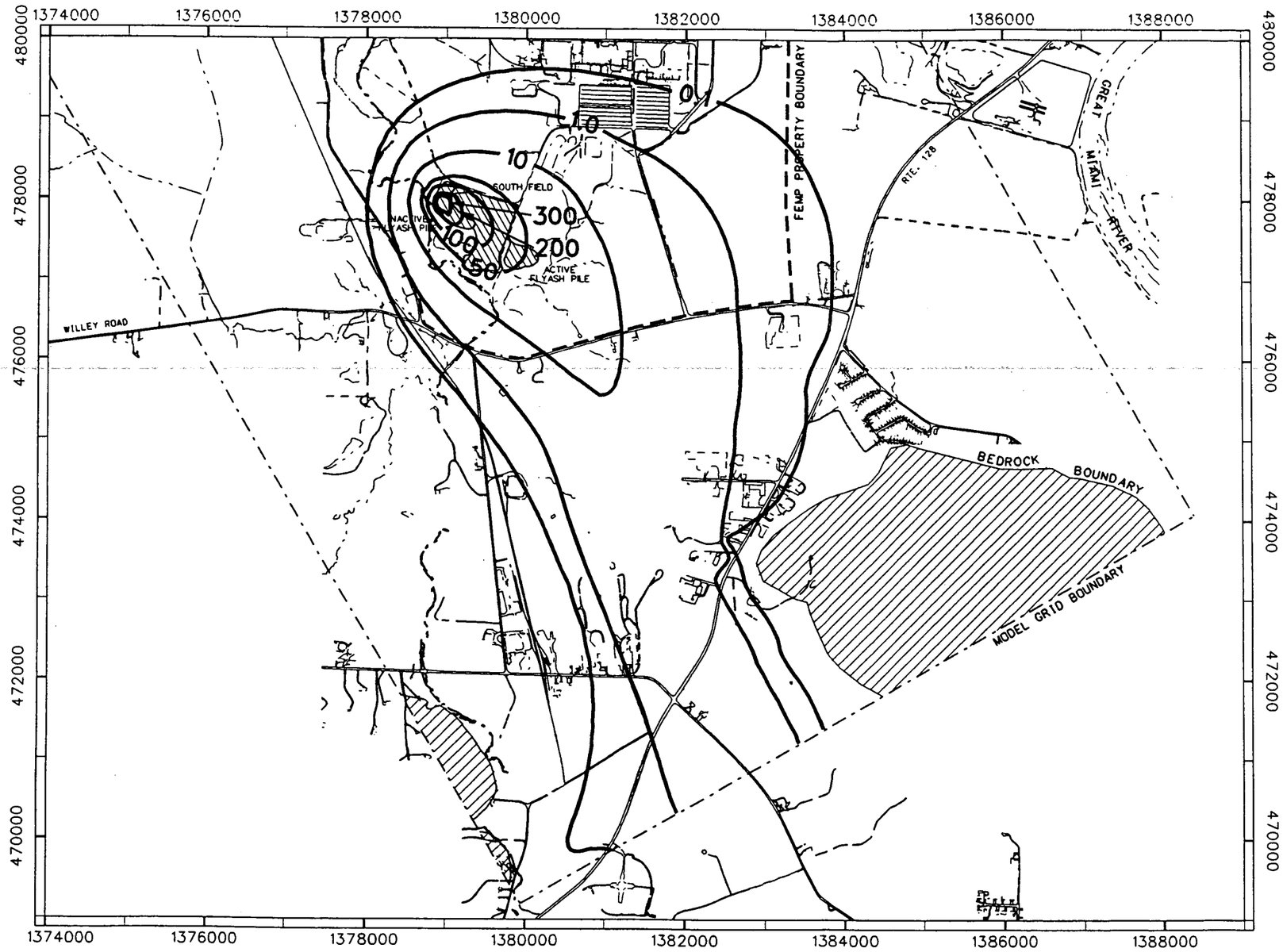
early, and loading increases very slowly up to 100 years (main contribution is from perched water subsurface seeps) and then rises sharply and reaches a peak at 160 years (due to breakthrough from the vadose zone pathway). Uranium-238 loading then decreases exponentially. Figure 5-20 shows the uranium-238 concentration at the interface of vadose zone Layer 2 (unsaturated Great Miami Aquifer) and saturated Great Miami Aquifer from the vadose zone pathway in grid block (29, 65). It does not show the concentration versus time history of perched water subsurface seep in the same grid block, which has an early arrival time but a lower peak concentration value.

Figures 5-21, 5-22, and 5-23 show the projected increase in uranium-238 concentrations due to Inactive Flyash Pile and South field at 160, 220, and 1,000 years, respectively. The maximum on-site uranium-238 concentration was predicted to occur at 160 years, while the maximum off-site concentration was predicted to occur at 220 years.

The groundwater fate and transport modeling results for the Inactive Flyash Pile and South Field are summarized in Table 5-38 for the CPCs that will reach the Great Miami Aquifer within 1,000 years from the Inactive Flyash Pile and South Field subunits. The table also presents the arrival time for the CPCs to reach the aquifer, the maximum loading concentration, the maximum concentrations of the CPC that would be expected in the aquifer within 1,000 years, and the time required for the CPC to reach the maximum value. It also presents the predicted maximum concentration at the FEMP boundary due to loading from the Inactive Flyash Pile and South Field subunits. Screening levels are also presented to provide a basis for understanding the risk to human health from the ingestion of water from the Great Miami Aquifer at the hypothetical receptor location. Uranium-238 concentrations are most elevated compared to the screening concentration and may control the overall risk from groundwater pathway (see Section 6.0 and Appendix B). Table 5-39 presents the on-site and off-site concentrations of CPCs at the uranium-238 maximum concentration location and time.

As noted earlier, total uranium, uranium-234, and uranium-235/236 concentrations were estimated from the results of uranium-238 modeling. Figures 5-24 through 5-26 show site-specific relationships between uranium-234 and uranium-238 activity at the Inactive Flyash Pile/South Field/Active Flyash Pile; uranium 235/236 and uranium-238 activity at the Inactive Flyash Pile/South Field/Active Flyash Pile; and uranium-238 and total uranium mass at the Inactive Flyash Pile/South Field, respectively. The following relationships were observed between various uranium forms:



LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

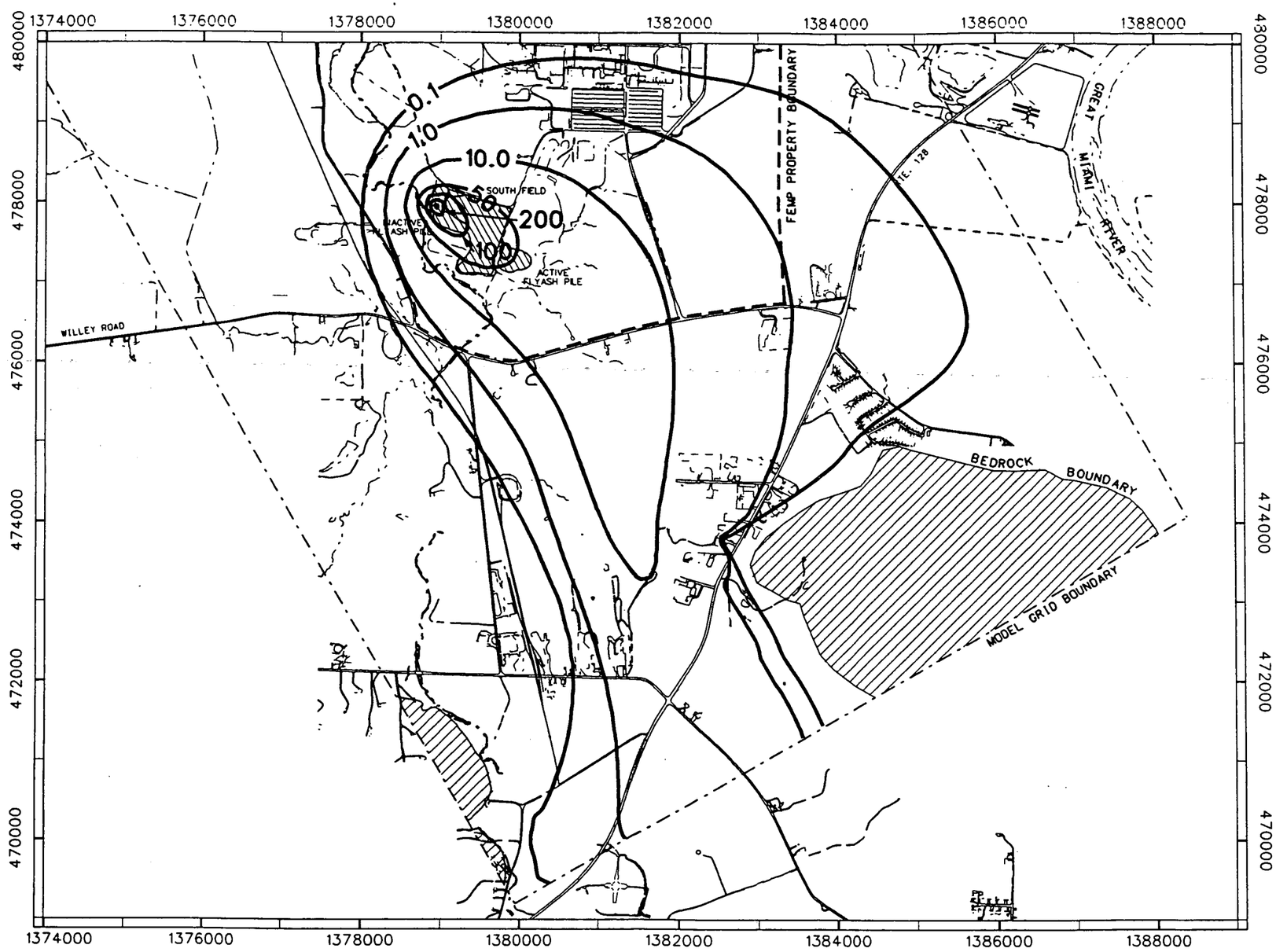
N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 517 pCi/L

fig0521.dgn

FIGURE 5-21
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 160 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD



LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 326 pCi/L

FIGURE 5-22
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 220 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

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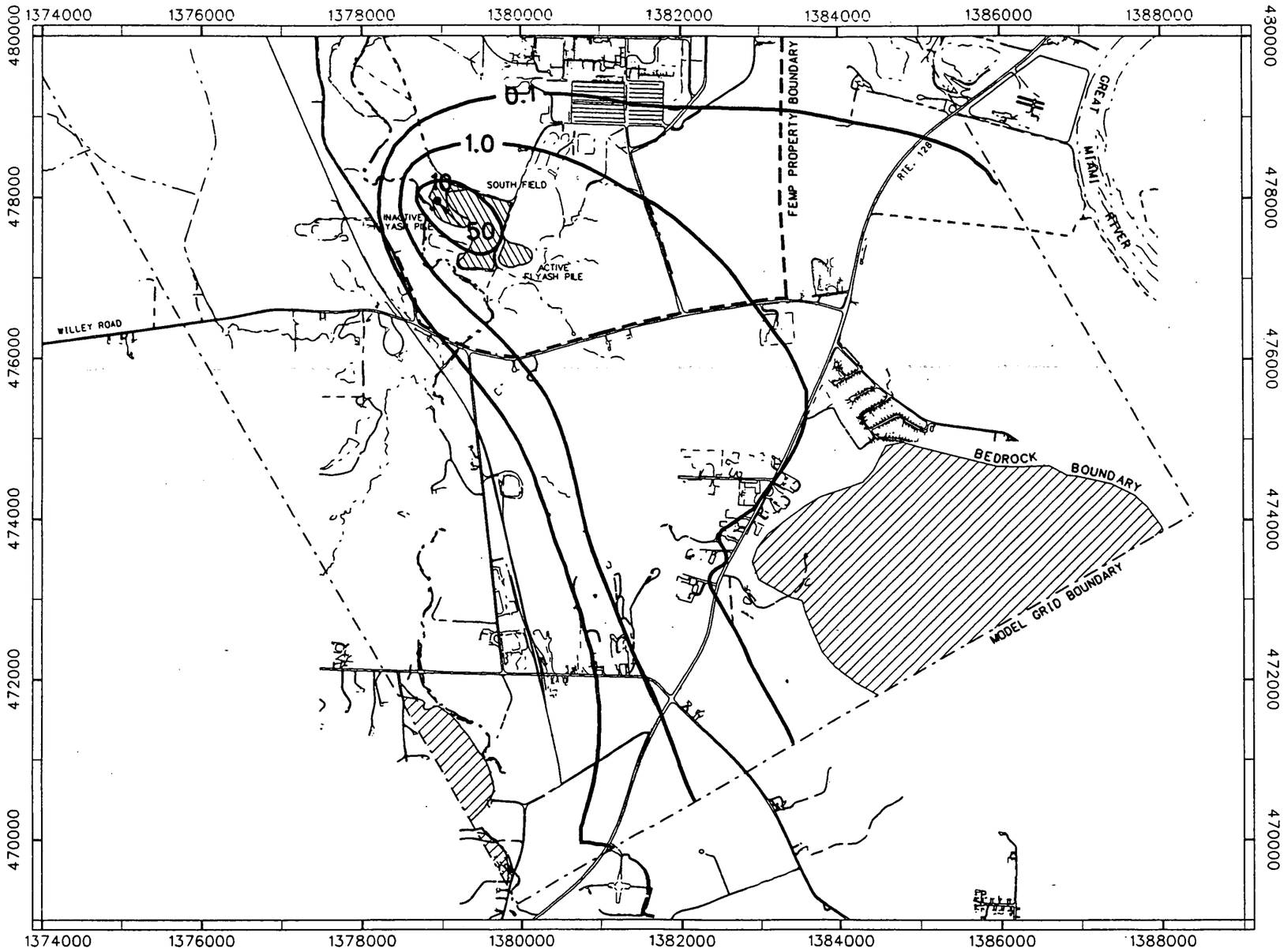

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 57.4 pCi/L

fig0523.dgn

FIGURE 5-23
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

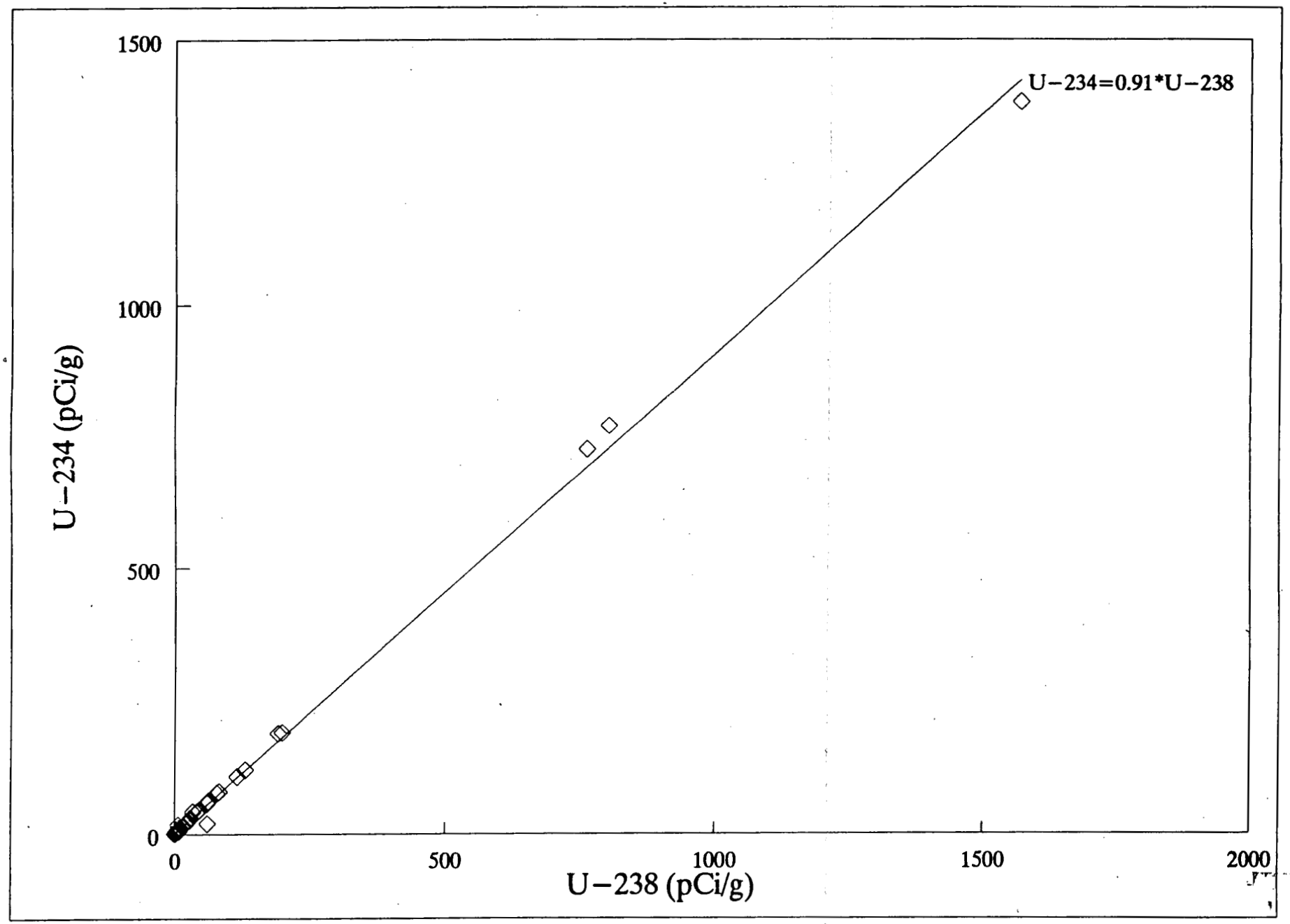

FIGURE 5−24 : U−234 vs. U−238 IN SOIL SAMPLES, SOUTH FIELD & FLYASH PILES

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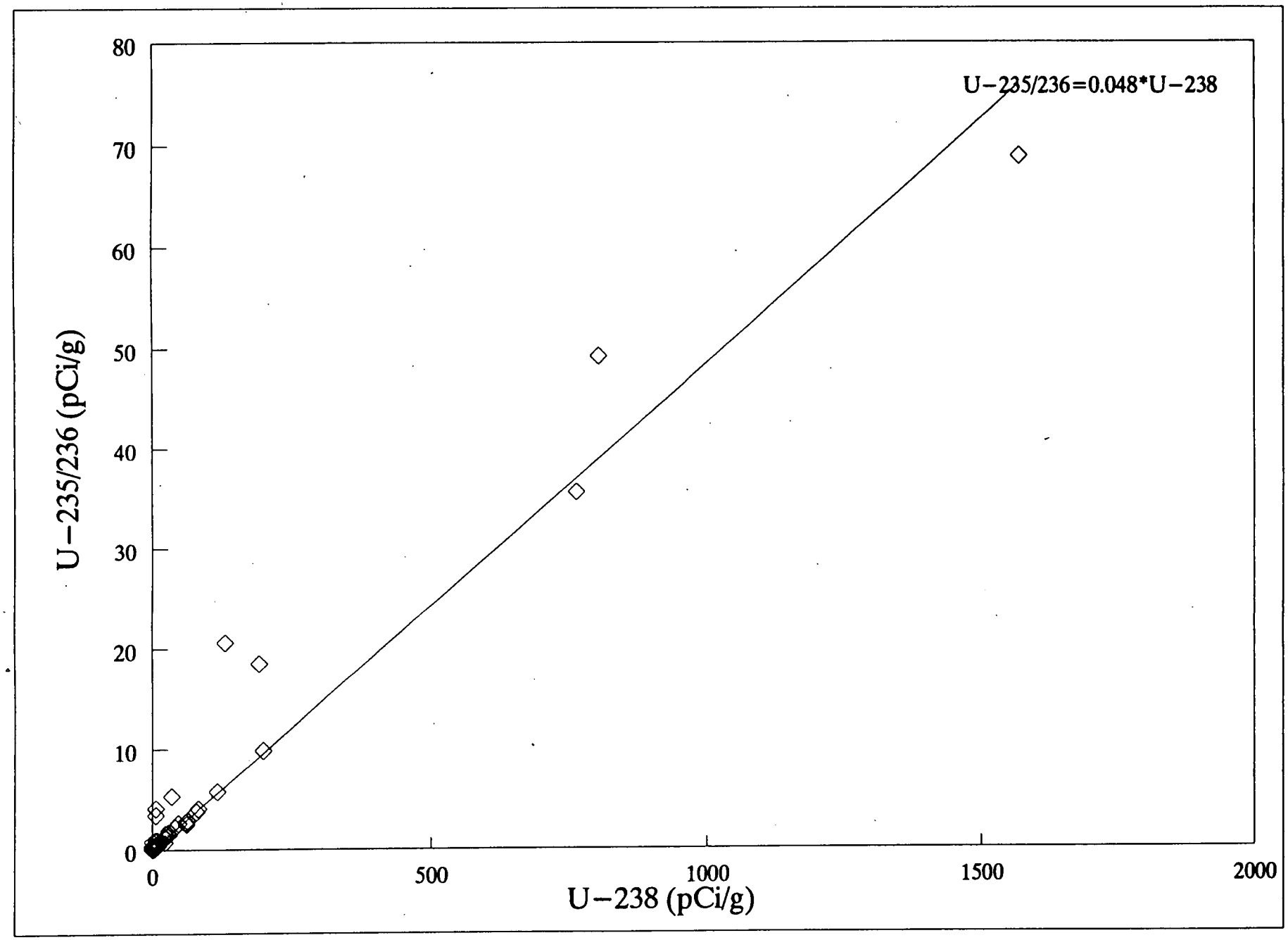

FIGURE 5−25 : U−235/236 vs. U−238 IN SOIL SAMPLES, SOUTH FIELD & FLYASH PILES

000822

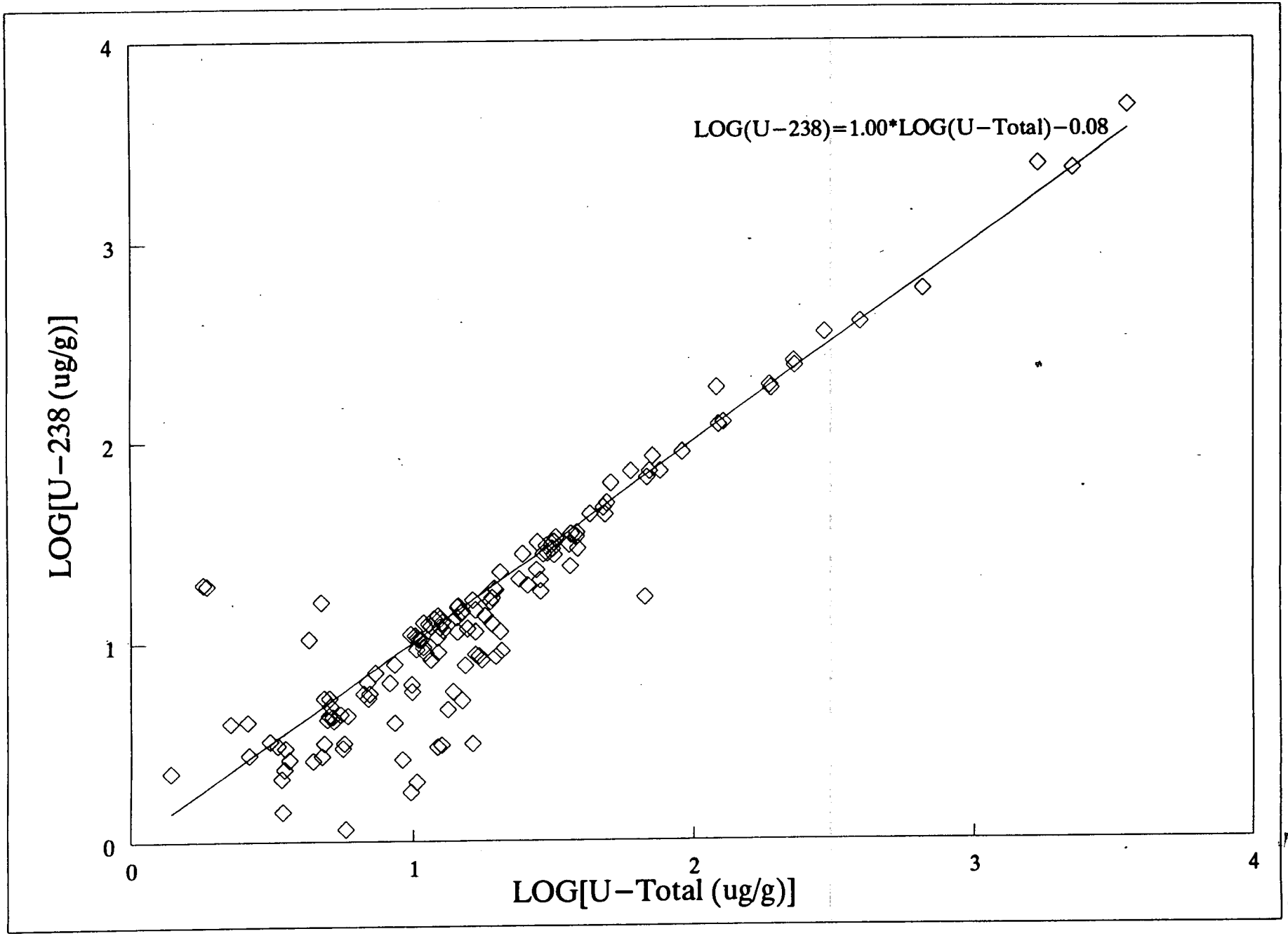

FIGURE 5-26 : U-238 vs. U-TOTAL IN SOIL SAMPLES, SOUTH FIELD & INACTIVE FLYASH PILE

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TABLE 5-38

SUMMARY OF SWIFT MODELING RESULTS FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Levels (pCi/L RAD) (μg/L non-RAD)
RADIONUCLIDES							
Neptunium-237	$1.06 \times 10^{+2}$	40	360	9.33×10^{-1}	540	8.59×10^{-2}	2.16×10^{-2}
Radium-226	1.58×10^{-1}	760	1,000	8.90×10^{-3}	1,000	1.13×10^{-9}	1.76×10^{-4}
Strontium-90	$1.53 \times 10^{+1}$	60	140	2.07×10^{-1}	200	4.48×10^{-3}	1.32×10^{-1}
Technetium-99	$7.72 \times 10^{+2}$	0	40	$1.03 \times 10^{+1}$	40	2.86×10^{0}	$3.65 \times 10^{+0}$
Uranium-234[a]	-[a, b]	0	160	$4.69 \times 10^{+2}$	220	$2.40 \times 10^{+1}$	2.97×10^{-1}
Uranium-235/236[a]	-[a, b]	0	160	$2.50 \times 10^{+1}$	220	1.28×10^{0}	2.97×10^{-1}
Uranium-238	$5.44 \times 10^{+5}$	0	160	$5.17 \times 10^{+2}$	220	$2.65 \times 10^{+1}$	1.70×10^{-1}
Uranium Total - (non-RAD)[a]	-[a, b]	0	160	$1.84 \times 10^{+3}$	220	$9.45 \times 10^{+1}$	$1.09 \times 10^{+1}$
ORGANICS							
2-Methylnaphthalene[c]	$1.98 \times 10^{+1}$	40	360	1.74×10^{-1}	540	1.61×10^{-2}	NA[d]
Benzo(a)anthracene	-[e]	0	1000	3.84×10^{-3}	-[e]	-[e]	2.82×10^{-3}
Benzo(a)pyrene	-[f]	0	1000	2.75×10^{-3}	-[f]	-[f]	2.82×10^{-4}
Benzo(g,h,i)perylene	-[g]	0	1000	1.32×10^{-2}	-[g]	-[g]	NA
Dibenzo(a,h)anthracene	-[e]	0	1000	6.66×10^{-4}	-[e]	-[e]	2.82×10^{-4}
Dieldrin	-[f]	0	1000	8.47×10^{-4}	-[f]	-[f]	1.12×10^{-4}
Phenanthrene	-[g]	0	1000	$4.10 \times 10^{+0}$	-[g]	-[g]	NA
Tributyl phosphate[h]	$3.95 \times 10^{+1}$	60	660	4.01×10^{-1}	1000	3.72×10^{-2}	NA

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TABLE 5-38
(Continued)

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Levels (pCi/L RAD) (μg/L non-RAD)
			INORGANICS				
Arsenic[j]	1.29×10^{-5} [i]	0	1000	3.35×10^{-4}	1,000	8.56×10^{-5}	1.46×10^{-4}
Lead	$5.61 \times 10^{+1}$	200	1,000	4.86×10^{0}	1,000	5.94×10^{-3}	NA[c]
Beryllium[j]	-[i]	0	1000	2.61×10^{-5}	1000	6.73×10^{-6}	2.37×10^{-4}

[a]Results for uranium-234, uranium-235/236, and total uranium were established by using appropriate scaling ratios to uranium-238 results.
[b]ODAST results were not used for SWIFT III modeling and therefore not shown in this table.
[c]Results for 2-Methylnaphathalene were estimated based on the results for Neptunium-237.
[d]NA=No data available to calculate EPA RAGs, Part B screening value.
[e]Benzo(a)anthracene and dibenzo(a,h)anthracene were not modeled using SWIFT III because the concentrations in the Great Miami Aquifer fall below the EPA RAGs, Part B screening concentrations after mixing in the SWIFT III grid cell. The maximum predicted concentration based on 30-ft. wide Paddys Run are reported as the maximum on-site concentration.
[f]The predicted maximum concentration after mixing in the full SWIFT III grid cell is marginally above the EPA RAGs, Part B screening concentration. Therefore, SWIFT III modeling was not performed and the maximum predicted concentration based on 30 feet wide Paddys Run is reported as the maximum on-site concentration.
[g]Benzo(g,h,i)perylene and phenanthrene were not modeled using SWIFT III because EPA RAGs, Part B screening concentrations could not be calculated. Maximum predicted concentration based on 30 feet wide Paddys Run are reported as the maximum on-site concentration.
[h]Results for tributyl phosphate are estimated based on results for CPCs with similar adsorption properties.
[i]The main contribution to the Great Miami Aquifer is from the surface water runoff pathway.
[j]The results are scaled from the SWIFT III modeling results for the Active Flyash Pile because of no impact on overall risk, and the main pathway to the Great Miami Aquifer is the surface water runoff pathway.

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TABLE 5-39

SUMMARY OF SWIFT MODELING RESULTS AT THE TIME AND LOCATION OF THE U-238 MAXIMUM CONCENTRATION FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	On-Site Concentration at 160 Years (pCi/L RAD) (μg/L non-RAD)	Concentration at the FEMP Boundary at 220 Years (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Levels (pCi/L RAD) (μg/L non-RAD)
RADIONUCLIDES			
Neptunium-237	1.90×10^{-2}	2.81×10^{-4}	2.16×10^{-2}
Radium-226	0.0	0.0	1.76×10^{-4}
Strontium-90	2.72×10^{-2}	2.26×10^{-3}	1.32×10^{-1}
Technetium-99	1.82×10^{0}	9.81×10^{-1}	$3.65 \times 10^{+0}$
Uranium-234[a]	$4.69 \times 10^{+2}$	$2.40 \times 10^{+1}$	2.97×10^{-1}
Uranium-235/236[a]	$2.50 \times 10^{+1}$	1.28×10^{0}	2.97×10^{-1}
Uranium-238	$5.17 \times 10^{+2}$	$2.65 \times 10^{+1}$	1.70×10^{-1}
Uranium - Total (non-RAD)[a]	$1.84 \times 10^{+3}$	$9.45 \times 10^{+1}$	$1.09 \times 10^{+1}$
ORGANICS			
2-Methylnaphthalene	3.55×10^{-3}	5.25×10^{-5}	NA[b]
Benzo(g,h,i)perylene	0.0	0.0	NA
Phenanthrene	0.0	0.0	NA
Tributyl phosphate	1.67×10^{-1}	3.11×10^{-6}	NA
INORGANICS			
Arsenic	0.0	0.0	1.46×10^{-4}
Lead	$1.43 \times 10^{+0}$	2.05×10^{-14}	NA

[a]Uranium-234, uranium-235/236, and total uranium were modeled by applying ratios to uranium-238 results.

[b]NA = Note data available to calculate EPA RAGs, Part B screening value.

Uranium-234 = 0.91 (Uranium-238)	activity ratio
Uranium-235/236 = 0.048 (Uranium-238)	activity ratio
Uranium-238 = 0.832 (Uranium-total)	mass ratio at Inactive Flyash Pile/South Field

The uranium-238 vs. total uranium relationship was used a limited number of times when total uranium analysis was available for a soil but uranium-238 analysis was not available. The total uranium analysis is not as accurate as the isotope analysis. Therefore, while converting modeled uranium-238 results to total uranium results, total uranium concentration was calculated by adding all uranium isotope concentrations. This is equivalent to assuming 99.25 percent of total uranium consists of uranium-238. This is consistent with naturally occurring uranium distribution. Although these relationships were developed from soil samples, these relationships should apply to uranium concentrations in the groundwater because all uranium isotopes have very long half-lives (greater than 10,000 years) and have similar adsorption properties. These relationships can be used to estimate uranium-234, uranium-235/256, and total uranium concentrations.

Constituents projected to be above screening levels when they reach the Great Miami Aquifer directly beneath the Inactive Flyash Pile and South Field subunits were the uranium isotopes (uranium-234, uranium-235/236, and uranium-238), neptunium-237, radium-226, strontium-90, technetium-99, antimony, cadmium, lead, manganese, and molybdenum. Only uranium isotopes (uranium-234, uranium-235/236, and uranium-238), total uranium, neptunium-237, technetium-99, lead, and manganese were projected to exceed screening levels in the Great Miami Aquifer. Of these CPCs; only uranium isotopes, total uranium, neptunium-237, and technetium-99 were projected to exceed screening levels at the FEMP boundary. Contour plots were made for these CPCs at different time periods and are presented in Appendix A-2 along with the loading curves. Contour plots at the maximum CPC concentration in the Great Miami Aquifer and at 1,000 years are shown in Figures 5-27 through 5-31. As an example, Figure 5-27 depicts a plume of neptunium-237 in groundwater moving towards the southeastern boundary of the FEMP. Contour plots show projected increases in the CPCs' concentrations and do not take into account the background concentrations or contributions from other FEMP sources. Figure 5-28 shows two contours for 6.1×10^{-3} pCi/L Neptunium-237 concentration. This is due to early breakthrough time from some SWIFT cells and late breakthrough time from other SWIFT cells (see Figure A.2-27). The downgradient 6.1×10^{-3} pCi/L contour is related to early breakthrough while 6.1×10^{-3} pCi/L contour in the South Field vicinity is due to late breakthrough.

5.4.4.4 Active Flyash Pile

The groundwater fate and transport modeling results are summarized in Table 5-40 for CPCs that will reach the Great Miami Aquifer from the Active Flyash Pile. The table also presents the arrival time for CPCs in the aquifer, the maximum loading concentration, the maximum concentration of the CPC that could be expected in the aquifer within 1,000 years, and the time required for the CPC to reach the maximum value. CPCs projected to be above screening levels as they reach the Great Miami Aquifer directly beneath the Active Flyash Pile were uranium isotopes (uranium-238, uranium-234, and uranium-235/236), total uranium, neptunium-237, strontium-90, plutonium-238, plutonium-239/240, arsenic, and beryllium. Although all CPCs are above screening concentrations, only neptunium-237, uranium isotopes, arsenic, and beryllium are expected to be above screening concentrations at the FEMP boundary.

As noted earlier, total uranium, uranium-234, and uranium-235/236 concentrations were estimated from the results of uranium-238 modeling. Figure 5-34 shows the site-specific relationships between uranium-238 and total uranium at the Active Flyash Pile. Figure 5-34 shows that 91 percent of total uranium mass consists of uranium-238. The uranium-238 vs. total uranium relationship was used a limited number of times when total uranium analysis was available for a soil but uranium-238 analysis was not available. Relationships of uranium-238 with uranium-234 and uranium-235/236 are shown in Figures 5-24 and 5-25. These relationships were used to estimate uranium-234, uranium-235/236, and total uranium concentrations.

Uranium isotopes, neptunium-237, arsenic and beryllium concentrations are significantly elevated compared to the screening concentrations and may control the overall risk from groundwater pathway. Table 5-41 presents on-site and off-site concentrations of CPCs at uranium-238 maximum concentration location and time. Loading curves and contour plots for CPCs at different time periods are presented in Appendix A-2. Contour plots at the maximum CPC concentration in the Great Miami Aquifer and at 1,000 years are shown in Figures 5-35 through 5-42. All concentration contours show a southerly migration from the Active Flyash Pile. For uranium-238 and neptunium-237, the peak and most of the contaminant loading occurs before 400 years. Therefore, the center of the plume, as shown in Figures A.2-48 and A.2-53, has moved off the Active Flyash Pile at 1000 years.

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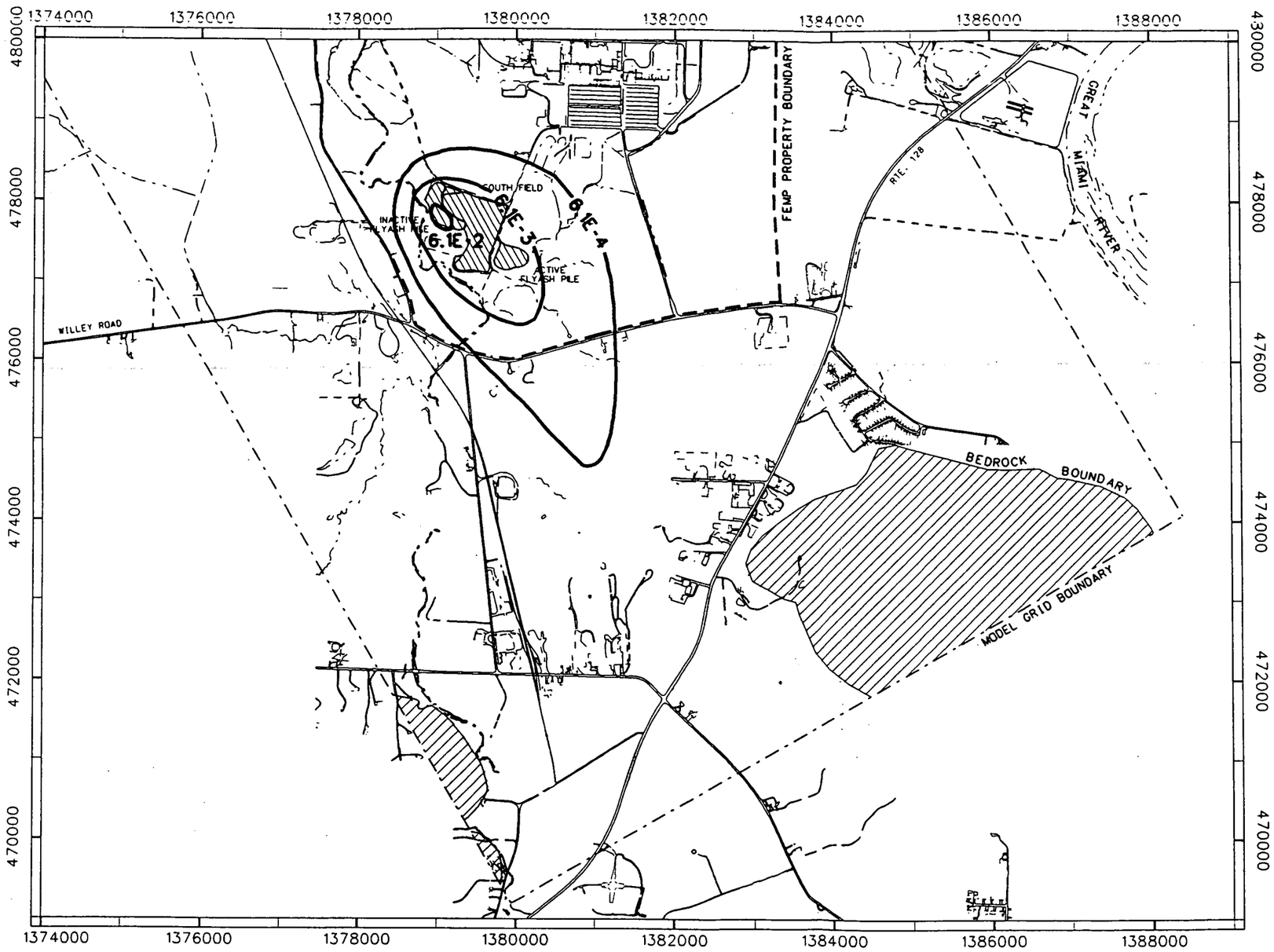

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- NEPTUNIUM-237 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 0.92 pCi/L

FIGURE 5-27
PROJECTED INCREASE IN NEPTUNIUM-237 CONCENTRATION IN GREAT MIAMI AQUIFER AT 360 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

fig0524.dgn

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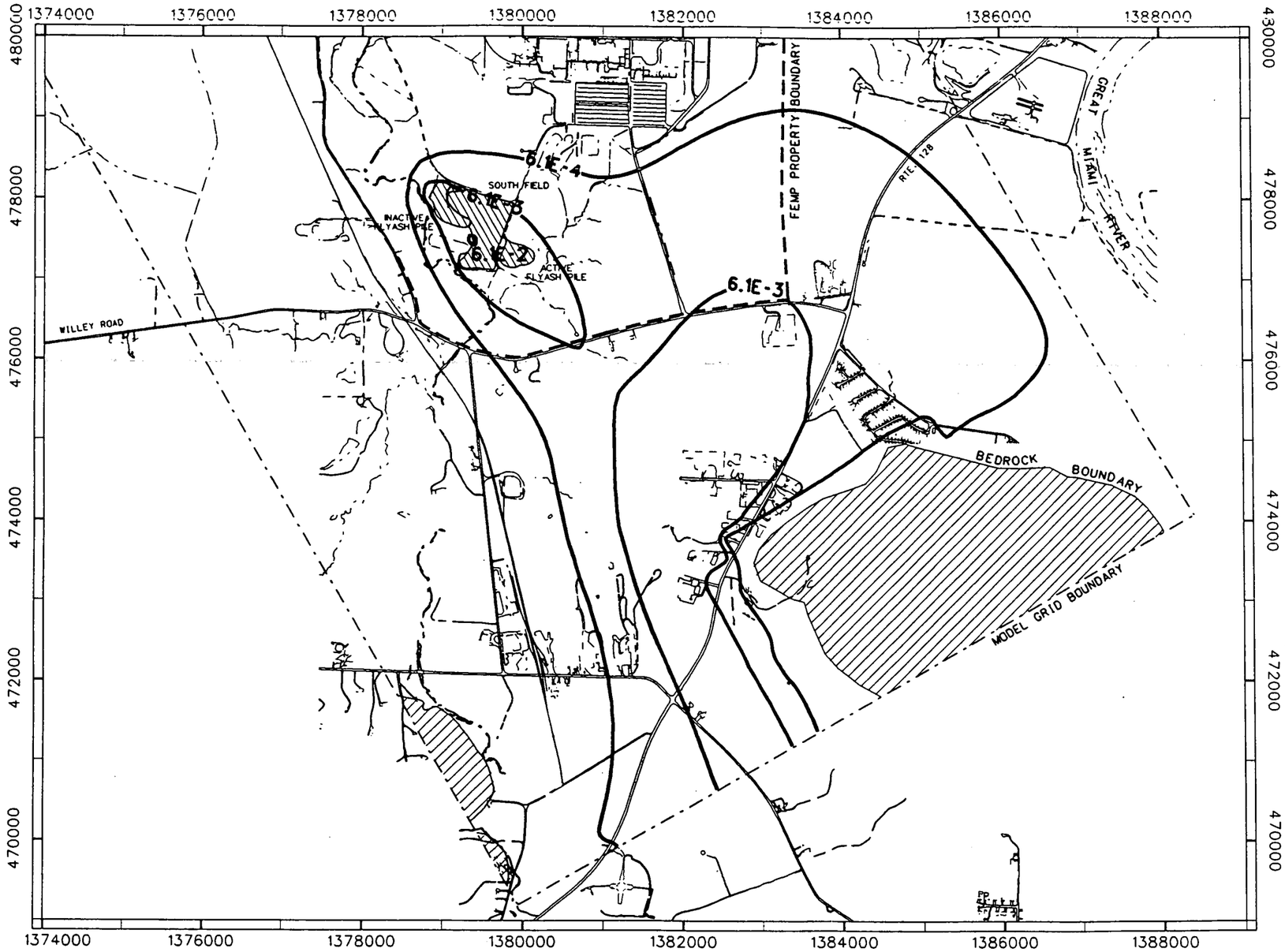


LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — NEPTUNIUM-237 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

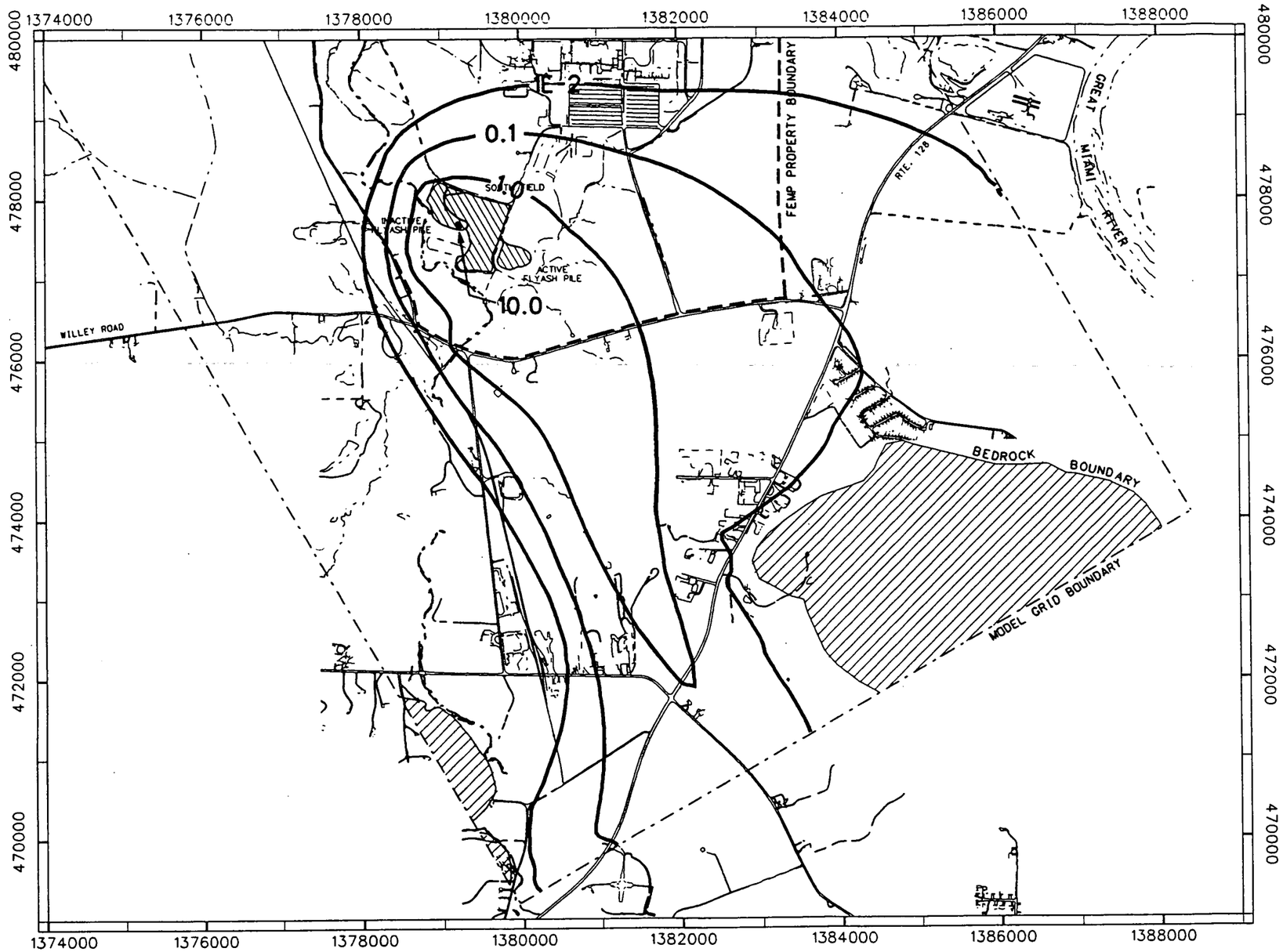
N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 0.079 pCi/L

FIGURE 5-28
PROJECTED INCREASE IN NEPTUNIUM-237 CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

fig0525.dgn



LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — TECHNETIUM-99 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 10.3 pCi/L

fig0526.dgn

FIGURE 5-29
PROJECTED INCREASE IN TECHNETIUM-99 CONCENTRATION IN GREAT MIAMI AQUIFER AT 40 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

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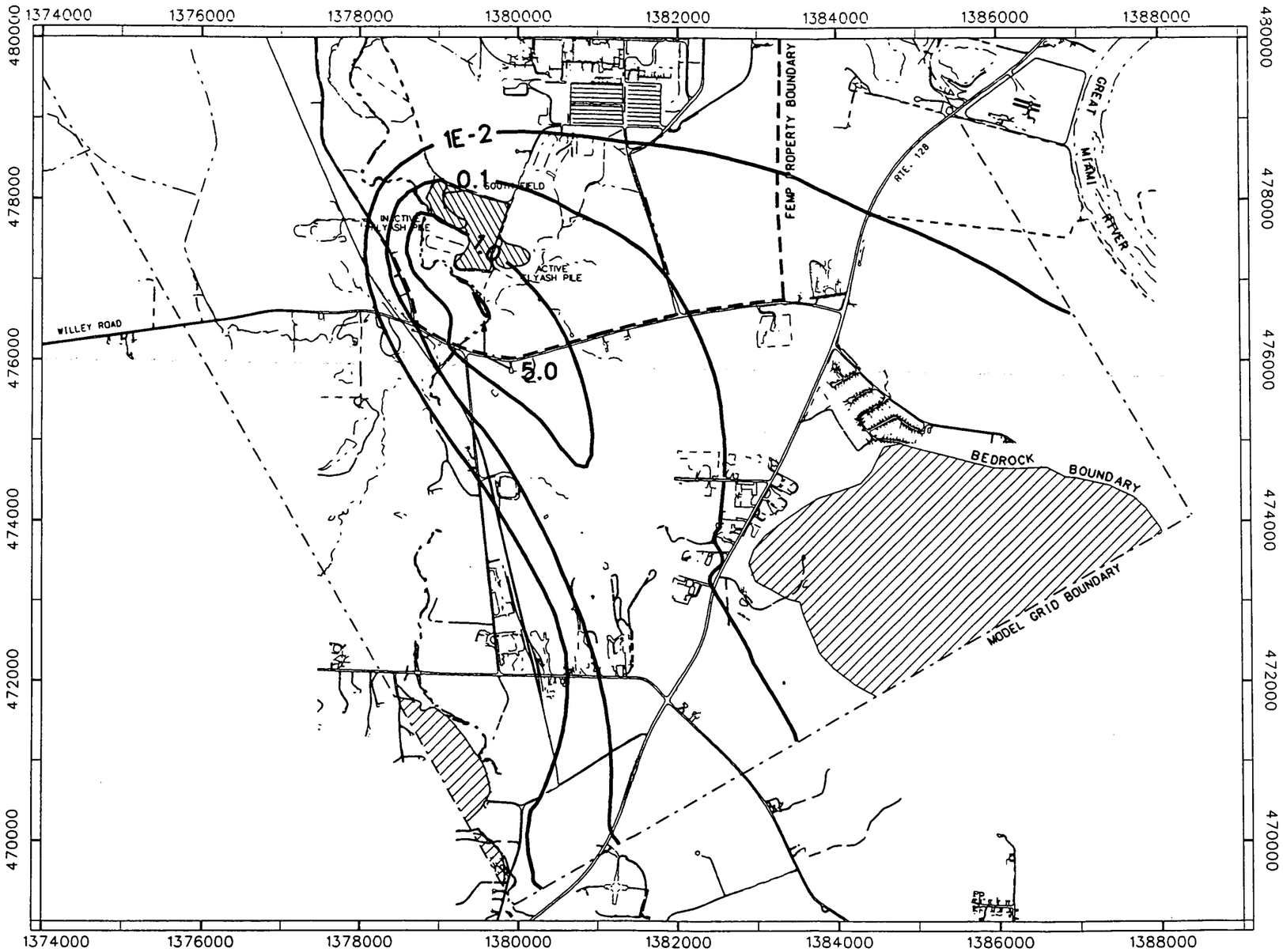

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — TECHNETIUM-99 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 5.4 pCi/L

FIGURE 5-30
PROJECTED INCREASE IN TECHNETIUM-99 CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

fig0527.dgn

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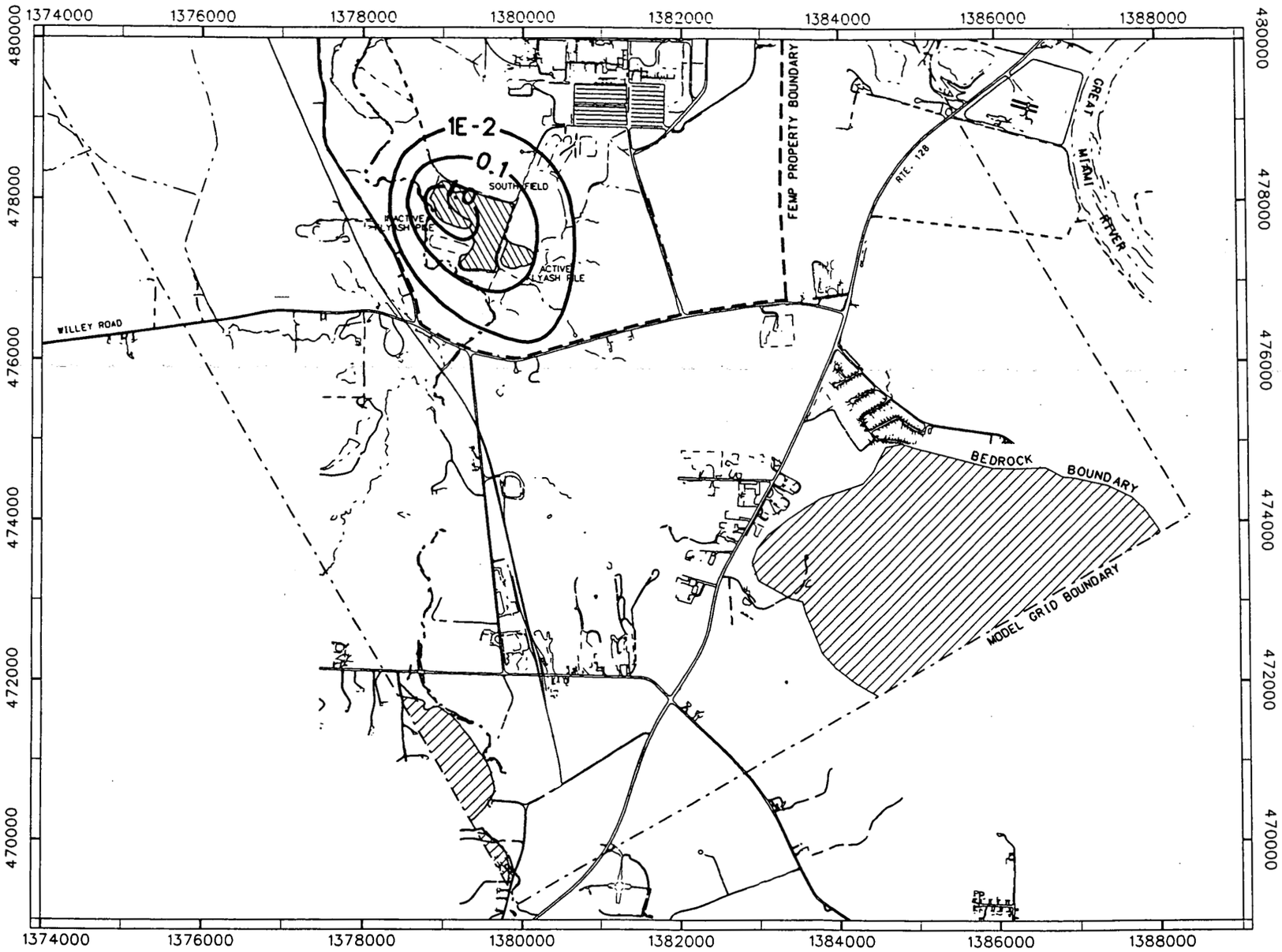

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — LEAD CONCENTRATION CONTOUR (ug/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

FIGURE 5-31
PROJECTED INCREASE IN LEAD CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

MAXIMUM INCREASE IN CONCENTRATION = 4.86 ug/L

fig0528.dgn

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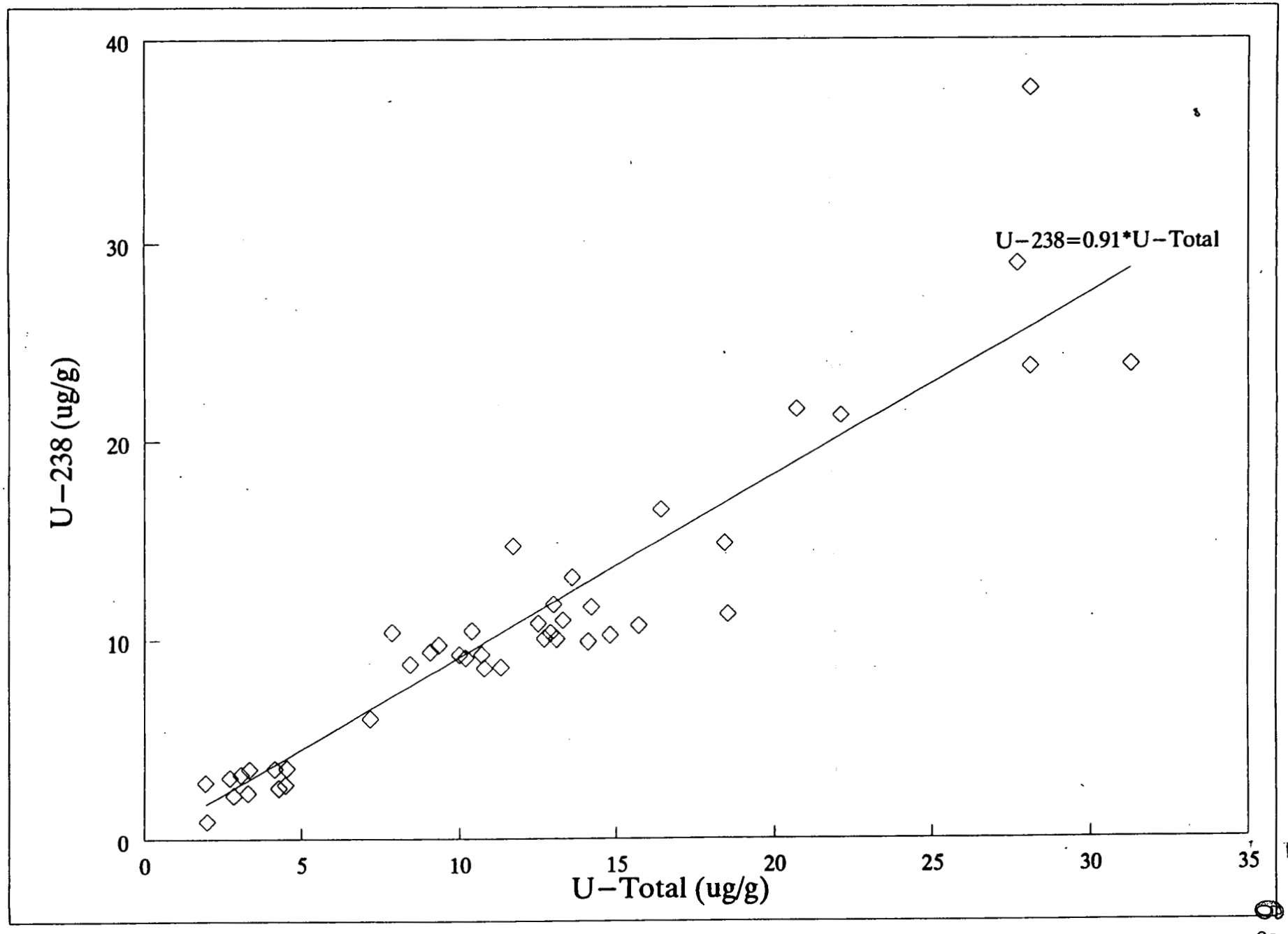

FIGURE 5−34 : U−238 vs. U−TOTAL IN SOIL SAMPLES, ACTIVE FLYASH PILE

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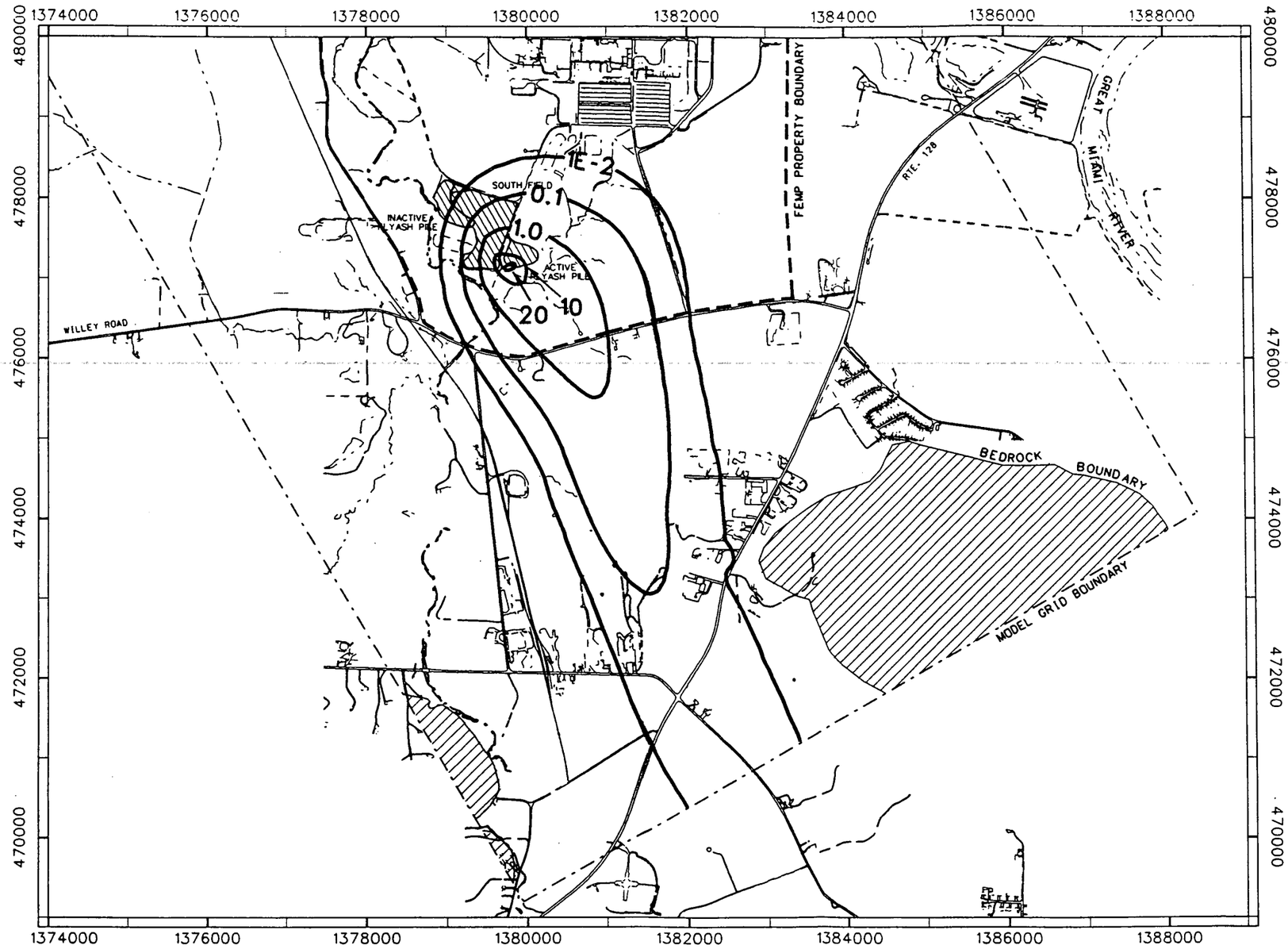


LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

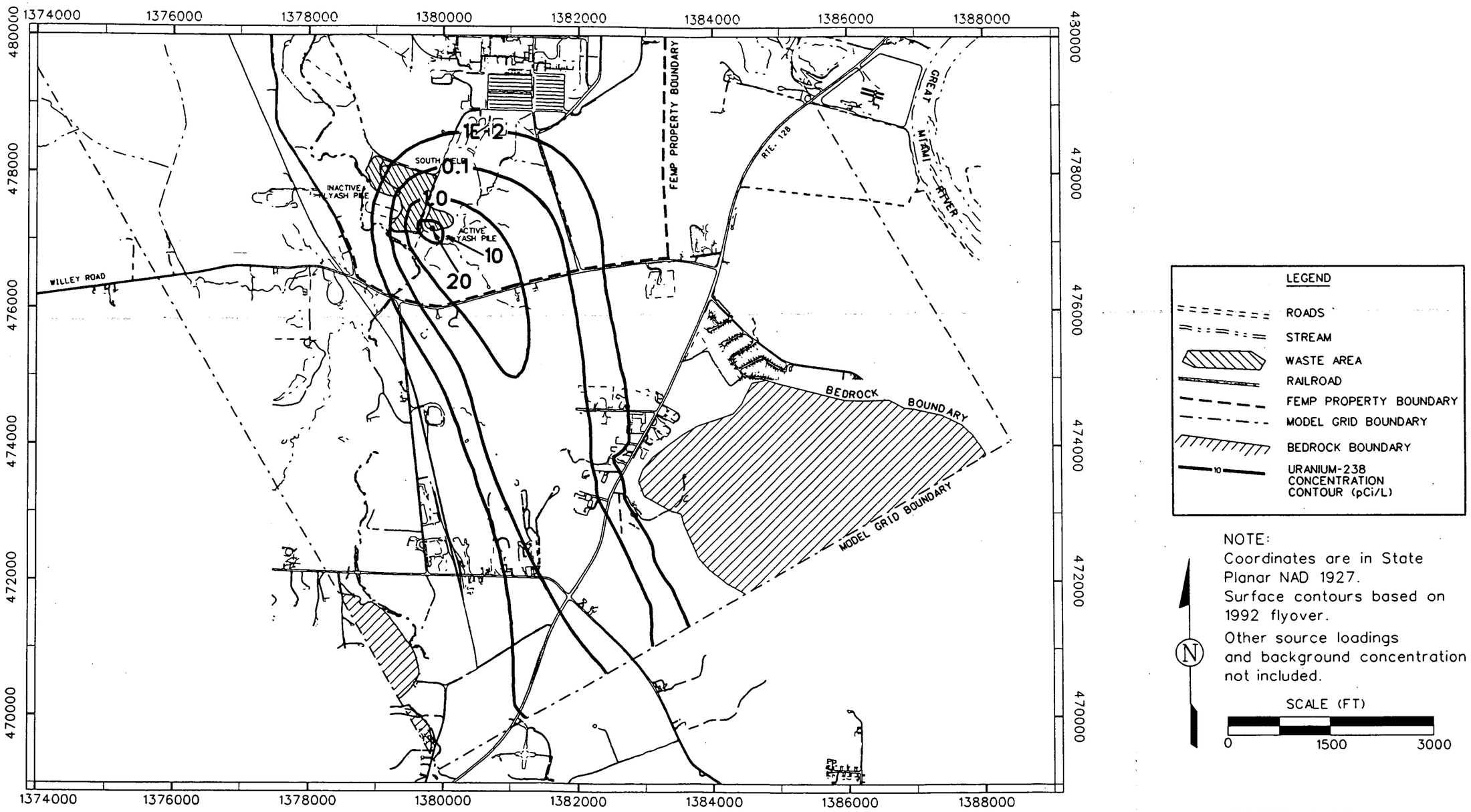
N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 21.8 pCi/L

FIGURE 5-35
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 100 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

fig0536.dgn



MAXIMUM INCREASE IN CONCENTRATION = 21.4 pCi/L

FIGURE 5-36
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 120 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

fig0537.dgn

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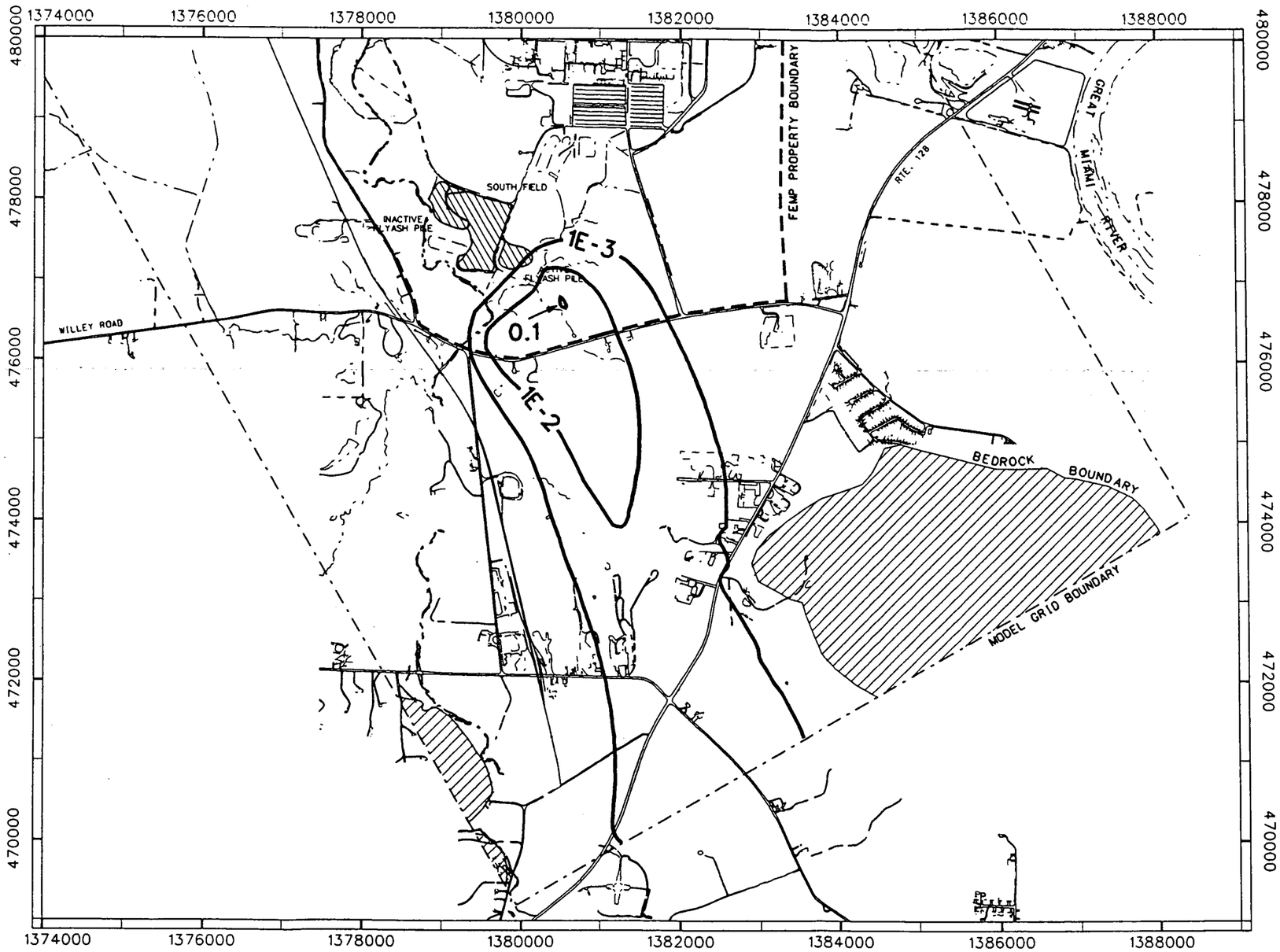


LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

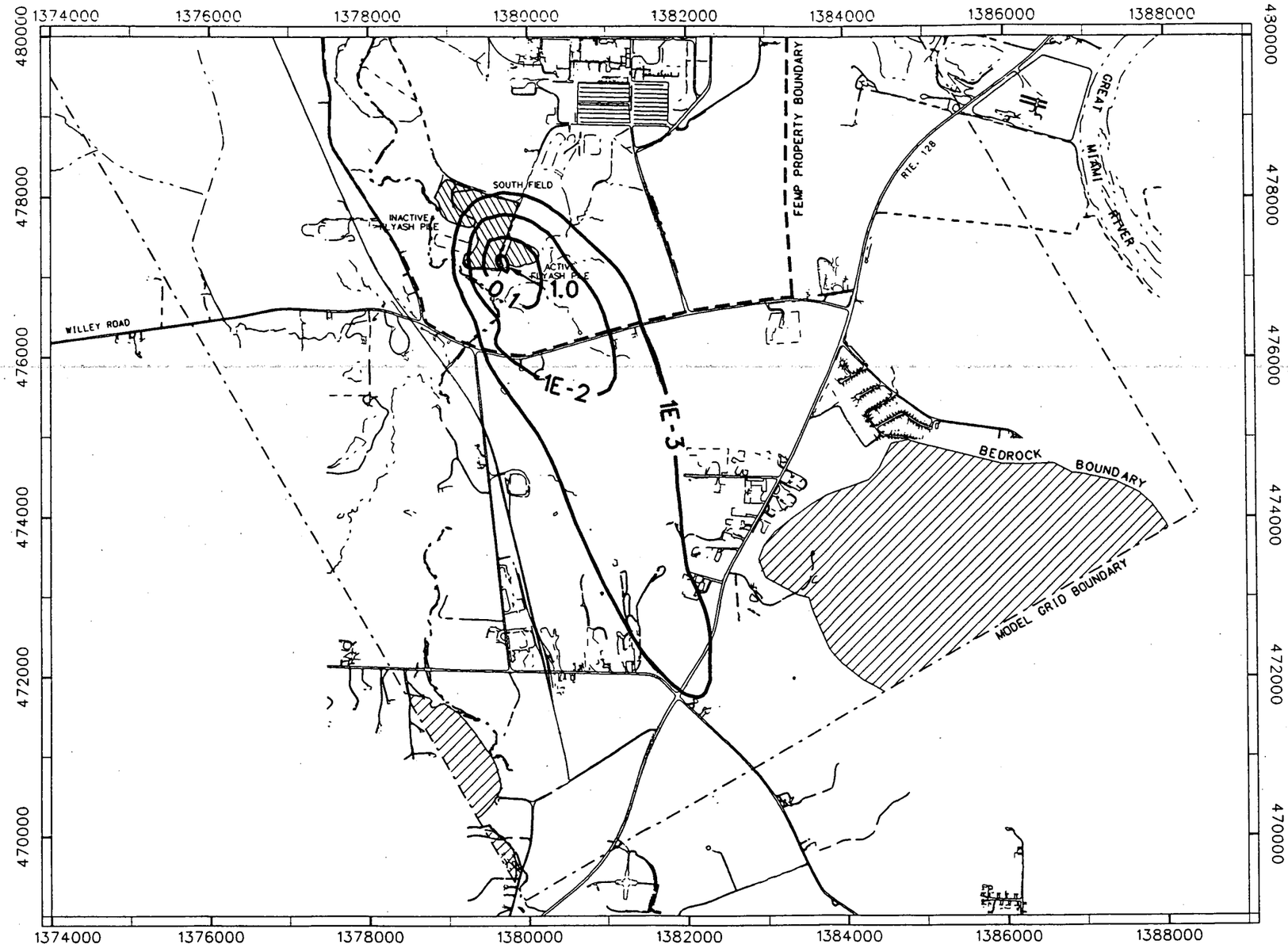
N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 0.11 pCi/L

FIGURE 5-37
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

fig0538.dgn



LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — NEPTUNIUM-237 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 1.52 pCi/L

fig05.39.dgn

FIGURE 5-38
PROJECTED INCREASE IN NEPTUNIUM-237 CONCENTRATION IN GREAT MIAMI AQUIFER AT 160 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

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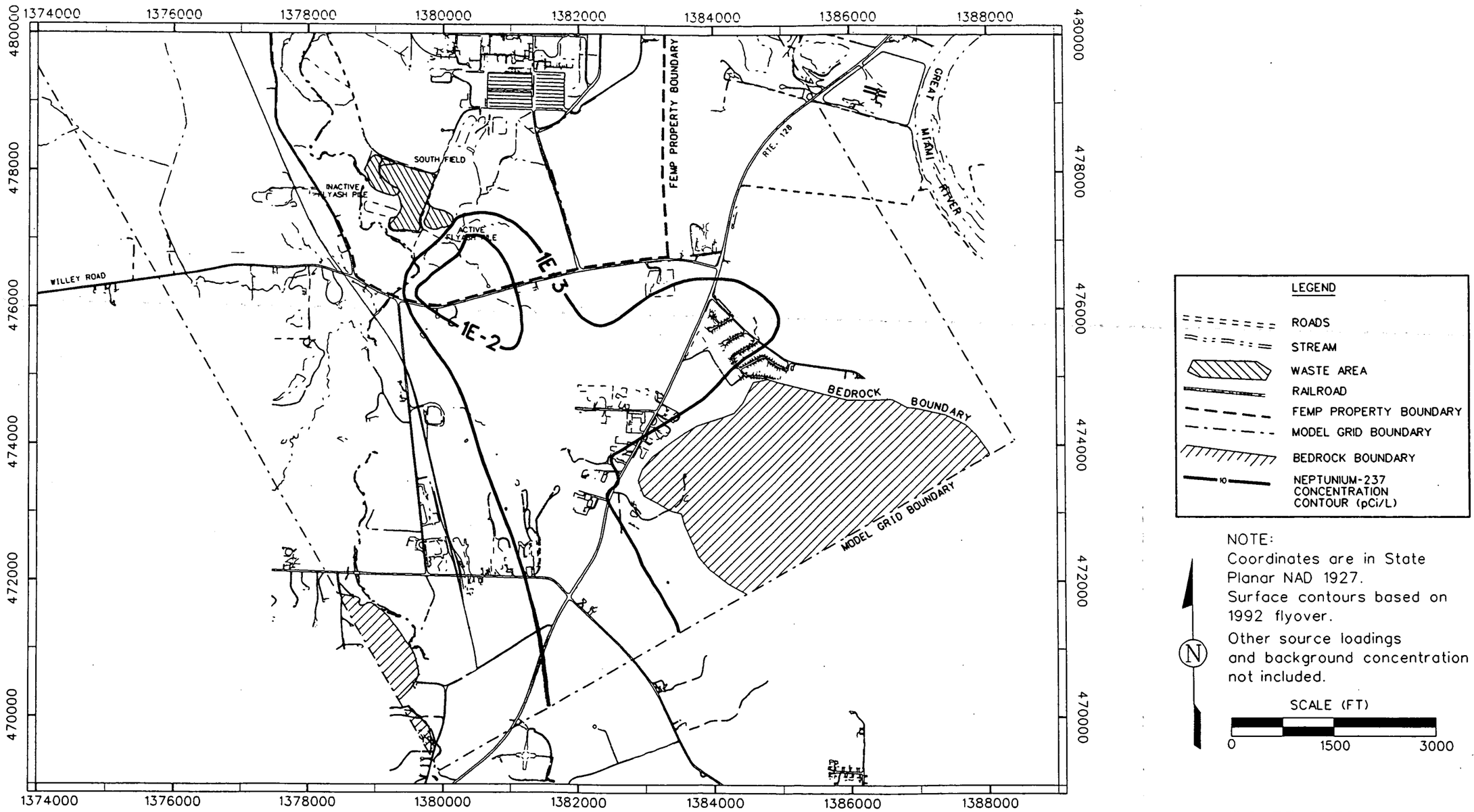

MAXIMUM INCREASE IN CONCENTRATION = 0.054 pCi/L

FIGURE 5-39
PROJECTED INCREASE IN NEPTUNIUM-237 CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

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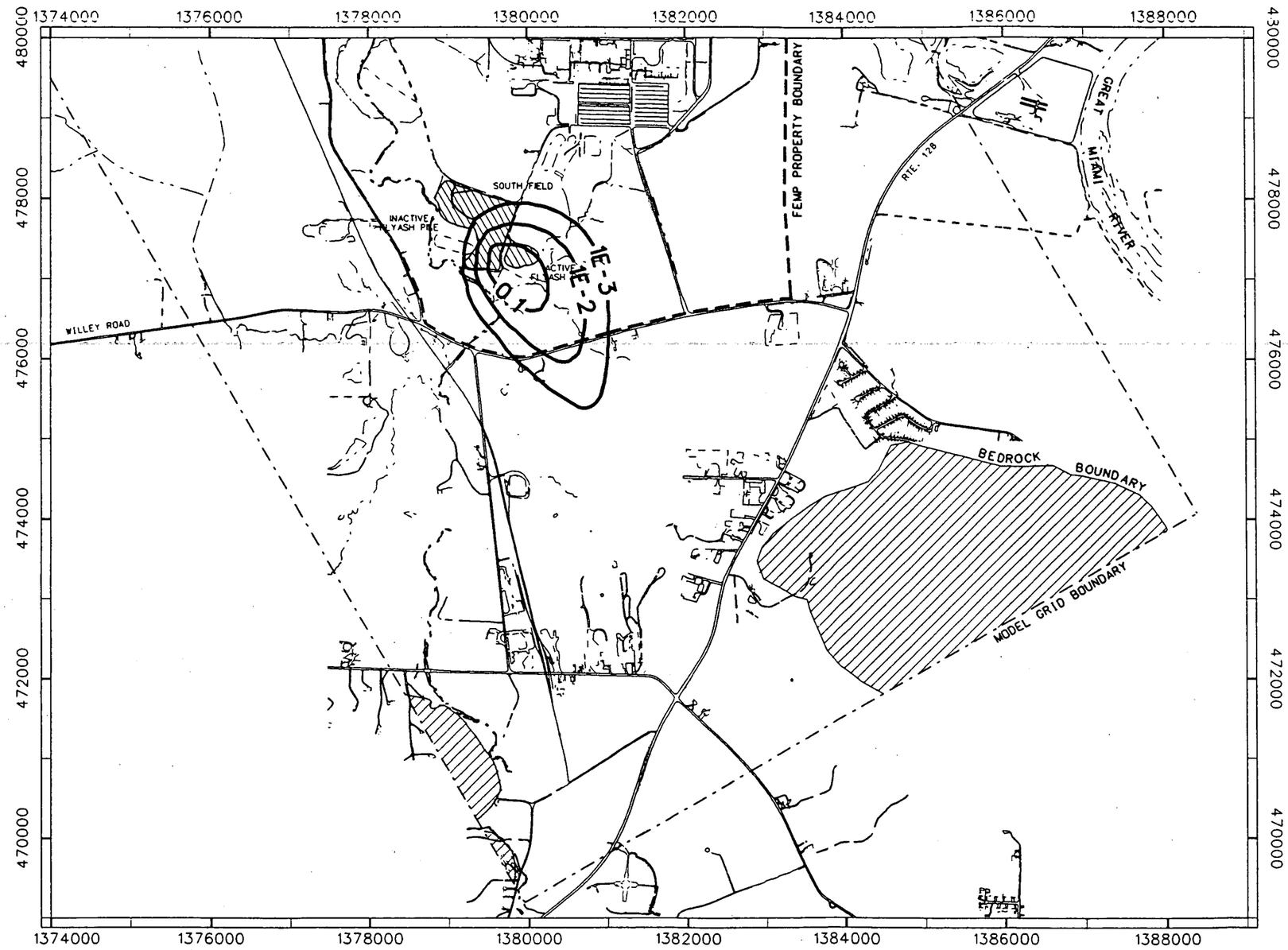

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — STRONTIUM-90 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 1.0 pCi/L

FIGURE 5-40
PROJECTED INCREASE IN STRONTIUM-90 CONCENTRATION IN GREAT MIAMI AQUIFER AT 100 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

fig0548.dgn

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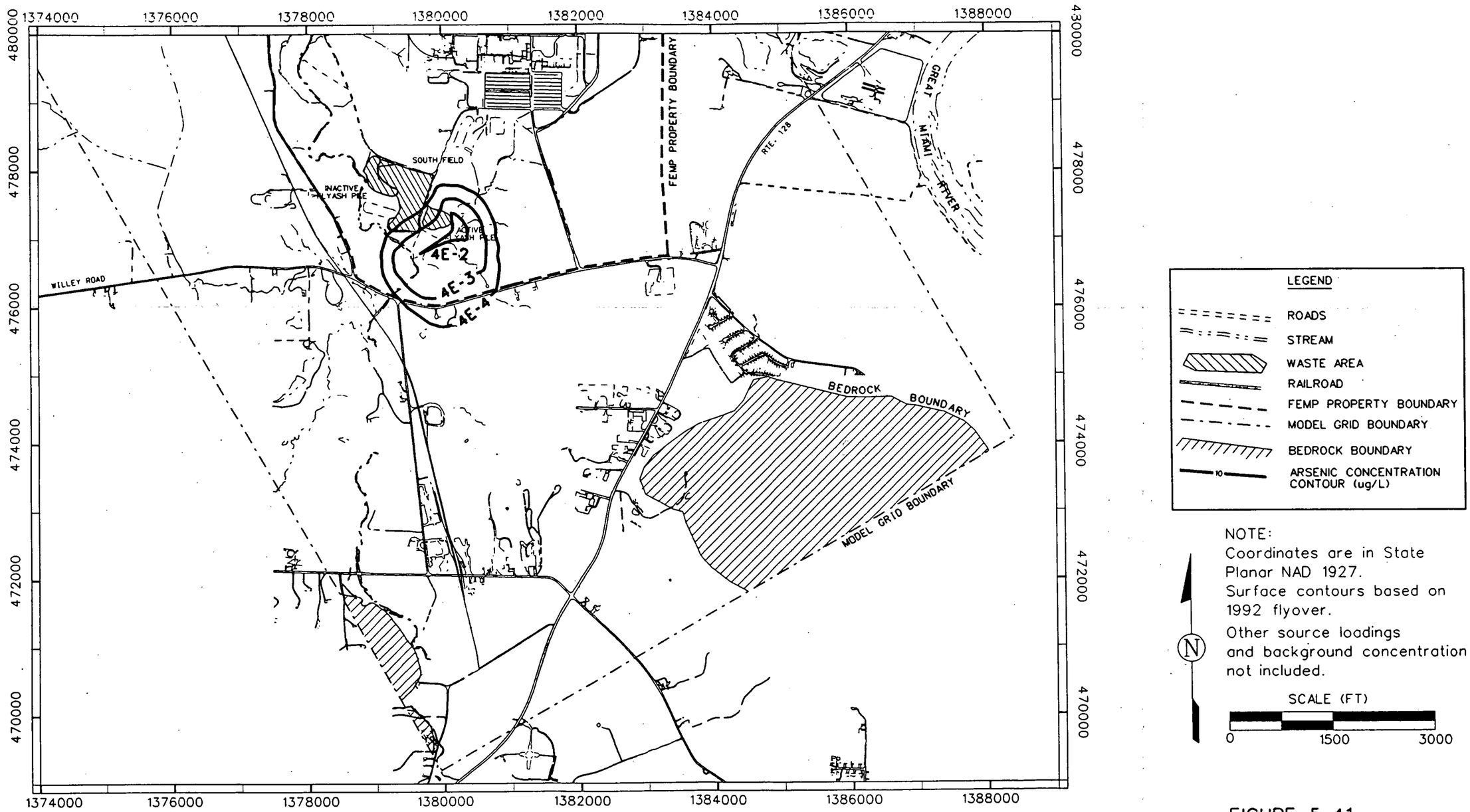

MAXIMUM INCREASE IN CONCENTRATION = 0.072 ug/L

FIGURE 5-41
PROJECTED INCREASE IN ARSENIC CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

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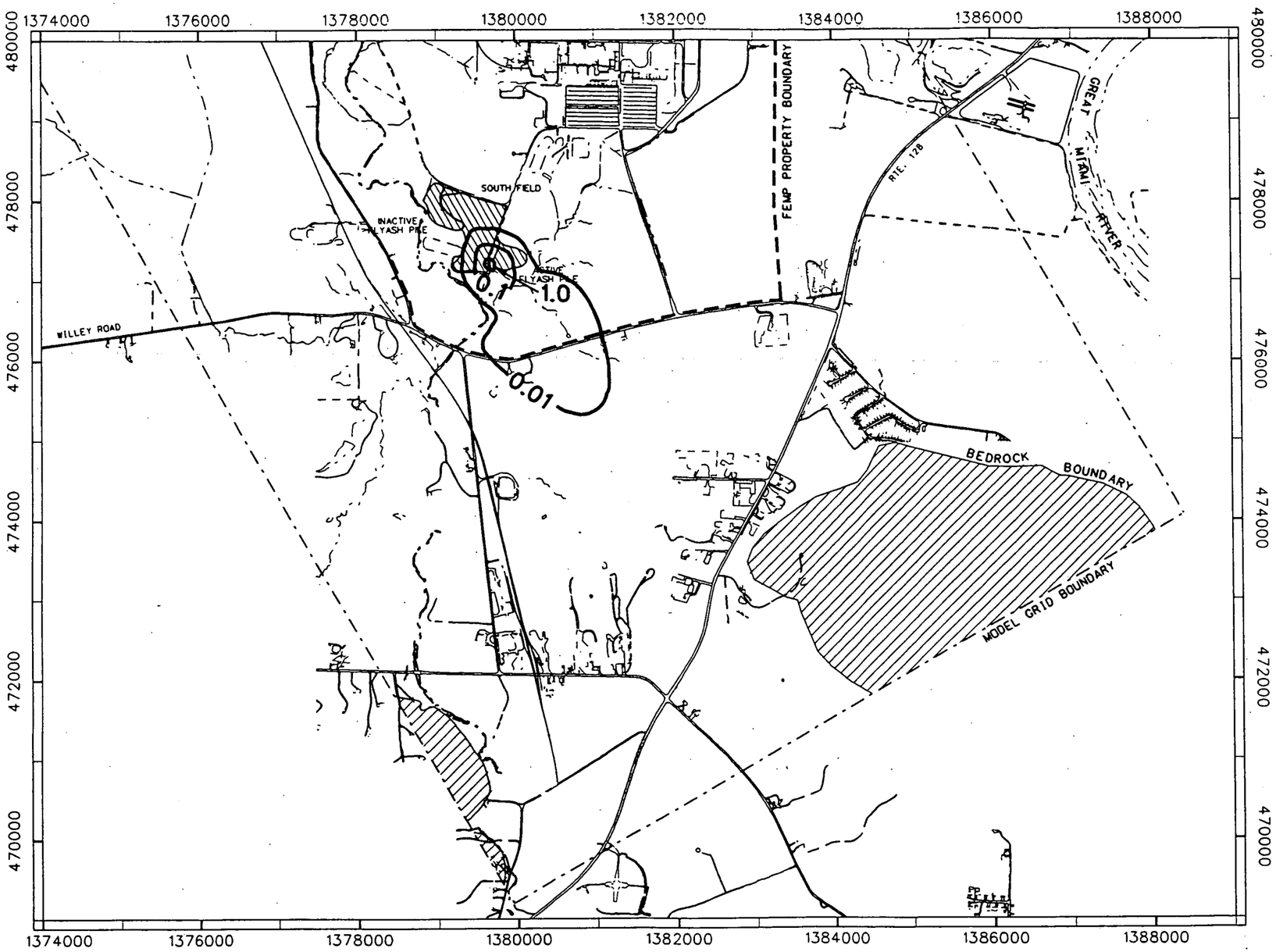

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- LEAD CONCENTRATION CONTOUR (ug/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 1.6 ug/L

FIGURE 5-42
PROJECTED INCREASE IN LEAD CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

fig0542.dgn

TABLE 5-40

SUMMARY OF SWIFT MODELING RESULTS FOR THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Hazard Index Screening Levels (pCi/L RAD) (μg/L non-RAD)
RADIONUCLIDES							
Neptunium-237	$3.28 \times 10^{+1}$	0	160	$1.52 \times 10^{+1}$	280	1.63×10^{-1}	2.16×10^{-2}
Plutonium-238	-[c]	0	1000	5.61×10^{-2}	-[c]	-[c]	2.16×10^{-2}
Plutonium-239/240	-[c]	0	1000	2.57×10^{-2}	-[c]	-[c]	2.07×10^{-2}
Radium-226[c]	-[c]	0	1000	3.37×10^{-1}	-[c]	-[c]	1.76×10^{-4}
Radium-228[c]	-[c]	0	1000	2.34×10^{-1}	-[c]	-[c]	4.75×10^{-2}
Strontium-90	$1.79 \times 10^{+1}$	60	100	1.02×10^{0}	160	8.92×10^{-2}	1.32×10^{-1}
Uranium-234[a]	-[a, b]	0	100	$1.98 \times 10^{+1}$	120	2.58×10^{0}	2.97×10^{-1}
Uranium-235/236[a]	-[a, b]	0	100	1.05×10^{0}	120	1.38×10^{-1}	2.97×10^{-1}
Uranium-238	$4.87 \times 10^{+2}$	0	100	$2.18 \times 10^{+1}$	120	2.85×10^{0}	1.70×10^{-1}
Uranium - Total (non-RAD)[a]	-[a, b]	0	100	$7.76 \times 10^{+1}$	120	$1.02 \times 10^{+1}$	$1.09 \times 10^{+1}$
ORGANICS							
2-Methylnapthalene[e]	-[e]	-[e]	-[e]	$1.95 \times 10^{+0}$	-[e]	$1.95 \times 10^{+0}$	NA[d]

See footnotes at end of table

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TABLE 5-40
(Continued)

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Hazard Index Screening Levels (pCi/L RAD) (μg/L non-RAD)
INORGANICS							
Arsenic	N/A[f]	0	1,000	7.12×10^{-2}	1,000	1.82×10^{-2}	1.46×10^{-4}
Beryllium	N/A	0	1,000	2.75×10^{-3}	1,000	7.08×10^{-4}	2.37×10^{-4}
Lead	$2.87 \times 10^{+1}$	0	1,000	1.64×10^{0}	1,000	3.47×10^{-2}	NA[d]

[a]Uranium-234, uranium-235/236, and total uranium were modeled by applying ratios to uranium-238 results.
[b]ODAST results were not used for SWIFT III modeling and therefore not shown in this table.
[c]Plutonium-238, plutonium-239/240, radium-226, and radium-228, were not modeled using SWIFT III because concentrations in the Great Miami Aquifer falls below the EPA RAGs, Part B screening concentration after mixing in SWIFT III grid cell. The maximum predicted concentration based on the Storm Sewer Outfall Ditch width of 10 feet is reported as the maximum on-site concentration.
[d]NA - No data available to calculate EPA RAGs, Part B screening value for lead and 2-methylnaphthalene
[e]2-Methylnaphthalene was not modeled using ODAST/SWIFT because EPA RAGs, Part B screening value cannot be calculated. Reported concentrations are same as predicted leachate values. If concentrations are needed for risk assessment in future, ODAST/SWIFT model or equivalent should be used to calculate the concentration in the Great Miami Aquifer.
[f]N/A = Not applicable because arsenic and beryllium did not have loading from the vadose zone pathway. The only loading for arsenic and beryllium was from the surface runoff pathway.

TABLE 5-41

SUMMARY OF SWIFT MODELING RESULTS AT THE TIME AND LOCATION OF THE U-238 MAXIMUM CONCENTRATION FOR THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituents of Potential Concern	On-Site Concentration at 100 Years (pCi/L RAD) (μg/L non-RAD)	Concentration at the FEMP Boundary at 120 Years (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Levels (pCi/L RAD) (μg/L non-RAD)
RADIONUCLIDES			
Neptunium-237	3.14×10^{-4}	2.52×10^{-2}	2.16×10^{-2}
Strontium-90	5.47×10^{-1}	5.19×10^{-2}	1.32×10^{-1}
Uranium-234[a]	$1.98 \times 10^{+1}$	2.58×10^{0}	2.97×10^{-1}
Uranium-235/236[a]	1.05×10^{0}	1.38×10^{-1}	2.97×10^{-1}
Uranium-238	$2.18 \times 10^{+1}$	2.85×10^{0}	1.70×10^{-1}
Uranium - Total (non-RAD)[a]	$7.76 \times 10^{+1}$	$1.02 \times 10^{+1}$	$1.09 \times 10^{+1}$
ORGANICS			
2-Methylnaphthalene[b]	$1.95 \times 10^{+0}$	$1.95 \times 10^{+0}$	NA[c]
INORGANICS			
Arsenic	1.84×10^{-10}	7.46×10^{-5}	1.46×10^{-4}
Beryllium	1.82×10^{-12}	1.46×10^{-6}	2.37×10^{-4}
Lead	2.06×10^{-6}	5.82×10^{-3}	NA

[a]Uranium-234, uranium-235/236, and total uranium were modeled by applying ratios to uranium-238 results
[b]2-Methylnaphthalene was not modeled using SWIFT because EPA RAGs, Part B screening values cannot be calculated. Reported concentrations are predicted leachate values. If concentrations are needed for risk assessment in future, ODAST/SWIFT model or equivalent should be used to calculate the concentrations in the Great Miami Aquifer.
[c]NA = No data available to calculate EPA RAGs, Part B screening values.

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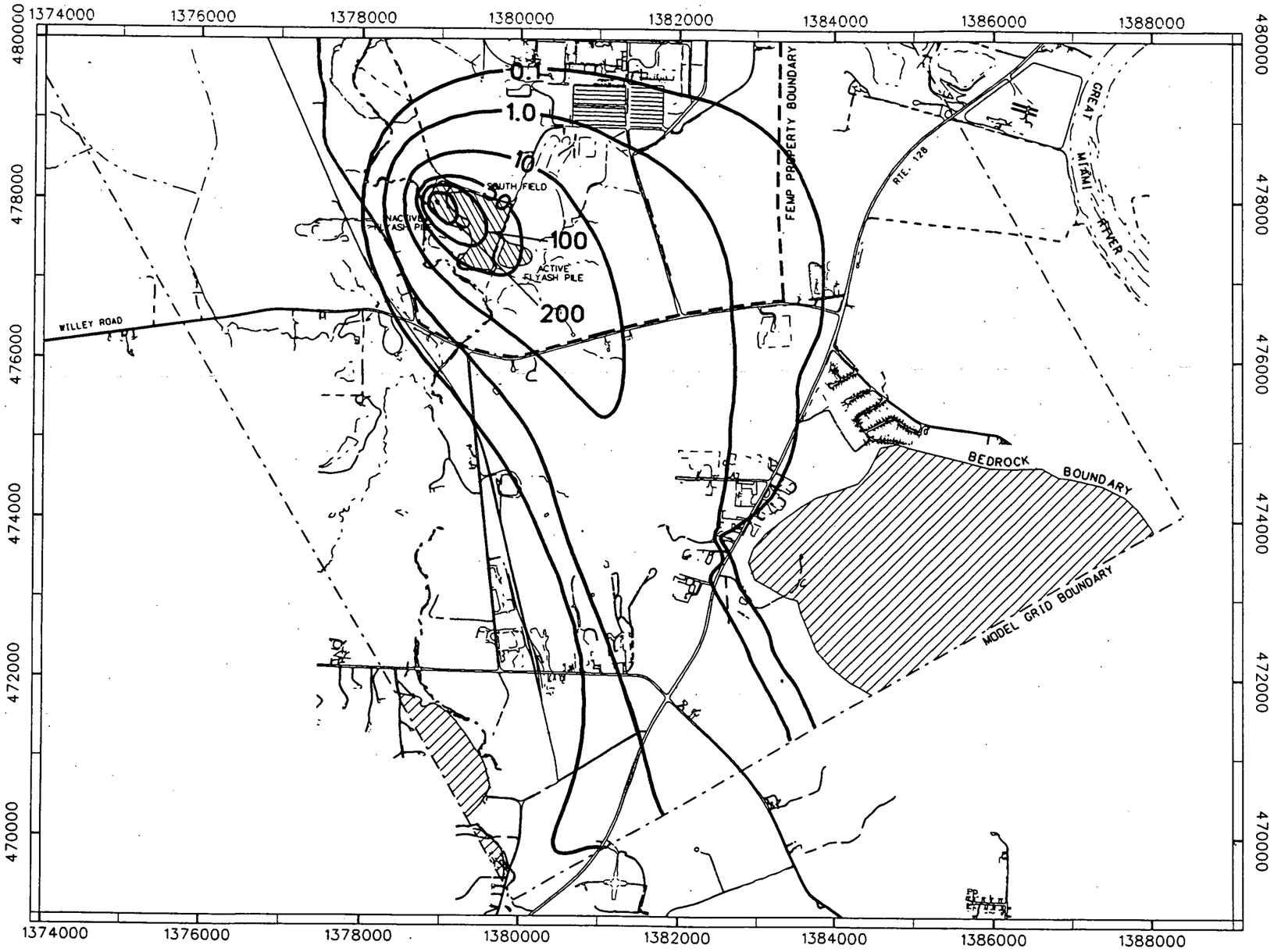
5.4.4.5 Combined Impact of All Operable Unit 2 Subunits

Uranium isotopes, neptunium-237, technetium-99, and lead were the only constituents that were CPCs for groundwater from more than one subunit. The Inactive Flyash Pile and South Field are the major contributors of the four CPCs to groundwater. Figures 5-44 through 5-47 show projected increase in concentrations of these CPCs at the time of maximum concentration in the Great Miami Aquifer. These figures present the overall impact of all applicable pathways for each Operable Unit 2 subunit. These figures were generated by adding the concentration contributions from individual subunits at the selected time. These figures were generated at the time of maximum concentration on-site due to all Operable Unit 2 subunits. SWIFT results for each subunit were added at the selected time and then concentration contours were generated. A comparison of Figures 5-21 and 5-29 with Figures 5-44 and 5-46 indicates that the point of on-site and off-site maximum concentration for uranium-238 and technetium-99 considering all subunits are almost identical to the point of on-site and off-site maximum concentrations of these parameters due to the South Field and Inactive Flyash Pile. The Figures 5-27 and 5-31 compared to Figures 5-45 and 5-47 indicate that the point of maximum on-site concentrations for neptunium-237 and lead change when considering all Operable Unit 2 subunits but the point of maximum off-site concentrations for neptunium-237 and lead do not change significantly.

The assessment of all Operable Unit 2 subunits together does not significantly change the location of the point of maximum concentration for the four constituents, but it does increase the maximum concentration at the maximum point. For other constituents that were CPCs from only one subunit, results are presented in Sections 5.4.4.3 and 5.4.4.4. Table 5-41A provides the concentrations of all Operable Unit 2 CPCs for the Great Miami Aquifer at the location and time of uranium-238 maximums. Uranium-238 maximum time and location was selected because it has maximum influence on the baseline risk assessment.

5.4.5 Modeling Results of Waste at Background Concentrations

Modeling results presented so far are based on analytical results from soil samples and perched water samples. This section presents results of vadose zone modeling if the waste and perched water were at background concentrations. Modeling using background concentrations was performed to test the level of conservativeness of the modeling methodology and check reasonableness of the assumptions. For example, if the 70-year rule was applied to the background soil concentrations, what Great Miami Aquifer concentrations would be predicted. Selected block(s) in each Operable Unit 2 subunit were modeled using the ODAST to predict loadings to the Great Miami Aquifer. Except for waste perched



LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- URANIUM 238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

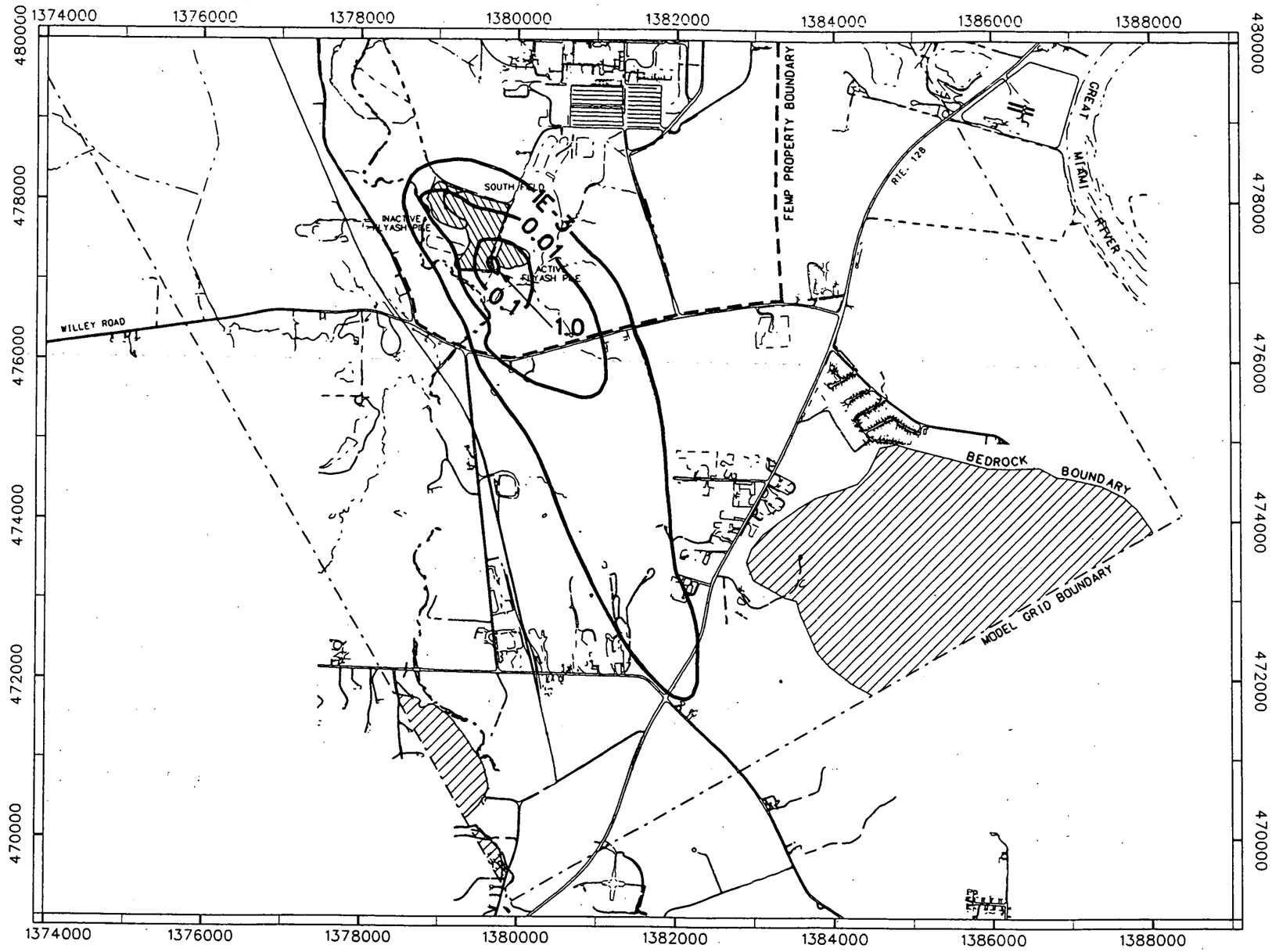
N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 517 pCi/L

fig0544.dgn

FIGURE 5-44
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 160 YEARS DUE TO LOADING FROM ALL AREA SUBUNITS



LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — NEPTUNIUM 237 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 1.5 pCi/L

fig0545.dgn

FIGURE 5-45
PROJECTED INCREASE IN NEPTUNIUM-237 CONCENTRATION IN GREAT MIAMI AQUIFER AT 160 YEARS DUE TO LOADING FROM ALL AREA SUBUNITS

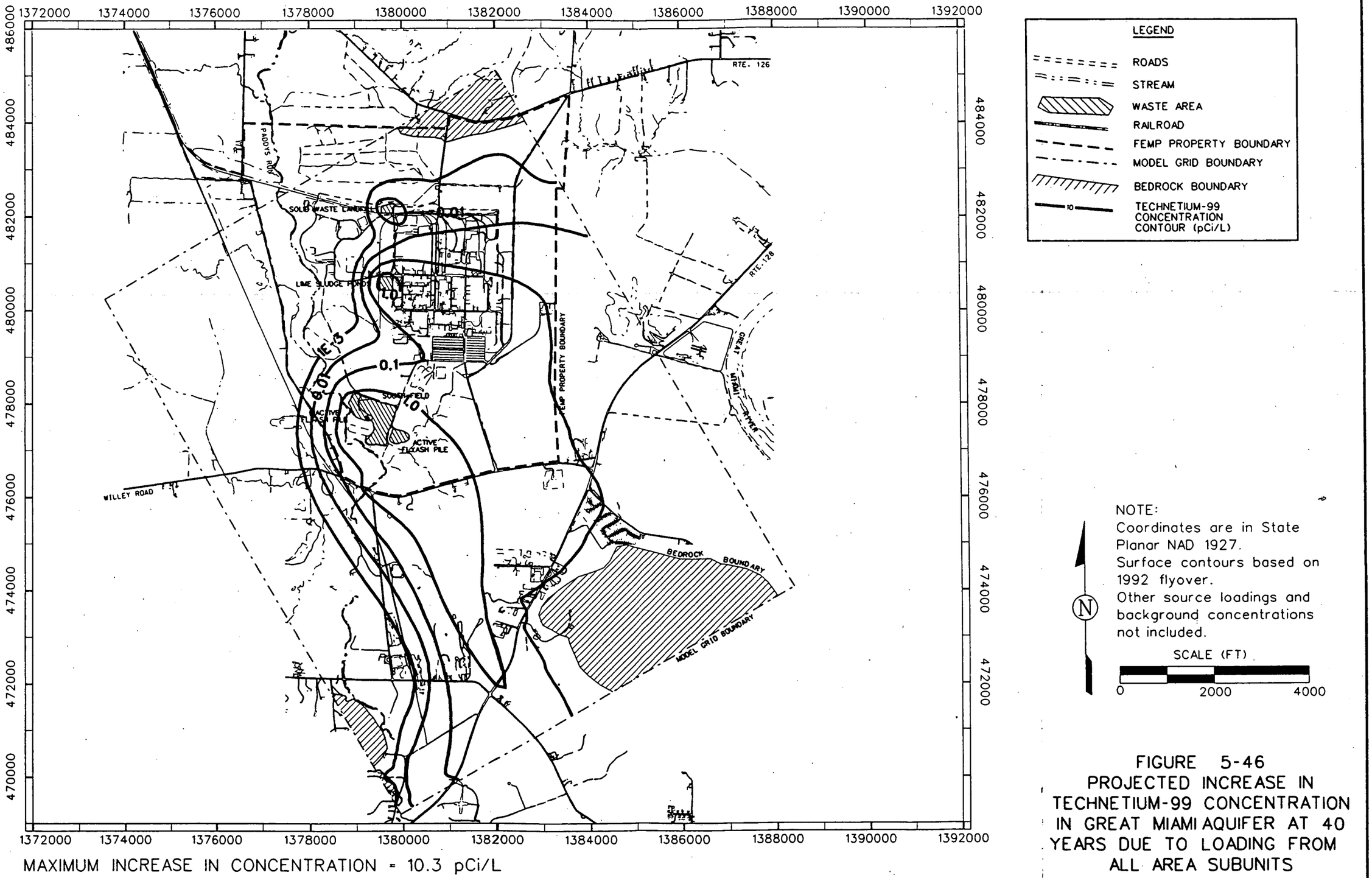


FIGURE 5-46
PROJECTED INCREASE IN TECHNETIUM-99 CONCENTRATION IN GREAT MIAMI AQUIFER AT 40 YEARS DUE TO LOADING FROM ALL AREA SUBUNITS

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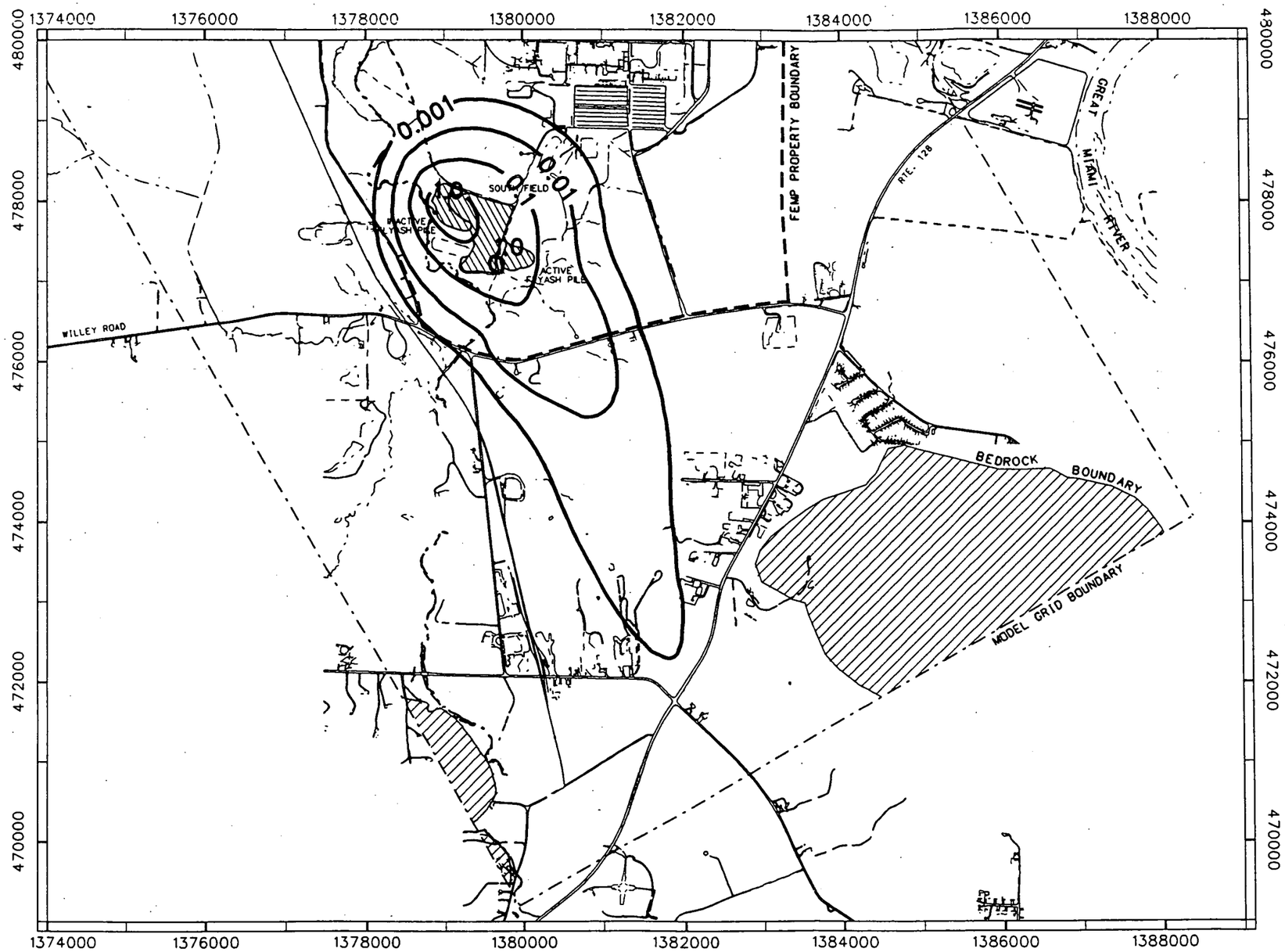

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 LEAD CONCENTRATION CONTOUR (ug/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.
Other source loadings and background concentration not included.

N

SCALE (FT)
0 1500 3000

MAXIMUM INCREASE IN CONCENTRATION = 4.9 ug/L

FIGURE 5-47
PROJECTED INCREASE IN LEAD CONCENTRATION IN GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM ALL AREA SUBUNITS

fig0547.dgn

TABLE 5-41A

SUMMARY OF SWIFT MODELING RESULTS AT THE TIME AND LOCATION OF THE U-238 MAXIMUM CONCENTRATION FOR ALL OPERABLE UNIT 2 SUBUNITS OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	On-Site Concentration at 160 Years	Concentration at the FEMP Boundary	EPA RAGs, Part B Screening Concentration
		RADIONUCLIDES		
Neptunium-237	pCi/L	1.90×10^{-2}	2.00×10^{-2}	2.16×10^{-2}
Radium-226	pCi/L	0.0	0.0	1.76×10^{-4}
Strontium-90	pCi/L	2.72×10^{-2}	5.00×10^{-2}	1.32×10^{-1}
Technetium-99	pCi/L	$1.80 \times 10^{+0}$	9.81×10^{-1}	$3.65 \times 10^{+0}$
Uranium-234	pCi/L	$4.69 \times 10^{+2}$	$2.54 \times 10^{+1}$	2.97×10^{-1}
Uranium-235/236	pCi/L	$2.50 \times 10^{+1}$	$1.35 \times 10^{+0}$	2.97×10^{-1}
Uranium-238	pCi/L	$5.17 \times 10^{+2}$	$2.80 \times 10^{+1}$	1.70×10^{-1}
Total Uranium (non-RAD)	μg/L	$1.84 \times 10^{+3}$	$9.98 \times 10^{+1}$	$1.09 \times 10^{+1}$
		ORGANICS		
2-Methylnaphthalene	μg/L	3.55×10^{-3}	5.25×10^{-5}	NA[a]
Benzo(g,h,i)perylene	μg/L	0.0	0.0	NA
Phenanthrene	μg/L	0.0	0.0	NA
Tributyl phosphate	μg/L	1.67×10^{-1}	3.11×10^{-6}	NA
		INORGANICS		
Arsenic	μg/L	0.0	1.00×10^{-4}	1.46×10^{-4}
Beryllium	μg/L	0.0	1.00×10^{-5}	2.37×10^{-4}
Lead	μg/L	$1.43 \times 10^{+0}$	2.00×10^{-2}	NA

[a]NA = No data available to calculate EPA RAGs, Part B screening concentrations

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water concentrations, the technical approach and parameters used in the modeling were the same as presented in Sections 5.4.1 through 5.4.3. Leachate concentrations were estimated using the EPA 70-year rule. Only CPCs present in individual subunits and with non-zero background concentrations were modeled. No background concentrations were available for organic CPCs and were not expected to be present in the background soils and perched water. Therefore, no organic CPCs were modeled. Physical parameters including waste size and infiltration rates were assumed to remain at current conditions.

5.4.5.1 Solid Waste Landfill

Grid cell (51,91), the grid cell with highest waste volume (Table 5-13), was selected for background modeling in the Solid Waste Landfill. Table 5-42 shows the summary of vadose zone modeling results if waste and perched water concentrations were at background levels. Table 5-42 shows that the impact of the Solid Waste Landfill waste at background level is negligible on the Great Miami Aquifer within 1,000 years.

5.4.5.2 Lime Sludge Ponds

Grid cell (44,81), the grid cell with highest waste volume (Table 5-14), was selected for background modeling in the Lime Sludge Ponds. Table 5-43 shows the summary of vadose zone modeling results if waste and perched water concentrations were at background levels. Table 5-43 shows that the impact of the Lime Sludge Ponds waste at background level is negligible on the Great Miami Aquifer within 1,000 years. Only strontium-90, mercury, and cyanide were predicted to reach the Great Miami Aquifer within 1,000 years at non-zero concentrations. However, all are below the 10^{-7} risk or 0.1 HI concentration (Table 5-43).

5.4.5.3 Inactive Flyash Pile and South Field

Three grid cells were selected for background modeling in the Inactive Flyash Pile and South Field. Grid cell (31,60) represents a typical South Field grid cell where waste is underlain by the glacial till. Only vadose zone and perched water vertical infiltration pathways are applicable to this grid cell. Grid cell (30,61) does not have glacial till beneath the waste. Vadose zone pathways including lateral drainage from other grid cells were simulated for the background modeling. Grid cell (29,65) receives maximum flow of perched water subsurface seeps. This cell also receives lateral drainage. Vadose zone pathways (including lateral drainage) and perched water subsurface seep pathways were

TABLE 5-42

SUMMARY OF VADOSE ZONE MODELING RESULTS IF WASTE AND PERCHED WATER CONCENTRATIONS WERE AT BACKGROUND LEVELS, SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent	Units for Groundwater Concentration	Screening Concentration	Subsurface Soils Background Concentration (mg/kg non-RAD) (pCi/g RAD)	Perched Water Background Concentration	Predicted Maximum GMA Concentration	Critical CPC
			RADIONUCLIDES			
Lead-210	pCi/L	7.20×10^{-3}	5.64×10^{-1}	0.00	0.00	NO
Radium-224	pCi/L	1.25×10^{-1}	6.62×10^{-1}	0.00	0.00	NO
Radium-226	pCi/L	1.76×10^{-4}	7.80×10^{-1}	$1.00 \times 10^{+0}$	0.00	NO
Radium-228	pCi/L	4.75×10^{-2}	8.52×10^{-1}	$4.50 \times 10^{+0}$	0.00	NO
Thorium-228	pCi/L	8.64×10^{-2}	8.82×10^{-1}	$1.04 \times 10^{+0}$	0.00	NO
Thorium-230	pCi/L	3.65×10^{-1}	$1.24 \times 10^{+0}$	$2.00 \times 10^{+0}$	0.00	NO
Thorium-232	pCi/L	2.79×10^{-2}	8.05×10^{-1}	0.00	0.00	NO
Uranium-234	pCi/L	2.97×10^{-1}	8.44×10^{-1}	$1.06 \times 10^{+0}$	0.00	NO
Uranium-235/236	pCi/L	2.97×10^{-1}	7.60×10^{-2}	0.00	0.00	NO
Uranium-238	pCi/L	1.70×10^{-1}	8.44×10^{-1}	$1.07 \times 10^{+0}$	0.00	NO
Total Uranium	μg/L	$1.09 \times 10^{+1}$	$2.54 \times 10^{+0}$	$3.22 \times 10^{+0}$	0.00	NO
			INORGANICS			
Arsenic	μg/L	1.46×10^{-4}	$5.64 \times 10^{+0}$	$1.50 \times 10^{+1}$	0.00	NO
Beryllium	μg/L	2.37×10^{-4}	4.80×10^{-1}	$1.80 \times 10^{+0}$	0.00	NO
Lead	μg/L	NA[a]	$9.52 \times 10^{+0}$	$2.70 \times 10^{+0}$	0.00	NO

[a]No data available to calculate EPA RAGs, Part B screening value for lead.

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TABLE 5-43

SUMMARY OF VADOSE ZONE MODELING RESULTS IF WASTE AND PERCHED WATER CONCENTRATIONS WERE AT BACKGROUND LEVELS, LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent	Units for Groundwater Concentration	Screening Concentration	Subsurface Soils Background Concentration (mg/kg non-RAD) pCi/g RAD)	Perched Water Background Concentration	Predicted Maximum GMA Concentration	Critical CPC
RADIONUCLIDES						
Radium-226	pCi/L	1.76×10^{-4}	7.80×10^{-1}	$1.00 \times 10^{+0}$	0.00	No
Radium-228	pCi/L	4.75×10^{-2}	8.52×10^{-1}	$4.50 \times 10^{+0}$	0.00	No
Strontium-90	pCi/L	1.32×10^{-1}	5.60×10^{-1}	0.00	4.92×10^{-5}	No
Thorium-228	pCi/L	8.64×10^{-2}	8.82×10^{-1}	$1.04 \times 10^{+0}$	0.00	No
Thorium-230	pCi/L	3.65×10^{-1}	$1.24 \times 10^{+0}$	$2.00 \times 10^{+0}$	0.00	No
Thorium-232	pCi/L	2.79×10^{-2}	8.05×10^{-1}	0.00	0.00	No
Uranium-234	pCi/L	2.97×10^{-1}	8.44×10^{-1}	$1.06 \times 10^{+0}$	0.00	No
Uranium-235/236	pCi/L	2.97×10^{-1}	7.60×10^{-2}	0.00	0.00	No
Uranium-238	pCi/L	1.70×10^{-1}	8.44×10^{-1}	$1.07 \times 10^{+0}$	0.00	No
Total Uranium	μg/L	$1.09 \times 10^{+1}$	$2.54 \times 10^{+0}$	$3.22 \times 10^{+0}$	0.00	No
INORGANICS						
Arsenic	μg/L	1.46×10^{-4}	$5.64 \times 10^{+0}$	$1.50 \times 10^{+1}$	0.00	No
Beryllium	μg/L	2.37×10^{-4}	4.80×10^{-1}	$1.80 \times 10^{+0}$	0.00	No
Lead	μg/L	NA[a]	$9.52 \times 10^{+0}$	$2.70 \times 10^{+0}$	0.00	No

[a]No data available to calculate EPA RAGs, Part B screening value for lead.

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modeled for grid cell (29,65). Table 5-44 shows the summary of vadose zone modeling results if waste and perched water concentrations were at background levels. Table 5-44 shows that the impact of the waste at background level is negligible on the Great Miami Aquifer within 1,000 years if waste is underlain by glacial till. However, when waste at background concentrations is left in-place where glacial till is not present, concentrations of certain CPCs exceed screening concentrations (Table 5-44). In grid cell (30,61), where lateral drainage was simulated, uranium isotopes, total uranium, and strontium-90 concentrations exceed screening concentrations. In grid cell (29,65), which receives perched water subsurface seep water, uranium isotopes, total uranium, radium-226, and strontium-90 concentrations exceed screening concentrations.

Table 5-44A shows the concentrations in the Great Miami Aquifer of the CPCs above screening concentrations in Table 5-44. Concentrations are reported at the uranium-238 maximum (on-site and FEMP boundary) locations and time. These concentrations were estimated from the results reported in Tables 5-38 and 5-39 by applying a scaling factor equal to the ratio of ODAST output for background modeling to the ODAST output for the waste at current conditions. Table 5-44A shows that except uranium-238, all CPCs are below the screening concentrations. Predicted maximum uranium-238 concentration in the Great Miami Aquifer was 0.18 pCi/L compared to a screening concentration of 0.17 pCi/L for uranium-238.

5.4.5.4 Active Flyash Pile

Two grid cells were selected for background modeling in the Active Flyash Pile. Grid cell (32,57) represents a typical Active Flyash Pile grid cell where flyash is underlain by the glacial till. Only vadose zone and perched water vertical infiltration pathways are applicable to this grid cell. Grid cell (32,56) does not have glacial till beneath the flyash. The vadose zone pathway including lateral drainage from other grid cells were simulated for the background modeling. Table 5-45 shows the summary of vadose zone modeling results if flyash and perched water concentrations were at background levels. Table 5-45 shows that the impact of the flyash at background level is negligible on the Great Miami Aquifer within 1,000 years if flyash is underlain by glacial till. However, when flyash at background concentrations is left in-place where glacial till is not present, concentrations of uranium isotopes, total uranium, and strontium-90 exceed screening concentrations (Table 5-45). In grid cell (32,56), where lateral drainage was simulated, uranium isotopes, total uranium, strontium-90, barium, and cadmium concentrations exceed screening concentrations.

TABLE 5-44

SUMMARY OF VADOSE ZONE MODELING RESULTS IF WASTE AND PERCHED WATER CONCENTRATIONS WERE AT BACKGROUND LEVELS, INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

					Waste Underlain by Till		Vertical and Lateral Drainage Loading		Vertical and Lateral Drainage and Perched Water Subsurface Seep Loading			
Constituent	Units for Groundwater Concentration	Screening Concentration	Subsurface Soils Background Concentration (mg/kg non-RAD) (pCi/g RAD)	Perched Water Background Concentration	Predicted Maximum GMA Concentration	Critical CPC	Predicted Maximum GMA Concentration	Critical CPC	Vadose Zone Pathway Concentration	Critical CPC	Perched Water Subsurface Seep Pathway Concentration	Critical CPC
RADIONUCLIDES												
Lead-210	pCi/L	7.20×10^{-3}	5.64×10^{-1}	0.0	0.0	NO	0.0	NO	0.0	NO	0.0	NO
Radium-224	pCi/L	1.25×10^{-1}	6.62×10^{-1}	0.0	0.0	NO	0.0	NO	0.0	NO	0.0	NO
Radium-226	pCi/L	1.76×10^{-4}	7.80×10^{-1}	$1.00 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO	6.32×10^{-1}	YES
Radium-228	pCi/L	4.75×10^{-2}	8.52×10^{-1}	$4.50 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO	0.0	NO
Strontium-90	pCi/L	1.32×10^{-1}	5.60×10^{-1}	0.0	0.0	NO	8.65×10^{-1}	YES	$2.07 \times 10^{+0}$	YES	0.0	NO
Thorium-228	pCi/L	8.64×10^{-2}	8.82×10^{-1}	$1.04 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO	0.0	NO
Thorium-230	pCi/L	3.65×10^{-1}	$1.24 \times 10^{+0}$	$2.00 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO	0.0	NO
Thorium-232	pCi/L	2.79×10^{-2}	8.05×10^{-1}	0.0	0.0	NO	0.0	NO	0.0	NO	0.0	NO
Uranium-234	pCi/L	2.97×10^{-1}	8.44×10^{-1}	$1.06 \times 10^{+0}$	0.0	NO	$1.52 \times 10^{+1}$	YES	$1.87 \times 10^{+2}$	YES	9.89×10^{-1}	YES
Uranium-235/236	pCi/L	2.97×10^{-1}	7.60×10^{-2}	0.0	0.0	NO	$1.37 \times 10^{+0}$	YES	$1.69 \times 10^{+1}$	YES	0.0	NO
Uranium-238	pCi/L	1.70×10^{-1}	8.44×10^{-1}	$1.07 \times 10^{+0}$	0.0	NO	$1.52 \times 10^{+1}$	YES	$1.87 \times 10^{+2}$	YES	$1.00 \times 10^{+0}$	YES
Total Uranium	ug/L	$1.09 \times 10^{+1}$	$2.54 \times 10^{+0}$	$3.22 \times 10^{+0}$	0.0	NO	$4.57 \times 10^{+1}$	YES	$5.64 \times 10^{+2}$	YES	$3.01 \times 10^{+0}$	NO
INORGANICS												
Arsenic	ug/L	1.46×10^{-4}	$5.64 \times 10^{+0}$	$1.50 \times 10^{+1}$	0.0	NO	0.0	NO	0.0	NO	6.44×10^{-5}	NO
Beryllium	ug/L	2.37×10^{-4}	4.80×10^{-1}	$1.80 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO	0.0	NO
Lead	ug/L	NA[a]	$9.52 \times 10^{+0}$	$2.70 \times 10^{+0}$	0.0	NO	8.98×10^{-4}	NA	0.0	NO	$2.52 \times 10^{+0}$	NA

[a]NA = No data available to calculate EPA RAGs, Part B screening value for lead.

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TABLE 5-44A

SUMMARY OF THE IMPACT TO THE GREAT MIAMI AQUIFER IF WASTE AND PERCHED WATER WERE AT BACKGROUND CONCENTRATIONS, INACTIVE FLYASH PILE AND SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	On-Site Maximum Concentration at Uranium-238 Maximum Location and at 160 Years	FEMP Boundary Maximum Concentration at Uranium-238 Maximum Location and at 220 Years	EPA RAGs, Part B Screening Concentration
		RADIONUCLIDES		
Radium-226	pCi/L	0.0	0.0	1.76×10^{-4}
Strontium-90	pCi/L	3.67×10^{-3}	3.04×10^{-4}	1.32×10^{-1}
Uranium-234	pCi/L	1.78×10^{-1}	9.11×10^{-3}	2.97×10^{-1}
Uranium-235/236	pCi/L	1.61×10^{-2}	8.23×10^{-4}	2.97×10^{-1}
Uranium-238	pCi/L	1.78×10^{-1}	9.11×10^{-3}	1.70×10^{-1}
Total Uranium (non-RAD)	ug/L	5.36×10^{-1}	2.75×10^{-2}	$1.09 \times 10^{+1}$
		INORGANICS		
Arsenic	ug/L	6.42×10^{-2}	9.21×10^{-16}	NA

NA = No data available to calculate EPA RAGs, Part B screening concentration

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TABLE 5-45

SUMMARY OF VADOSE ZONE MODELING RESULTS IF WASTE AND PERCHED WATER CONCENTRATIONS WERE AT BACKGROUND LEVELS, ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

					Flyash Directly on Unsaturated GMA		Flyash Underlain by Till			
Constituent	Units for Groundwater Concentrations	Screening Concentration	Subsurface Soils Background Concentration (mg/kg non-RAD) (pCi/g RAD)	Perched Water Background Concentration	Predicted GMA Concentration	Critical CPC	Vadose Pathway Predicted GMA Concentration	Critical CPC	Perched Water Pathway Predicted GMA Concentration	Critical CPC
RADIONUCLIDES										
Lead-210	pCi/L	7.20×10^{-3}	5.64×10^{-1}	0.0	0.0	NO	0.0	NO	0.0	NO
Radium-224	pCi/L	1.25×10^{-1}	6.62×10^{-1}	0.0	0.0	NO	0.0	NO	0.0	NO
Radium-226	pCi/L	1.76×10^{-4}	7.80×10^{-1}	$1.00 \times 10^{+0}$	0.00	NO	0.0	NO	0.0	NO
Radium-228	pCi/L	4.75×10^{-2}	8.52×10^{-1}	$4.50 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO
Strontium-90	pCi/L	1.32×10^{-1}	5.60×10^{-1}	0.0	$4.91 \times 10^{+0}$	YES	1.43×10^{-6}	NO	0.0	NO
Thorium-228	pCi/L	8.64×10^{-2}	8.82×10^{-1}	$1.04 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO
Thorium-230	pCi/L	3.65×10^{-1}	$1.24 \times 10^{+0}$	$2.00 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO
Thorium-232	pCi/L	2.79×10^{-2}	8.05×10^{-1}	0.0	0.0	NO	0.0	NO	0.0	NO
Uranium-234	pCi/L	2.97×10^{-1}	8.44×10^{-1}	$1.06 \times 10^{+0}$	$7.90 \times 10^{+1}$	YES	0.0	NO	2.37×10^{-4}	NO
Uranium-235/236	pCi/L	2.97×10^{-1}	7.60×10^{-2}	0.0	$7.13 \times 10^{+0}$	YES	0.0	NO	3.60×10^{-5}	NO
Uranium-238	pCi/L	1.70×10^{-1}	8.44×10^{-1}	$1.07 \times 10^{+0}$	$7.93 \times 10^{+1}$	YES	0.0	NO	2.48×10^{-4}	NO
Total Uranium	ug/L	$1.09 \times 10^{+1}$	$2.54 \times 10^{+0}$	3.22×10^{-3}	$2.38 \times 10^{+2}$	YES	0.0	NO	1.13×10^{-3}	NO
INORGANICS										
Arsenic	ug/L	1.46×10^{-4}	$5.64 \times 10^{+0}$	$1.50 \times 10^{+1}$	0.0	NO	0.0	NO	0.0	NO

See footnotes at end of table

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TABLE 5-45
(Continued)

Constituent	Units for Groundwater Concentrations	Screening Concentration	Subsurface Soils Background Concentration (mg/kg non-RAD) (pCi/g RAD)	Perched Water Background Concentration	Flyash Directly on Unsaturated GMA		Flyash Underlain by Till			
					Predicted GMA Concentration	Critical CPC	Vadose Pathway Predicted GMA Concentration	Critical CPC	Perched Water Pathway Predicted GMA Concentration	Critical CPC
INORGANICS (Continued)										
Beryllium	ug/L	2.37×10^{-4}	4.80×10^{-1}	$1.80 \times 10^{+0}$	0.0	NO	0.0	NO	0.0	NO
Lead	ug/L	NA[a]	$9.52 \times 10^{+0}$	$2.70 \times 10^{+0}$	6.79×10^{-3}	NA	0.0	NO	0.0	NO
Thallium`	ug/L	2.55×10^{-1}	4.90×10^{-1}	N/A[b]	0.0	NO	0.0	NO	0.0	NO

[a]NA - No data available to calculate EPA RAGs, Part B screening value for lead.

[b]N/A - Not analyzed, assumed to be zero.

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Table 5-45A shows the concentrations in the Great Miami Aquifer of the CPCs above screening concentrations in Table 5-45. Concentrations are reported at the uranium-238 maximum (on-site and FEMP boundary) locations and time. These concentrations were estimated from the results reported in Tables 5-40 and 5-41 by applying a scaling factor equal to the ratio of ODAST output for background modeling to the ODAST output for the waste at current conditions. Table 5-45A shows that maximum concentrations of uranium isotopes and strontium-90 can exceed screening concentrations.

5.4.6 Uncertainty Analysis

The groundwater fate and transport modeling performed for Operable Unit 2 is subject to uncertainty and variability due to factors such as the limited compound-specific characterization data, the inability of the models to simulate natural systems with 100 percent accuracy, and the assumptions for future site conditions for the waste units. Of these factors, the assumptions made for the future conditions of the waste units have the most impact on the modeling results. The waste units were all assumed to release contaminants to the environment without future maintenance. This is a worst-case scenario and thus, yields higher contamination levels than would be considered if a vegetative cover or cap was constructed. However, this type of assumption is the primary premise in performing a baseline risk assessment and the most conservative for the purpose of evaluating the risk from the groundwater pathway.

The inherent assumptions built into the models and the assumptions made to develop input parameters for the models also have an impact on the final results. Some general uncertainties associated with modeling can be attributed to the following sources:

- Source terms for the modeling were defined based on analytical results from the soil and water samples collected during the RI/FS field investigations. It was assumed that these concentrations are representative of CPC concentrations in the past. Although CPC concentrations in the past may have exceeded the present concentrations or some hot spots may not have been identified, use of the UCL concentration may counter the uncertainties introduced by using analytical results from the RI/FS field investigation.

- Except for uranium-238, the total mass of each constituent was estimated by multiplying the UCL by the volume of the entire waste area, thus assuming that the UCL concentration is uniformly distributed through the entire source area. This methodology introduces an obvious potential for overestimation of CPC mass.

- The total mass of uranium-238 was estimated from average concentrations in each 125 ft by 125-foot model grid block and the associated volume.

TABLE 5-45A

SUMMARY OF THE IMPACT TO THE GREAT MIAMI AQUIFER IF THE ACTIVE FLYASH PILE WAS AT BACKGROUND CONCENTRATIONS OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Constituent of Potential Concern	Units	On-Site Maximum Concentration at Uranium-238 Maximum Location and at 100 Years	FEMP Boundary Maximum Concentration at Uranium-238 Maximum Location and at 120 Years	EPA RAGs, Part B Screening Concentration
		RADIONUCLIDES		
Strontium-90	pCi/L	1.50×10^{-1}	1.42×10^{-2}	1.32×10^{-1}
Uranium-234	pCi/L	$3.54 \times 10^{+0}$	4.62×10^{-1}	2.97×10^{-1}
Uranium-235/236	pCi/L	3.19×10^{-1}	4.17×10^{-2}	2.97×10^{-1}
Uranium-238	pCi/L	$3.55 \times 10^{+0}$	4.64×10^{-1}	1.70×10^{-1}
Total Uranium (non-RAD)	ug/L	$1.07 \times 10^{+1}$	$1.39 \times 10^{+0}$	$1.09 \times 10^{+1}$
		INORGANICS		
Lead	ug/L	4.87×10^{-10}	1.38×10^{-6}	NA

NA = No data available to calculate EPA RAGs, Part B screening concentration

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- Uncertainty is introduced into the estimation of leachate compositions even when in situ leachate analysis are available. In situ leachate samples may have missed the highest leachate concentration in the subunit. Greater uncertainty is introduced when in situ leachate analysis are lacking. The use of TCLP data to estimate leachate composition will probably result in constituent concentrations that are greater than values expected for in situ leachate. As mentioned previously, this occurs due to the enhanced leaching by acetic acid versus rainwater. The possibility of underestimating leachate concentrations from TCLP data also exist if a soil sample used for TCLP analysis does not contain representative concentrations of CPCs. Calculations carried out to estimate contaminant concentrations using the EPA 70-year rule will introduce a large conservative uncertainty for all but the most soluble contaminants (e.g., cesium). The possibility exists to underestimate the constituents concentration when the EPA 70-year rule is applied to very soluble constituents. Even if leaching time is underestimated by a factor of two to three, peak concentration in the Great Miami Aquifer will occur very early, while concentrations of other (less soluble) contaminants is low. Therefore, if a soluble constituent was screened out (all were), risk from these CPCs will still remain below a carcinogenic risk of 10^{-6} and a HI of 1 when peak concentration of risk controlling CPC is predicted in the Great Miami Aquifer.

- The selection of parameters related to the attenuation and retardation of constituents is a major uncertainty in the groundwater fate and transport analysis. The attenuation and retardation factors of every constituent except uranium were determined after an extensive literature search. It should be noted that the actual retardation factors at the FEMP may not follow the assumed literature values, particularly over the long term. Site-specific attenuation and retardation factors were used when available. The use of site-specific values were assumed to result in lower uncertainty than using literature values.

- The organic decay rates at the FEMP were determined after an extensive literature search. The actual decay rates may or may not follow the literature values because of site-specific conditions. The use of site data to determine organic decay rates would result in lower uncertainty than that resulting from the use of literature values.

- Transport through the vadose zone was approximated by using a one-dimensional model and assuming each of the two zones, glacial till and the unsaturated Great Miami Aquifer, is homogeneous. The unsaturated seepage flow rate is a function of several parameters, such as porosity, residual saturation, and pore size distribution index. Due to the heterogeneous nature of the till, these parameters actually change from location to location and from depth to depth.

- Average properties and uniform loading in a 125 ft by 125 ft model grid block was used even when mass loading may occur through a much smaller area within the grid block. Although this may result in underestimating concentrations in the immediate vicinity of the source covering partial cell, it does not affect concentrations significantly downgradient of the source area.

- The transport models individually made assumptions regarding the fate of individual constituents within source media. However, these models were not combined or linked to consider assumptions made regarding depletion of chemicals from one model and the effect of that assumption on another model (i.e., the leaching models did not consider source

depletion from surface water runoff, volatilization, or fugitive emissions, and the surface water runoff models did not consider losses via leaching). Furthermore, the direct exposure pathways to a particular source (i.e., incidental ingestion of surface soil) did not consider source depletion by leaching, surface water transport, or air emissions. Consequently, this assumption is considered very conservative.

These uncertainties for modeling are collectively assumed to moderately overestimate the concentrations expected in groundwater.

The following sections discuss uncertainty associated with the different models used in the fate and transport modeling.

5.4.6.1 HELP Model

The HELP model is mainly sensitive to the hydraulic conductivity of the till and waste and moderately sensitive to parameters used to define evapotranspiration and runoff. The majority of water exiting the system is lost through evapotranspiration and runoff. The remaining water becomes the seepage passing through the waste unit. Evapotranspiration is controlled by the plant cover type used. The better the vegetation, the more evapotranspiration and less infiltration takes place. Conservative assumptions were used to underestimate evapotranspiration and overestimate infiltration. For example, the vegetative cover at the Inactive Flyash Pile is excellent, but it was specified as good.

Runoff in the HELP model is controlled by the SCS runoff curve number used, derived from the ground type, vegetation type, and land use. Present conditions were used to define these factors. If future conditions change, available water for seepage could change and thus loading to the aquifer would change. For example, if vegetative cover is removed, runoff will increase, and evapotranspiration will decrease. SCS runoff curve numbers vary between 0 and 100. Increasing the SCS runoff curve number increases the runoff. Table 5-46 shows that reducing the SCS curve number by 10 (reducing runoff) from base case has very little impact on the infiltration. However, increasing runoff (SCS curve number) at the Active Flyash Pile, for example due to no vegetation and steep slopes, does reduce infiltration significantly. For other subunits, increasing SCS curve number by 10 from base case does not have any impact on the infiltration.

TABLE 5-46

SENSITIVITY OF CALCULATED INFILTRATION BY HELP MODEL TO THE SCS RUNOFF CURVE NUMBER OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

			Infiltration in Inch/Year		
Subunit	Zone	Base Value of SCS* Runoff Curve Number	(Base -10) SCS Runoff Curve Number	Base SCS Runoff Curve Number	(Base +10) SCS Runoff Curve Number
Solid Waste Landfill	2	58	9.04	9.03	9.00
Lime Sludge Ponds	2	86	14.57	14.57	14.57
Inactive Flyash Pile and South Field	3	61	9.29	9.28	9.27
	5	61	5.81	5.81	5.76
	13	61	2.21	2.21	2.21
Active Flyash Pile	1	86	3.27	3.16	2.46
	3	86	12.84	11.56	5.48

*SCS - Soil Conservation Service

Uncertainty was also involved in the computation of seepage flow rates for the glacial till and the unsaturated sand and gravel layer. The unsaturated seepage flow rate is a function of the unsaturated hydraulic conductivity dependant on parameters such as porosity, residual saturation, and pore size distribution index. All of these parameters vary in a physical formation matrix and thus, cannot be fully defined for use in a numerical model. A typical HELP run for the Operable Unit 2 subunits had three layers: (1) waste/fill, (2) till, and (3) unsaturated aquifer. Thicknesses, as measured in the field program, were used. A further refinement of these layers is possible. However, zone-by-zone infiltration calculations indicate that further refinement of layers was unwarranted.

The lowest hydraulic conductivity was that of the till layer and it may control the overall infiltration. An increase in till hydraulic conductivity by two orders of magnitude does not cause a significant increase in infiltration (Table 5-47). However, a decrease in hydraulic conductivity of till by an order of magnitude causes significant reduction in infiltration (Table 5-47). It is assumed that infiltration is limited by other factors (i.e., water that is available for seepage).

Table 5-48 shows the effect of an order of magnitude change in waste hydraulic conductivity. The higher the waste hydraulic conductivity, more water infiltrates and less is available for evapotranspiration and runoff and vice versa.

Table 5-49 shows the effect of an order of magnitude variation in the Great Miami Aquifer hydraulic conductivity. Whenever the Great Miami Aquifer is overlain by glacial till, infiltration is not at all sensitive to the hydraulic conductivity of the Great Miami Aquifer. However, when the Great Miami Aquifer is directly overlain by the waste, infiltration is moderately sensitive to the hydraulic conductivity of the Great Miami Aquifer, particularly when waste thickness is less than 2 feet (Zone 3 of Inactive Flyash Pile/South Field in Table 5-49). Otherwise, infiltration is not sensitive to the hydraulic conductivity of the Great Miami Aquifer. Selection of base case parameters used in HELP model runs for vadose zone modeling were such that worst-case infiltrations were predicted. Tables 5-46 through 5-49 indicate that either infiltration is not sensitive to estimated parameters or change in estimated parameters will not significantly increase the infiltration, although a significant decrease in infiltration is possible. Table 5-47 indicates that hydraulic conductivity of the glacial till at the Inactive Flyash Pile/South Field/Active Flyash Pile is an exception. However, increased infiltration is accompanied by a reduction in the lateral drainage at the interface of the glacial till and the waste/fill. Lateral drainage was assumed to infiltrate in other areas where waste/fill is directly

TABLE 5-47

SENSITIVITY OF CALCULATED INFILTRATION BY HELP MODEL TO THE HYDRAULIC CONDUCTIVITY OF THE GLACIAL TILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

			Infiltration in Inch/Year			
Subunit	Zone	Base Value of the Glacial Till Hydraulic Conductivity (cm/sec)	Base/10 Hydraulic Conductivity	Base Hydraulic Conductivity	Base x 10 Hydraulic Conductivity	Base X 100 Hydraulic Conductivity
Solid Waste Landfill	2	1.9×10^{-6}	2.88	9.03	9.03	9.03
Lime Sludge Ponds	2	1.9×10^{-6}	3.02	14.57	14.58	14.58
Inactive Flyash Pile and South Field	13	1.4×10^{-7}	0.23	2.21	8.22	8.27
Active Flyash Pile	1	1.4×10^{-7}	0.35	3.16	11.54	11.57

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TABLE 5-48

SENSITIVITY OF CALCULATED INFILTRATION BY HELP MODEL TO THE HYDRAULIC CONDUCTIVITY OF WASTE/FILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

			Infiltration in Inch/Year		
Subunit	Zone	Base Value of Waste/Fill Hydraulic Conductivity (cm/sec)	Base/10 Hydraulic Conductivity	Base Hydraulic Conductivity	Base x 10 Hydraulic Conductivity
Solid Waste Landfill	2	1.1×10^{-4}	2.30	9.03	10.08
Lime Sludge Ponds	2	1.0×10^{-3}	12.01	14.57	15.98
Inactive Flyash Pile and South Field	3	2.0×10^{-4}	6.20	9.28	9.63
	5	2.0×10^{-4}	1.85	5.81	7.43
	13	2.0×10^{-4}	2.15	2.21	2.03
Active Flyash Pile	1	1.8×10^{-4}	3.69	3.16	2.13
	3	1.8×10^{-4}	5.11	11.56	16.05

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TABLE 5-49

SENSITIVITY OF CALCULATED INFILTRATION BY HELP MODEL TO THE HYDRAULIC CONDUCTIVITY OF THE GREAT MIAMI AQUIFER OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

			Infiltration in Inch/Year		
Subunit	Zone	Base Value of the GMA* Hydraulic Conductivity (cm/sec)	Base/10 Hydraulic Conductivity	Base Hydraulic Conductivity	Base x 10 Hydraulic Conductivity
Solid Waste Landfill	2	1.59×10^{-2}	9.03	9.03	9.03
Lime Sludge Ponds	2	1.59×10^{-2}	14.57	14.57	14.57
Inactive Flyash Pile and South Field	3	1.59×10^{-2}	8.59	9.28	10.05
	5	1.59×10^{-2}	5.81	5.81	5.81
	13	1.59×10^{-2}	2.21	2.21	2.21
Active Flyash Pile	1	1.59×10^{-2}	3.16	3.16	3.16
	3	1.59×10^{-2}	11.56	11.56	11.56

*GMA - Great Miami Aquifer

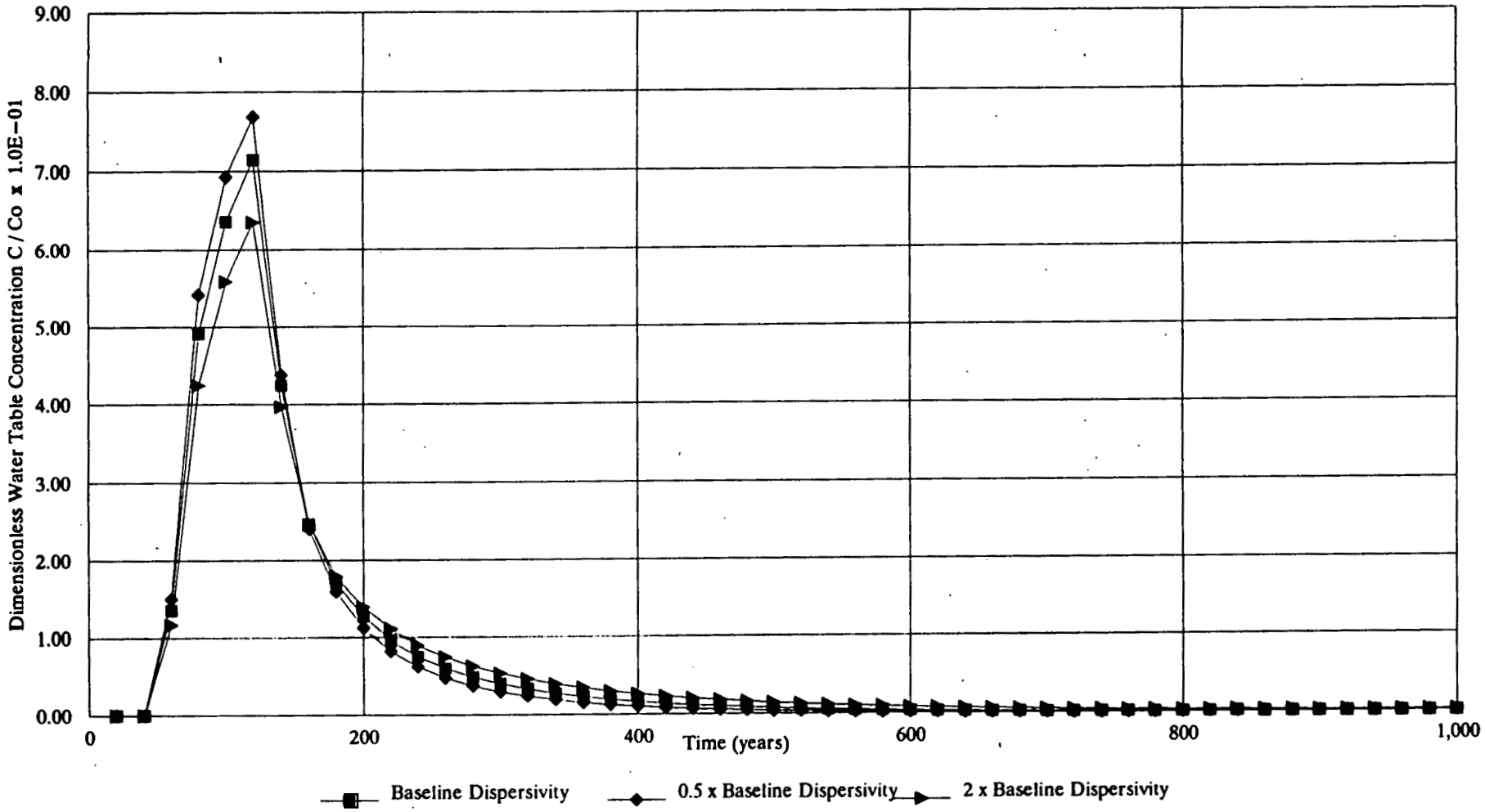
underlain by the unsaturated Great Miami Aquifer. Therefore, the overall impact of increase in the till hydraulic conductivity on the subunit wide infiltration is minimal.

5.4.6.2 ODAST Model

The selection of the longitudinal dispersivity and parameters for biodegradation and retardation of constituents is a major uncertainty in the ODAST model. These parameters were primarily estimated from an extensive literature search. These parameters mainly influence the concentration and time required for the maximum loading to reach the aquifer. Longitudinal dispersivity has a negligible impact on the time for maximum loading to reach the aquifer (Figure 5-48). The maximum loading is moderately sensitive to dispersivity. As dispersivity increases, maximum loading decreases. However, concentration at the leading edge and trailing edge of the plume is sensitive to the value of longitudinal dispensivity.

The parameters for retardation influence the time required for the maximum loading to reach the aquifer and the maximum concentration. As retardation factors increase, the maximum concentration decreases with a resulting increase in the time required for the maximum loading to reach the aquifer. (Figures 5-49 and 5-50). Figure 5-49 shows the sensitivity of the Great Miami Aquifer loading to distribution coefficient for the Great Miami Aquifer. Figure 5-50 shows the sensitivity of the Great Miami Aquifer loading to distribution coefficients for glacial till. Figure 5-50 shows that decreasing uranium-238 K_d for glacial till from 200 to 100 mL/g results in approximately 25 percent increase in maximum loading concentration (ODAST output). The range for measured uranium desorption K_d for the glacial till was 200 to 9350 mL/g. Modeling used minimum desorption K_d of 200 mL/g. The adsorption K_d measured for the glacial till during OU2 Uranium Partition Coefficient Evaluation Study was 81 mL/g. Breakthrough time evaluations indicate that results for uranium in 1000 years at the Solid Waste Landfill and Lime Sludge Ponds does not change when K_d is lowered to 81 mL/g (no breakthrough in 1000 years). Conclusions for the Inactive Flyash Pile and South Field also do not change when glacial till K_d is lowered to 81 mL/g because early breakthrough at these subunits occurs from waste directly underlain by the Great Miami Aquifer which is independent of glacial till parameters.

Decay rates significantly influence maximum concentrations. As decay rates increase (half-life decrease), the maximum concentrations decrease. Radioactive decay rates are well defined in literature and are applicable to the FEMP. However, biodegradation rates are site-specific. The



Initial Concentration – 3819.0 ug/l
Baseline Dispersivity = 0.14

Figure 5–48 – Sensitivity of ODAST Model Results to Dispersivity

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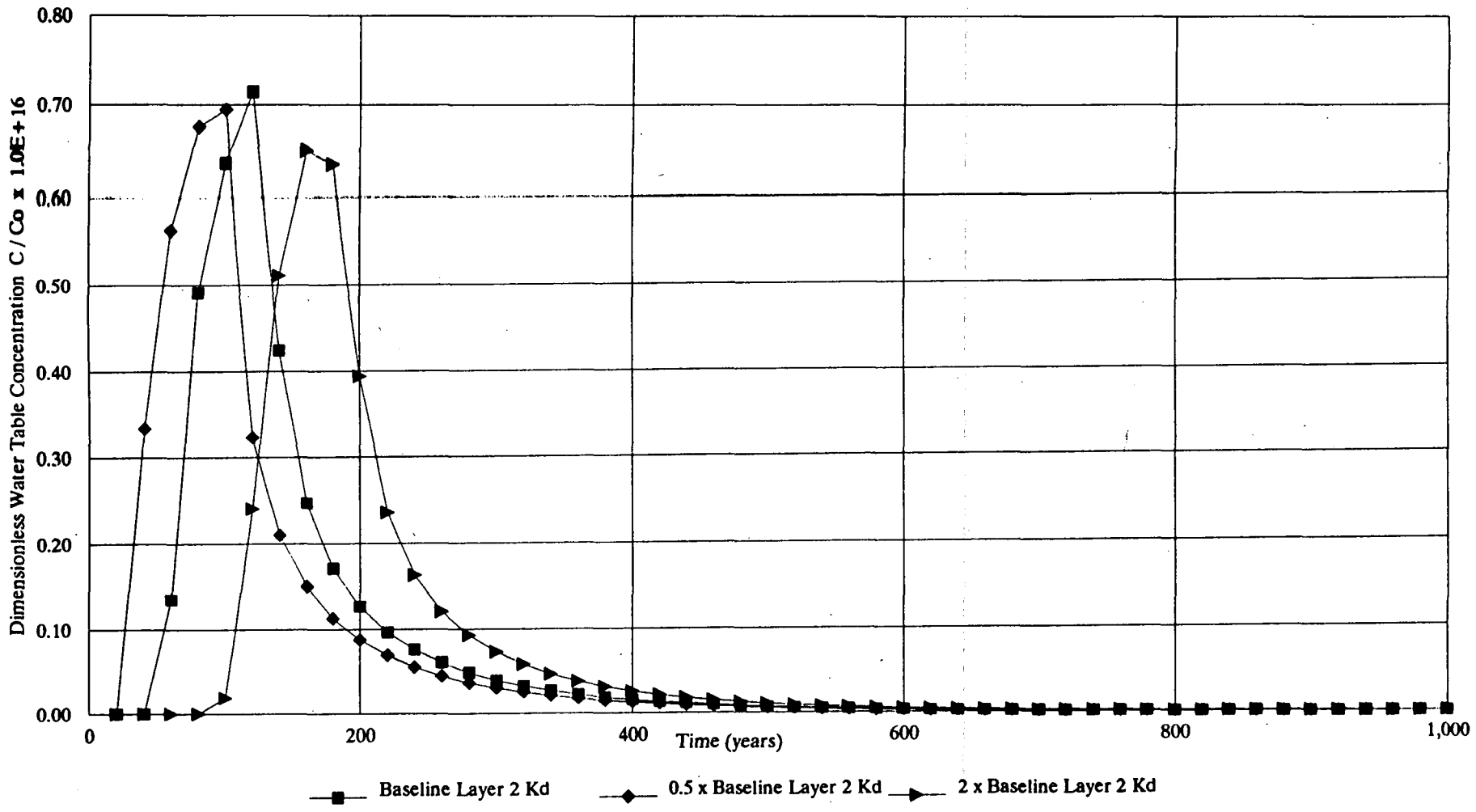

Initial Concentration – 3819.0 ug/l
Baseline Layer 2 Kd = 1.48 ml/g

Figure 5–49 – Sensitivity of ODAST Model Results to the Great Miami Aquifer Distribution Coefficient for U–238 Inactive Flyash Pile and South Field

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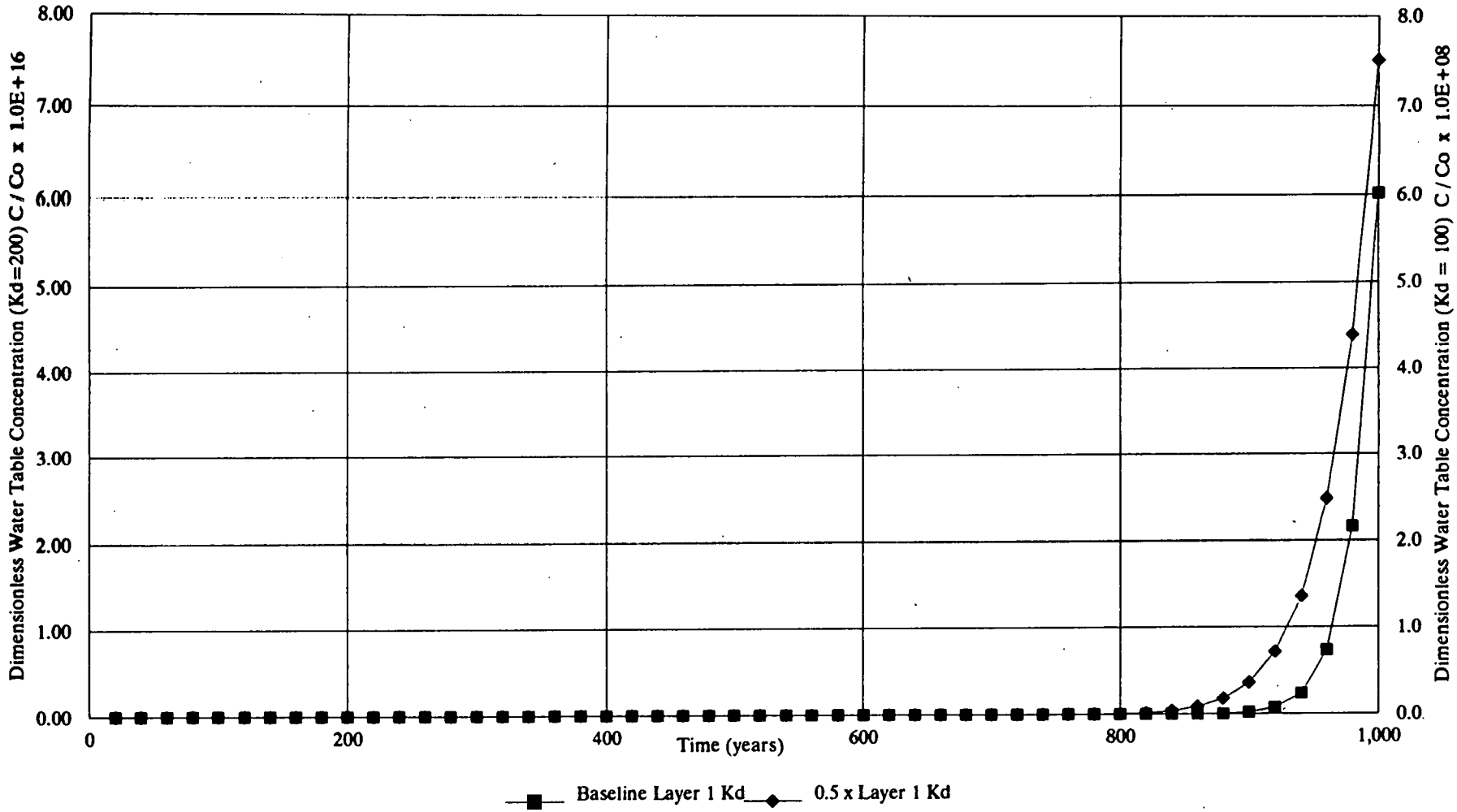

Initial Concentration – 5483.0 ug/l
Baseline Layer 1 Kd = 200.0 ml/g

Figure 5–50 – Sensitivity of ODAST Model Results to Glacial Till Distribution Coefficient for Uranium–238, Active Flyash Pile

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movement of organic constituents to the Great Miami Aquifer is greatly impeded by high biodegradation rates (low half-lives). Figure 5-51 shows the effect of doubling biodegradation half-life on loading to the Great Miami Aquifer when the Great Miami Aquifer is directly overlain by the waste. These figures show the effect that doubling the half-life can result in a 7 order of magnitude increase in maximum concentration, depending on the half-life itself and other parameters controlling travel time. However, one should note that concentrations are still very small (for example, less than 10^{-7} μg/L in Figure 5-51).

When the decay is combined with high retardation due to adsorption, the constituent concentration in the Great Miami Aquifer is significantly reduced. This is evident in a case where glacial till is present. Figure 5-53 shows that concentrations for bis (2-Ethylhexyl) phthalate remains below 10^{-41} μg/L even when the half-life is increased by a factor of 2.

Retardation parameters for all CPCs, except uranium and the organic decay rates at the FEMP, may not follow the literature values because of site-specific conditions. To be conservative, lowest decay rates and retardation parameters were used in the fate and transport modeling.

The impact of the Darcy velocity and layer thickness on the models is somewhat limited due to the derivation of the parameters themselves. Layer thicknesses were derived from Operable Unit 2 boring data, which should not vary over a large range within the operable unit. Darcy velocity is a function of the seepage rate (calculated by the HELP model) and the formation porosity, which is fairly well defined for the media simulated by the models. The sensitivity of seepage rates and the HELP model is discussed in Section 5.4.6.1.

5.4.6.3 SWIFT III Model

Like the vadose zone models, SWIFT is mostly influenced by the solute transport parameters it uses to simulate contaminant movement through the aquifer. Of these, retardation is the least well defined and has the most impact on the fate of contaminants in the groundwater. Calibration of the SWIFT model for uranium was performed as part of the RI/FS process. The SWIFT flow model was calibrated by comparing hydraulic heads calculated by the model against heads measured in numerous monitoring wells throughout the FEMP and surrounding areas. The flow calibration is described in Appendix A-2. The SWIFT solute transport model was calibrated by simulation of uranium transport in the Great Miami Aquifer (IT 1990) over the period of operation at the FEMP. A portion of this

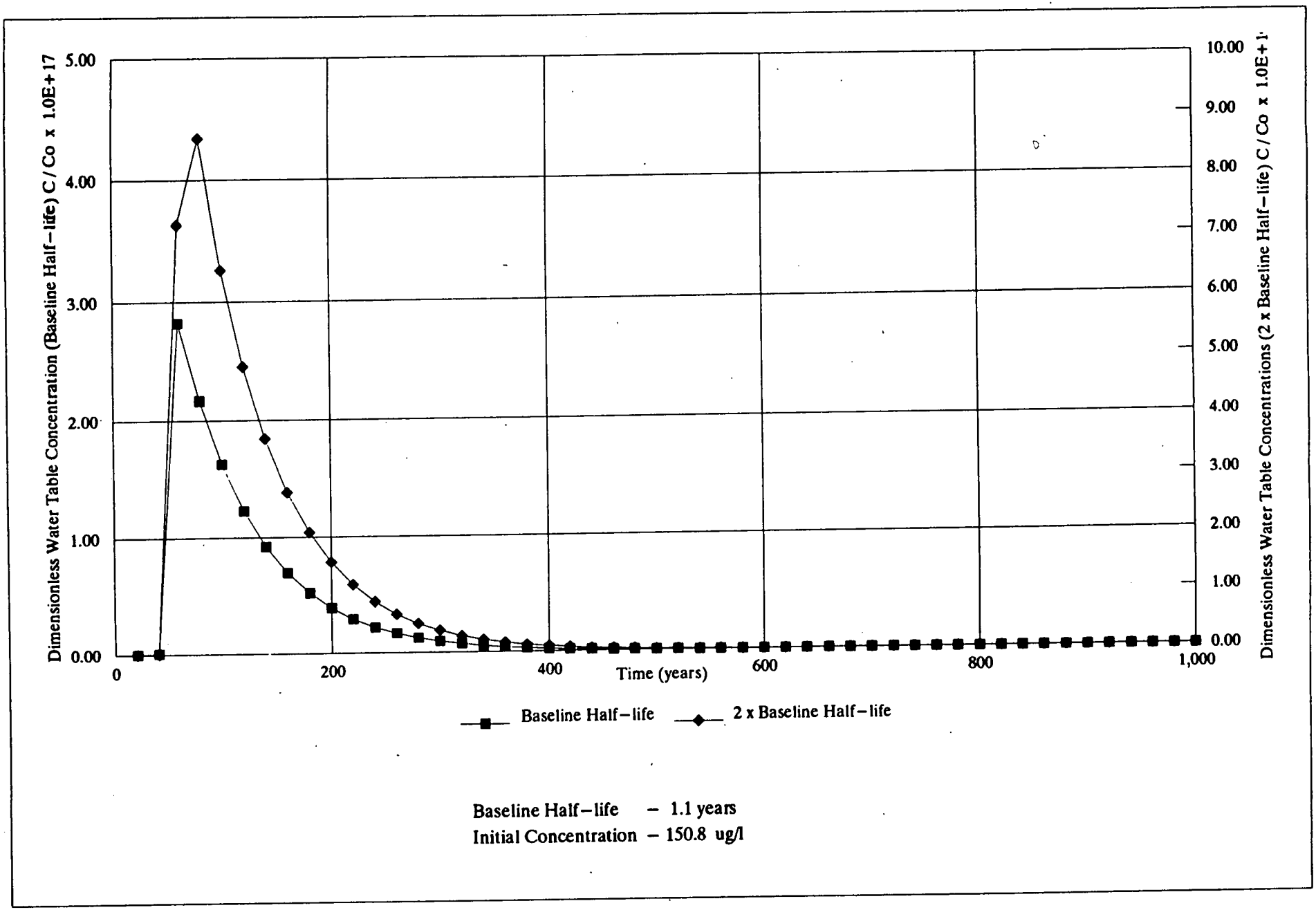

Figure 5-51 – Sensitivity of ODAST Model Results to Biodegradation Half-life for bis(2-Ethylhexyl) Phthalate Inactive Flyash Pile and South Field

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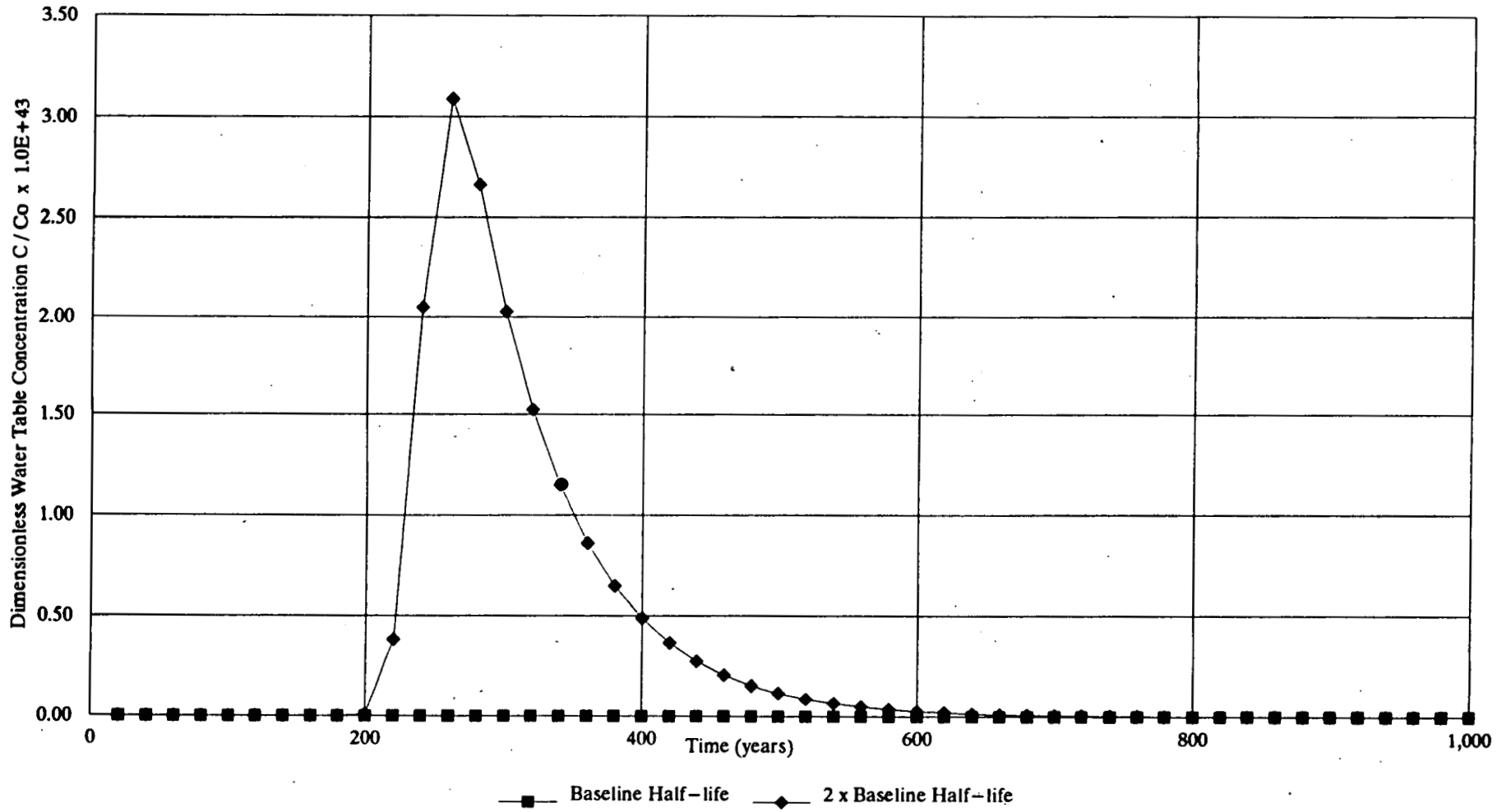

Baseline Half-life – 1.1 years
Initial Concentration – 97.5 ug/l

Figure 5-53 – Sensitivity of ODAST Model Results to Biodegradation Half-life for bis(2-Ethylhexyl) Phthalate, Lime Sludge Ponds

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calibration involved testing uranium retardation values to determine which value fit historical loading data and present day groundwater concentration data most accurately. Uranium retardation factors below 4 were found to transport uranium too quickly through the system and thus did not match historical data. Retardation factors above 15 were found to not match present day uranium distributions without large aquifer dispersion values, which were felt to be unrealistic. Consequently, a retardation factor of 12 (K_d of 1.48 mL/g) was found to give the best match for uranium during the modeling process. A K_d value of 1.48 mL/g for uranium was also found to match the observed data for Operable Unit 2 and was used in uranium fate and transport modeling.

The major parameter affecting solute transport is retardation. Higher retardation factors delay the appearance of a concentration peak at a receptor almost proportionately. Experimental determination of retardation factors for CPCs, which have relatively large source terms and are relatively toxic, is an important factor in reducing uncertainty in solute transport.

5.5 AIR TRANSPORT MODELING

An air transport analysis was conducted for Operable Unit 2 to support the determination of the fate and transport of contaminants in the baseline risk assessment. The objective of the air transport analysis is to estimate the maximum on-site and off-site ambient air concentrations for the current and future emission source terms, which are described in the conceptual model for Operable Unit 2. This section provides an overview of the methodology, input data, and results of the analysis. Appendix A contains more detail regarding the technical approach, calculation procedures, and model output associated with the air transport analysis.

The air transport analysis was conducted in accordance with EPA guidelines (EPA 1989e) for air quality dispersion modeling, using on-site data whenever possible. If on-site information was not available, conservative assumptions were made to provide an estimate of the realistic worse case emission from the Operable Unit 2 areas.

Two emission models and an air dispersion model were used to estimate air emissions from each source and to calculate annual average concentrations and deposition rates at the receptor locations. One emission model predicted the quantity of exposed soil that would be resuspended by the wind, and the other emission model estimated the flux of radon-222 gas from soil and waste containing radium-226. The air dispersion model accounted for dispersion and dilution of the contaminants

under defined meteorological conditions such as wind speed and direction, atmospheric stability, and mixing height. The primary meteorological parameters used were collected from an on-site meteorological station.

The methodology used to determine the maximum on-site and off-site concentrations included three principal tasks. The first task was to determine the contaminant emission rate for each subunit within Operable Unit 2. The second task was to calculate downwind contaminant concentrations using representative source emission, meteorological and receptor data, and an EPA-approved air dispersion model. The air dispersion model used in this analysis was the Industrial Source Complex Long Term 2 (ISCLT2) model. Third, model calculations of on-site and off-site concentrations were organized into tabular and graphical summaries for use in the baseline risk assessment.

5.5.1 Emission Source Terms

The conceptual model emission scenarios for the Operable Unit 2 air transport analysis represented two physical configurations of the Operable Unit 2 area. The two configurations examined are a "current" emissions source term for Operable Unit 2 and conservative "future" source term which is represented by an on-site farmer scenario where certain subunits undergo a physical change that affects the subunit emissions.

For the current emissions source term, the Operable Unit 2 subunit areas are assumed to have the following physical conditions:

- The Solid Waste Landfill, South Sludge Pond, Inactive Flyash Pile, and South Field are assumed to be 85 percent covered by vegetation.
- The North Sludge Pond is assumed to have 10 percent of the surface area covered with water and only 5 percent covered by vegetation. The remaining area of the North Sludge Pond is assumed to be non-vegetated and susceptible to wind erosion; however, much of the surface soil is crusted and thus, has a limited erosion potential.
- The Active Flyash Pile is assumed to have no vegetative cover. However, the pile has limited erosion potential because a dust suppressant is used to control wind erosion and most of the material is composed of large agglomerations of flyash material.

For the future emissions source term, the only changes that occur to the subunit emissions involve the Solid Waste Landfill and the South Field. Both of these subunits are assumed to be used for the

farming of crops for human and animal consumption. On an annual basis, these subunits are assumed to have crops for six months of the year to simulate the growing season, while, for the remaining six months of the year, both subunits are assumed to have no vegetation. This land use scenario results in the assumption of a 50 percent vegetation cover factor. This assumption of the crop growing scenario is consistent with local agricultural practices. The emissions for all other Operable Unit 2 subunits remain the same as described above in the current emissions source term.

5.5.2 Air Transport Contaminants

The constituents associated with Operable Unit 2 were identified based on surface soil and waste area material sampling performed during the RI. The upper 95 percent confidence limit on the mean for constituent concentrations in the surface soil and waste area were used in the air dispersion modeling to calculate annual average constituent concentrations in the air for the current and future emission source terms.

A review of the RI database indicated that the Operable Unit 2 waste area materials include organics, inorganics, and radionuclides. The principal sources of constituent emissions were assumed to be associated with the wind erosion of surface soil and evolution of radon-222 from radium-226 decay for each Operable Unit 2 subunit. The volatilization of organics from the surface soils and the waste area materials was evaluated as a possible source in both emission source terms. All of the organic compounds found in the RI database for the waste area materials are considered to have relatively low vapor pressures and do not currently represent a significant source term on an annual basis. Also, over time, the volatilization rate for the organics should gradually decrease and not be a significant source for the future. As a result, the volatilization of organics was not considered as a release mechanism for organics; however, particulate transport of organics was modeled.

A complete listing of the surface soil activity levels (pCi/g) for radionuclides and concentrations (mg/kg) for inorganics and organics used in the air transport modeling analysis for the Operable Unit 2 current and future emission source terms are shown in Tables 5-50 through 5-54.

5.5.3 Constituent Emission Rate Estimates

Constituent emissions from the Operable Unit 2 subunit areas were assumed to occur primarily as a result of the wind erosion of surface soil particulate matter. In calculating the wind erosion emission rate for each subunit in this analysis, the constituents were assumed to be part of the particulate.

TABLE 5-50

SURFACE SOIL CONTAMINATION ACTIVITY LEVELS AND CONCENTRATIONS FOR THE ACTIVE FLYASH PILE CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Contaminant	Current and Future Contamination Parameter
RADIOLOGICAL (pCi/g)	
Neptunium 237	5.5
Plutonium 238	0.7
Plutonium 239/240	0.3
Radium 226	4.6
Radium 228	3.2
Strontium 90	4.5
Thorium 228	3.8
Thorium 230	3.7
Thorium 232	2.7
Uranium 234	3.6
Uranium 235/236	0.2
Uranium 238	3.6
INORGANICS/ORGANICS (mg/kg)	
Arsenic	89.8
Barium	253.9
Beryllium	4.7
Chromium	13.3
Cobalt	18.8
Copper	73.8
Cyanide	0.3
Lead	55.4
Molybdenum	8.6
Nickel	40.1
Selenium	5.9
Thallium	2.7
Toluene	0.1
Vanadium	50.2
Zinc	78.3

TABLE 5-51

SURFACE SOIL CONTAMINATION ACTIVITY LEVELS AND CONCENTRATIONS FOR THE INACTIVE FLYASH PILE CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Contaminant	Current and Future Contamination Parameter
RADIOLOGICAL (pCi/g)	
Cesium 137	4.62E-01
Neptunium 237	7.97E-01
Plutonium 238	8.10E-02
Plutonium 239/240	2.10E-02
Radium 226	1.98E+00
Radium 228	2.24E+00
Strontium 90	8.70E-01
Thorium 228	2.71E+00
Thorium 230	2.77E+00
Thorium 232	2.33E+00
Uranium 234	8.65E+00
Uranium 235/236	4.20E-01
Uranium 238	8.87E+00
INORGANICS (mg/kg)	
Arsenic	3.32E+01
Beryllium	2.27E+00
Cadmium	3.10E+00
Chromium	1.14E+01
Lead	2.39E+01
ORGANICS(mg/kg)	
Carbazole	5.10E-01
Dibenzo(a,h)anthracene	2.20E+00
OTHER(mg/kg)	
Total Uranium	2.62E+01

TABLE 5-52

SURFACE SOIL CONTAMINATION ACTIVITY LEVELS AND CONCENTRATIONS FOR THE SOUTH FIELD CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Contaminant	Current and Future Contamination Parameter
RADIOLOGICAL (pCi/g)	
Cesium 137	4.99E-01
Neptunium 237	2.28E-01
Plutonium 238	1.20E-01
Plutonium 239/240	5.10E-02
Radium 226	3.08E+01
Radium 228	3.88E+00
Strontium 90	1.00E+00
Technecium 99	1.42E+02
Thorium 228	4.41E+00
Thorium 230	1.38E+01
Thorium 232	3.99E+00
Uranium 234	8.66E+00
Uranium 235/236	4.19E-01
Uranium 238	9.31E+00
INORGANICS(mg/kg)	
Arsenic	7.27E+00
Beryllium	9.42E-01
Chromium	1.39E+01
Lead	2.46E+01
ORGANICS(mg/kg)	
Aroclor-1254	8.90E-02
Aroclor-1260	5.20E-02
Dieldrin	1.00E-02
Benzo(a)anthracene	5.50E+00
Benzo(a)pyrene	9.40E+00
Benzo(b)fluoranthene	6.20E+00
Benzo(k)fluoranthene	7.30E+00
Carbazole	1.70E-01
Chrysene	6.00E+00
Dibenzo(a,h)anthracene	1.90E+00
Indeno(1,2,3-cd)pyrene	6.00E+00
bis(2-ethylhexyl)phthalate	1.10E-01
Methylene chloride	5.00E-03
OTHER (mg/kg)	
Total Uranium	2.96E+01

TABLE 5-53

SURFACE SOIL CONTAMINATION ACTIVITY LEVELS AND CONCENTRATIONS FOR THE SOLID WASTE LANDFILL CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Contaminant	Current and Future Contamination Parameter
RADIOLOGICAL (pCi/g)	
Cesium 137	2.67E-01
Neptunium 237	1.19E+00
Plutonium 238	7.72E-01
Plutonium 239/240	8.20E-02
Radium 226	1.90E+00
Radium 228	1.68E+00
Strontium 90	9.55E-01
Thorium 228	1.63E+00
Thorium 230	6.48E+00
Thorium 232	1.51E+00
Uranium 234	4.21E+01
Uranium 235/236	2.84E+00
Uranium 238	7.72E+01
INORGANICS (mg/kg)	
Arsenic	6.67E+00
Beryllium	6.98E-01
Cadmium	8.50E-01
Chromium	1.55E+01
Lead	1.90E+01
ORGANICS (mg/kg)	
4,4-DDE	1.20E-02
Benzo(a)anthracene	3.86E-01
Benzo(a)pyrene	3.40E-01
Benzo(b)fluoranthene	7.10E-01
Benzo(k)fluoranthene	8.85E-01
bis(2-ethylhexyl)phthalate	4.80E-02
Carbazole	7.70E-02
Chrysene	4.53E-01
Dibenzo(a,h)anthracene	2.00E-01
Indeno(1,2,3-cd)pyrene	4.80E-01
OTHER (mg/kg)	
Total Uranium	2.25E+02

TABLE 5-54

SURFACE SOIL CONTAMINATION ACTIVITY LEVELS AND CONCENTRATIONS FOR THE NORTH AND SOUTH LIME SLUDGE POND CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Contaminant	Current and Future Contamination Parameter
RADIOLOGICAL (pCi/g)	
Cesium 137	7.02E-01
Neptunium 237	7.20E-01
Plutonium 238	5.76E-01
Plutonium 239/240	1.35E-01
Radium 226	1.92E+00
Radium 228	1.64E+00
Strontium 90	7.85E-01
Thorium 228	2.91E+00
Thorium 230	4.48E+01
Thorium 232	1.31E+00
Uranium 234	2.10E+01
Uranium 235/236	1.74E+00
Uranium 238	7.14E+01
INORGANICS (mg/kg)	
Arsenic	7.19E+00
Beryllium	1.52E+00
Cadmium	1.20E+00
Chromium	1.66E+01
Lead	2.76E+01
ORGANICS (mg/kg)	
Aroclor-1254	5.90E+02
Benzo(a)anthracene	9.10E-01
Benzo(a)pyrene	1.10E+00
Benzo(b)fluoranthene	1.00E+00
Benzo(k)fluoranthene	8.00E-01
bis(2-ethylhexyl)phthalate	1.00E+01
Carbazole	1.40E-01
Chrysene	1.10E+00
Dibenzo(a,h)anthracene	3.20E-01
Indeno(1,2,3-cd)pyrene	7.20E-01
OTHER (mg/kg)	
Total Uranium	2.14E+02

Gaseous radon-222 was assumed to be emitted from soil and material containing radium-226. The concentration or activity level of each constituent within the subunit surface soil was obtained from the RI database. The air transport analysis assumed that the constituent concentration or activity level was uniformly distributed throughout each individual waste area. The methodologies used to calculate wind erosion and gaseous radon emission rates are discussed below. Appendix A provides additional details, examples of particulate matter wind erosion emission rate calculations, and radon-222 emission modeling output.

5.5.3.1 Contaminated Particulate Matter

The methodology used to determine the wind erosion emission rate requires an evaluation of the physical characteristics of each subunit surface area. The physical characteristics that affect wind erosion are the surface soil particle size distribution, vegetative cover, and condition of the surface soil. Information regarding the particle size distribution and modal diameter for each subunit was obtained from Operable Unit 2 surface soil samples.

The technical approach used for estimating particulate emissions due to wind erosion was based on the concept of "threshold friction velocity" (TFV). This approach is recommended by EPA for estimating wind erosion rates from flat soil surfaces at hazardous waste sites (EPA 1985). The approach assumes that a minimum wind speed is required for the resuspension of particulate matter from the soil and that the emission rate is a function of two factors, specifically; a) the TFV and b) the erosion potential of the soils. The lower the TFV is, the higher the potential for erosion of the soil by the wind. Depending on the characteristics of the surface soil, an area source can be defined as having either a "limited" or "unlimited" erosion potential.

Various steps are required in the wind erosion emission rate calculation process using the TFV concept. These steps are described in further detail in Appendix A, along with the calculation used to determine the wind erosion emission rate for Operable Unit 2 waste area sources. The Operable Unit 2 subunit areas have a variety of surface covers that include partial water cover, no vegetative cover, and almost complete vegetative cover.

5.5.3.2 Radon-222

Total emissions of radon-222 were calculated from surface and subsurface soil radium-226 concentrations in each Operable Unit 2 subunit. The radon-222 emissions were calculated using the

RAECOM model algorithms developed for the NRC (NRC 1984). The model converts radium-226 soil concentrations (in pCi/g) to radon-222 emission fluxes (in pCi/s/m^2). The basic equations are presented in the Risk Assessment Work Plan Addendum (DOE 1992a). The RAECOM model input parameters and output are presented in Appendix A.

5.5.4 Air Dispersion Modeling

The air transport modeling was conducted using a specific modeling protocol. The objective of the protocol was to use the most representative source area emissions data and on-site meteorological data in an air quality dispersion model to calculate annual average concentrations for all CPCs in the current and future emission scenarios. The modeling protocol is based on EPA modeling guidelines (EPA 1989e and EPA 1986b), the Fernald Particulate Modeling Policy (FERMCO 1993), and a recent site inspection tour of each Operable Unit 2 subunit. All modeling results reported in the air transport analysis are for the worst case annual meteorological period. The on-site meteorological data used in this remedial investigation included five years of meteorological statistics. Each year was analyzed separately and the highest annual concentration or deposition rate from the five annual periods was reported.

A general overview of the modeling protocol is discussed below. The reader is referred to Appendix A for more specific details of model input data and model assumptions.

5.5.4.1 On-Site Meteorological Data

Meteorological and climatological data are required as input for the ISCLT2 dispersion model. This data includes wind speed, wind direction, atmospheric stability, ambient air temperature, and mixing height. The principal source of meteorological data was the on-site FEMP meteorological monitoring system, which was installed in 1986. Other supplementary meteorological and climatological data, not available from the on-site system, was obtained from the National Weather Service (NWS) Office at the Greater Cincinnati-Northern Kentucky International Airport and from the James A. Cox International Airport at Dayton, Ohio. Climatological data regarding the annual average temperature and precipitation was obtained from both the FEMP on-site station and the NWS office at the Greater Cincinnati-Northern Kentucky International Airport. Upper air data, in support of determining mixing heights, was obtained from the James A. Cox International Airport at Dayton, Ohio.

A review of meteorological data measured and recorded at the FEMP monitoring station during the 1987-1992 period indicates that the prevailing wind direction is from the southwest. The on-site meteorological data was processed into a frequency distribution format known as the STability ARray (STAR) format for input into the ISCLT2 model. The STAR data summaries for the five years 1987, 1988, 1989, 1991, and 1992 were used in the air transport modeling analysis. These five annual periods were chosen because they attained the highest data recovery levels since the start of the on-site meteorological monitoring program. The collection efficiency or completeness of the 1990 meteorological parameters was approximately 76 percent (DOE 1993d). Therefore, the 1990 data was not used for dispersion modeling since the collection efficiency was well below the 90 percent EPA guideline (EPA 1987c). The STAR summaries for each annual period are provided in Appendix A. Graphical illustrations of the wind roses for each of the five annual periods are also given in Appendix A.

5.5.4.2 Modeling Approach

The ISCLT2 model was used to calculate annual average concentrations and deposition rates using a number of model options that allow the user to specify the atmospheric conditions of constituent dispersion, the type of emission source, and source emission parameters.

The selection of rural or urban dispersion coefficients for use in the ISCLT2 model was based on a land use analysis conducted previously for the FEMP. The land use types within a three-km radius of Operable Unit 2 were estimated from a review of USGS maps and a site survey of the area. Based on the review, no more than 10 percent of the area within a three-km radius of Operable Unit 2 can be classified as industrial, commercial, or compact residential. Therefore, the area was classified as rural for the purpose of dispersion modeling, and rural dispersion coefficients were selected for use in the modeling.

All source emissions were assumed to result from the resuspension of particulate matter due to wind erosion. All Operable Unit 2 source areas were defined as area sources in the model, and emission rates were in the units of grams (g) or pCi per second per square meter.

Because of the large number of constituents that were addressed in this analysis, each subunit area source was modeled using a wind erosion unit emission rate. Individual subunit constituent data from the RI database surface soils was then used in conjunction with the wind erosion unit emission rate

dispersion coefficients to calculate specific constituent concentrations at all receptor locations. All maximum constituent concentrations for on-site and off-site receptors are reported for the worst case annual meteorological period. Further detailed information regarding the modeling process can be found in Appendix A.

Receptor Network

The maximum annual constituent concentrations resulting from both the current and future emission scenarios were determined by having the ISCLT2 model calculate concentrations at a number of receptor locations in various directions and distances from the Operable Unit 2 waste areas. Receptor points included locations within and outside the FEMP boundary.

The receptor network for the modeling demonstration consisted of a 4.3 km. x 3.0 km. grid, based on a 50 meter separation between each receptor. This resulted in a total of 5, 246 receptor locations. The origin of the receptor network is located approximately 100 meters west of the northwestern FEMP boundary at State Planar coordinate 482,752.690 ft. north and 1,376,778.760 ft. east. All receptors and area emission sources were assumed to be at the same elevation.

A discrete receptor network was also used to calculate annual average concentrations at sensitive locations. The discrete receptor network included four elementary schools, one middle/high school, and one day nursery identified below:

(1) Crosby Elementary School
(2) Morgan Elementary School
(3) Elda Elementary School
(4) St. John Elementary School
(5) Ross Middle/High School
(6) Ross County Day Nursery

Additional information regarding the air transport receptor network, including an illustration of the spatial coverage of the receptor network relative to the FEMP, can be found in Appendix A.

5.5.5 Solid Waste Landfill

Airborne concentrations for constituents resulting from the Solid Waste Landfill are presented in Table 5-55. Annual average concentrations were calculated for both the current and future emission source terms.

TABLE 5-55

MAXIMUM ANNUAL AIR CONCENTRATIONS RESULTING FROM THE SOLID WASTE LANDFILL FOR THE CURRENT AND FUTURE EMISSION SOURCE TERMS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	Current Source Term			Future Source Term		
	Maximum Annual Exposure Point Concentration			Maximum Exposure Point Concentrations		
	On-Subunit[a]	On-Site[b]	Off-Site[c]	On-Subunit[d]	On-Site[e]	Off-Site[f]
RADIOLOGICAL (pCi/m³)						
Cesium 137	8.01E-07	8.01E-07	1.32E-08	2.43E-05	2.43E-05	4.01E-07
Neptunium 237	3.57E-06	3.57E-06	5.87E-08	1.08E-04	1.08E-04	1.78E-06
Plutonium 238	2.32E-06	2.32E-06	3.81E-08	7.03E-05	7.03E-05	1.16E-06
Plutonium 239/240	2.46E-07	2.46E-07	4.05E-09	7.46E-06	7.46E-06	1.23E-07
Radium 226	5.69E-06	5.69E-06	9.37E-08	1.73E-04	1.73E-04	2.85E-06
Radium 228	5.04E-06	5.04E-06	8.30E-08	1.53E-04	1.53E-04	2.52E-06
Radon 222	1.60E+00	1.60E+00	2.63E-02	1.60E+00	1.60E+00	2.63E-02
Strontium 90	2.87E-06	2.87E-06	4.72E-08	8.69E-05	8.69E-05	1.43E-06
Thorium 228	4.88E-06	4.88E-06	8.03E-08	1.48E-04	1.48E-04	2.44E-06
Thorium 230	1.94E-05	1.94E-05	3.20E-07	5.89E-04	5.89E-04	9.71E-06
Thorium 232	4.53E-06	4.53E-06	7.46E-08	1.38E-04	1.38E-04	2.27E-06
Uranium 234	1.26E-04	1.26E-04	2.08E-06	3.83E-03	3.83E-03	6.32E-05
Uranium 235/236	8.51E-06	8.51E-06	1.40E-07	2.58E-04	2.58E-04	4.26E-06
Uranium 238	2.31E-04	2.31E-04	3.81E-06	7.02E-03	7.02E-03	1.16E-04
INORGANICS (mg/m³)						
Arsenic	2.00E-08	2.00E-08	3.29E-10	6.07E-07	6.07E-07	1.00E-08
Beryllium	2.09E-09	2.09E-09	3.45E-11	6.35E-08	6.35E-08	1.05E-09
Cadmium	2.55E-09	2.55E-09	4.20E-11	7.74E-08	7.74E-08	1.28E-09
Chromium	4.64E-08	4.64E-08	7.64E-10	1.41E-06	1.41E-06	2.32E-08
Lead	5.70E-08	5.70E-08	9.39E-10	1.73E-06	1.73E-06	2.85E-08

See footnotes at end of table

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TABLE 5-55
(Continued)

Parameter	Current Source Term			Future Source Term		
	Maximum Annual Exposure Point Concentration			Maximum Exposure Point Concentrations		
	On-Subunit[a]	On-Site[b]	Off-Site[c]	On-Subunit[d]	On-Site[e]	Off-Site[f]
ORGANICS (mg/m³)						
4,4-DDE	3.60E-11	3.60E-11	5.93E-13	1.09E-09	1.09E-09	1.80E-11
Benzo(a)anthracene	1.16E-09	1.16E-09	1.91E-11	3.51E-08	3.51E-08	5.79E-10
Benzo(a)pyrene	1.02E-09	1.02E-09	1.68E-11	3.09E-08	3.09E-08	5.10E-10
Benzo(b)fluoranthene	2.13E-09	2.13E-09	3.51E-11	6.46E-08	6.46E-08	1.07E-09
Benzo(k)fluoranthene	2.66E-09	2.66E-09	4.37E-11	8.05E-08	8.05E-08	1.33E-09
bis(2-Ethylhexyl)phthalate	1.44E-10	1.44E-10	2.37E-12	4.37E-09	4.37E-09	7.20E-11
Carbazole	2.31E-10	2.31E-10	3.80E-12	7.01E-09	7.01E-09	1.16E-10
Chrysene	1.36E-09	1.36E-09	2.24E-11	4.12E-08	4.12E-08	6.80E-10
Dibenzo(a,h)anthracene	6.00E-10	6.00E-10	9.88E-12	1.82E-08	1.82E-08	3.00E-10
Indeno(1,2,3-cd)pyrene	1.44E-09	1.44E-09	2.37E-11	4.37E-08	4.37E-08	7.20E-10
OTHER (mg/m³)						
Total Uranium	6.76E-07	6.76E-07	1.11E-08	2.05E-05	2.05E-05	3.38E-07

[a]Within the boundary of the subunit itself, 3.0 ug/m3, approximately 30 meters southeast from the center of Solid Waste Landfill.
[b]Between the subunit boundary and the FEMP boundary, 3.0 ug/m3, approximately 75 meters east-northeast fromn the center of Solid Waste Landfill.
[c]At or beyond the FEMP boundary, 0.0494 ug/m3, approximately 600 meters north - northeast from the center of the Solid Waste Landfill.
[d]Within the boundary of the subunit itself, 91 ug/m3, approximately 30 meters southeast from the center of Solid Waste Landfill.
[e]Between the subunit boundary and the FEMP boundary, 91 ug/m3, approximately 75 meters east - northeast from the center of Solid Waste Landfill.
[f]At or beyond the FEMP boundary, 1.5 ug/m3, approximately 600 meters north - northeast from the center of the Solid Waste Landfill.

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For the current emission source term, the maximum annual average concentrations were calculated to occur from the Solid Waste Landfill subunit. The constituents with the highest calculated concentrations are radon-222, uranium-238, lead, and benzo(k)fluoranthene. The respective maximum annual average concentrations for these constituents were 1.6×10^{0} pCi/m^3, 2.31×10^{-4} pCi/m^3, 5.70×10^{-8} mg/m^3, and 66×10^{-9} mg/m^3. The maximum annual average concentration for Total Uranium was 6.76×10^{-7} mg/m^3.

Air transport modeling results for the Solid Waste Landfill future source terms are also shown in Table 5-55. Except for radon-222, these values are generally 1 to 2 orders of magnitude higher than calculated for the current scenario because of the land use assumptions. For the future source term, the Solid Waste Landfill is assumed to be used to grow crops. As in the current emissions source term, the constituents with the highest annual average concentrations on site and off site were radon-222, uranium-238, lead, and benzo(k)fluoranthene; however, the concentration values are higher due to the change in the wind erosion emission rate source term. Maximum annual average concentrations were 1.60×10^{0} pCi/g, 7.02×10^{-3} pCi/m, 1.73×10^{-6} mg/m^3, and 8.05×10^{-8} mg/m^3, respectively. The maximum future source terms concentration of total uranium was calculated to be 2.05×10^{-5}. Radon-222 emission rates and concentrations are the same for the current and future cases since the scenario assumptions do not affect gaseous contaminant emissions.

5.5.6 Lime Sludge Ponds

The results of air transport modeling for the Lime Sludge Ponds are presented in Table 5-56. This table lists the maximum annual average concentrations for the current and future emission source terms. Since the conceptual model assumes no alteration in the physical condition or use of the sludge ponds, there is no change in the source term for the two emission scenarios. The modeling results in Table 5-56 reflect the calculated impact for both sludge ponds.

The constituents with the highest annual average concentrations for the North and South Sludge Ponds were radon-222, uranium-238, lead, and Aroclor-1254. The respective concentrations calculated for each of these constituents were 3.93×10^{-1} pCi/m^3, 1.86×10^{-3} pCi/m^3, 7.17×10^{-7} mg/m^3, and 1.53×10^{-5} mg/m^3. The maximum annual average concentration for Total Uranium is calculated to be 5.57×10^{-6} mg/m^3. These maximum concentrations all occurred on the sludge pond subunit.

TABLE 5-56

MAXIMUM ANNUAL AIR CONCENTRATIONS RESULTING FROM THE NORTH AND SOUTH LIME SLUDGE PONDS FOR THE CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Current and Future Source Terms		
	Maximum Annual Exposure Point Concentration		
Parameter	On-Subunit[a]	On-Site[b]	Off-Site[c]
RADIOLOGICAL (pCi/m³)			
Cesium 137	1.83E-05	1.05E-05	1.24E-07
Neptunium 237	1.87E-05	1.08E-05	1.28E-07
Plutonium 238	1.50E-05	8.64E-06	1.02E-07
Plutonium 239/240	3.51E-06	2.03E-06	2.39E-08
Radium 226	4.99E-05	2.88E-05	3.40E-07
Radium 228	4.26E-05	2.46E-05	2.90E-07
Radon 222	3.93E-01	3.90E-01	3.02-02
Strontium 90	2.04E-05	1.18E-05	1.39E-07
Thorium 228	7.57E-05	4.37E-05	5.15E-07
Thorium 230	1.16E-03	6.72E-04	7.93E-06
Thorium 232	3.40E-05	1.96E-05	2.31E-07
Uranium 234	5.46E-04	3.15E-04	3.72E-06
Uranium 235/236	4.53E-05	2.61E-05	3.09E-07
Uranium 238	1.86E-03	1.07E-03	1.26E-05
INORGANICS (mg/m³)			
Arsenic	1.87E-07	1.08E-07	1.27E-09
Beryllium	3.95E-08	2.28E-08	2.69E-10
Cadmium	3.12E-08	1.80E-08	2.13E-10
Chromium	4.31E-07	2.49E-07	2.94E-09
Lead	7.17E-07	4.13E-07	4.88E-09
ORGANICS (mg/m³)			
Aroclor-1254	1.53E-05	8.85E-06	1.04E-07
Benzo(a)anthracene	2.37E-08	1.37E-08	1.61E-10
Benzo(a)pyrene	2.86E-08	1.65E-08	1.95E-10
Benzo(b)fluoranthene	2.60E-08	1.50E-08	1.77E-10
Benzo(k)fluoranthene	2.08E-08	1.20E-08	1.42E-10
bis(2-Ethylhexyl)phthalate	2.60E-07	1.50E-07	1.77E-09
Carbazole	3.64E-09	2.10E-09	2.48E-11

See footnotes at end of table

TABLE 5-56
(Continued)

Parameter	Current and Future Source Terms		
	Maximum Annual Exposure Point Concentration		
	On-Subunit[a]	On-Site[b]	Off-Site[c]
ORGANICS (mg/m³) (Continued)			
Chrysene	2.86E-08	1.65E-08	1.95E-10
Dibenzo(a,h)anthracene	8.32E-09	4.80E-09	5.67E-11
Indeno(1,2,3-cd)pyrene	1.87E-08	1.08E-08	1.28E-10
OTHER (mg/m³)			
Total Uranium	5.57E-06	3.21E-06	3.80E-08

[a]Within the boundary of the subunit itself, 26 $\mu g/m^3$, approximately 25 meters east - northeast from the center of the Sludge Ponds.

[b]Between the subunit boundary and the FEMP boundary, 15 $\mu g/m^3$, approximately 75 meters east-northeast fromn the center of the Sludge Ponds.

[c]At or beyond the FEMP boundary, 0.1771 $\mu g/m^3$, approximately 700 meters west - southwest from the center of the Sludge Ponds.

5.5.7 Inactive Flyash Pile/South Field

The results of the air transport modeling for the Inactive Flyash Pile are presented in Table 5-57 for the current and future emissions source terms. The conceptual model for the Inactive Flyash Pile assumes that the pile remains in the same condition as specified for the current source term and therefore, results in no change for the future source term emissions. Therefore, maximum annual exposure concentrations given in Table 5-57 represent both the current and future emission source terms.

The maximum annual concentrations from the Inactive Flyash Pile occurred approximately 50 meters north-northeast from the center of the pile. This receptor point is situated in the northwestern corner of the South Field subunit. The constituents with the maximum concentrations were radon-222, uranium-238, arsenic, and dibenzo(a,h)anthracene. The respective maximum annual average for these constituents were calculated to be 4.76×10^{0} pCi/m^3, 6.21×10^{-5} pCi/m^3, 2.32×10^{-7} mg/m^3, and 1.54×10^{-8} mg/m^3. The maximum annual concentration for total uranium was calculated to be 1.83×10^{-7} mg/m^3.

5.5.8 South Field

Table 5-58 presents the air transport modeling results for the South Field subunit. The future source term of the conceptual model assumes that the South Field subunit becomes part of a farm and is used to grow crops for human and animal consumption. As a result, the future source term for the South Field increases and results in higher exposure concentrations than the current source term results. For the current source term, the highest annual average concentrations resulting from the South Field occurred within the boundary of the South Field subunit were for radon-222, technetium-99, lead, and benzo(a)pyrene. The respective concentrations for these contaminants were 7.74×10^{1} pCi/m^3, 1.41×10^{-3} pCi/m^3, 2.43×10^{-7} mg/m^3, and 9.31×10^{-8} mg/m^3. The maximum annual concentration for Total Uranium was 2.93×10^{-7} mg/m^3. The impact calculated from the South Field for the future source term also identified radon-222, technetium-99, lead, and benzo(a)pyrene as having the highest annual average concentrations within the subunit boundary. Except for radon-222, the impacts calculated for the future source terms were generally one order of magnitude higher than for the current source terms. The maximum on-subunit concentrations for radon-222, technetium-99, lead, and benzo(a)pyrene were 7.74×10^{1} pCi/m^3, 5.82×10^{-2} pCi/m^3, 1.01×10^{-5} mg/m^3, and 3.85×10^{-6} mg/m^3, respectively. The maximum concentration calculated for total uranium for the future source

TABLE 5-57

MAXIMUM ANNUAL AIR CONCENTRATIONS RESULTING FROM THE INACTIVE FLYASH PILE FOR THE CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Current and Future Source Term		
	Maximum Annual Exposure Point Concentration		
Parameter	On-Subunit[a]	On-Site[b]	Off-Site[c]
RADIOLOGICAL (pCi/m³)			
Cesium 137	2.77E-06	3.23E-06	1.66E-07
Neptunium 237	4.78E-06	5.58E-06	2.87E-07
Plutonium 238	4.86E-07	5.67E-07	2.92E-08
Plutonium 239/240	1.26E-07	1.47E-07	7.56E-09
Radium 226	1.19E-05	1.38E-05	7.11E-07
Radium 228	1.35E-05	1.57E-05	8.07E-07
Radon 222	4.08E+00	4.76E+00	2.45E-01
Strontium 90	5.22E-06	6.09E-06	3.13E-07
Thorium 228	1.63E-05	1.90E-05	9.76E-07
Thorium 230	1.66E-05	1.94E-05	9.97E-07
Thorium 232	1.40E-05	1.63E-05	8.39E-07
Uranium 234	5.19E-05	6.05E-05	3.11E-06
Uranium 235/246	2.52E-06	2.94E-06	1.51E-07
Uranium 238	5.32E-05	6.21E-05	3.19E-06
INORGANICS (mg/m³)			
Arsenic	1.99E-07	2.32E-07	1.20E-08
Beryllium	1.36E-08	1.59E-08	8.18E-10
Cadmium	1.86E-08	2.17E-08	1.12E-09
Chromium	6.82E-08	7.95E-08	4.09E-09
Lead	1.44E-07	1.68E-07	8.61E-09
ORGANICS (mg/m³)			
Carbazole	3.06E-09	3.57E-09	1.84E-10
Dibenzo(a,h)anthracene	1.32E-08	1.54E-08	7.92E-10
OTHER (mg/m³)			
Total Uranium	1.57E-07	1.83E-07	9.43E-09

[a]Within the subunit itself, 6.0 ug/m3, approximately 25 meters east - southeast of Inactive Flyash Pile center.
[b]Area from subunit boundary to FEMP boundary, 7.0 ug/m3, approximately 50 meters north - northeast of Inactive Flyash Pile center.
[c]Area beyond the FEMP boundary, 0.36 ug/m3, approximately 250 meters southwest of Inactive Flyash Pile center.

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TABLE 5-58

MAXIMUM ANNUAL AIR CONCENTRATIONS RESULTING FROM THE SOUTH FIELD FOR THE CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	Current Source Terms			Future Source Terms		
	Maximum Annual Exposure Point Concentration			Maximum Exposure Point Concentrations		
	On-Subunit[a]	On-Site[b]	Off-Site[c]	On-Subunit[d]	On-Site[e]	Off-Site[f]
RADIOLOGICAL (pCi/m³)						
Cesium 137	4.94E-06	4.44E-06	3.65E-07	2.05E-04	1.79E-04	1.30E-05
Neptunium 237	2.26E-06	2.03E-06	1.67E-07	9.35E-05	8.16E-05	5.93E-06
Plutonium 238	1.19E-06	1.07E-06	8.78E-08	4.92E-05	4.30E-05	3.12E-06
Plutonium 239/240	5.05E-07	4.54E-07	3.73E-08	2.09E-05	1.83E-05	1.33E-06
Radium 226	3.05E-04	2.74E-04	2.25E-05	1.26E-02	1.10E-02	8.01E-04
Radium 228	3.84E-05	3.45E-05	2.84E-06	1.59E-03	1.39E-03	1.01E-04
Radon 222	7.74E+01	6.76E+01	4.91E+00	7.74E+01	6.76E+01	4.91E+00
Strontium 90	9.90E-06	8.90E-06	7.32E-07	4.10E-04	3.58E-04	2.60E-05
Technecium 99	1.41E-03	1.26E-03	1.04E-04	5.82E-02	5.08E-02	3.69E-03
Thorium 228	4.37E-05	3.92E-05	3.23E-06	1.81E-03	1.58E-03	1.15E-04
Thorium 230	1.37E-04	1.23E-04	1.01E-05	5.66E-03	4.94E-03	3.59E-04
Thorium 232	3.95E-05	3.55E-05	2.92E-06	1.64E-03	1.43E-03	1.04E-04
Uranium 234	8.57E-05	7.71E-05	6.33E-06	3.55E-03	3.10E-03	2.25E-04
Uranium 235/236	4.15E-06	3.73E-06	3.07E-07	1.72E-04	1.50E-04	1.09E-05
Uranium 238	9.22E-05	8.29E-05	6.81E-06	3.82E-03	3.33E-03	2.42E-04
INORGANICS (mg/m³)						
Arsenic	7.20E-08	6.47E-08	5.32E-09	2.98E-06	2.60E-06	1.89E-07
Beryllium	9.33E-09	8.38E-09	6.89E-10	3.86E-07	3.37E-07	2.45E-08
Chromium	1.38E-07	1.24E-07	1.02E-08	5.70E-06	4.98E-06	3.61E-07
Lead	2.43E-07	2.19E-07	1.80E-08	1.01E-05	8.80E-06	6.39E-07

See footnotes at end of table

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TABLE 5-58
(Continued)

Parameter	Current Source Terms			Future Source Terms		
	Maximum Annual Exposure Point Concentration			Maximum Exposure Point Concentrations		
	On-Subunit[a]	On-Site[b]	Off-Site[c]	On-Subunit[d]	On-Site[e]	Off-Site[f]
ORGANICS (mg/m³)						
Aroclor-1254	8.81E-10	7.92E-10	6.51E-11	3.65E-08	3.19E-08	2.31E-09
Aroclor-1260	5.15E-10	4.63E-10	3.80E-11	2.13E-08	1.86E-08	1.35E-09
Dieldrin	9.90E-11	8.90E-11	7.32E-12	4.10E-09	3.58E-09	2.60E-10
Benzo(a)anthracene	5.45E-08	4.90E-08	4.02E-09	2.26E-06	1.97E-06	1.43E-07
Benzo(a)pyrene	9.31E-08	8.37E-08	6.88E-09	3.85E-06	3.37E-06	2.44E-07
Benzo(b)fluoranthene	6.14E-08	5.52E-08	4.54E-09	2.54E-06	2.22E-06	1.61E-07
Benzo(k)fluoranthene	7.23E-08	6.50E-08	5.34E-09	2.99E-06	2.61E-06	1.90E-07
Carbazole	1.68E-09	1.51E-09	1.24E-10	6.97E-08	6.09E-08	4.42E-09
Chrysene	5.94E-08	5.34E-08	4.39E-09	2.46E-06	2.15E-06	1.56E-07
Dibenzo(a,h)anthracene	1.88E-08	1.69E-08	1.39E-09	7.79E-07	6.80E-07	4.94E-08
Indeno(1,2,3-cd)pyrene	5.94E-08	5.34E-08	4.39E-09	2.46E-06	2.15E-06	1.56E-07
bis(2-ethylhexyl)phthalate	1.09E-09	9.79E-10	8.05E-11	4.51E-08	3.94E-08	2.86E-09
Methylene chloride	4.95E-11	4.45E-11	3.66E-12	2.05E-09	1.79E-09	1.30E-10
OTHER (mg/m³)						
Total Uranium	2.93E-07	2.63E-07	2.16E-08	1.21E-05	1.06E-05	7.69E-07

[a]Within the boundary of the subunit itself, 9.9 ug/m3, approximately 100 meters northwest from the center of South Field.
[b]Between the subunit boundary and the FEMP boundary, 8.9 ug/m3, approximately 125 meters northwest from the center of South Field.
[c]At or beyond the FEMP boundary, 0.7316 ug/m3, approximately 350 meters southwest of the center of South Field.
[d]Within the boundary of the subunit itself, 410 ug/m3, approximately 100 meters northwest from the center of South Field.
[e]Between the subunit boundary and the FEMP boundary, 358 ug/m3, approximately 125 meters northwest from the center of South Field.
[f]At or beyond the FEMP boundary, 26 ug/m3, approximately 350 meters southwest of the center of South Field.

term was 1.21 x 10^{-5} mg/m^3. Radon-222 emission rates and concentrations are the same for the current and future cases since the scenario assumptions do not affect gaseous contaminant emissions.

5.5.9 Active Flyash Pile

The results of the air transport modeling for the Active Flyash Pile current and future emission source terms are presented in Table 5-59. The conceptual model for Operable Unit 2 assumes that the Active Flyash Pile will remain in its present state for the future source term; therefore, the maximum exposure concentrations are the same for the current and future source terms. Table 5-59 lists the maximum annual concentrations for radiological and inorganic constituents associated the Active Flyash Pile.

The calculated highest annual average concentrations of resuspended radionuclides and inorganics contaminants occur within the subunit boundary of the Active Flyash Pile. The highest concentrations were reported for radon, neptunium, and barium. The respective maximum annual on-subunit concentrations for these constituents were calculated to be 1.81 x 10^0 pCi/m^3, 5.67 x 10^{-5} pCi/m^3 and 2.62 x 10^{-6} μg/m^3. The maximum annual concentration calculated for Total Uranium is 8.06 x 10^{-7} mg/m^3.

5.5.10 Combined Modeling Results and Summary

5.5.10.1 Results for Constituents in Wind Blown Particulate Matter

The air quality modeling results in Section 5.5 are presented for each of the individual subunits associated with Operable Unit 2. A review of the modeling results for each subunit in Tables 5-56 through 5-59 indicates that uranium-238 is the particulate-phase constituent that was calculated to have the highest annual average concentrations from the Solid Waste Landfill, the North and South Sludge Ponds, and the Inactive Flyash Pile. The remaining two subunits, the South Field and the Active Flyash Pile, were calculated to produce the highest annual average concentrations for technetium-99 and neptunium-237, respectively.

Of the three constituents identified above, uranium-238 is the most common among the Operable Unit 2 subunits and generally had the highest surface soil activity levels of all radionuclides. Collectively, uranium-238 appears to provide the most measurable impact from Operable Unit 2 on a

TABLE 5-59

MAXIMUM ANNUAL AIR CONCENTRATIONS RESULTING FROM THE ACTIVE FLYASH PILE FOR THE CURRENT AND FUTURE EMISSION SOURCE TERMS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Parameter	Current and Future Source Terms		
	Maximum Annual Exposure Point Concentration		
	On-Subunit[a]	On-Site[b]	Off-Site[c]
RADIOLOGICAL (pCi/m³)			
Neptunium 237	5.67E-05	4.13E-05	4.11E-06
Plutonium 238	7.21E-06	5.25E-06	5.24E-07
Plutonium 239/240	3.09E-06	2.25E-06	2.24E-07
Radium 226	4.74E-05	3.45E-05	3.44E-06
Radium 228	3.30E-05	2.40E-05	2.39E-06
Radon 222	1.81E+00	1.63E+00	1.34E-01
Strontium 90	4.64E-05	3.38E-05	3.37E-06
Thorium 228	3.91E-05	2.85E-05	2.84E-06
Thorium 230	3.81E-05	2.78E-05	2.77E-06
Thorium 232	2.78E-05	2.03E-05	2.02E-06
Uranium 234	3.71E-05	2.70E-05	2.69E-06
Uranium 235/236	2.06E-06	1.50E-06	1.50E-07
Uranium 238	3.71E-05	2.70E-05	2.69E-06
INORGANICS (mg/m³)			
Arsenic	9.25E-07	6.74E-07	6.72E-08
Barium	2.62E-06	1.90E-06	1.90E-07
Beryllium	4.84E-08	3.53E-08	3.52E-09
Chromium	1.37E-07	9.98E-08	9.95E-09
Cobalt	1.94E-07	1.41E-07	1.41E-08
Copper	7.60E-07	5.54E-07	5.52E-08
Cyanide	3.09E-09	2.25E-09	2.24E-10
Lead	5.71E-07	4.16E-07	4.14E-08
Molybdenum	8.86E-08	6.45E-08	6.43E-09
Nickel	4.13E-07	3.01E-07	3.00E-08
Selenium	6.08E-08	4.43E-08	4.41E-09
Thallium	2.78E-08	2.03E-08	2.02E-09
Toluene	1.03E-09	7.50E-10	7.48E-11
Vanadium	5.17E-07	3.77E-07	3.75E-08
Zinc	8.06E-07	5.87E-07	5.86E-08

[a]Within the subunit itself, 10.3 ug/m3, approximately 20 meters north of Active Flyash Pile center.
[b]Area from subunit boundary to FEMP boundary, 7.5 ug/m3, approximately 70 meters north of Active Flyash Pile center.
[c]Area beyond the FEMP boundary, 0.748 ug/m3, approximately 430 meters west - southwest of Active Flyash Pile center.

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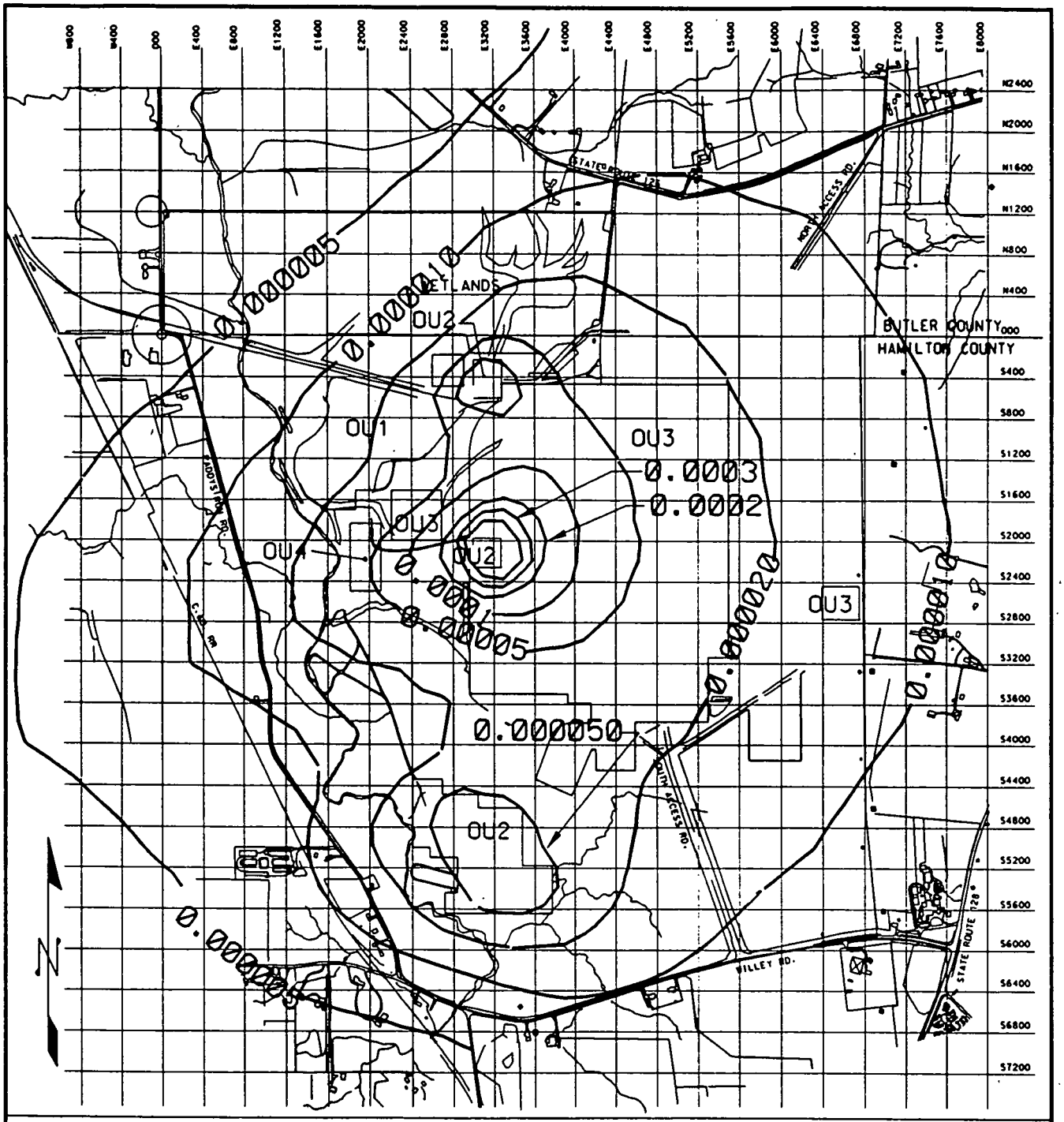
site-wide basis. The impact from technetium-99 will be more localized and will not provide the cumulative impact of uranium-238 because it is only associated with the South Field subunit.

Although neptunium-237 is also a common radionuclide among the Operable Unit 2 subunits, a comparison of the uranium-238 and neptunium-237 activity levels for each subunit in Tables 5-50 through 5-54 indicates that uranium-238 has much higher activity levels at all subunits, with the exception the Active Flyash Pile. However, the difference in activity levels at the Active Flyash Pile are minimal in comparison the differences between uranium-238 and neptunium-237 at the other subunits. Therefore, uranium-238 is a principal particulate-matter contaminant associated with Operable Unit 2.

The individual subunit model concentration calculations for uranium-238 to all receptors were combined using a specially written computer program to determine the combined impact of uranium-238 from all Operable Unit 2 sources. The concentrations were based on the worst case meteorological period, which was 1989. The results of this calculation procedure were then plotted to show the spatial distribution of uranium-238 annual average concentrations within and beyond the FEMP boundary. The results of this plotting procedure are shown in Figures 5-54 and 5-55 for the current and future emission scenarios. These figures show that the ISCLT2 model calculated the highest uranium-238 concentrations resulting from Operable Unit 2 subunits to occur at two distinct on-site locations for both emission scenarios.

5.5.10.2 Results for Gaseous Radon 222

The radionuclide present in Operable Unit 2 with the highest modeled activity concentration in air is radon-222. The graphical presentation of radon-222 air concentrations for Operable Unit 2 (all subunits) is presented in Figure 5-56. the maximum concentration is located over the South Field. this maximum is due to the relatively high surface soil concentration of radium-226 (30.8 pCi/g) in the South Field and subsequent decay of this radium to radon-222. Surface soil radium-226 concentrations in other subunits are one to two orders-of-magnitude below this value.

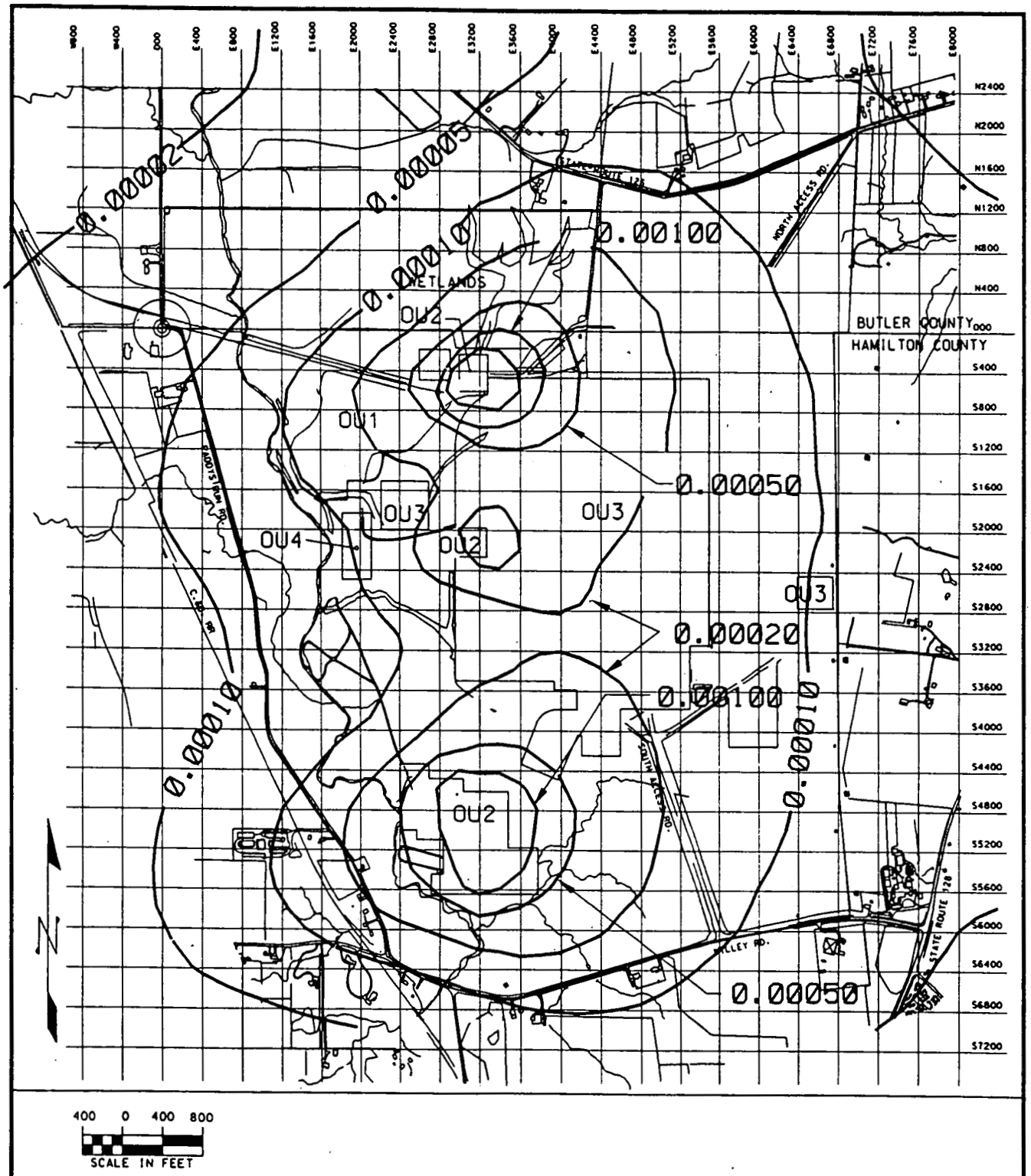


400 0 400 800
SCALE IN FEET

—5— CONCENTRATION ISOPLETHS ARE IN PICOCURIES PER CUBIC METER

2R1U238C.DGN

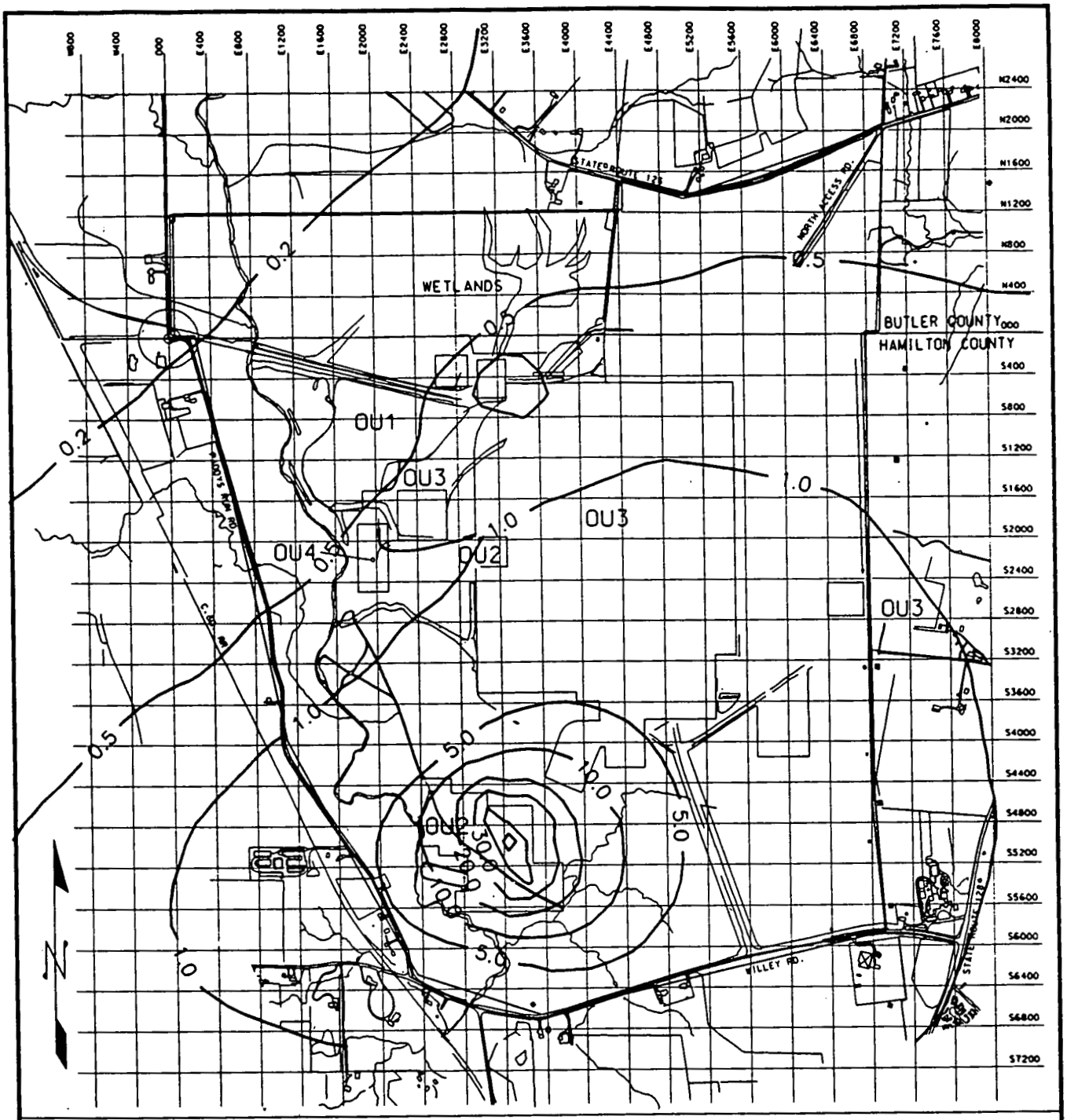
FIGURE 5-54
U-238 CONCENTRATION IN AIR FROM OU2
FOR CURRENT SOURCE TERMS



—5— CONCENTRATION ISOPLETHS ARE IN PICOCURIES PER CUBIC METER

2R1U238F.DGN

FIGURE 5-55
U-238 CONCENTRATION IN AIR FROM OU2
FOR FUTURE SOURCE TERMS



400 0 400 800
SCALE IN FEET

—5— CONCENTRATION ISOPLETHS ARE IN PICOCURIES PER CUBIC METER

OU2RIRDN.DGN

FIGURE 5-56
Rn-222 CONCENTRATION IN AIR FROM OU2

5.5.11 Uncertainty Analysis

5.5.11.1 Air Quality Modeling

All air transport analysis have some degree of uncertainty due to the approximations or assumptions made primarily for source emissions and model input parameters. To account for these uncertainties, conservative assumptions were made so risks were not underestimated. In addition, uncertainties can be related to the limitations of the air dispersion models, representativeness of the meteorological data, assumptions made in the conceptual model, and the methodologies used to predict the wind erosion emission rate of contaminated particulate matter and gaseous radon emissions.

Uncertainties are inherent in the mathematical model algorithms used to simulate dispersion and transport of air contaminants because no model can provide a perfect simulation of atmospheric physical processes. Dispersion models attempt to estimate the downwind concentration for specific receptor locations and averaging periods. These models attempt to account for different types of atmospheric conditions and other conditions influencing air dispersion. Despite these technical features, the models can still have difficulty calculating contaminant concentrations due to unknown conditions affecting source release and dispersion. Validation studies of model accuracy have shown that models are generally more reliable for long-term averaging periods than for short-term averaging periods and that models are reasonably accurate in estimating the magnitude of highest concentrations within an particular area. However, models can have difficulty predicting observed concentrations for a particular location and time period due to the affects of local topography, spatial and temporal variations in meteorology between the source, and receptor or temporal fluctuations in source emissions. Topography is not expected to be an influencing factor in this analysis because the area modeled is essentially flat. Therefore, a thorough understanding of modeling assumptions and limitations should be known before interpreting model results.

The conceptual model used in the air transport analysis assumed that all of the subunit areas will have particulate emissions as a result of wind erosion, depending on the physical characteristics of the surface area of subunit. The wind erosion of particulates is basically a function of vegetative cover, wind speed, particle size, the condition of the surface cover, and soil moisture content. For the current emission scenario, the emission potential was based for a large part on a recent site inspection of each subunit and geotechnical data on the size distribution of surface soil for each subunit. The availability of particle size data for each subunit helped to reduce the uncertainty factor in defining the

wind erosion potential for each subunit and the calculation of particulate deposition. The EPA recommended predictive model for calculating wind erosion emission rates includes the use of a conservatively low modal diameter in cases of unlimited potential. The lower the modal diameter used in the calculation procedure, the higher the calculated wind erosion emission rate.

In addition, the constituent concentrations used in the dispersion modeling were the 95 percent UCL of the mean for constituents with normal or lognormal distributions. However, for constituents with an undefined distribution, the maximum sampled value was used in the dispersion model. All of these assumptions can lead to conservatively high estimates of the Operable Unit 2 impact from contaminated particulate matter in both the current and future emission scenarios.

Despite the uncertainties discussed herein, the availability of subunit specific data and the conservative approach of estimating input parameters serves to support the representativeness of the air transport analysis and its ability to provide adequate data for the baseline risk assessment.

6.0 BASELINE RISK ASSESSMENT

6.1 INTRODUCTION

This section provides an overview of the methodology, results, summary, and uncertainties associated with the human health baseline risk assessment conducted for Operable Unit 2. The baseline risk assessment is an estimate of the risk to hypothetical receptors potentially exposed to site-related constituents, assuming no remedial actions are taken. The purpose of the baseline risk assessment is to estimate the possible risk to human health from exposure due to the hazardous on-site wastes at Operable Unit 2.

In a baseline risk assessment, information developed during site investigation is used to:

- Determine the constituents of potential concern (CPCs) for Operable Unit 2.
- Assess the potential for constituent transport from Operable Unit 2 sources to potential human exposure points.
- Quantify potential exposures to receptors under current and future land use scenarios.
- Characterize the nature and magnitude of potential risks associated with Operable Unit 2 assuming no remedial action.

Operable Unit 2 contains five subunits for which remedial decisions must be made. In order to facilitate remedial decisions for each independent subunit, risk was quantified separately for each. The specific methodology followed for the risk assessment is consistent across subunits. In addition, risks were quantified for Operable Unit 2 as a whole.

The results of the baseline risk assessment determine the need for remedial action for that subunit; identify specific media and areas for which cleanup is appropriate; present a "baseline" of potential human health risks for the no-action alternative in the subunit FS; and provide criteria for determining cleanup levels. A detailed summary of the methods used and quantitative results of the risk assessment are presented in Appendix B.

The Operable Unit 2 baseline risk assessment addresses only the potential risks associated with waste subunits within the boundaries of Operable Unit 2. It does not consider existing contamination in surface water, sediment, or soil unless it is contained within the boundaries of Operable Unit 2. It

does not consider existing contamination in groundwater. Risk due to existing contamination outside the boundaries of Operable Unit 2 and in groundwater will be evaluated in the Operable Unit 5 RI. Risks due to groundwater in this and other operable unit baseline risk assessments are based on estimates of future contaminant concentrations, which are based on modeling.

In accordance with an agreement between EPA Region V and DOE, ecological risks are not addressed in this Operable Unit 2 RI report. Baseline ecological risks for the FEMP will be addressed in the Site-Wide Ecological Risk Assessment to be submitted as part of the Operable Unit 5 RI/FS. The Site-Wide Ecological Risk Assessment will address only on-site and off-site areas not likely to be remediated on the basis of human health concerns. The potential impacts to ecological receptors associated with implementation of remedial alternatives within Operable Unit 2 will be considered in the Operable Unit 2 FS.

Section 6.2 summarizes the general methodology used to complete the baseline risk assessment. Section 6.3 summarizes the results of the baseline risk assessment on a subunit-by-subunit basis as well as cumulative Operable Unit 2 risk. Additionally, a summarized comparison of subunit specific risks and Operable Unit 2-wide risks to background is provided. Section 6.4 presents a discussion of associated uncertainties. Detailed discussions and presentations of the risk assessment methodology results and uncertainties are provided in Appendix B.

6.2 METHODOLOGY

The Operable Unit 2 baseline risk assessment was performed in accordance with the FEMP Risk Assessment Work Plan Addendum (DOE 1992a), as well as the refinements and revisions made to the addendum. Some risk assessment procedures described in the addendum were modified as necessary to incorporate new information or new guidance that were unavailable during preparation of the Risk Assessment Work Plan Addendum and to incorporate continued guidance from EPA and OEPA. Differences between the methods described in the Risk Assessment Work Plan Addendum and the methods used for this risk assessment are noted in Appendix B, Section B.2.0.

Figure 6-1 illustrates the general FEMP risk assessment process that was followed for this risk assessment. It generally reflects the four step EPA risk assessment process which involves: (1) identification of CPCs, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization and uncertainty analysis. The figure reflects the importance of the conceptual site

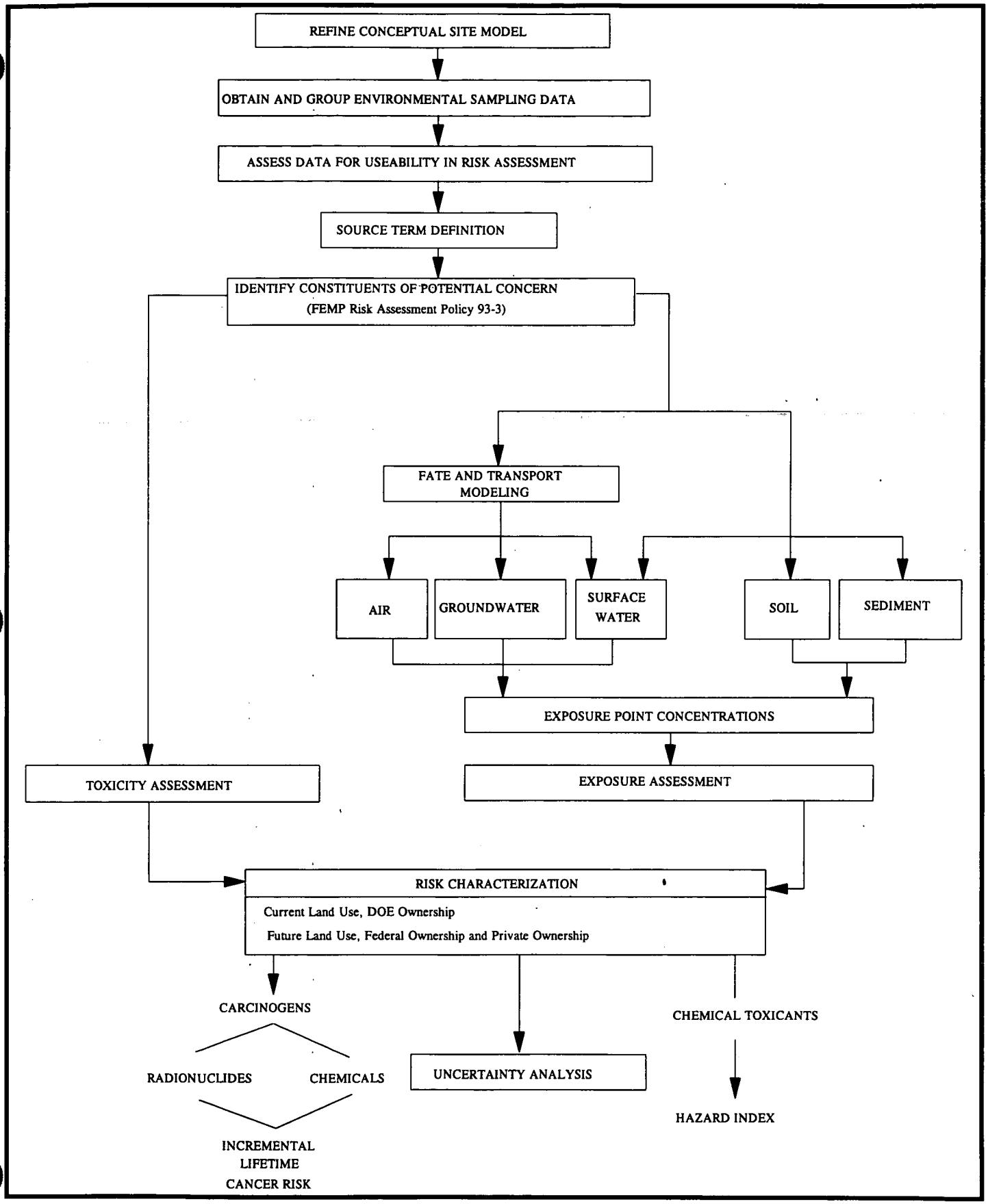


FIGURE 6-1. FEMP RISK ASSESSMENT PROCESS

model in grouping data and defining exposure pathways. It also reflects the critical dependence of this risk assessment on the results of constituent fate and transport modeling to complete the exposure assessment. The methodology followed for each of the steps highlighted in Figure 6-1 is summarized in the sections below and discussed in detail in Appendix B.

6.2.1 Refine Conceptual Site Model

To assist in appropriately grouping data to identify subunit- and medium-specific CPCs, the general conceptual site model (CSM) for Operable Unit 2 was refined to emphasize the current understanding of constituent migration and potential exposures. The overall purpose of the model is to illustrate and describe: (1) the most current understanding of the sources of constituent within Operable Unit 2, (2) how constituents may be released and transported, (3) impacted and potentially impacted media, and (4) the known and potential human receptors assuming both current and future land use. The CSM clarifies which environmental media and specific human receptors need to be addressed to adequately characterize risk resulting from waste areas within Operable Unit 2. This understanding is critical for the initial grouping of data into subsets relevant to assessing risk so that independent risk-based decisions can be made for each subunit and each medium. Refinement of the CSM is an important first step in completing the risk assessment.

The CSM developed for this Operable Unit 2 baseline risk assessment is shown in Figure 6-2, which shows the five waste areas that are the sources of constituents and the secondary sources (groundwater and soil) impacted by migration of constituents from these source areas. Figure 6-2 is based on the current understanding of constituent migration resulting from RI activities and illustrates the important release mechanisms by which constituents migrate from one medium to another and the contact media potentially encountered by human receptors. It also illustrates the specific current and future human receptors whose contact with impacted media is assessed in this risk assessment. These are the same receptors evaluated in other operable unit baseline risk assessments for the FEMP. The known nature and extent of constituents in environmental media is described in Section 4.0 of this RI; potential future impacted media (i.e., air, groundwater, and surface water) is described in Section 5.0.

6.2.1.1 Land Use

Potential exposures to the environmental media noted on Figure 6-2 are evaluated in the context of three land use configurations: (1) current land use assuming DOE ownership with both access and no access control, (2) future land use assuming federal ownership, and (3) future land use assuming

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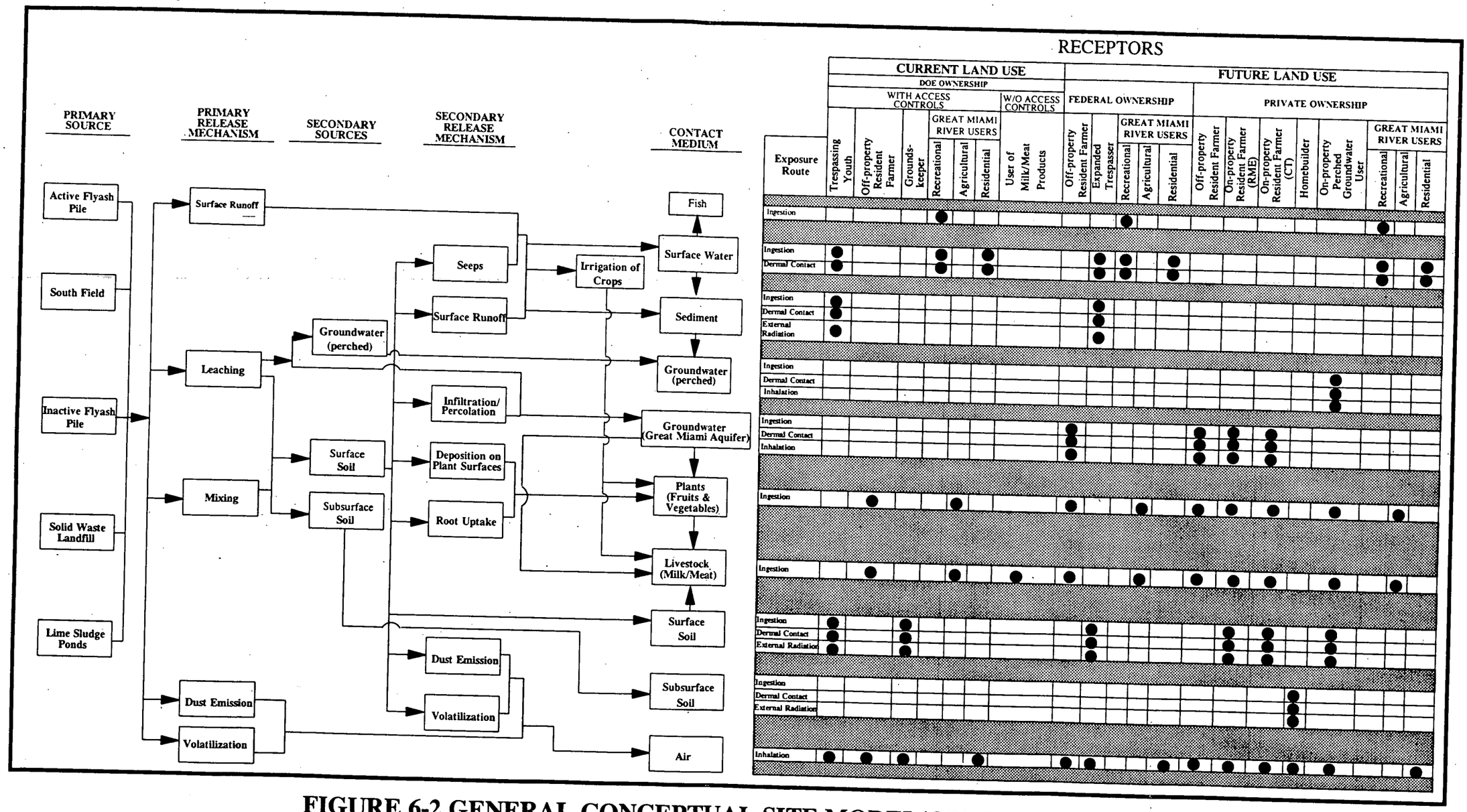

FIGURE 6-2 GENERAL CONCEPTUAL SITE MODEL/OPERABLE UNIT 2

private ownership. These land use designations reflect the current framework for assessing risk at the FEMP. As indicated in the CSM, current receptors are trespassers, off-property residents, on-property groundskeeper, and users of meat and milk products from livestock grazed on site. Future receptors, assuming federal ownership, are expanded trespassers and off-property residents. Future receptors, assuming private ownership, are on-property farmers, homebuilders, and perched groundwater users. Great Miami River users are future receptors regardless of whether private or federal ownership is assumed. These land use designations and receptor descriptions are further described in the Exposure Assessment, Section B.2.4 of Appendix B.

6.2.1.2 Exposure Scenarios

Land use assumptions and receptors were selected to ensure: (1) that they are consistent with the Risk Assessment Work Plan Addendum (DOE 1992a), where applicable; (2) that they allow adequate quantification of risk for every contaminated or potentially contaminated medium within each subunit; and (3) that they are consistent with FEMP risk assessment guidelines for exposure scenarios (DOE 1994). Table 6-1 summarizes land use and receptor designations utilized to quantify risk in this risk assessment. The rationale for land use designation and scenario selection is presented below.

For current land use assumptions, the FEMP is assumed to remain as it currently exists. In addition, no remedial action is assumed to have been taken beyond what is already accomplished. Existing current land use at and in the vicinity of Operable Unit 2 indicates that receptors most likely to be exposed to constituents on and migrating from Operable Unit 2 waste areas are trespassers who may routinely bypass existing controls and enter the site; off-property farm families who may live in the vicinity of the FEMP property; on-property groundskeeper conducting general maintenance activities not covered under FEMP health and safety and radiation programs; and users of meat and milk products from livestock grazing on the property. As summarized in Table 6-1, current land use with access controls include the following receptors:

- Off-Property Resident Farmer (Adult and Child) - This exposure scenario assumes that a farm family lives immediately adjacent to the FEMP property boundary. Exposure routes include:

  - Inhalation of fugitive dust, VOCs, and gases.
  - Consumption of farm product foodstuffs including vegetables, meat, and milk.

- Trespassing Youth - This exposure scenario considers the risk incurred by a trespassing youth who wanders freely over the site. Exposure routes include:

TABLE 6-1

GENERIC DESCRIPTION OF EXPOSURE SCENARIOS AND EXPOSURE POINT CONCENTRATIONS OPERABLE UNIT 2 BASELINE RISK ASSESSMENT

Current Land Use	Receptor	Direct Contact Medium	Route of Exposure		Exposure Point Concentration
Current with Access Controls (current use of FEMP continues, DOE ownership)	Trespassing Youth	surface soil	incidental ingestion dermal contact external radiation		surface soil within subunit
		air	inhalation	particulates, volatiles, and gases	maximum estimated on-subunit current concentration derived from air modeling
		surface water	incidental ingestion dermal contact		surface water within subunit
		sediment	incidental ingestion dermal contact external radiation		sediment within subunit
	Off-Property Resident Farmer (adult and child), homegrown produce off-property, livestock grazing off-property	air	inhalation	particulates, volatiles, and gases	maximum estimated off-property current concentrations derived from air modeling
		plants (homegrown produce)	ingestion	fruits and vegetables	maximum estimated off-property current concentrations derived from air modeling
		livestock (grazing off-property)	ingestion	milk beef	maximum estimated off-property current concentrations derived from air modeling
	Groundskeeper	air	inhalation	particulates, volatiles and gases	maximum estimated on-subunit current concentration derived from air modeling
		surface soil	incidental ingestion dermal contact external radiation		surface soil within subunit

TABLE 6-1
(Continued)

Current Land Use	Receptor		Direct Contact Medium	Route of Exposure		Exposure Point Concentration
Current with Access Controls (current use of FEMP continues, DOE ownership) (Continued)	Great Miami River Users	Recreational User	surface water	ingestion dermal contact		estimated concentrations in the Great Miami River
			fish	ingestion		estimated concentrations in the Great Miami River
		Agricultural User	plants (homegrown produce irrigated with water from Great Miami River)	ingestion	fruit and vegetables	estimated concentrations in the Great Miami River
			livestock (grazing on crops irrigated with water from Great Miami River)	ingestion	beef and milk	estimated concentrations in the Great Miami River
		Household User	surface water	inhalation ingestion dermal contact	particulates, volatiles, and gases	estimated concentrations in the Great Miami River
Current without Access Controls (current use of FEMP continues)	User of Meat and Milk Products		livestock (grazing on-property)	ingestion of milk and beef		maximum estimated on-property current concentrations derived from air modeling

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TABLE 6-1
(Continued)

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure		Exposure Point Concentration
Federal Ownership	Future Off-Property Farmer (adult and child), homegrown produce off-property, grazing off-property, groundwater off-property	air	inhalation	particulates, volatiles, and gases	maximum estimated off-property future concentrations derived from air modeling
		plants (homegrown produce)	ingestion	fruits and vegetables	maximum estimated off-property future concentrations derived from air modeling and groundwater modeling
		livestock (grazing at property boundary)	ingestion	milk and beef	maximum estimated off-property future concentrations derived from air modeling and groundwater modeling
		groundwater	ingestion dermal contact inhalation of volatiles released during household use		modeled groundwater concentrations at fenceline when concentration is greatest
	Expanded Trespasser (youth)	air	inhalation	particulates, volatiles, and gases	maximum estimated on-subunit air concentrations derived from air modeling
		surface soil	incidental ingestion dermal contact external radiation		surface soil within subunit
		surface water	incidental ingestion dermal contact		surface water within subunit
		sediment	ingestion dermal contact external radiation		sediment within subunit

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TABLE 6-1
(Continued)

Future Land Use	Receptor		Direct Contact Medium	Route of Exposure		Exposure Point Concentration
Federal Ownership (Continued)	Great Miami River Users	Recreational User	surface water	ingestion dermal contact		estimated concentrations in the Great Miami River
			fish	ingestion		estimated concentrations in the Great Miami River
		Agricultural User	plants (homegrown produce irrigated with water from Great Miami River)	ingestion	fruit and vegetables	estimated concentrations in the Great Miami River
			livestock (grazing on crops irrigated with water from Great Miami River)	ingestion	beef and milk	estimated concentrations in the Great Miami River
		Household User	surface water	inhalation ingestion dermal contact	particulates, volatiles and gases	estimated concentrations in the Great Miami River
Without Federal Ownership	Future Off-Property Farmer (adult and child), homegrown produce off-property, grazing off-property, groundwater off-property		air	inhalation	particulates, volatiles, and gases	maximum estimated off-property future concentrations derived from air modeling
			plants (homegrown produce)	ingestion	fruits and vegetables	maximum estimated off-property future concentrations derived from air modeling and groundwater modeling
			livestock (grazing at property boundary)	ingestion	milk and beef	maximum estimated off-property future concentrations derived from air modeling and groundwater modeling
			groundwater	ingestion dermal contact inhalation of volatiles released during household use		modeled groundwater concentrations at fenceline when concentration is greatest

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TABLE 6-1
(Continued)

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure		Exposure Point Concentration
Without Federal Ownership (continued)	Future On-Property Resident Farmer (adult and child), homegrown produce on-subunit, livestock grazing on-property, groundwater on-property; will include RME and CT estimates	air	inhalation	particulates, volatiles, gases, and indoor radon	maximum estimated on-subunit future concentrations derived from air modeling; radon estimated from soil radium concentrations
		plants (homegrown produce)	ingestion	fruits and vegetables	maximum estimated on-subunit future concentrations derived from air modeling and groundwater modeling of the Great Miami Aquifer.
		livestock (grazing on property)	ingestion	milk and beef	maximum estimated on-subunit future concentrations derived from air modeling and groundwater modeling of Great Miami Aquifer
		groundwater	inhalation	particulates, volatiles, and gases	groundwater concentration in Great Miami Aquifer underlying subunit at time when concentration is greatest
			ingestion dermal contact		
		surface soil	incidental ingestion dermal contact external radiation		surface soil within subunit
	Future Homebuilder	waste material/subsurface soil	external radiation incidental ingestion dermal contact		subsurface soil within subunit
		air	inhalation	particulates, volatiles, and gases	air concentrations at construction site based on modeling

TABLE 6-1
(Continued)

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure		Exposure Point Concentration
Without Federal Ownership (Continued)	Future Perched Groundwater User, homegrown produce on-subunit, groundwater on-property	air	inhalation	particulates, volatiles, gases, and indoor radon	maximum estimated on-subunit future concentrations derived from air modeling; radon estimated from soil radium concentrations
		plants (home grown produce)	ingestion	fruits and vegetables	maximum estimated on-subunit future concentrations derived from air modeling and groundwater modeling of the Great Miami Aquifer
		livestock (grazing on property)	ingestion	milk and beef	maximum estimated on-subunit future concentrations derived from air modeling and groundwater modeling of the Great Miami Aquifer
		perched groundwater directly underlying subunit	ingestion dermal contact inhalation of volatiles released during house use		perched groundwater concentrations directly underlying the subunit at time when concentrations are greatest
		surface soil	incidental ingestion dermal contact external radiation		surface soil within subunit

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- Inhalation of fugitive dust, VOCs, and gases.
- Incidental ingestion of, direct radiation exposure from, and dermal contact with contaminated soils.
- Incidental ingestion of and dermal contact with surface water.
- Incidental ingestion of and dermal contact with contaminated sediment.

- On- Property Groundskeeper - This exposure scenario considers the risks associated with the on-site maintenance receptor. Exposure pathways include:

  - Inhalation of fugitive dust, VOCs, and gases
  - Incidental ingestion of, dermal contact with, and direct radiation exposure from contaminated soil.

Current land use without access controls include the following receptors:

- Users of Meat and Milk Products from Livestock Grazing on the Site - This exposure scenario considers the risks associated with off-property use of animal products produced by cattle currently grazing on Operable Unit 2. Exposure pathways include:

  - Ingestion of beef and milk

Under the current scenario, the user of the Great Miami River was evaluated for three exclusive uses. This exposure scenario evaluates risks associated with the Great Miami River for recreational, agricultural, and residential uses. It is assumed that the preceding use receptors are exclusive. Exposure routes for each receptor include:

- Recreational Use
  - Ingestion of and dermal contact with surface water
  - Ingestion of fish

- Agricultural Use
  - Consumption of beef and milk produced using contaminated water
  - Consumption of fruits and vegetables produced using contaminated water

- Residential Use
  - Ingestion of drinking water
  - Inhalation of VOCs during household use
  - Dermal contact while bathing

Receptors listed in the Risk Assessment Work Plan Addendum not evaluated under current land use assumptions for this risk assessment include:

- Visitor - This scenario is intended to evaluate exposures incurred by the activities of a regular visitor to the FEMP site who is not covered by a health and safety or radiation protection program. An example of this receptor would be a delivery person making regular deliveries to a given building on site. This receptor was not considered applicable, since no visitor would consistently visit the Operable Unit 2 Study Area.

- On-Property Building User - This scenario considers risks from occupancy of an existing on-site building by a hypothetical receptor. This receptor was not considered since no existing habitable structures exist in Operable Unit 2.

- Hunter - this scenario examines risks due to consumption of animal products from wild animals found on the FEMP property. This receptor, as stated in the Risk Assessment Work Plan Addendum, will be evaluated in Operable Unit 5.

To evaluate risk to potential future receptors, it is assumed that the FEMP site will either be retained by the federal government (federal ownership) or will be released for private development (without federal ownership). If it is assumed that the most likely option of the FEMP site under federal ownership is continued restrictive access, therefore, the most likely future receptor might be an expanded trespasser. Potential exposures to an off-property farm family are also evaluated, assuming that the most likely off-site future land use would be agricultural. Specific exposure pathways by which these receptors may be exposed to contaminants on or migrating from Operable Unit 2 source areas are listed in Table 6-1.

For the purpose of establishing preliminary remediation goals (PRGs) for the Future Land Use With Continued Federal Ownership scenario, an on-property trespassing receptor was established. Under this exposure scenario, access to the site would be restricted and discouraged through the construction and maintenance of signs, fences, and locked gates around the perimeter of the restricted area. Despite these controls, it was assumed that trespassing would occur. The expanded trespasser scenario assumes a youth (ages 6 to 18) trespasses 110 days per year for two hours each day and the same person trespasses as an adult (ages 18 to 50) 40 days per year for one hour each day. This receptor and the associated exposure factors apply only to Operable Units 1, 2, 3, and 4. The risk assessment for the Operable Unit 5 FS will include additional trespassing and recreational exposure scenarios, which are to be fully developed on a site-wide basis within the Operable Unit 5 RI/FS. A full array of trespassing and recreational exposure scenarios from no trespassing through full recreational use of the site will be developed.

As summarized in Table 6-1, future land use receptors, assuming federal ownership, include:

- Expanded Trespasser - This scenario assumes that the same visitor will routinely visit what is now the Operable Unit 2 Study Area. The expanded trespasser is assumed to wander unrestricted over the entire site. Exposure routes include:

  - Inhalation of fugitive dust, VOCs, and gases.

- Incidental ingestion of, dermal contact with, and external radiation from contaminated soil.
- Incidental ingestion of and dermal contact with surface water.
- Incidental ingestion of, dermal contact with, and external radiation from contaminated sediment.

- Off-Property Resident Farmer (Adult and Child) - This scenario assumes that a farm family lives immediately adjacent to the FEMP property boundary. Exposure routes for this receptor include those listed for the same receptor assuming current land use, in addition to ingestion, dermal contact, and inhalation from groundwater.

Under the current scenario, the user of the Great Miami River was evaluated for three exclusive uses. This exposure scenario evaluates risks associated with the Great Miami River for recreational, agricultural, and residential uses. It is assumed that the preceding use receptors are exclusive. Exposure routes for each receptor include:

- Recreational Use
  - Ingestion of and dermal contact with surface water
  - Ingestion of fish

- Agricultural Use
  - Consumption of beef and milk produced using contaminated water
  - Consumption of fruits and vegetables produced using contaminated water

- Residential Use
  - Ingestion of drinking water
  - Inhalation of VOCs during household use
  - Dermal contact while bathing

If the FEMP property does not remain under the federal ownership, it is assumed that it will be held in private ownership and developed for agricultural use. As summarized in Table 6-1, future land use receptors, assuming private ownership, include:

- Reasonable Maximum Exposure (RME) On-Property Resident Farmer Receptor (Adult and Child) - This exposure assumes that a farmer resides on the property and conducts agricultural activities. Typical activities may include food and feed production, livestock production, and general farm work. This scenario includes only household use of perched groundwater because the perched groundwater zone would not be sufficient to support agricultural uses. Exposure routes include:

  - Inhalation of fugitive dust, VOCs, and gases.
  - Ingestion of groundwater (separate evaluations for groundwater from the Great Miami Aquifer and for perched groundwater).
  - Dermal contact and inhalation while using groundwater in the home.
  - Consumption of foodstuff grown on the property including vegetables, meat, and milk.
  - Incidental ingestion of, external radiation from, and dermal contact with soil.
  - Inhalation of indoor radon.

- Central Tendency (CT) On-Property Resident Farmer Receptor (Adult and Child) - This exposure assumes that a farmer resides on the property and conducts agricultural activities. This exposure is similar to the RME on-property resident farmer with modifications of exposure parameter values to more closely reflect values typical of the CT of exposure. Exposure routes for this receptor include those listed for the RME on-property resident farmer receptor, excluding ingestion of perched groundwater.

- Future Home Builder - This exposure scenario involves exposures to workers building residences or other structures within Operable Unit 2. This scenario includes only household use of perched groundwater because the perched groundwater zone would not be sufficient to support agricultural uses. Exposure routes include:

  - Incidental ingestion of, and dermal contact with, and external radiation from soil.
  - Inhalation of fugitive dust, VOCs, and gases.

- A Perched Groundwater User - This exposure scenario involves exposures to users of perched groundwater within Operable Unit 2. Exposure routes include:

  - Inhalation and dermal contact while using perched groundwater
  - Ingestion of perched groundwater

6.2.2 Constituents of Potential Concern (CPCs)

CPCs are defined as those compounds present in environmental media at levels that exceed background and that may present a risk to human health. These are the constituents for which analytical data are available and used for fate and transport modeling and risk characterization throughout baseline risk assessment. Constituents which remain a concern after baseline risks have been calculated become the contaminants of concern (COCs).

The selection of chemical and radionuclide CPCs for Operable Unit 2 is based on data developed in the Operable Unit 2 RI and included a critical review of site data characterizing soils, groundwater, surface water, and sediment within the Operable Unit 2 study areas. Data were collected in accordance with DQOs established in the FEMP QAPP, Sections 2.11 and 2.12 and the Operable Unit 2 Sampling and Analysis Plan (DOE 1993b). The raw data sets on which analyses were performed are presented in Section 4.0 of this RI report and are tabulated in Appendices C through G.

CPCs for this risk assessment were selected using a statistical and toxicological screening process which is described in detail in Appendix B.2.0. Statistical analyses compared and measured on-site concentrations of each detected constituent to background and the 95th percentile concentrations of

that same constituent in the same medium. Constituents whose concentration levels were not statistically greater than background or the 95th percentile concentrations were eliminated from further consideration in the risk assessment. Exceptions to the selection procedure are outlined in Appendix B.2.4 and include Group A and B chemical carcinogens (Section B.2.5.1.2) and radionuclides which were possible CPCs based on background screening. In the toxicological screening, each constituent detected above background in a given medium was compared to conservative toxicological screening criteria including risk-based screening values which were derived using EPA Risk Assessment Guidance Part B (EPA 1991c). Laboratory contaminants (identified during data validation), essential micronutrients and macronutrients (Ca, Mg, etc.), and ubiquitous minerals (Si, Cl, etc.) were excluded as CPCs. Calculated EPA screening values were based on a carcinogenic risk of 1.0×10^{-7} and a noncarcinogenic Hazard Index (HI) of 0.1. Constituents that were present below screening levels were excluded from quantification in the risk assessment. Details of the CPC identification process for Operable Unit 2 are presented in Section B.2.4.

Tables 6-2 through 6-6 summarize the Operable Unit 2 CPCs identified by media for each subunit. The detailed results of application of the CPC selection process to each medium within each operable unit subunit are described in Section B.3.0 of Appendix B.

6.2.3 Exposure Assessment

The exposure assessment is the determination of the magnitude of contact that a potential receptor may have with site-related CPCs. The general procedure for conducting an exposure assessment involves the following three steps: (1) characterization of the physical setting, (2) identification of exposure pathways, and (3) quantification of exposure.

In the first step, the general physical characteristics of the site and characteristics of potential receptor populations are described. Physical characteristics of the Operable Unit 2 subunits are summarized in detail in Section 3.0 of this RI report.

In the second step, the predominant migration and exposure pathways are identified. Pathways are identified on the basis of specific sources, releases, types, and locations of chemicals at the site; environmental fate of chemical and radioactive constituents; and locations and activities of potentially exposed populations. Section B.2.0 in Appendix B summarizes this information for Operable Unit 2.

TABLE 6-2

ACTIVE FLYASH PILE
OPERABLE UNIT 2 CONTAMINANTS OF POTENTIAL CONCERN

Surface Soil	Subsurface Soil	Surface Water	Sediment	Groundwater (GMA)
arsenic	arsenic	arsenic	arsenic	arsenic
beryllium	beryllium		berylium	berylium
lead	lead		neptunium-237	lead
thallium	thallium		plutonium-238	molybdenum
cesium-137	neptunium-237		plutonium-239/240	neptunium-237
neptunium-237	lead-210		radium-226	strontium-90
plutonium-238	plutonium-238		radium-228	uranium-234
plutonium-239/240	plutonium-239/240		strontium-90	uranium-235/236
radium-226	radium-224		uranium-234	uranium-238
radium-228	radium-226		uranium-235/236	uranium-total
strontium-90	radium-228		uranium-238	2-methylnaphthalene
thorium-228	strontium-90			
thorium-230	thorium-228			
thorium-232	thorium-230			
thorium-total	thorium-232			
uranium-234	thorium-total			
uranium-235/236	uranium-234			
uranium-238	uranium-235			
	uranium-235/236			
	uranium-238			
	2-methylnaphthalene			
	phenanthrene			

TABLE 6-3

SOUTH FIELD
OPERABLE UNIT 2 CONSTITUENTS OF POTENTIAL CONCERN

Surface Soil	Subsurface Soil	Surface Water	Sediment	Groundwater (GMA)
arsenic	arsenic	arsenic	arsenic	arsenic
beryllium	beryllium	lead	beryllium	lead
lead	lead	uranium-234	lead	neptunium-237
cesium-137	cesium-137	uranium-235/236	nickel	radium-226
neptunium-237	neptunium-237	uranium-238	neptunium-237	strontium-90
plutonium-238	lead-210	uranium-total	plutonium-238	technetium-99
plutonium-239/240	plutonium-238	neptanium-237	radium-226	uranium-234
radium-226	plutonium-239/240	radium-226	radium-228	uranium-235/236
radium-228	radium-224	technetium-99	strantium-90	uranium-238
strontium-90	radium-226	2-methylnaphthalene	technetium-99	uranium-total
technetium-99	radium-228	benzo(a)pyrene	uranium-234	2-methylnaphthalene
thorium-228	ruthenium-106	phenanthrene	uranium-235/236	benzo(g,h,i)perylene
thorium-230	thorium-228	tributyl phosphate	uranium-238	phenanthrene
thorium-232	thorium-230		uranium-total	tributyl phosphate
thorium-total	thorium-232		benzo(a)anthracene	
uranium-234	thorium-total		benzo(a)pyrene	
uranium-235/236	uranium-234		benzo(b)fluoranthene	
uranium-238	uranium-235		benzo(g,h,i)perylene	
Aroclor-1254	uranium-235/236		bis(2-ethylhexyl)phthalate	
Aroclor-1260	uranium-238		dibenzo(a,h)anthracene	
dieldrin	uranium-total		dieldrin	
benzo(a)anthracene	2-methylnaphthalene		phenanthrene	
benzo(a)pyrene	benzo(a)anthracene			
benzo(b)fluoranthene	benzo(a)pyrene			
benzo(g,h,i)perylene	benzo(b)fluoranthene			
benzo(k)fluoranthene	benzo(g,h,i)perylene			
dibenzo(a,h)anthracene	phenanthrene			
indeno(1,2,3-cd)pyrene	tributyl phosphate			
phenanthrene	octachlo-odibenzo-p-dioxin			
	tetrachlorodibenzofuran			
	Aroclor-1254			
	Aroclor-1260			
	dieldrin			

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TABLE 6-4

INACTIVE FLYASH PILE
OPERABLE UNIT 2 CONSTITUENTS OF POTENTIAL CONCERN

Surface Soil	Subsurface Soil	Surface Water	Sediment	Groundwater (GMA)
arsenic	arsenic	arsenic	plutonium-239/240	neptunium-237
beryllium	beryllium	berylium	strontium-90	radium-226
lead	lead	cadmium	uranium-234	strontium-90
neptunium-237	cesium-137	lead	uranium-235/236	technetium-99
plutonium-238	neptunium-237	nickel	uranium-238	uranium-234
plutonium-239/240	lead-210	neptunium-237	uranium-total	uranium-235/236
radium-226	plutonium-238	plutonium-238	arsenic	uranium-238
radium-228	plutonium-239/240	plutonium-239/240	berylium	uranium-total
strontium-90	radium-224	radium-226	dibenzo(a,h)anthracene	lead
thorium-228	radium-226	radium-228	neptunium-237	arsenic
thorium-230	radium-228	strontium-90	plutonium-238	2-methylnaphthalene
thorium-232	ruthenium-106	uranium-234	radium-226	benzo(g,h,i)perylene
thorium-total	thorium-228	uranium-235/236	radium-228	phenanthrene
uranium-234	thorium-230	uranium-238		tributyl phosphate
uranium-235/236	thorium-232	uranium-total		
uranium-238	thorium-total	2-methylnaphthalene		
2-methylnaphthalene	uranium-234			
dibenzo(a,h)anthracene	uranium-235			
	uranium-235/236			
	uranium-238			
	uranium-total			
	2-methylnaphthalene			
	benzo(a)anthracene			
	benzo(a)pyrene			
	benzo(b)fluoranthene			
	benzo(g,h,i)perylene			
	phenanthrene			
	tributyl phosphate			
	octachlorodibenzo-p-dioxin			
	tetrachlorodibenzofuran			
	Aroclor-1254			
	Aroclor-1260			
	dieldrin			

TABLE 6-5

SOLID WASTE LANDFILL
OPERABLE UNIT 2 CONSTITUENTS OF POTENTIAL CONCERN

Surface Soil	Subsurface Soil	Surface Water	Sediment	Perched Water	Groundwater (GMA)
arsenic	antimony	arsenic	neptunium-237	technetium-99	technetium-99
beryllium	arsenic	beryllium	arsenic	carbazole	
lead	beryllium	lead	berylium	2-methylnaphthlene	
neptunium-237	lead	neptunium	radium-226	endosulfan sulfate	
plutonium-238	cesium-137	radium-226	radium-228		
plutonium-239/240	neptunium-237	radium-228	strontium-90		
radium-226	lead-210	strontium-90	uranium-234		
radium-228	plutonium-238	uranium-234	uranium-235/236		
strontium-90	plutonium-239/240	uranium-235/236	uranium-238		
thorium-228	radium-224	uranium-238	uranium-total		
thorium-230	radium-226	uranium-total	benzo(a)anthracene		
thorium-232	radium-228	benzo(g,h,i)peryle	benzo(a)pyrene		
thorium-total	strontium-90	dibenzo(a,h)anthracene	dibenzo(a,h)anthracene		
uranium-234	technetium-99	phenanthrene			
uranium-235/236	thorium-228				
uranium-238	thorium-230				
benzo(a)anthracene	thorium-232				
benzo(a)pyrene	thorium-total				
benzo(b)fluoranthene	uranium-234				
benzo(g,h,i)perylene	uranium-235				
dibenzo(a,h)anthracene	uranium-235/236				
indeno(1,2,3-cd)pyrene	uranium-238				
phenanthrene	uranium-total				
	2-methylnaphthalene				
	benzo(a)anthracene				
	benzo(a)pyrene				

TABLE 6-5
(Continued)

Surface Soil	Subsurface Soil	Surface Water	Sediment	Perched Water	Groundwater (GMA)
	benzo(b)fluoranthene				
	benzo(g,h,i)perylene				
	carbazole				
	dibenzo(a,h)anthracene				
	indeno(1,2,3-cd)pyrene				
	phenanthrene				
	1,4-dioxane				
	heptachlorodibenzo-p-dioxin				
	heptachlorodibenzofuran				
	octachlorodibenzo-p-dioxin				
	Aroclor-1254				
	Aroclor-1260				
	dieldrin				
	endosulfan sulfate				
	endrin aldehyde				

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TABLE 6-6

LIME SLUDGE PONDS
OPERABLE UNIT 2 CONSTITUENTS OF POTENTIAL CONCERN

Surface Soil	Waste Material	Perched Water	Groundwater (GMA)
arsenic	arsenic	neptunium-237	technetium-99
beryllium	beryllium	strontium-90	
lead	lead	technetium-99	
cesium-137	cesium-137	arsenic	
neptunium-237	neptunium-237	1,1,2-trichlorotrifluoroethane	
plutonium-238	plutonium-238	1,2-diethylbenzene	
plutonium-239/240	plutonium-239/240		
radium-226	radium-226		
radium-228	radium-228		
strontium-90	strontium-90		
thorium-228	technetium-99		
thorium-230	thorium-228		
thorium-232	thorium-230		
thorium-total	thorium-total		
uranium-234	uranium-234		
uranium-235/236	uranium-235/236		
uranium-238	uranium-238		
uranium-total	Aroclor-1254		
Aroclor-1254	benzo(g,h,i)perylene		
benzo(a)anthracene	dibenzo(a,h)anthracene		
benzo(a)pyrene	ideno(1,2,3-cd)pyrene		
benzo(b)fluoranthene	phenanthrene		
benzo(g,h,i)perylene	1,1,2trichlorotriflurorethane		
bis(2-Ethylhexyl)phthalate	1,2-diethylbenzene		
dibenzo(a,h)anathracene	acrylonitrile		
ideno(1,2,3-cd)pyrene			
phenanthrene			

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The third step, quantification of exposures, involves calculation of estimated intake of contaminants. For each identified receptor, chemicals are calculated in mg/kg per day (mg/kg-day) and for radionuclides in pCi. Equations used to derive intakes are summarized in Section B.2.0 of Appendix B, while the calculated intakes are included in Attachment III of Appendix B.

6.2.3.1 Exposure Point Concentrations

The exposure point concentration is the concentration of a constituent in an environmental medium that may be contacted by a real or hypothetical receptor. It is used in combination with other exposure parameters in intake equations to quantify the actual intake (in mg/kg-day for chemicals and pCi for radionuclides) that a receptor may receive via a specific pathway (e.g., soil, groundwater, etc.), and route of exposure (e.g., ingestion, inhalation, and dermal contact).

Exposure point concentrations for Operable Unit 2 were determined in different ways, depending on whether exposures were assumed to be current or future and depending on the environmental medium of interest. To be consistent with the concept of the RME scenario required by EPA, an estimate of the highest exposure that can reasonably be expected to occur requires a reasonable maximum estimate of the concentration of each contaminant in each exposure medium. Because of the uncertainty associated with any estimate of exposure point concentrations, the upper 95 percent confidence limit on the calculated mean for either a normal or lognormal distribution is the recommended statistic (concentration value) to be constructed from measured contaminant concentration data and used in risk assessments (EPA 1992a). This term is generally called the upper 95 percent confidence limit (UCL). Derivation of the 95 percent UCL for each environmental medium is described in detail in Appendix B, Section B.2.0.

Exposure Point Concentrations for Soil

Exposure point concentrations for direct contact surface soil exposure pathways, under both current and future land use assumptions, are the 95 percent UCLs determined from surface soil data using the process described in the FEMP guidelines for determining CPCs and Appendix B, Section B.2.0.

Exposure Point Concentrations for Groundwater

Current exposures to groundwater at the FEMP will be addressed as part of the Operable Unit 5 RI. Exposure to potential future concentrations of constituents in groundwater from each operable unit are addressed during each operable unit RI baseline risk assessment. Future exposure point

concentrations for groundwater are determined from the results of groundwater transport modeling, as described in detail in Section 5.0 and Appendix A.

For assessment of exposures to constituents migrating in groundwater from the South Field and Inactive Flyash Pile, source terms from these two subunits were combined. For assessment of exposures to contaminants migrating from the Active Flyash Pile, Solid Waste Landfill, and Lime Sludge Ponds, independent source terms were derived.

Soil CPCs for each subunit (Inactive Flyash Pile and South Field combined) were subjected to leachate estimations as described in Section 5.4.2.1. CPCs determined to be present in leachate above screening criteria (derived from EPA RAGs Part B risk of 1.0×10^{-7} and a HI of 0.1) were then modeled in the vadose zone using the methodology outlined in Section 5.4.2.2. Leachate concentrations are modeled through the vadose zone to the regional aquifer to yield the calculated future concentrations in the aquifer directly underlying the waste area. Concentrations of CPCs determined to be present at this interface at levels above EPA Region III tap water criteria (risk of 1×10^{-7} and a HI of 0.1) were then selected as groundwater CPCs; their concentrations were estimated at specific locations (on-subunit, on-property, and off-property).

Off-property concentrations of constituents in groundwater were calculated using the regional aquifer model, SWIFT III (Geotrans 1987b). The maximum calculated concentrations in the aquifer underlying the Active Flyash Pile; South Field and Inactive Flyash Pile Area (combined); Solid Waste Landfill; and Lime Sludge Ponds were used to estimate on-subunit exposures. The maximum calculation concentrations on-property and at the fenceline were used for exposure point concentrations for on-property and off-property future groundwater exposures. Details of the model and parameters used to calculate future CPC concentrations in the Great Miami Aquifer are presented in Section 5.0. The locations of calculated maximum off-property concentrations of contaminants transported from the waste areas of Operable Unit 2 by groundwater are also shown in Section 5.0.

Exposure Point Concentrations for Surface Water and Sediment

Like groundwater, exposures to current concentrations in surface water and sediment, if present, outside the boundaries of Operable Unit 2 waste areas are to be addressed in the Operable Unit 5 risk assessment. CPC exposure point concentrations for current exposures to surface water and sediment within each subunit were estimated using fate and transport modeling. For future exposures to

surface water in Paddys Run and the Great Miami River, fate and transport modeling was used to determine CPC exposure point concentrations. Surface water CPCs included all CPCs selected for surface soil within each subunit. The Modified Universal Soil Loss Equation (MUSLE), a commonly used soil loading model (EPA 1988c), was used to determine if soil runoff, and hence sorbed constituent runoff, would contribute significantly to constituent concentrations in Paddys Run and consequently in the Great Miami River. The source term for this model is the 95 percent UCL surface soil concentrations. The model and modeling results are presented in Section 5.0 and Appendix A.

Exposure Point Concentrations for Air

Operable Unit 2 airborne concentrations of constituents from the individual waste areas were modeled for both current and future conditions at on-subunit, on-property, and off-property locations. The model assumed mass loading (fugitive dust emissions) of surface soil to the air from each waste area and subsequent transport and dispersion of contaminants. The model and parameters for air dispersion are described in Section 5.0. The initial source term for air modeling is the 95 percent UCL soil concentration. The results of air modeling provide the highest annual average air concentrations and deposition rates at each of the specified locations (on-subunit, on-property, off-property). This allows for calculation of exposures to constituents being released to air and exposures resulting from ingestion of vegetation on which air particulates are deposited.

6.2.3.2 Intake Equations

The equations and parameter values used in estimating intake are provided in Section B.2.2 of Appendix B. Attachment III of Appendix B presents the calculated intakes by subunit for each current and future receptor, media, and pathway.

6.2.4 Toxicity Assessment

A toxicity assessment examines information concerning the potential effects of exposure to CPCs and summarizes EPA-approved toxicity values. The goal is to provide a quantitative estimate of the relationship between the magnitude and type of exposure and severity or probability of human health effects for each CPC. The toxicity assessment, Section B.2.5 of Appendix B, contains a compilation of toxicity values for CPCs. Summaries of the toxic effects associated with major CPCs are included as toxicity profiles collected in Attachment II, Appendix B.

6.2.5 Risk Characterization

Risk characterization is the final step in the risk assessment process, combining the information developed in the exposure assessment (Section B.2.4) and the toxicity assessment (Section B.2.5) . Risk characterization is discussed in detail in Section B.2.6 of Appendix B. The potential of a CPC to cause carcinogenic effects is presented as the incremental lifetime cancer risk (ILCR). Potential noncarcinogenic effects are presented as hazard quotients (HQs) or HIs, as defined in Section B.2.6 of Appendix B.

All site-related risks in the risk assessment are calculated without subtracting the contribution from natural background. In some areas in Operable Unit 2, the concentrations of CPCs are only slightly above background levels. Therefore, it is informative to calculate the risks from background contributions to provide a point of comparison for the site-related risk estimates.

Risks and HIs are calculated for background concentrations of CPCs in soil and groundwater using the same exposure pathways quantitatively evaluated for the RME on-property resident farmer for soil. Exposure point concentrations, which are dependent on the results of air and groundwater modeling, were derived assuming background soil concentrations for the source terms in both groundwater and soil modeling. The parameter values used for calculating background intakes are also the same as those used for evaluating subunit-specific risks to the RME on-property resident farmer. Soil concentrations used for background risk and hazard calculations are calculated UCL values for the site-specific background soil sample analytical results.

6.3 RESULTS

This section presents the COCs and results of risks and hazards from each subunit as well as cumulative risk from Operable Unit 2 as a whole. COCs are constituents (i.e., CPCs) which remain a concern (greater than 1 x 10^{-6} ILCR or 0.2 HI) after baseline risks have been calculated. Summary of tables in this section present the total risks and hazards posed to each receptor via the various pathways (e.g., soil, sediment, homegrown produce, etc.). Additionally, summaries of major contributors to risks and hazards by pathways are provided for selected future land use receptors. These receptors include the off-property farmers, expanded trespasser, and on-property farmer (RME). Major contributors to current land use receptors are discussed briefly in this section and are presented in detail in Section B.3.0 of Appendix B.

Summary tables in Appendix B present detailed lists of CPCs contributing risk to specific scenarios and receptors via the various pathways.

6.3.1 Active Flyash Pile

Table 6-7 presents the COCs by media identified for the Active Flyash Pile.

TABLE 6-7

ACTIVE FLYASH PILE
CONTAMINANTS OF CONCERN (COCs)

SOIL		SURFACE WATER
cesium-137 neptunium-237 radium-226 radium-228	thorium-228 thorium-232 arsenic beryllium	No COCS
SEDIMENT		**GROUNDWATER**
radium-226	arsenic	uranium-234 uranium-238 uranium-total
PERCHED GROUNDWATER		**AIR**
no COCs		radon
DUST ON BEEF/MILK AND HOMEGROWN PRODUCE		**GROUNDWATER ON BEEF/MILK AND HOMEGROWN PRODUCE**
arsenic		strontium-90 radium-226 uranium-235/236 uranium-total
GREAT MIAMI RIVER SURFACE WATER		
no COCs		

Tables 6-8A and 6-8B summarize total risks and hazards by media, respectively, associated with the Active Flyash Pile for all receptors assuming current land use. Exposure of the trespassing youth and groundskeeper to contaminated soil were associated with carcinogenic risks in the 1.0×10^{-6} to 1.0×10^{-5} range. Major contributors to total receptor risk posed to the trespassing youth were from radium-226 (23.27 percent), radium-228 (7.69 percent), thorium-228 (17.85 percent), and thorium-232 (19 percent) in soil via external radiation and from arsenic (8.28 percent) in soil via dermal contact. Exposure of the groundskeeper to contaminated soil was associated with a risk of 7.9×10^{-5}. Exposure to this receptor was mostly from radium-226, radium-228, thorium-228, and thorium-232 which accounted for 82 percent combined of the total risk to this receptor. Arsenic also contributed an additional 10 percent of the total receptor risk. No exposures resulted in HIs exceeding 1.0.

TABLE 6-8A

CURRENT LAND USE
ACTIVE FLYASH PILE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User Recrea.	Resid.	Agric.
Soil								
Total Rad Risk	1.8E-05	1.1E-07	1.9E-09	N/A[a]	6.9E-05	N/A	N/A	N/A
Total Chem Risk	2.6E-06	6.7E-08	5.7E-09	N/A	1.0E-05	N/A	N/A	N/A
Total Risk	2.1E-05	1.7E-07	7.6E-09	N/A	7.9E-05	N/A	N/A	N/A
Surface Water								
Total Rad Risk	1.9E-07	N/A	N/A	N/A	N/A	-[b]	-	N/A
Total Chem Risk	5.0E-07	N/A	N/A	N/A	N/A	1.4E-09	7.7E-09	N/A
Total Risk	6.9E-07	N/A	N/A	N/A	N/A	1.4E-09	7.7E-09	N/A
Sediment								
Total Rad Risk	2.8E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	1.2E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	4.0E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (Dust Affected)								
Total Rad Risk	N/A	7.2E-12	5.1E-10	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	1.3E-07	4.4E-08	N/A	N/A	N/A	N/A	N/A
Total Risk	N/A	1.3E-07	4.4E-08	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.0E-09
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.0E-09
Beef/Milk (Dust Affected)								
Total Rad Risk	N/A	1.1E-09	1.9E-10	1.2E-08	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	4.6E-08	1.2E-08	4.6E-07	N/A	N/A	N/A	N/A
Total Risk	N/A	4.7E-08	1.2E-08	4.7E-07	N/A	N/A	N/A	N/A

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TABLE 6-8A
(Continued)

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User Recrea.	Resid.	Agric.
Beef/Milk (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.5E-10
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.5E-10
Ambient Radon	2.4E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

[b]No risk greater than the threshold level of 1×10^{-6}.

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TABLE 6-8B

CURRENT LAND USE
ACTIVE FLYASH PILE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User Rec.	Great Miami River User Res.	Great Miami River User Agric.
Soil								
Total Hazard	3.1E-02	N/D[a]	N/D	N/A[b]	5.9E-02	N/A	N/A	N/A
Surface Water								
Total Hazard	4.9E-03	N/A	N/A	N/A	N/A	6.1E-06	1.5E-05	N/A
Homegrown Produce (Dust Affected)								
Total Hazard	N/A	2.5E-04	9.7E-04	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Hazard	NA	N/A	N/A	N/A	N/A	N/A	5.7E-06	5.7E-06
Beef/Milk (Dust Affected)								
Total Hazard	N/A	3.6E-04	1.2E-03	3.7E-03	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)								
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	1.0E-06	1.0E-06

[a]N/D Not determined because toxicity data are not available.

[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

Tables 6-9A and 6-9B summarize total risks and hazards by media, respectively, associated with the Active Flyash Pile for receptors assuming future land use. Tables 6-10A and 6-10B present the major contributors by media to total risks and hazards, respectively, posed to the selected receptors. The greatest risks associated with the Active Flyash Pile are from external radiation via surface soil (surface flyash material) and ingestion of groundwater. Total estimated risks to the expanded trespasser exceeded the 1.0×10^{-3} level due mostly to the estimated presence of radium-226, radium-228, throrium-228, thorium-232, neptunium-237, and arsenic in flyash material which accounted for 86.5 percent of the total risk to this receptor.

Total estimated risk to the off-property farmer exceeded the 1.0×10^{-5} level due mostly to direct exposure to the estimated future concentrations of uranium-234 and uranium-238 and in groundwater which together accounted for about 56 percent of total risk to this receptor. The estimated presence of strontium-90 in flyash material accounted for another 14.61 percent of total risk to this receptor due to its estimated deposition on produce.

Total estimated risks to future on-property residents were greatest for the RME farmer. Total risks to this receptor was 1.9×10^{-3} due mostly to the presence of uranium-234 and uranium-238 in groundwater which accounted for 54.4 percent of the total receptor risk. Contributions of homegrown and produce risk for this receptor are 23.7 percent of the total receptor risk due primarily from arsenic in dust affected produce, and strontium-90 and radium-226 in groundwater affected produce.

The only receptor associated with total HI greater than 1.0 is the future on-property child. Total HI for the future on-property child is 2.8, due mostly to the presence of uranium-total in groundwater which accounted for 62.1 percent of the total receptor risk, and uranium-total in groundwater affected produce which accounted for an additional 29.63 percent of the total receptor risk.

Total estimated risk and hazard to the users of the Great Miami River were on the order of 1.0×10^{-9} and well below 1.0, respectively, for all receptors.

TABLE 6-9A

ACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Great Miami River User Rec.	Res.	Agric.
Soil								
Total Rad Risk	3.8E-05	1.1E-07	1.9E-09	1.1E-06	1.9E-08	N/A[a]	N/A	N/A
Total Chem Risk	6.3E-06	6.7E-08	5.7E-09	6.7E-07	5.7E-08	N/A	N/A	N/A
Total Risk	4.5E-05	1.7E-07	7.6E-09	1.7E-06	7.6E-08	N/A	N/A	N/A
Sediment								
Total Rad Risk	2.8E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	1.2E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	4.0E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater								
Total Rad Risk	N/A	6.4E-06	2.7E-07	4.7E-05	2.0E-06	N/A	N/A	N/A
Total Chem Risk	N/A	3.9E-09	7.8E-10	9.3E-15	1.9E-15	N/A	N/A	N/A
Total Risk	N/A	6.4E-06	2.8E-07	4.7E-05	2.0E-06	N/A	N/A	N/A
Surface Water								
Total Rad Risk	1.9E-07	N/A	N/A	N/A	N/A	-	-	N/A
Total Chem Risk	5.0E-07	N/A	N/A	N/A	N/A	1.4E-09	7.7E-09	N/A
Total Risk	6.9E-07	N/A	N/A	N/A	N/A	1.4E-09	7.7E-09	N/A
Homegrown Produce (Dust Affected)								
Total Rad Risk	N/A	7.2E-09	5.1E-10	7.3E-08	5.1E-09	N/A	N/A	N/A
Total Chem Risk	N/A	1.3E-07	4.4E-08	1.3E-06	4.4E-07	N/A	N/A	N/A
Total Risk	N/A	1.4E-07	4.4E-08	1.4E-06	4.5E-07	N/A	N/A	N/A
Homegrown Produce			**(Groundwater Affected)**			**(GMR Surface Water Affected)**		
Total Rad Risk	N/A	3.0E-06	2.1E-07	2.4E-05	1.7E-06	N/A	N/A	-
Total Chem Risk	N/A	9.4E-10	1.9E-10	3.4E-15	1.2E-15	N/A	N/A	3.0E-09
Total Risk	N/A	3.0E-06	2.1E-07	2.4E-05	1.7E-06	N/A	N/A	3.0E-09
Beef/Milk (Dust Affected)								
Total Rad Risk	N/A	1.1E-09	1.9E-10	1.2E-08	1.9E-09	N/A	N/A	N/A
Total Chem Risk	N/A	4.6E-08	1.2E-08	4.6E-07	1.2E-07	N/A	N/A	N/A
Total Risk	N/A	4.7E-08	1.2E-08	4.7E-07	1.2E-07	N/A	N/A	N/A
Beef/Milk			**(Groundwater Affected)**			**(GMR Surface Water Affected)**		
Total Rad Risk	N/A	9.2E-07	1.7E-07	7.2E-06	1.3E-06	N/A	N/A	-
Total Chem Risk	N/A	2.6E-10	6.0E-11	6.3E-16	1.5E-16	N/A	N/A	5.5E-10
Total Risk	N/A	9.2E-07	1.7E-07	7.2E-06	1.3E-06	N/A	N/A	5.5E-10

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

TABLE 6-9B

ACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Great Miami River User		
						Rec.	Res.	Agric.
Soil								
Total Hazard	3.7E-02	N/D[a]	N/D	N/D	N/D	N/A[b]	N/A	N/A
Sediment								
Total Hazard	2.7E-02	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater								
Total Hazard	N/A	9.9E-02	2.3E-01	7.5E-01	1.7E+00	N/A	N/A	N/A
Surface Water								
Total Hazard	4.9E-03	N/A	N/A	N/A	N/A	6.1E-06	1.5E-05	N/A
Homegrown Produce (Dust Affected)								
Total Hazard	N/A	2.5E-04	9.7E-04	2.5E-03	9.8E-03	N/A	N/A	N/A
Homegrown Produce			**(Groundwater Affected)**			**(GMR Surface Water Affected)**		
Total Hazard	N/A	9.2E-02	5.4E-01	2.1E-01	8.2E-01	N/A	N/A	5.7E-06
Beef/Milk (Dust Affected)								
Total Hazard	N/A	3.6E-04	1.2E-03	3.7E-03	1.2E-02	N/A	N/A	N/A
Beef/Milk			**(Groundwater Affected)**			**(GMR Surface Water Affected)**		
Total Hazard	N/A	2.7E-O3	2.7E-02	2.1E-02	2.1E-01	N/A	N/A	1.0E-06

[a]N/D not determined because toxicity data are not available.

[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-10A

ACTIVE FLYASH PILE
SUMMARY OF TOTAL CARCINOGENIC RISK
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Soil	1.7E-07[c]	1.60%	-[d]		4.5E-05	90.42%	Ra-226	25.25%	1.7E-06	2.07%	-	
							Th-232	20.60%				
							Th-228	19.33%				
							Arsenic	10.75%				
							Ra-228	8.33%				
							Neptunium	2.22%				
Groundwater	6.4E-06	59.38%	U-238	36.24%	NA[e]		-		4.7E-05	56.53%	U-238	35.81%
			U-234	18.74%							U-234	18.58%
Sediment	NA		-		4.0E-06	8.09%	Ra-226	4.00%	NA		-	
							Arsenic	2.11%				
Beef/Milk (Groundwater Affected)	9.2E-07		-		NA		-		7.2E-06	8.63%	Sr-90	7.22%
Home Grown Produce (Dust Affected)	1.4E-07[c]	1.30%	-		NA		-		1.4E-06	1.69%	Arsenic	1.43%

TABLE 6-10A
(Continued)

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Home Grown Produce (Groundwater Affected)	3.0E-06	27.69%	Sr-90	14.61%	NA		-		2.4E-05	28.76%	Sr-90	14.49%
											Ra-226	7.81%
											U-235/236	6.17%
ALL MEDIA	1.1E-05				4.9E-05				8.1E-05			

[a]RME = Reasonable Maximum Exposure

[b]COC = Contaminant of Concern

[c]Below risk threshold level - provided for comparison purposes

[d]No major risk contributors

[e]NA = not applicable to conceptual model

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TABLE 6-10B

ACTIVE FLYASH PILE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total
Soil	ND[c]		-[d]		3.7E-02[e]	53.20%	-		ND		-	
Sediment	ND		-		2.7E-08	39.20%			ND			
Groundwater	9.9E-02[e]	50.73%	U-Total	55.30%	NA[f]		-		7.5E-01	75.70%	U-Total	75.70%
Home Grown Produce (Groundwater Affected)	9.2E-02[e]	47.54%	-		NA		-		2.1E-01	21.57%	U-Total	21.57%
Surface Water	ND				4.9E-03	7.11%			ND			
ALL MEDIA	1.9E-01				6.9E-02				9.9E-01			

[a]RME = Reasonable Maximum Exposure

[b]COC = Contaminant of Concern

[c]ND = Not determined because toxicity data are not available

[d]No major hazard contributors

[e]Below hazard threshold level - provided for comparison purposes

[f]NA = not applicable to conceptual model

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6.3.2 South Field

Table 6-11 presents the COCs by media identified for the South Field.

TABLE 6-11

SOUTH FIELD
CONTAMINANTS OF CONCERN (COCs)

SOIL	
cesium-137	arsenic
neptunium-237	beryllium
radium-226	Aroclor-1254
radium-228	Aroclor-1260
thorium-228	benzo(a)anthracene
thorium-230	benzo(a)pyrene
thorium-232	benzo(b)fluoranthene
uranium-234	benzo(k)fluoranthene
uranium-235/236	dibenzo(a,h)anthracene
uranium-238	dieldrin
uranium-total	indeno(1,2,3-cd)pyrene

SURFACE WATER	
uranium-total	arsenic
dieldrin	

SEDIMENT
radium-226

GROUNDWATER	
uranium-234	uranium-238
uranium-235/236	uranium-total

PERCHED GROUNDWATER
no COCs

AIR
radon-222

DUST ON BEEF/MILK AND HOMEGROWN PRODUCE	
cesium-137	Aroclor-1260
radium-226	benzo(a)anthracene
radium-228	benzo(a)pyrene
strontium-90	benzo(b)fluoranthene
technetium-99	benzo(k)fluoranthene
uranium-238	dibenzo(a,h)anthracene
arsenic	dieldrin
beryllium	indeno(1,2,3-cd)pyrene
Aroclor-1254	

GROUNDWATER ON BEEF/MILK AND HOMEGROWN PRODUCE	
uranium-234	uranium-238
uranium-235/236	uranium-total

GREAT MIAMI RIVER SURFACE WATER	
radium-226	technetium-99

Tables 6-12A and 6-12B summarize risks and hazards by media, respectively, associated with the South Field for receptors assuming current land use. Total carcinogenic risk to the trespassing youth was 1.0×10^{-4}. Major contributors to total risk were from radium-226, radium-228, thorium-228, and thorium-232 via external radiation in surface soil which accounted for 54 percent of the total receptor risk; radium-226 in sediment which accounted for approximately 13 percent of total receptor risk; and exposure to dieldrin in surface water which accounted for an additional 23 percent of the total receptor risk.

TABLE 6-12A

CURRENT LAND USE
SOUTH FIELD
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User Rec.	Great Miami River User Res.	Great Miami River User Agric.
Soil								
Total Rad Risk	5.5E-05	1.8E-07	3.3E-09	N/A[a]	2.1E-04	N/A	N/A	N/A
Total Chem Risk	3.7E-06	9.4E-09	7.9E-10	N/A	1.1E-05	N/A	N/A	N/A
Total Risk	5.9E-05	1.9E-07	4.1E-09	N/A	2.2E.04	N/A	N/A	N/A
Sediment								
Total Rad Risk	1.4E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	6.7E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	1.5E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water								
Total Rad Risk	7.2E-07	N/A	N/A	N/A	N/A	4.1E-06	5.5E-08	N/A
Total Chem Risk	2.7E-05	N/A	N/A	N/A	N/A	1.1E-07	7.9E-09	N/A
Total Risk	2.8E-05	N/A	N/A	N/A	N/A	4.2E-06	6.3E-08	N/A
Homegrown Produce (Dust Affected)								
Total Rad Risk	N/A	1.2E-08	1.3E-09	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	7.3E.08	2.4E-08	N/A	N/A	N/A	N/A	N/A
Total Risk	N/A	8.5E-08	2.5E-08	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.8E-08
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.3E-09
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.9E-08
Beef/Milk (Dust Affected)								
Total Rad Risk	N/A	3.4E-09	6.0E-10	4.2E-08	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	3.6E-07	2.1E-07	4.4E-06	N/A	N/A	N/A	N/A
Total Risk	N/A	3.7E-07	2.1E-07	4.5E-06	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.4E-06
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.2E-09
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.4E-06

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.
[b]No risk greater than the threshold level of 1×10^{-6}

TABLE 6-12B

CURRENT LAND USE
SOUTH FIELD
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User Rec.	Great Miami River User Res.	Great Miami River User Agric.
Soil								
Total Hazard	4.7E-03	N/D[a]	N/D	N/A[b]	N/A	N/A	N/A	N/A
Sediment								
Total Hazard	4.9E-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water								
Total Hazard	5.3E+01	N/A	N/A	N/A	N/A	8.0E-07	2.5E-06	N/A
Homegrown Produce (Dust Affected)								
Total Hazard	N/A	1.8E-05	6.5E-05	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.0E-05
Beef/Milk (Dust Affected)								
Total Hazard	N/A	2.4E-06	6.7E-06	3.0E-05	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)								
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.6E-07

[a]Not determined because toxicity data are not available.
[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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Total HI for this receptor was 53 due primarily to the presence of uranium-total in surface water. Total estimated risk to the current groundskeeper is 2.2 x 10^{-4} due primarily to radium-226, radium-228, thorium-228, thorium-232, and benzo(a)pyrene in contaminated surface soil which accounted for 97.4 percent of total risk to this receptor. No hazard was associated with this receptor.

Tables 6-13A and 6-13B summarize risks and hazards by media, respectively, associated with the South Field for receptors assuming future land use. Tables 6-14A and 6-14B present the major contributors by media to total risks and hazards for the three selected receptors. The greatest risk was for the RME on-property farmer, which was 3.4 x 10^{-2}. Risks associated with all pathways were in the range of 1.0 x 10^{-5} to 1.0 x 10^{-2}. The greatest proportion of the risks to the on-property farmer (RME) was attributable to the future estimated concentrations of benzo(a)pyrene (57.2 percent) in dust affected beef and milk products, and from the presence of radium-226 (23.18 percent), thorium-228 (3.1 percent), and thorium-232 (4.25 percent) in surface soil. Total receptor risks to other on- and off-property receptors (off-property farmer and resident child; and on-property resident child) via contact with groundwater, beef and milk, and homegrown produce were in the 1.0 x 10^{-6} to 1.0 x 10^{-3} range. Total HIs to all on- and off-property farm receptors ranged from 1.1 (off-property farmer) to 63 (on-property child) due almost entirely to the estimated future presence of uranium-total in groundwater.

Total estimated risk and hazard to the users of the Great Miami River were on the order of 1.0 x 10^{-6} to 1.0 x 10^{-8}. Total receptor risk for the recreation user of the Great Miami River was 4.2 x 10^{-6} due primarily to the ingestion of fish contaminated with radium-226 and technetium-99 is surface water which accounted for approximately 77 percent of the total receptor risk. Total receptor risk for the agricultural user of the Great Miami River was 4.4 x 10^{-6} due almost entirely to beef and milk products irrigated with water from the Great Miami River containing technetium-99 which accounted for 97.3 percent of the total receptor risk. Total receptor risk for the residential user of the Great Miami River was 6.3 x 10^{-8}. Total HI for all users of the Great Miami River were well below 1.0.

6.3.3 Inactive Flyash Pile

Table 6-15 presents the COCs by media identified for the Inactive Flyash Pile.

TABLE 6-13A

SOUTH FIELD
FUTURE LAND USE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer (Private Owned)	Off-Property Resident Child (Private Owned)	On-Property Resident Farmer (RME)	On-Property Resident Child	Home Builder	Great Miami River User		
							Rec.	Res.	Agric.
Soil									
Total Rad Risk	1.2E-04	6.5E-06	1.2E-07	1.1E-02	8.1E-04	9.2E-06	N/A[a]	N/A	N/A
Total Chem Risk	6.1E-06	3.3E-07	2.8E-08	5.4E-04	2.4E-04	2.3E-06	N/A	N/A	N/A
Total Risk	1.2E-04	6.8E-06	1.5E-07	1.1E-02	1.0E-03	1.1E-05	N/A	N/A	N/A
Sediment									
Total Rad Risk	1.4E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	7.7E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	1.5E-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater									
Total Rad Risk	N/A	5.6E-05	2.4E-06	1.1E-03	4.7E-05	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	-[b]	-	-	-	N/A	N/A	N/A	N/A
Total Risk	N/A	5.6E-05	2.4E-06	1.1E-03	4.7E-05	N/A	N/A	N/A	N/A
Surface Water									
Total Rad Risk	7.2E-07	N/A	N/A	N/A	N/A	N/A	4.1E-06	5.5E-08	N/A
Total Chem Risk	1.1E-07	N/A	N/A	N/A	N/A	N/A	1.1E-07	7.9E-09	N/A
Total Risk	8.3E-07	N/A	N/A	N/A	N/A	N/A	4.2E-06	6.3E-08	N/A
Homegrown Produce (Dust Affected)									
Total Rad Risk	N/A	1.0E-06	7.3E-08	4.3E-04	3.0E-05	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	2.6E-06	8.7E-07	1.0E-03	3.4E-04	N/A	N/A	N/A	N/A
Total Risk	N/A	3.7E-06	9.4E-07	1.5E-03	3.7E-04	N/A	N/A	N/A	N/A

See footnotes at end of table

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TABLE 6-13A
(Continued)

Media	Expanded Trespasser	Off-Property Resident Farmer (Private Owned)	Off-Property Resident Child (Private Owned)	On-Property Resident Farmer (RME)	On-Property Resident Child	Home Builder	Great Miami River User		
Homegrown Produce			**(Groundwater Affected)**				**(GMR Surface Water Affected)**		
Total Rad Risk	N/A	1.7E-05	1.2E-06	3.3E-04	2.3E-05	N/A	N/A	N/A	1.8E-08
Total Chem Risk	-	-	-	-	-	N/A	N/A	N/A	1.3E-09
Total Risk	N/A	1.7E-05	1.2E-06	3.3E-04	2.3E-05	N/A	N/A	N/A	1.9E-08
Beef/Milk (Dust Affected)									
Total Rad Risk	N/A	2.0E-07	3.5E-08	8.0E-03	1.3E-03	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	1.7E-05	9.9E-06	1.1E-02	6.4E-03	N/A	N/A	N/A	N/A
Total Risk	N/A	1.7E-05	9.9E-06	1.9E-02	7.8E-03	N/A	N/A	N/A	N/A
Beef/Milk (Groundwater Affected)			**(Groundwater Affected)**				**(GMR Surface Water Affected)**		
Total Rad Risk	N/A	1.7E-06	3.1E-07	3.2E-05	5.9E-06	N/A	N/A	N/A	4.4E-06
Total Chem Risk	-	-	-	-	-	N/A	N/A	N/A	1.2E-09
Total Risk	N/A	1.7E-06	3.1E-07	3.2E-05	5.9E-06	N/A	N/A	N/A	4.4E-06

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

[b]No risk great than the threshold level of $1x10^{-6}$.

TABLE 6-13B

SOUTH FIELD
FUTURE LAND USE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Homebuilder	Great Miami River User		
							Rec.	Res.	Agric.
Soil									
Total Hazard	4.2E-03	N/A[a]	N/A	7.8E-02	3.4E-01	5.4E-01	N/A	N/A	N/A
Sediment									
Total Hazard	4.9E-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater									
Total Hazard	N/A	8.6E-01	2.1E+00	1.8E+01	4.1E+01	N/A	N/A	N/A	N/A
Surface Water									
Total Hazard	7.1E-02	N/A	N/A	N/A	N/A	N/A	8.0E-07	2.5E-06	N/A
Homegrown Produce (Dust Affected)									
Total Hazard	N/A	6.6E-04	2.5E-03	4.2E-01	1.6E+00	N/A	N/A	N/A	N/A
Homegrown Produce			**(Groundwater Affected)**				**(GMR Surface Water Affected)**		
Total Hazard	N/A	2.6E-01	1.0E+00	5.1E+00	1.9E+01	N/A	N/A	N/A	4.0E-05
Beef/Milk (Dust Affected)									
Total Hazard	N/A	2.2E-04	6.1E-04	1.4E-01	3.8E-01	N/A	N/A	N/A	N/A
Beef/Milk			**(Groundwater Affected)**				**(GMR Surface Water Affected)**		
Total Hazard	N/A	1.4E-02	9.3E-04	1.0E-02	3.5E-02	N/A	N/A	N/A	1.6E-07

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-14A

SOUTH FIELD
SUMMARY OF TOTAL CARCINOGENIC RISK
FOR SELECTED FUTURE LAND USE RECEPTOR
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Soil	1.9E-07[c]	6.35%	-[d]		1.2E-04	87.34%	Th-232	10.91%	1.1E-02	33.89%	Th-232	4.25%
							Th-228	7.94%			Th-228	3.10%
							Ra-228	59.89%			Ra-226	23.18%
Sediment	NA[e]		-		1.5E-05	10.67%	Ra-226	9.51%	NA		-	
Groundwater	5.6E-05	52.46%	U-238	33.91%	NA		-		1.1E-03	3.26%	U-238	2.11%
			U-234	17.55%							U-234	1.09%
Home Grown Produce (Dust Affected)	8.5E-08	3.43%	Benzo(a) pyrene	1.42%	NA		-		1.5E-03	4.39%	Tc-99	1.09%
											Benzo(a) pyrene	1.70%
Home Grown Produce (Groundwater Affected)	1.7E-05	15.81%	U-238	10.22%	NA		-		3.3E-04	0.98%		
			U-234	5.29%								
Beef/Milk (Dust Affected)	3.7E-07	16.27%	Benzo(a) pyrene	5.73%	NA		-		1.9E-02	57.20%	Tc-99	23.28%
											Benzo(a) anthracene	16.06%
											Dibenzo(a,h) anthracene	11.90%

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TABLE 6-14A
(Continued)

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Beef/Milk (Groundwater Affected)	1.7E-06[c]	1.58%	Dibenzo(a,h) anthracene	6.32%	NA		-		3.2E-05	0.10%		
ALL MEDIA	8.7E-05				1.1E-04				3.4E-02			

[a]RME = Reasonable Maximum Exposure

[b]COC = Contaminant of Concern

[c]Below risk threshold level - provided for comparison purposes

[d]No major risk contributors

[e]NA = not applicable to conceptual model

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TABLE 6-14B

SOUTH FIELD
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD FOR SELECTED FUTURE LAND USE RECEPTORS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total
Soil	ND[c]	0.00%	-[d]		4.2E-03	5.27%			7.8E-02	1.23%	U-Total	0.80%
							Beryllium	3.43%			Arsenic	0.28%
							Arsenic	1.61%				
Sediment	NA[e]		-		4.9E-03	6.14%	Beryllium	4.00%	NA		-	
							Arsenic	1.17%				
Groundwater	8.6E-01	76.80%	U-Total	76.80%	NA		-		1.8E+01	75.70%	U-Total	75.66%
Surface Water	NA		-		7.1E-02	88.59%	U-Total	87.87%	NA		-	
Home Grown Produce (Groundwater Affected)	2.6E-01	11.40%	U-Total	23.13%	NA		-		5.1	21.54%	U-Total	21.53%
Beef/Milk (Groundwater Affected)	1.4E-04[f]	0.01%	-		NA		-		1.0E-02	0.04%	-	
ALL MEDIA	1.1E+00				8.0E-02				2.3E+01			

[a]RME = Reasonable Maximum Exposure
[b]COC = Contaminant of Concern
[c]ND = not determined because toxicity data are not available
[d]No major hazard contributors
[e]NA = not applicable to conceptual model
[f]Below hazard threshold level - provided for comparison purposes

TABLE 6-15

INACTIVE FLYASH PILE CONTAMINANTS OF CONCERN (COCs)

SOIL	
radium-226	thorium-232
radium-228	arsenic
thorium-228	dibenzo(a,h)anthracene

SURFACE WATER
No COCS

SEDIMENT
No COCS

GROUNDWATER	
uranium-234	uranium-238
uranium-235/236	uranium-total

PERCHED GROUNDWATER
no COCs

AIR
radon

DUST ON BEEF/MILK AND HOMEGROWN PRODUCE
dibenzo(a,h)anthracene

GROUNDWATER ON BEEF/MILK AND HOMEGROWN PRODUCE	
uranium-234	uranium-238
uranium-235/236	uranium-total

GREAT MIAMI RIVER SURFACE WATER
no COCs

Tables 6-16A and 6-16B summarize risks and hazards by media, respectively, associated with the Inactive Flyash Pile for receptors assuming current land use. No exposures resulted in HIs exceeding 1.0. Exposures of the trespassing youth to contaminated soils were associated with a total risk of 3.3 x 10^{-5} due to the presence of radium-226, radium-228, and thorium-228 in surface soil, which account for 74 percent of total receptor risk. Total estimated risk to the groundskeeper was 5.0 x 10^{-5} due primarily to radium-226 (19 percent of total risk), thorium-228 (25 percent of total risk) and thorium-232 (32 percent of total risk) in soil. Radium-228 in soil contributes 10 percent of total risk.

Tables 6-17A and 6-17B summarize risks and hazards by media, respectively, associated with the Inactive Flyash Pile for receptors assuming future land use. Major contributors by media to total risks and hazards, respectively, posed to the selected receptors are presented in Tables 6-18A and 6-18B. The greatest carcinogenic risk was the risk associated with groundwater use by the RME on-property farmer which slightly exceeded 1.0 x 10^{-3}. Total risk for this receptor was 1.5 x 10^{-3} due mostly to the future estimated concentrations of uranium-234 (25 percent) and uranium-238 (48 percent) in groundwater and consequently in irrigated produce and beef and milk from livestock watered with contaminated groundwater.

Exposures resulting in HIs greater than 1.0 were associated with ingestion of groundwater and homegrown produce contaminated with uranium-total (approximately 82 and 15 percent, respectively).

TABLE 6-16A

CURRENT LAND USE
INACTIVE FLYASH PILE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User		
						Recreation	Residential	Agricultural
Soil								
Total Rad Risk	1.2E-05	5.3E-08	9.6E-10	N/A[a]	4.3E-05	N/A	N/A	N/A
Total Chem Risk	1.3E-06	1.2E-08	1.0E-09	N/A	5.6E-06	N/A	N/A	N/A
Total Risk	1.3E-05	6.5E-08	2.0E-09	N/A	4.9E-05	N/A	N/A	N/A
Sediment								
Total Rad Risk	1.4E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	7.7E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	2.1E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water								
Total Rad Risk	1.7E-07	N/A	N/A	N/A	N/A	3.7E-11	1.9E-09	N/A
Total Chem Risk	1.6E-07	N/A	N/A	N/A	N/A	8.3E-09	1.1E-09	N/A
Total Risk	3.4E-07	N/A	N/A	N/A	N/A	8.4E-09	3.0E-09	N/A
Homegrown Produce (Dust Affected)								
Total Rad Risk	N/A	1.6E-09	1.1E-10	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	2.9E-08	9.6E-09	N/A	N/A	N/A	N/A	N/A
Total Risk	N/A	3.1E-08	9.7E-09	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.5E-10
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.3E-10
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.8E-10
Beef/Milk (Dust Affected)								
Total Rad Risk	N/A	3.5E-10	6.4E-11	3.5E-10	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	1.1E-07	6.3E-08	1.1E-07	N/A	N/A	N/A	N/A
Total Risk	N/A	1.1E-07	6.3E-08	1.1E-07	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.3E-09
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.5E-10
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.4E-09

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-16B

CURRENT LAND USE
INACTIVE FLYASH PILE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User		
						Rec.	Res.	Agric.
Soil								
Total Hazard	1.5E-02	N/A[a]	N/A	N/A	2.0E-02	N/A	N/A	N/A
Sediment								
Total Hazard	3.9E-02	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water								
Total Hazard	7.7E-02	N/A	N/A	N/A	N/A	1.9E-06	4.2E-06	N/A
Homegrown Produce (Dust Affected)								
Total Hazard	N/A	4.1E-05	1.6E-04	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.4E-05
Beef/Milk (Dust Affected)								
Total Hazard	N/A	1.4E-05	3.9E-05	1.4E-05	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)								
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.2E-05

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-17A

INACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Expanded Trespasser	Off-Property[c] Resident Farmer	Off-Property[c] Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Great Miami River User		
						Rec.	Res.	Agric.
Soil								
Total Rad Risk	2.4E-05	5.3E-08	9.6E-10	8.3E-07	1.5E-08	N/A[a]	N/A	N/A
Total Chem Risk	3.2E-06	1.2E-08	1.0E-09	1.9E-07	1.6E-08	N/A	N/A	N/A
Total Risk	2.7E-05	6.5E-08	2.0E-09	1.0E-06	3.1E-08	N/A	N/A	N/A
Sediment								
Total Rad Risk	1.4E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	8.1E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	2.2E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater								
Total Rad Risk	N/A	5.6E-05	2.4E-06	1.1E-03	4.7E-05	N/A	N/A	N/A
Total Chem Risk	N/A	-[b]	-	-	-	N/A	N/A	N/A
Total Risk	N/A	5.6E-05	2.4E-06	1.1E-03	4.7E-05	N/A	N/A	N/A
Surface Water(Includes Fish for GMR users)								
Total Rad Risk	1.7E-07	N/A	N/A	N/A	N/A	3.7E-11	1.9E-09	N/A
Total Chem Risk	1.6E-07	N/A	N/A	N/A	N/A	8.3E-09	1.1E-09	N/A
Total Risk	3.4E-07	N/A	N/A	N/A	N/A	8.4E-09	3.0E-09	N/A
Homegrown Produce (Dust Affected)								
Total Rad Risk	N/A	1.6E-09	1.1E-10	2.4E-08	1.7E-09	N/A	N/A	N/A
Total Chem Risk	N/A	2.9E-08	9.6E-09	4.5E-07	1.5E-07	N/A	N/A	N/A
Total Risk	N/A	3.1E-08	9.7E-09	4.8E-07	1.5E-07	N/A	N/A	N/A
Homegrown Produce			**(Groundwater affected)**			**(GMR Surface Water Affected)**		
Total Rad Risk	N/A	1.7E-05	1.2E-06	3.3E-04	2.3E-05	N/A	N/A	2.5E-10
Total Chem Risk	N/A	-	-	-	-	N/A	N/A.	3.3E-10
Total Risk	N/A	1.7E-05	1.2E-06	3.3E-04	2.3E-05	N/A	N/A	5.8E-10
Beef/Milk (Dust Affected)								
Total Rad Risk	N/A	3.5E-10	6.4E-11	5.5E-09	9.9E-10	N/A	N/A	N/A
Total Chem Risk	N/A	1.1E-07	6.3E-08	1.8E-06	1.0E-06	N/A	N/A	N/A
Total Risk	N/A	1.1E-07	6.3E-08	1.8E-06	1.0E-06	N/A	N/A	N/A

See footnotes at end of table

TABLE 6-17A
(Continued)

Media	Expanded Trespasser	Off-Property[c] Resident Farmer	Off-Property[c] Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Great Miami River User Rec.	Great Miami River User Res.	Great Miami River User Agric.
Beef/Milk			**(Groundwater Affected)**			**GMR Surface Water Affected)**		
Total Rad Risk	N/A	1.7E-06	3.1E-07	3.2E-05	5.9E-06	N/A	N/A	4.3E-09
Total Chem Risk	N/A	-	-	-	-	N/A	N/A	1.5E-10
Total Risk	N/A	1.7E-06	3.1E-07	3.2E-05	5.9E-06	N/A	N/A	4.4E-09

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

[b]No risk greater than the threshold level of $1x10^{-6}$.

[c]Off property resident private and federal ownership pose the same risk.

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TABLE 6-17B

INACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Expanded Trespasser	Off-Property[c] Resident Farmer	Off-Property[c] Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Great Miami River User Rec.	Great Miami River User Res.	Great Miami River User Agric.
Soil								
Total Hazard	1.3E-02	N/D[a]	N/D	N/D	N/D	N/A[b]	N/A	N/A
Sediment								
Total Hazard	1.2E-02	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater								
Total Hazard	N/A	9.1E-01	2.1E+00	1.8E+01	4.1E+01	N/A	N/A	N/A
Surface Water								
Total Hazard	7.7E-02	N/A	N/A	N/A	N/A	1.9E-06	4.2E-06	N/A
Homegrown Produce (Dust Affected)								
Total Hazard	N/A	4.1E-05	1.6E-04	6.3E-04	2.4E-03	N/A	N/A	N/A
Homegrown Produce			**(Groundwater Affected)**			**(GMR Surface Water Affected)**		
Total Hazard	N/A	2.6E-01	2.4E-01	3.3E+00	1.9+01	N/A	N/A	2.4E-05
Beef/Milk (Dust Affected)								
Total Hazard	N/A	1.4E-05	3.9E-05	2.2E-04	6.0E-04	N/A	N/A	N/A
Beef/Milk			**(Groundwater Affected)**			**(GMR Surface Water Affected)**		
Total Hazard	N/A	1.5E-O2	1.5E-01	4.9E-01	4.9E+00	N/A	N/A	1.2E-05

[a]N/D = Not determined because toxicity data is not available.
[b]N/A = Signifies that exposer of the receptor to the indicated medium is not applicable.
[c]Off property resident private and federal ownership pose the same risk.

000557

TABLE 6-18A

INACTIVE FLYASH PILE
SUMMARY OF TOTAL CARCINOGENIC RISK
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

MEI Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Soil	6.5E-08[c]	0.09%	-[d]		2.7E-05	91.35%	Th-228	22.65%	1.0E-06	0.07%		
							Ra-226	17.88%				
							Ra-228	9.71%				
							Th-232	29.85%				
							Arsenic	6.52%				
Sediment	NA[e]		-		2.2E-06	7.20%	Ra-226	2.84%	NA		-	
							Arsenic	2.08%				
Groundwater	5.6E-05	74.66%	U-238	24.98%	NA		-		1.1E-03	74.75%	U-238	48.33%
			U-234	24.98%							U-234	25.06%
Surface Water	NA		-		3.4E-07[c]	1.12%	-		NA		-	
Home Grown Produce (Groundwater Affected)	1.7E-05	22.51%	U-238	14.54%	NA		-		3.3E-04	22.53%	U-238	14.57%
			U-234	7.53%							U-234	7.55%
Beef/Milk (Groundwater Affected)	1.7E-06[c]	2.26%	U-238	1.42%	NA		-		3.2E-05	2.20%	U-238	1.42%
											U-234	0.74%
ALL MEDIA	7.5E-05				3.0E-05				1.5E-03			

[a]RME = Reasonable Maximum Exposure
[b]COC = Contaminant of Concern
[c]Below risk threshold level- provided for comparison only
[d]No major risk contributors
[e]NA = not applicable to conceptual model

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TABLE 6-18B

INACTIVE FLYASH PILE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total
Surface Soil	0.00[c]		-[d]		1.3E-02	12.37%	Beryllium Arsenic	6.57% 5.83%	ND[f]			
Sediment	NA[e]		-		1.2E-02	11.85%	Arsenic Beryllium	4.23% 7.62%	NA		-	
Groundwater	9.9E-01	82.5%	U-Total	82.5%	NA		-		18.0	81.82%	U-Total	81.82%
Surface Water	NA		-		7.7E-02	75.78%	U-Total	74.30%	NA		-	
Homegrown Produce (Groundwater Affected)	2.6E-01	21.67%	U-Total	21.67%	NA		-		3.3	15.00%	U-Total	15.00%
Beef/Milk (Groundwater Affected)	1.5E-02[c]	1.25%	-		NA		-		4.9E-01	2.22%	U-Total	2.22%
ALL MEDIA	1.2E+00				1.0E-01				2.2E+01			

[a]RME = Reasonable Maximum Exposure
[b]COC = Contaminant of Concern
[c]Below hazard threshold level - provided for comparison purposes
[d]No major hazard contributors
[e]NA = not applicable to conceptual model
[f]ND = not determined because toxicity data is not available

000859

6.3.4 Solid Waste Landfill

Table 6-19 presents the COCs by media identified for the Solid Waste Landfill.

TABLE 6-19

SOLID WASTE LANDFILL CONTAMINANTS OF CONCERN (COCs)

SOIL		SURFACE WATER	
neptunium-237	uranium-238	uranium-total	arsenic
radium-226	antimony		
radium-228	arsenic		
thorium-228	beryllium		
thorium-230	benzo(a)anthracene		
thorium-232	benzo(a)pyrene		
plutonium-238	benzo(b)fluoranthene		
uranium-234	dibenzo(a,h)anthracene		
uranium-235/236	indeno(1,2,3-cd)pyrene		
SEDIMENT		**GROUNDWATER**	
uranium-total		No COCs	
PERCHED GROUNDWATER		**AIR**	
technetium-99	carbazole	radon-222	
DUST ON BEEF/MILK AND HOMEGROWN PRODUCE		**GROUNDWATER ON BEEF/MILK AND HOMEGROWN PRODUCE**	
neptunium-237	beryllium	No COCs	
radium-226	benzo(a)anthracene		
strontium-90	benzo(a)pyrene		
uranium-234	benzo(b)fluoranthene		
uranium-238	dibenzo(a,h)anthracene		
arsenic	indeno(1,2,3-cd)pyrene		
GREAT MIAMI RIVER SURFACE WATER			
No COCs			

Tables 6-20A and 6-20B summarize risks and hazards by media, respectively, associated with the Solid Waste Landfill for receptors assuming current land use. Exposure of the trespassing youth to contaminated surface soil was associated with a total risk of 1.0×10^{-5} due to external radiation from radium-228 (12.3 percent), thorium-228 (13.3 percent), and thorium-232 19 percent) in soil. The HI for the trespassing youth is 8.3 due to uranium-total (96 percent) in surface water.

Total risk to the groundskeeper contacting air and surface soil was 4.3×10^{-3}. Dermal contact with arsenic in surface water accounts for 30 percent of total risk. External radiation from uranium-238, thorium-228, thorium-232, radium-226, and radium-228 accounts for 8, 22, 31, 20, and 15 percent of total risk, respectively. Total hazard for this receptor did not exceed 1.0.

TABLE 6-20A

CURRENT LAND USE
SOLID WASTE LANDFILL
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User		
						Rec.	Res.	Agric.
Soil								
Total Rad Risk	8.5E-06	3.3E-08	6.0E-10	N/A[a]	3.2E-05	N/A	N/A	N/A
Total Chem Risk	4.2E-07	3.5E-10	3.0E-11	N/A	1.4E-06	N/A	N/A	N/A
Total Risk	8.9E-06	3.3E-08	6.2E-10	N/A	3.3E-05	N/A	N/A	N/A
Sediment								
Total Rad Risk	1.2E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	1.2E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	1.4E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water								
Total Rad Risk	2.6E-08	N/A	N/A	N/A	N/A	6.8E-12	4.4E-10	N/A
Total Chem Risk	4.4E-06	N/A	N/A	N/A	N/A	2.8E-10	3.7E-09	N/A
Total Risk	4.4E-06	N/A	N/A	N/A	N/A	2.8E-10	4.2E-09	N/A
Homegrown Produce (Dust Affected)								
Total Rad Risk	N/A	4.0E-10	2.9E-11	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	1.0E-09	3.4E-10	N/A	N/A	N/A	N/A	N/A
Total Risk	N/A	1.4E-09	3.7E-10	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.9E-08
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.7E-08
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.6E-08
Beef/Milk (Dust Affected)								
Total Rad Risk	N/A	1.1E-10	1.9E-11	6.6E-09	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	2.4E-09	1.3E-09	2.4E-09	N/A	N/A	N/A	N/A
Total Risk	N/A	2.5E-09	1.3E-09	9.0E-09	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)								
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.1E-07
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.9E-09
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.2E-07

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-20B

CURRENT LAND USE
SOLID WASTE LANDFILL
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper	Great Miami River User		
						Rec.	Res.	Agric.
Soil								
Total Hazard	1.8E-03	N/D[a]	N/D	N/A[b]	4.3E-03	N/A	N/A	N/A
Sediment								
Total Hazard	2.6E-01	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water								
Total Hazard	8.3E+00	N/A	N/A	N/A	N/A	1.1E-07	2.2E-06	N/A
Homegrown Produce (Dust Affected)								
Total Hazard	N/A	1.3E-06	4.8E-06	N/A	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)								
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.7E-05
Beef/Milk (Dust Affected)								
Total Hazard	N/A	5.8E-07	1.6E-06	5.8E-07	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)								
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.0E-05

[a]N/D not determined because toxicity data are not available.

[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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Tables 6-21A and 6-21B summarize risks and hazards by media, respectively, associated with the Solid Waste Landfill assuming future land use. Tables 6-22A and 6-22B summarize the major contributors to total risk for the off-property farmer, expanded trespasser, and on-property farmer (RME). Total risks barely exceeded 1.0×10^{-6} for the future off-property farmer (private ownership) receptor only. This risk was mostly due to the estimated presence of the naturally occurring radionuclides uranium-234 and uranium-238 in soil which contributed approximately 77 percent to the total risk. Risks exceeded the 1.0×10^{-3} level for on-property RME farmer and the perched groundwater user. This was due mostly to the estimated presence of radium-226, thorium-228, and thorium-232 in surface soil and benzo(a) pyrene and dibenzo(a,h) anthracene in dust affected beef and milk products which accounted for a combined 68 percent of total risk to this receptor. Risks exceeded 1.0×10^{-4} for the child exposed to the same exposures as the RME farmer. Total HIs exceeded 1.0 only for the on-property child due mostly to arsenic in soil and dust affected homegrown produce and beef and milk products. This is further discussed in Section B.4.0 of Appendix B.

Total risk to the homebuilder was 9.0×10^{-6} due to radium-226, radium-228, thorium-228, thorium-232, arsenic, and benzo(a)pyrene in subsurface soil. Total HI for this receptor was less than 1.0.

Total estimated risk and hazard to the users of the Great Miami River were less than 1.0×10^{-6} and well below 1.0, respectively, for all receptors.

6.3.5 Lime Sludge Ponds

Table 6-23 presents the COCs by media identified for the Lime Sludge Ponds.

Tables 6-24A and 6-24B summarize risks and hazards by media, respectively, associated with Lime Sludge Pond receptors assuming current land use. Risks to the trespassing youth exceeded 1.0×10^{-5} due to external radiation exposure to surface soil containing radium-226, thorium-228, thorium-232, and uranium-238 in soil. Total risk to the current groundskeeper exposed to soil was 4.5×10^{-5} due mostly to the presence of radium-226, thorium-228, and thorium-232 accounting for 21, 29, and 20 percent of total risk, respectively. All calculated HIs were below 1.0.

TABLE 6-21A

SOLID WASTE LANDFILL
FUTURE LAND USE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer[c]	Off-Property Resident Child[c]	On-Property Resident Farmer (RME)	On-Property Resident Child	Home-builder	Perched Groundwater User	Great Miami River User		
								Rec.	Res.	Agric.
Soil										
Total Rad Risk	1.8E-05	1.0E-06	1.8E-08	1.7E-03	1.3E-04	4.8E-06	1.7E-03	N/A[a]	N/A	N/A
Total Chem Risk	7.8E-07	1.1E-08	9.1E-10	7.0E-05	3.1E-05	4.2E-06	7.0E-05	N/A	N/A	N/A
Total Risk	1.9E-05	1.0E-06	1.9E-08	1.8E-03	1.6E-04	9.0E-06	1.8E-03	N/A	N/A	N/A
Sediment										
Total Rad Risk	1.2E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	1.3E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Risk	1.4E-06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater										
Total Rad Risk	N/A	3.4E-09	1.5E-10	3.9E-08	1.7E-09	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	-[b]	-	-	-	-	-	-	N/A	N/A
Total Risk	N/A	3.4E-09	1.5E-10	3.9E-08	1.7E-09	N/A	N/A	N/A	N/A	N/A
Perched Groundwater										
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	N/A	1.8E-06	N/A	N/A	N/A
Total Chem Risk	N/A	-	-	-	-	-	5.3E-06	N/A	N/A	N/A
Total Risk	N/A	N/A	N/A	N/A	N/A	N/A	7.1E-06	N/A	N/A	N/A
Surface Water										
Total Rad Risk	2.6E-08	N/A	N/A	N/A	N/A	N/A	N/A	6.8E-12	4.4E-10	N/A
Total Chem Risk	3.5E-08	N/A	N/A	N/A	N/A	N/A	N/A	2.8E-10	3.7E-09	N/A
Total Risk	6.1E-08	N/A	N/A	N/A	N/A	N/A	N/A	2.8E-10	4.2E-09	N/A
Homegrown Produce (Dust Affected)										
Total Rad Risk	N/A	1.2E-08	8.7E-10	3.2E-05	2.2E-06	N/A	3.2E-05	N/A	N/A	N/A
Total Chem Risk	N/A	3.2E-08	1.0E-08	8.9E-05	2.9E-05	N/A	8.9E-05	N/A	N/A	N/A
Total Risk	N/A	4.4E-08	1.1E-08	1.2E-04	3.1E-05	N/A	1.2E-04	N/A	N/A	N/A

TABLE 6-21A
(Continued)

Media	Expanded Trespasser	Off-Property Resident Farmer[c]	Off-Property Resident Child[c]	On-Property Resident Farmer (RME)	On-Property Resident Child	Home-builder	Perched Groundwater User	Great Miami River User		
								Rec.	Res.	Agric.
Homegrown Produce				**(Groundwater Affected)**					**(GMR Surface Water Affected)**	
Total Rad.Risk	N/A	1.2E-09	8.1E-11	1.3E-08	9.2E-10	N/A	1.3E-08	N/A	N/A	1.9E-08
Total Chem Risk	N/A	-	-	-	-	-	-	-	N/A	1.7E-08
Total Risk	N/A	1.2E-09	8.1E-11	1.3E-08	9.2E-10	N/A	1.3E-08	N/A	N/A	3.6E-08
Beef/Milk (Dust Affected)										
Total Rad Risk	N/A	3.3E-09	5.8E-10	6.9E-05	1.3E-05	N/A	N/A	N/A	N/A	N/A
Total Chem Risk	N/A	7.3E-08	3.8E-08	8.0E-04	4.4E-04	N/A	N/A	N/A	N/A	N/A
Total Risk	N/A	7.7E-08	3.9E-08	8.7E-04	4.5E-04	N/A	N/A	N/A	N/A	N/A
Beef/Milk				**(Groundwater Affected)**					**(GMR Surface Water Affected)**	
Total Rad Risk	N/A	3.1E-09	5.2E-10	3.5E-08	5.9E-09	N/A	N/A	N/A	N/A	6.1E-07
Total Chem Risk	-	-	-	-	-	-	-	-	N/A	8.9E-09
Total Risk	N/A	3.1E-09	5.2E-10	3.5E-08	5.9E-09	N/A	N/A	N/A	N/A	6.2E-07

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

[b]No risk greater than the threshold level of 1×10^{-6}.

[c]Risk is provided for the off-property privately owned scenario because it is a higher risk than for federally owned.

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TABLE 6-21B

SOLID WASTE LANDFILL
FUTURE LAND USE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Home-builder	Great Miami River User		
							Rec.	Res.	Agric.
Soil									
Total Hazard	3.2E-03	N/D[a]	N/D	6.8E-02	3.1E-01	4.8E-01	N/A[b]	N/A	N/A
Sediment									
Total Hazard	2.6E-01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water									
Total Hazard	1.1E-02	N/A	N/A	N/A	N/A	N/A	1.1E-07	2.2E-06	N/A
Homegrown Produce (Dust Affected)									
Total Hazard	N/A	3.8E-05	1.5E-04	9.6E-02	3.7E-01	N/A	N/A	N/A	N/A
Homegrown Produce (GMR Surface Water Affected)									
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.7E-05
Beef/Milk (Dust Affected)									
Total Hazard	N/A	1.8E-05	4.8E-05	1.3E-01	3.5E-01	N/A	N/A	N/A	N/A
Beef/Milk (GMR Surface Water Affected)									
Total Hazard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.0E-05

[a]N/D not determined because toxicity data are not available.

[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-22A

SOLID WASTE LANDFILL
SUMMARY OF TOTAL CARCINOGENIC RISK
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

MEI Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Soil	3.3E-08[c]	48.56%	-[d]		1.9E-05	92.65%	Th-228	20.43%	1.8E-03	64.29%	Th-228	13.73%
											Th-232	19.33%
											Ra-226	12.76%
							U-238	6.76%			Ra-228	7.32%
							Ra-226	18.96%			U-238	6.03%
							Ra-228	10.92%				
							Th-232	28.74%				
Sediment	NA[e]		-		1.4E-06	6.85%	Ra-226	2.99%	NA		-	
							U-238	1.03%				
Home Grown Produce (Dust Affected)	1.4E-09[c]	2.11%	-		NA		-		1.2E-04	4.34%	Arsenic	1.82%
											Benzo(a) pyrene	0.74%
Beef/Milk (Dust Affected)	2.5E-09[c]	3.69%	-		NA		-		8.7E-04	31.37%	Dibenzo(a) pyrene	10.85%
			Dibenzo(a,h) pyrene	1.98%							Benzo(a) pyrene	5.03%
ALL MEDIA	6.8E-08				2.0E-05				2.8E-03			

[a]RME = Reasonable Maximum Exposure
[b]COC = Contaminant of Concern
[c]Below risk threshold level - provided for comparison purposes
[d]No major risk contributors
[e]NA = not applicable to conceptual model

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TABLE 6-22B

SOLID WASTE LANDFILL
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total
Soil	0.00[c]	0.00%	-[d]		3.2E-03	1.23%			6.8E-02	23.25%	Arsenic	19.38%
Sediment	NA[e]		-		2.6E-01	98.64%	U-Total	97.64%	NA		-	
Surface Water	NA		-		1.1E-02	0.14%			NA		-	
Home Grown Produce (Dust Affected)	1.3E-06	68.62%	Arsenic	68.34%	NA		-		9.6E-02	32.95%	Arsenic	32.90%
Beef/Milk (Dust Affected)	5.8E-07	31.38%	Arsenic	31.27%	NA		-		1.3E-01	43.8%	Arsenic	43.75%
ALL MEDIA	1.8E-06				2.7E-01				2.9E-01			

[a]RME = Reasonable Maximum Exposure

[b]COC = Contaminant of Concern

[c]Below hazard threshold level - provided for comparison purposes

[d]No major hazard contributors

[e]NA = not applicable to conceptual model

TABLE 6-23

LIME SLUDGE PONDS
CONTAMINANTS OF CONCERN (COCs)

SOIL		SURFACE WATER
cesium-137	thorium-230	No COCs
radium-226	thorium-232	
radium-228	uranium-238	
thorium-228	uranium-total	
SEDIMENT		**GROUNDWATER**
No COCs		No COCs
PERCHED GROUNDWATER		**AIR**
neptunium-237 technetium-99	strontium-90	No COCs
DUST ON BEEF/MILK AND HOMEGROWN PRODUCE		**GROUNDWATER ON BEEF/MILK AND HOMEGROWN PRODUCE**
No COCs		No COCs
GREAT MIAMI RIVER SURFACE WATER		
No COCs		

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TABLE 6-24A

CURRENT LAND USE
LIME SLUDGE PONDS
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper
Soil					
Total Rad Risk	1.1E-05	1.2E-07	2.2E-09	N/A[a]	4.2E-05
Total Chem Risk	6.7E-07	1.5E-09	1.3E-10	N/A	2.7E-06
Total Risk	1.1E-05	1.3E-07	2.4E-09	N/A	4.5E-05
Homegrown Produce (Dust Affected)					
Total Rad Risk	N/A	1.4E-09	1.0E-10	N/A	N/A
Total Chem Risk	N/A	5.4E-09	1.8E-09	N/A	N/A
Total Risk	N/A	6.8E-09	1.9E-09	N/A	N/A
Beef/Milk (Dust Affected)					
Total Rad Risk	N/A	2.1E-10	3.5E-11	3.1E-08	N/A
Total Chem Risk	N/A	1.7E-08	9.6E-09	1.4E-06	N/A
Total Risk	N/A	1.7E-08	9.6E-09	1.4E-06	N/A

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-24B

CURRENT LAND USE
LIME SLUDGE PONDS
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Trespassing Youth	Off-Property Resident Farmer	Off-Property Resident Child	User of Milk and Meat	Groundskeeper
Soil					
Total Hazard	2.1E-01	N/D[a]	N/D	N/A[b]	1.3E-01
Homegrown Produce (Dust Affected)					
Total Hazard	N/A	1.5E-05	5.9E-05	N/A	N/A
Beef/Milk (Dust Affected)					
Total Hazard	N/A	5.0E-06	3.4E-05	4.3E-04	N/A

[a]N/D Not determined because toxicity data not available.

[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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Tables 6-25A and 6-25B summarize risks and hazards by media, respectively, associated with Lime Sludge Pond receptors assuming future land use. Tables 6-26A and 6-26B present the major contributors by media to total risks and hazards for the three selected receptors. The total risk to the on-property RME farmer was 1.3 x 10^{-5} due primarily to direct contact with surface soil containing thorium-230 (17 percent) and uranium-238 (48 percent). Total risk to the expanded trespasser exceeded 1.0 x 10^{-5} due to radium-226 (22 percent), thorium-228 (30 percent), and thorium-232 (21 percent). Total HIs for future receptors were less than 1.0. Total risk to the off-property farmer and child under both private and federal ownership did not exceed the 1.0 x 10^{-6} threshold risk and hazard was well below 1.0.

6.3.6 Operable Unit 2 Cumulative Risk

Tables 6-27A and 6-27B summarize the risks and hazards by media to future receptors due to the cumulative impact of contaminants present within Operable Unit 2. The three most conservative future receptors were considered for the Operable Unit 2-wide risk assessment: 1) expanded trespasser, 2) off-property farmer, and 3) on-property RME farmer. These receptors were evaluated for the same pathways evaluated for under subunit risk (e.g., inhalation, ingestion, dermal contact, etc.). It is emphasized that the risks and hazards presented are those resulting primarily from the three subunits contributing most to groundwater contamination: the Active Flyash Pile, South Field and Inactive Flyash Pile.

The greatest carcinogenic risk posed was to the RME on-property farmer which had a total risk of 3.3 x 10^{-2}. Major contributors to risks and hazards for the off-property farmer, expanded trespasser, and on-property farmer (RME) are presented in Tables 6-28A and 6-28B. The major contributor to risk for the on-property receptor is from the presence of radium-226 (23 percent) in soil by direct radiation, and the estimated presence of technetium-99 (23 percent), benzo(a)pyrene (16 percent), and dibenzo(a,h)anthracene (12 percent) in dust affected beef and milk products ingested.

Total risk to the off-property farmer slightly exceeded 1.1 x 10^{-4} due primarily to uranium-234 (18 percent) and uranium-238 (34 percent) in drinking water through groundwater, radium-226 (8 percent) in soil through inhalation and radium-226 (12 percent)through ingestion of dust affected produce.

TABLE 6-25A

LIME SLUDGE PONDS
FUTURE LAND USE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer[c]	Off-Property Resident Child[c]	On-Property Resident Farmer (RME)	On-Property Resident Child	Perched Groundwater User (Adult)
Soil						
Total Rad Risk	2.2E-05	1.2E-07	2.2E-09	1.0E-05	1.9E-07	1.0E-05
Total Chem Risk	1.7E-06	1.5E-09	1.3E-10	1.3E-07	1.1E-08	1.3E-07
Total Risk	2.4E-05	1.3E-07	2.4E-09	1.1E-05	2.0E-07	1.1E-05
Groundwater						
Total Rad Risk	N/A[a]	1.1E-08	4.6E-10	1.9E-07	8.1E-09	N/A
Total Chem Risk	N/A	-[b]	-	-	-	N/A
Total Risk	N/A	1.1E-08	4.6E-10	1.9E-07	8.1E-09	N/A
Perched Groundwater						
Total Rad Risk	N/A	N/A	N/A	N/A	N/A	6.3E-05
Total Chem Risk	N/A	N/A	N/A	N/A	N/A	7.0E-07
Total Risk	N/A	N/A	N/A	N/A	N/A	6.4E-05
Homegrown Produce (Dust Affected)						
Total Rad Risk	N/A	1.4E-09	1.0E-10	1.3E-07	9.0E-09	1.3E-07
Total Chem Risk	N/A	5.4E-09	1.8E-09	4.6E-07	1.5E-07	4.6E-07
Total Risk	N/A	6.8E-09	1.9E-09	5.9E-07	1.6E-07	5.9E-07
Homegrown Produce (Groundwater Affected)						
Total Rad Risk	N/A	3.5E-09	2.5E-10	6.1E-08	4.3E-09	6.1E-08
Total Chem Risk	N/A	-	-	-	-	-
Total Risk	N/A	3.5E-09	2.5E-10	6.1E-08	4.3E-09	6.1E-08
Beef/Milk (Dust Affected)						
Total Rad Risk	N/A	2.1E-10	3.5E-11	3.1E-08	5.4E-09	3.1E-08
Total Chem Risk	N/A	1.7E-08	9.6E-09	1.4E-06	7.5E-07	1.4E-06
Total Risk	N/A	1.7E-08	9.6E-09	1.4E-06	7.5E-07	1.4E-06

TABLE 6-25A
(Continued)

Media	Expanded Trespasser	Off-Property Resident Farmer[c]	Off-Property Resident Child[c]	On-Property Resident Farmer (RME)	On-Property Resident Child	Perched Groundwater User (Adult)
Beef/Milk (Groundwater Affected)						
Total Rad Risk	N/A	8.3E-09	1.4E-09	1.4E-07	2.4E-08	1.4E-07
Total Chem Risk	N/A	-	-	-	-	N/A
Total Risk	N/A	8.3E-09	1.4E-09	1.4E-07	2.4E-08	1.4E-07

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

[b]No risk greater than the threshold level of $1x10^{-6}$.

[c]Off-property resident private and federal scenarios pose the same risk.

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TABLE 6-25B

LIME SLUDGE PONDS
FUTURE LAND USE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child	On-Property Resident Farmer (RME)	On-Property Resident Child	Perched Groundwater User (Adult)
Soil						
Total Hazard	2.2E-01	N/D[a]	N/D	N/D	N/D	N/D
Perched Groundwater						
Total Hazard	N/A[b]	N/A	N/A	N/A	N/A	1.3E-03
Homegrown Produce (Dust Affected)						
Total Hazard	N/A	1.5E-05	5.9E-05	1.3E-03	5.0E-03	1.3E-03
Beef/Milk (Dust Affected)						
Total Hazard	N/A	5.0E-06	3.4E-05	4.3E-04	2.9E-03	4.3E-04

[a]N/D not determined because toxicity data not available.

[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

TABLE 6-26A

LIME SLUDGE PONDS
SUMMARY OF TOTAL CARCINOGENIC RISK
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Soil	1.3E-07[c]	71.63%	-[d]		2.4E-05	100%	Ra-228	8.88%	1.1E-05	79.62%	Th-230	16.94%
							Ra-226	21.66%			U-234	7.12%
							U-238	6.37%			U-238	48.38%
							Th-228	30.44%				
							Th-232	20.81%				
Perched Groundwater[f]	N/A				NA				6.4E-05	82.93%	Np-237	70.84%
											Sr-90	4.38%
											Tc-99	6.81%
Home Grown Produce (Dust Affected)	6.8E-09[c]	3.91%	Arsenic	1.29%	NA[e]		-		5.9E-07	4.41%	Arsenic	1.44%
Beef/Milk (Dust Affected)	1.7E-08[c]	9.99%	-		NA		-		1.4E-06	10.41%	Dibenzo(a,h) anthracene	4.95%
											Benzo(a)-pyrene	3.12%
ALL MEDIA	1.7E-07				2.4E-05				1.3E-05			

[a]RME = Reasonable Maximum Exposure
[b]COC = Contaminant of Concern
[c]Below risk threshold - provided for comparison purposes
[d]No major risk contributors
[e]NA = not applicable to conceptual model
[f]N/A = On-property resident farmer that drinks perched water

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TABLE 6-26B

LIME SLUDGE PONDS
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor	% Total	Major Hazard	% Hazard	Receptor	% Total	Major Hazard	% Hazard	Receptor	% Total	Major Hazard	% Hazard
Soil	0.00[c]	0.00%	-[d]		2.2E-01	100%	U-Total	97.34%	-			
							Beryllium	2.05%				
Home Grown Produce (Dust Affected)	1.5E-05	75.52%	U-Total	53.94%	NA[e]		-		1.3E-03	75.48%	U-Total	53.78%
			Arsenic	20.99%								
Beef/Milk (Dust Affected)	5.0E-06[c]	24.48%	U-Total	9.62%	NA		-		4.3E-04[c]	24.52%	U-Total	9.59%
			Arsenic	7.29%								
			bis (2ethylexyl) phthalate	7.54%								
ALL MEDIA	2.0E-05				2.2E-01				1.7E-03			

[a]RME = Reasonable Maximum Exposure

[b]COC = Contaminant of Concern

[c]Below hazard threshold level - provided for comparison purposes

[d]No major hazard contributors

[e]NA = not applicable to conceptual model

TABLE 6-27A

OPERABLE UNIT 2-WIDE
FUTURE LAND USE
SUMMARY OF TOTAL CARCINOGENIC RISK BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer	On-Property Resident Farmer (RME)
Soil			
Total Rad Risk	7.1E-05	1.3E-05	1.1E-02
Total Chem Risk	4.6E-06	2.6E-07	5.4E-04
Total Risk	7.6E-05	1.3E-05	1.1E-02
Groundwater			
Total Rad Risk	N/A	6.0E-05	1.3E-03
Total Chem Risk	N/A	6.9E-09	-[b]
Total Risk	N/A	6.0E-05	1.3E-03
Surface Water			
Total Rad Risk	4.1E-07	N/A	N/A
Total Chem Risk	2.1E-07	N/A	N/A
Total Risk	6.2E-07	N/A	N/A
Homegrown Produce (Dust Affected)			
Total Rad Risk	N/A	1.3E-05	4.3E-04
Total Chem Risk	N/A	1.8E-06	1.0E-03
Total Risk	N/A	1.5E-05	1.5E-03
Homegrown Produce (Groundwater Affected)			
Total Rad Risk	N/A	6.9E-06	1.2E-04
Total Chem Risk	N/A	2.2E-09	-
Total Risk	N/A	6.9E-06	1.2E-04
Beef/Milk (Dust Affected)			
Total Rad Risk	N/A	2.4E-06	8.0E-03
Total Chem Risk	N/A	1.1E-05	1.1E-02
Total Risk	N/A	1.4E-05	1.9E-02

See footnotes at end of table

TABLE 6-27A
(Continued)

Media	Expanded Trespasser	Off-Property Resident Farmer	On-Property Resident Farmer (RME)
Beef/Milk (Groundwater Affected)			
Total Rad Risk	N/A	6.8E-07	1.2E-05
Total Chem Risk	N/A	3.6E-10	-
Total Risk	N/A	6.8E-07	1.5E-07

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

[b]No risk greater than the threshold level of $1x10^{-6}$.

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TABLE 6-27B

FUTURE LAND USE
OPERABLE UNIT 2-WIDE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD BY MEDIA

Media	Expanded Trespasser	Off-Property Resident Farmer	On-Property Resident Farmer (RME)
Soil			
Total Hazard	9.0E-03	N/D[a]	7.8E-02
Groundwater			
Total Hazard	N/A[b]	9.1E-01	1.7E+01
Surface Water			
Total Hazard	5.5E-02	N/A	N/A
Homegrown Produce (Dust Affected)			
Total Hazard	N/A	5.7E-04	4.2E-01
Homegrown Produce (Groundwater Affected)			
Total Hazard	N/A	2.7E+00	5.0E+00
Beef/Milk (Dust Affected)			
Total Hazard	N/A	2.0E-04	1.4E-01
Beef/Milk (Groundwater Affected)			
Total Hazard	N/A	1.5E-04	2.6E-03

[a]ND not determined because toxicity data are not available.

[b]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE 6-28A

OPERABLE UNIT 2 WIDE
SUMMARY OF TOTAL CARCINOGENIC RISK
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Soil	1.3E-05	11.82%	Ra-226	3.12%	7.6E-05	87.36%	Th-228	10.72%	1.1E-02	33.33%	Th-228	1.35%
			U-238	0.35%			Th-232	13.58%			Ra-226	10.13%
							Ra-226	53.58%			Ra-228	0.61%
											Th-232	1.86%
Groundwater	6.0E-05	54.55%	U-238	13.43%	NA[c]		-[d]		1.3E-03	3.94%	U-238	0.92%
			U-234	6.96%							U-234	0.48%
Surface Water	NA		-		6.2E-7	0.71%	Th-228	2.60%	NA		-	
Homegrown Produce (Dust Affected)	1.5E-05	13.64%	Ra-226	4.56%	NA		-		1.5E-03	4.55%	Benzo(a)pyrene	0.74%
											Tc-99	0.46%
Home Grown Produce (Groundwater Affected)	6.9E-06	6.27%	U-235/236	2.10%	NA		-		1.2E-04	0.36%	U-235/236	0.14%
Beef/Milk (Dust Affected)	1.4E-05	12.73%	Benzo(a)pyrene	1.39%	NA		-		1.9E-02	57.58%	Indeno(1,2,3-cd)pyrene	1.01%
			Dibenzo(a,h) anthracene	1.54%							Benzo(a)pyrene	7.02%
											Dibenzo(a,h) anthracene	5.20%

TABLE 6-28A
(Continued)

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total	Receptor Risk	% Total Risk	Major Risk Contributors	% Risk of Total
Beef/Milk (Groundwater Affected)	6.8E-07	0.62%	-		NA		-		1.5E-07	0.00%	U-235/236	0.00%
ALL MEDIA	1.1E-04				8.7E-05				3.3E-02			

[a]RME = Reasonable Maximum Exposure
[b]COC = Contaminant of Concern
[c]NA = not applicable to conceptual model
[d]No major hazard contributors

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TABLE 6-28B

OPERABLE UNIT 2 WIDE
SUMMARY OF TOTAL NONCARCINOGENIC HAZARD
FOR SELECTED FUTURE LAND USE RECEPTORS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Receptor:	Federal Ownership								Private Ownership			
	Off-Property Resident Farmer				Expanded Trespasser				On-Property Resident Farmer (RME)[a]			
			COC[b]				COC				COC	
Media	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total	Receptor Hazard	% Total Hazard	Major Hazard Contributors	% Hazard of Total
Soil	N/D[f]				9.0E-03[c]	7.5%	-[d]		-		-	
Groundwater	9.1E-01	24.91%	U-Total	24.91%	NA[e]		-		1.7E+01	73.91%	U-Total	75.19%
1Sediment	N/A				5.3E-02	44.17%	U-Total					
Surface Water	N/A				5.5E-02	45.83%			NA		-	
Home Grown Produce (Groundwater Affected)	2.7E+00	75.06%	U-Total	75.06%	NA		-		5.0E+00	21.74%	U-Total	21.43%
Beef/Milk (Groundwater Affected)	-		-		NA		-		-		-	
ALL MEDIA	3.7E+00				1.2E-01				2.3E+01			

[a]RME = Reasonable Maximum Exposure
[b]COC = Contaminant of Concern
[c]Below hazard threshold level - provided for comparison purposes
[d]No major hazard contributors
[e]NA = not applicable to conceptual model
[f]ND = not determined because toxicity data not available

Total HIs exceed 1.0 for both the on- and off-property farmers due primarily to the estimated presence of total uranium in ingestion of groundwater and groundwater affected produce (99 and 96 percent, respectively).

Total risk to the expanded trespasser was 8.7 x 10^{-5} due primarily to direct radiation from radium-226, thorium-228, and thorium-232 in soil which contributed 52 percent, 10 percent, and 13 percent, respectively. Total HI for this receptor was below 1.0.

6.3.7 Background Risks

All subunit-specific risks in the risk assessment are calculated without accounting for the potential contribution from natural background concentrations of CPCs. In many cases, the concentrations of CPCs in soil at Operable Unit 2 waste areas are only slightly above natural background concentrations; however, the risks and HIs for these site-related concentrations are often greater than 1 x 10^{-6} and 1.0, respectively. Background contributions provide a useful point of comparison for subunit-specific risk estimates.

Therefore, risks and HIs are calculated for the RME on-property future farmer using background concentrations of CPCs in soil and groundwater as direct contact exposure point concentrations where appropriate. Naturally occurring background soil concentrations were also used as the source term for subunit-specific air and groundwater modeling. Exposure assumptions and models used for these background calculations are the same as those used for evaluating subunit-specific risks to the RME on-property resident farmer.

Tables 6-29A through 6-29E present a summary of comparison of subunit-specific risks to the future on-property RME farmer with the risk that would exist to that receptor if naturally occurring CPCs were present at naturally occurring background concentrations. Details of the major contributions to risks are presented in Section B.4.0 of Appendix B. These background comparison tables presented in this section indicate that:

- For the Active Flyash Pile [Table 6-29A], cumulative subunit-specific risk for the future on-property RME farmer is approximately seven times greater than what it would be if CPCs were present in surface flyash material and groundwater at background concentrations. This is due primarily to elevated (compared to background) levels of strontium-90, uranium-234, and uranium-238 in groundwater.

TABLE 6-29A

COMPARISON SUMMARY OF BACKGROUND RISKS TO ON-SITE RISKS ACTIVE FLYASH PILE: CARCINOGENS

Media	On-Property Resident Farmer (RME)	Background
Soil		
Total Radiological Risk	1.1E-06	3.0E-07
Total Chemical Risk	6.7E-07	4.5E-08
Total Risk	1.7E-06	3.4E-07
Groundwater		
Total Radiological Risk	4.7E-05	8.2E-06
Total Chemical Risk	9.3E-15	-
Total Risk	4.7E-05	8.2E-06
Homegrown Produce (Dust Affected)		
Total Radiological Risk	7.3E-08	1.6E-08
Total Chemical Risk	1.3E-06	9.4E-08
Total Risk	1.4E-06	1.1E-07
Homegrown Produce (Groundwater Affected)		
Total Radiological Risk	2.4E-05	2.5E-06
Total Chemical Risk	3.5E-15	9.4E-08
Total Risk	2.4E-05	2.5E-06
Beef/Milk (Dust Affected)		
Total Radiological Risk	1.2E-08	3.0E-09
Total Chemical Risk	4.6E-07	2.9E-08
Total Risk	4.7E-07	3.2E-08
Beef/Milk (Groundwater Affected)		
Total Radiological Risk	7.2E-06	2.8E-07
Total Chemical Risk	6.3E-16	-
Total Risk	7.2E-06	2.8E-07
All Media	8.2E-05	1.1E-05

TABLE 6-29B

COMPARISON SUMMARY OF BACKGROUND RISKS TO ON-SITE RISKS SOUTH FIELD: CARCINOGENS

Media	On-Property Resident Farmer (RME)	Background
Soil		
Total Radiological Risk	1.1E-02	1.1E-03
Total Chemical Risk	5.4E-04	4.1E-05
Total Risk	1.1E-02	1.2E-03
Groundwater		
Total Radiological Risk	1.1E-03	4.0E-07
Total Chemical Risk	-	-
Total Risk	1.1E-03	4.0E-07
Homegrown Produce (Dust Affected)		
Total Radiological Risk	4.3E-04	2.8E-06
Total Chemical Risk	1.0E-03	4.7E-05
Total Risk	1.5E-03	4.9E-05
Homegrown Produce (Groundwater Affected)		
Total Radiological Risk	3.3E-04	1.2E-07
Total Chemical Risk	-	-
Total Risk	3.3E-04	1.2E-07
Beef/Milk (Dust Affected)		
Total Radiological Risk	8.0E-03	1.0E-05
Total Chemical Risk	1.1E-02	6.1E-05
Total Risk	1.9E-02	7.1E-05
Beef/Milk (Groundwater Affected)		
Total Radiological Risk	3.2E-05	1.3E-08
Total Chemical Risk	-	0.0E+00
Total Risk	3.2E-05	1.3E-08
All Media	3.4E-02	1.3E-03

TABLE 6-29C

COMPARISON SUMMARY OF BACKGROUND RISKS TO ON-SITE RISKS INACTIVE FLYASH PILE: CARCINOGENS

Media	On-Property Resident Farmer (RME)	Background
Soil		
Total Radiological Risk	8.3E-07	2.2E-07
Total Chemical Risk	1.9E-07	4.2E-08
Total Risk	1.0E-06	2.7E-07
Groundwater		
Total Radiological Risk	1.1E-03	4.0E-10
Total Chemical Risk	-	-
Total Risk	1.1E-03	4.0E-10
Homegrown Produce (Dust Affected)		
Total Radiological Risk	2.4E-08	1.2E-08
Total Chemical Risk	4.5E-07	8.8E-08
Total Risk	4.8E-07	1.0E-07
Homegrown Produce (Groundwater Affected)		
Total Radiological Risk	3.3E-04	1.3E-10
Total Chemical Risk	-	-
Total Risk	3.3E-04	1.3E-10
Beef/Milk (Dust Affected)		
Total Radiological Risk	5.5E-09	1.6E-09
Total Chemical Risk	1.8E-06	2.7E-08
Total Risk	1.8E-06	2.8E-08
Beef/Milk (Groundwater Affected)		
Total Radiological Risk	3.2E-05	2.3E-11
Total Chemical Risk	-	-
Total Risk	3.2E-05	2.3E-11
All Media	1.5E-03	3.9E-07

TABLE 6-29D

COMPARISON SUMMARY OF BACKGROUND RISKS TO ON-SITE RISKS SOLID WASTE LANDFILL: CARCINOGENS

Media	On-Property Resident Farmer (RME)	Background
Soil		
Total Radiological Risk	1.7E-03	1.1E-03
Total Chemical Risk	7.0E-05	3.9E-05
Total Risk	1.8E-03	1.1E-03
Groundwater		
Total Radiological Risk	3.9E-08	N/A[a]
Total Chemical Risk	-	
Total Risk	3.9E-08	
Homegrown Produce (Dust Affected)		
Total Radiological Risk	3.2E-05	2.4E-06
Total Chemical Risk	8.0E-05	4.7E-05
Total Risk	1.2E-04	4.9E-05
Homegrown Produce (Groundwater Affected)		
Total Radiological Risk	1.3E-08	N/A
Total Chemical Risk	-	
Total Risk	1.3E-08	
Beef/Milk (Dust Affected)		
Total Radiological Risk	6.9E-05	5.3E-06
Total Chemical Risk	8.0E-04	6.1E-05
Total Risk	8.7E-04	6.6E-05
Beef/Milk (Groundwater Affected)		
Total Radiological Risk	3.5E-08	N/A
Total Chemical Risk	-	
Total Risk	3.5E-08	
All Media	2.8E-03	1.2E-03

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

TABLE 6-29E

COMPARISON SUMMARY OF BACKGROUND RISKS TO ON-SITE RISKS LIME SLUDGE PONDS: CARCINOGENS

Media	On-Property Resident Farmer (RME)	Background
Soil		
Total Radiological Risk	1.0E-05	6.0E-07
Total Chemical Risk	1.3E-07	8.9E-08
Total Risk	1.1E-05	6.9E-07
Homegrown Produce (Dust Affected)		
Total Radiological Risk	1.3E-07	3.5E-08
Total Chemical Risk	4.5E-07	2.0E-07
Total Risk	5.8E-07	2.3E-07
Homegrown Produce (Groundwater Affected)		
Total Radiological Risk	6.1E-08	6.1E-11
Total Chemical Risk	-	-
Total Risk	6.1E-08	6.1E-11
Beef/Milk (Dust Affected)		
Total Radiological Risk	3.1E-08	1.3E-08
Total Chemical Risk	1.4E-06	6.4E-08
Total Risk	1.4E-06	7.7E-08
Beef/Milk (Groundwater Affected)		
Total Radiological Risk	1.4E-07	0.0E+00
Total Chemical Risk	-	-
Total Risk	1.4E-07	0.0E+00
All Media	1.3E-05	9.9E-07

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- For the South Field [Table 6-29B], cumulative subunit-specific risk for this receptor is greater than two orders of magnitude greater than what it would be if CPCs were present in surface soil and groundwater at background concentrations. This is due primarily to elevated levels of uranium-234 and uranium-238 in groundwater.

- For the Inactive Flyash Pile [Table 6-29C], cumulative subunit-specific risk for this receptor is over 300 orders of magnitude greater than what it would be if CPCs were present at background levels. This is due primarily to elevated levels of uranium-234 and uranium-238 in groundwater. The risk due to the presence of these radionuclides in groundwater was greater than six orders of magnitude greater than what it would be if these compounds were assumed to be present in groundwater as a result of naturally occurring levels in soils.

- For the Solid Waste Landfill [Table 6-29D], cumulative subunit-specific risk again is about two times greater than what it would be if CPCs were present at background levels. This is due primarily to elevated levels of the radionuclides radium-226, radium-228, thorium-228, and thorium-232 in soil and dust affected produce and beef and milk products.

- For the Lime Sludge Ponds [Table 6-29E], cumulative subunit-specific risk is 13 times greater than what it would be if CPCs were present at background levels. The cumulative risk is primarily due to elevated levels of thorium-230, neptunium-237 (was not detected in background samples), and the presence of several PAHs in soil which were not detected in background samples.

6.3.8 Risks Due to Estimated Ambient Radon Emissions

Tables 6-30A through 6-30E present estimated risks due to inhalation of ambient radon concentrations estimated from detected concentrations of radium-226 in soil according to methodology described in Section 5.0 and Appendix A of this RI report. The risks that would exist if radium-226 were present at these subunits at background concentrations are presented for comparison.

These tables indicate that the only receptor at the Active Flyash Pile, Inactive Flyash Pile, and Solid Waste Landfill that may be at a slightly elevated risk (compared to background) due to ambient concentrations of radon resulting from detected levels of radium-226 is the future on-property RME farmer; and that no receptors at the Lime Sludge Ponds are at risk.

Estimated risks to the future RME farmer due to estimated radon emissions are greatest at the South Field [Table 6-30B] where risks are estimated to range from 1.2×10^{-5} to 6.0×10^{-5} compared to the estimated background risk of 2.6×10^{-6}. Risks to all other receptors at the South Field are in the 1×10^{-6} range or below. This suggests that the concentrations of radium-226 in soil within this subunit may contribute to risk under the future farmer scenario.

TABLE 6-30A
ACTIVE FLYASH PILE
RISKS DUE TO ESTIMATED RN-222 EMISSION

	Subunit			Background		
	Maximum RN-222 Air Concentration (pCi/m3)*	Intake (pCi)	Risk	Background RN-222 Air Concentration (pCi/m3)**	Intake (pCi)	Risk
Current Trespassing Youth	1.8E+00	3.7E+03	2.9E-08	3.6E-01	7.4E+02	5.7E-09
Current/Future Off-Property Farmer	1.3E-01	1.6E+04	1.2E-07	2.6E-02	3.0E+03	2.3E-08
Current/Future Off-Property Child	1.3E-01	2.8E+02	2.2E-09	2.6E-02	5.5E+01	4.3E-10
Current Groundskeeper	1.8E+00	3.2E+04	2.4E-07	3.6E-01	6.2E+03	4.8E-08
Future Expanded Trespasser (Adult + Child)	1.8E+00	5.9E+03	4.5E-08	3.6E-01	1.2E+03	8.9E-09
Future, RME On-Property Farmer	1.6E+00	1.9E+05	1.5E-06	3.2E-01	3.7E+04	2.9E-07
Future, CT On-Property Farmer	1.6E+00	1.4E+04	1.1E-07	3.2E-01	2.7E+03	2.1E-08
Future On-Property Child	1.6E+00	3.4E+03	2.6E-08	3.2E-01	6.7E+02	5.2E-09

*Represents the maximum surface soil Ra-226 hit of 4.6 pCi/g.
**Assumes RA-226 concentration is 1.228 pCi/g in surface soil and 0.78 pCi/g in subsurface soil.

TABLE 6-30B
SOUTH FIELD
RISKS DUE TO ESTIMATED RN-222 EMISSION

	Subunit			Background		
	Maximum RN-222 Air Concentration (pCi/m3)*	Intake (pCi)	Risk	Background RN-222 Air Concentration (pCi/m3)**	Intake (pCi)	Risk
Current Trespassing Youth	7.7E+01	1.6E+05	1.2E-06	3.4E+00	7.0E+03	5.4E-08
Current/Future Off-Property Farmer	4.9E+00	5.7E+05	4.4E-06	2.2E-01	2.5E+04	1.9E-07
Current/Future Off-Property Child	4.9E+00	1.0E+04	7.9E-08	2.2E-01	4.5E+02	3.5E-09
Current Groundskeeper	7.7E+01	1.4E+06	1.0E-05	3.4E+00	5.9E+04	4.6E-07
Future Expanded Trespasser (Adult + Child)	7.7E+01	2.5E+05	1.9E-06	3.4E+00	1.1E+04	8.5E-08
Future, RME On-Property Farmer	6.8E+01	7.8E+06	6.0E-05	3.0E+00	3.4E+05	2.6E-06
Future, CT On-Property Farmer	6.8E+01	5.8E+05	4.5E-06	3.0E+00	2.5E+04	2.0E-07
Future On-Property Child	6.8E+01	1.4E+05	1.1E-06	3.0E+00	6.2E+03	4.8E-08

*Value represents maximum surface soil hit of 30.8 pCi/g.
**Assumes RA-226 concentration is 1.228 pCi/g in surface soil and 0.78 pCi/g in subsurface soil.

TABLE 6-30C
INACTIVE FLYASH PILE
RISKS DUE TO ESTIMATED RN-222 EMISSION

	Submit			Background		
	Maximum RN-222 Air Concentration (pCi/m3)*	Intake (pCi)	Risk	Background RN-222 Air Concentration (pCi/m3)**	Intake (pCi)	Risk
Current Trespassing Youth	4.1E+00	8.5E+03	6.5E-08	1.8E+00	3.7E+03	2.9E-08
Current/Future Off-Property Farmer	2.5E-01	2.8E+04	2.2E-07	1.7E-01	2.0E+04	1.5E-07
Current/Future Off-Property Child	2.5E-01	5.1E+02	4.0E-09	1.1E-01	2.2E+02	1.7E-09
Current Groundskeeper	4.1E+00	7.1E+04	5.5E-07	1.8E+00	3.1E+04	2.4E-07
Future, Expanded Trespasser (Adult + Child)	4.1E+00	1.3E+04	1.0E-07	1.8E+00	5.8E+03	4.5E-08
Future, RME On-Property Farmer	4.8E+00	5.5E+05	4.2E-06	2.1E+00	2.4E+05	1.9E-06
Future, CT On-Property Farmer	4.8E+00	4.1E+04	3.1E-07	2.1E+00	1.8E+04	1.4E-07
Future, On-Property Child	4.8E+00	1.0E+04	7.7E-08	2.1E+00	4.4E+03	3.4E-08

*Represents the upper 95 percent confidence interval on the mean Ra-226 soil concentration.
**Assumes Ra-226 concentration is 1.228 pCi/g in surface soil and 0.78 pCi/g in subsurface soil.

TABLE 6-30D
SOLID WASTE LANDFILL
RISKS DUE TO ESTIMATED RN-222 EMISSION

	Subunit			Background		
	Maximum RN-222 Air Concentration (pCi/m3)*	Intake (pCi)	Risk	Background RN-222 Air Concentration (pCi/m3)**	Intake (pCi)	Risk
Current Trespassing Youth	1.6E+00	3.3E+03	2.6E-08	9.0E-01	1.9E+03	1.4E-08
Current/Future Off-Property Farmer	2.6E-02	3.0E+03	2.3E-08	1.5E-02	1.7E+03	1.3E-08
Current/Future Off-Property Child	2.6E-02	5.5E+01	4.3E-10	1.5E-02	3.1E+01	2.4E-10
Current Groundskeeper	1.6E+00	2.8E+04	2.2E-07	9.0E-01	1.6E+04	1.2E-07
Future Expanded Trespasser (Adult + Child)	1.6E+00	5.2E+03	4.0E-08	9.0E-01	2.9E+03	2.3E-08
Future, RME On-Property Farmer	1.6E+00	1.9E+05	1.4E-06	9.0E-01	1.0E+05	8.1E-07
Future, CT On-Property Farmer	1.6E+00	1.4E+04	1.1E-07	9.0E-01	7.7E+03	6.0E-08
Future, On-Property Child	1.6E+00	3.4E+03	2.6E-08	9.0E-01	1.9E+03	1.5E-08

*Represents subsurface soil Ra-226 estimate of 1.55 pCi/g.
**Assumes RA-226 concentration is 1.228 pCi/g in surface soil and 0.78 pCi/g in subsurface soil.

TABLE 6-30E
LIME SLUDGE PONDS
RISKS DUE TO ESTIMATED RN-222 EMISSION

	Subunit			Background		
	Maximum RN-222 Air Concentration (pCi/m3)*	Intake (pCi)	Risk	Background RN-222 Air Concentration (pCi/m3)**	Intake (pCi)	Risk
Current Trespassing Youth	3.9E-01	8.1E+02	6.3E-09	1.4E+00	2.8E+03	2.2E-08
Current/Future Off-Property Farmer	3.0E-03	3.5E+02	2.7E-09	1.0E-02	1.2E+03	9.3E-09
Current/Future Off-Property Child	3.0E-03	6.3E+00	4.9E-11	1.0E-02	2.2E+01	1.7E-10
Current Groundskeeper	3.9E-01	6.9E+03	5.3E-08	1.4E+00	2.4E+04	1.8E-07
Future Expanded Trespasser (Adult+ Child)	3.9E-01	1.3E+03	9.8E-09	1.4E+00	4.4E+03	3.4E-08
Future, RME On-Property Farmer	3.9E-01	4.5E+04	3.5E-07	1.4E+00	1.6E+05	1.2E-06
Future, CT On-Property Farmer	3.9E-01	3.3E+03	2.6E-08	1.4E+00	1.2E+04	8.9E-08
Future, On-Property Child	3.9E-01	8.2E+02	6.3E-09	1.4E+00	2.8E+03	2.2E-08

*Represents upper 95 percent confidence interval on the mean Ra-226 concentration.
**Assumes RA-226 concentration is 1.228 pCi/g in surface soil and 0.78 pCi/g in subsurface soil.

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6.4 UNCERTAINTIES

The types and magnitudes of uncertainties associated with each stage of the process are of major importance for evaluating and interpreting risk assessments at the FEMP. Uncertainties associated with calculations that occur in the risk assessment may be magnified in the final results. While it is not possible to eliminate all uncertainties from the analysis, they must be identified and discussed to determine their significance when making risk management decisions. This section presents an analysis of the major uncertainties contributing to the final results of the Operable Unit 2 baseline risk assessment. A more detailed discussion of these topics is present in Appendix B, Section B.4.3.

6.4.1 SOURCES OF UNCERTAINTY IN OPERABLE UNIT 2

Uncertainties are associated with the information and data used for the selection of CPCs, exposure and toxicity assessments, and risk characterization for the Operable Unit 2 baseline risk assessment. Uncertainty in the selection of CPCs is associated with the analytical data. In the exposure assessment, these uncertainties are the result of a number of factors, including assumptions on land use and receptors, assumptions made for parameters and parameter variability (random errors or natural variations), and the necessity of using computer models to predict complex environmental interactions. Uncertainty associated with the toxicity assessment is associated with the dose-response data. Uncertainties are evaluated in this section to provide a basis for interpreting the overall quality of the risk assessment results. Sources of uncertainty are discussed below.

6.4.2 Selection of Constituents of Potential Concern

Uncertainty associated with the selection process used to determine the CPCs in Operable Unit 2 can be attributed to the following major sources:

- Evaluation of the existing data raises the question as to whether all pockets of elevated contamination have been identified. This is particularly important because risks from radionuclides dominate the overall risks to all receptors evaluated in this risk assessment. No conclusion can be drawn for chemical constituents detected on the property. The impact of this uncertainty to total risk for a receptor may underestimate the risk by as much as one order of magnitude.

- Sample analytical techniques produce results that have an unknown degree of uncertainty associated with them. These uncertainties are documented by using data qualifiers to reflect the assumed degree of certainty of measurement. These analytical uncertainties affect the selection of CPCs or the calculation of exposure point concentrations (either measured or modeled) that may be based on a particular analytical result. Data qualifiers were interpreted in a way that produced more false positives than negatives, causing a conservative impact and possible increasing risks up to one order of magnitude.

- Concentrations of inorganics and radionuclides are compared to background concentrations to determine if their presence is do to naturally occurring concentrations from native soils or are due to site activities. However, sampling procedures for groundwater and air used to determine background concentrations have high detection limits. A chemical that was not detected during background sampling could result in the erroneous inclusion of a chemical from those selected for further evaluation. The impact of this uncertainty is conservative by including CPCs that could be at background, causing a possible increase in risk by one order of magnitude.

- The selection of CPCs includes minimally detected compounds or compounds with a small data set. The screening process for handling minimally detected compounds is to include the compound as a CPC if it was detected once or more in more than one media. In this instance the one or two hits are assumed to be hot-spot indications and not outliers, and are conservatively included as CPCs if the highest hit passes the other screening criteria. The impact of this uncertainty on risks to receptors could overestimate the risk by greater than one order of magnitude.

6.4.3 Uncertainty in Exposure Assessment

Sources of uncertainty for the exposure assessment arise from calculation of exposure point concentrations, selection of receptors, determination of land use scenarios and selection of exposure factors. Uncertainty associated with calculation of exposure point concentrations in Operable Unit 2 can be attributed to the following sources:

- According to the "Risk Assessment Guidance for Superfund" (EPA 1989a), the UCLs are used for all exposure concentrations. This means that 95 percent of the time, the actual mean concentration can be less than the value used in the exposure assessment. Conversely, 5 percent of the time the actual mean concentration can be greater than the value used in the exposure assessment. This assumption will overestimate the risk by maximally exposing the receptor. The impact varies depending on concentration distribution, but could be up to one order of magnitude.

- Sample analytical techniques produce results that have a degree of uncertainty associated with them. These uncertainties are documented by using data qualifiers to reflect the degree of uncertainty of measurement. These analytical uncertainties affect the exposure point concentrations (either measured or modeled) that may be based on a particular analytical result. Data qualifiers were interpreted in a way that produced more false positives than false negatives, causing an overestimation of risk by up to one order of magnitude.

- There is also large uncertainty when exposure concentrations were based on the maximum detected concentration. The conservative approach was taken in the statistical interpretation for the selection of minimally detected compounds and their concentration term. The screening methodology for handling minimally detected compounds was to include the compound in the risk assessment if it was detected more than once in more than one media. In this instance it is difficult to determine statistical properties of a data set when most of the samples are non-detects, or when there are only a few data points. The screening

methodology is to set the concentration term, which is used as the source term in the risk assessment, to the highest detection when a 95 UCL cannot be calculated. This uncertainty could overestimate risks by more than one order of magnitude.

Predicted concentrations were used as exposure point concentrations when measured data were not available (e.g., the future). These predictions were made using mathematical representations (models) of the natural systems found or suspected to exist in the study area. Due to the complexity of natural environments, conservative assumptions were often used in these models to calculate exposure point concentrations. Uncertainties associated with modeled exposure point concentrations in Operable Unit 2 can be attributed to the following sources:

- Use of Toxicity Characteristic Leaching Procedure (TCLP) data to characterize leachate concentrations in the natural environment adds conservatism to the groundwater fate and transport modeling process because TCLP leaching is performed with an acidic solution. This tends to overestimate the leachate concentration of inorganics over natural (more neutral) leaching conditions. This impact is less than one order of magnitude overestimation.

- The selection of parameters related to the attenuation and retardation of constituents is a major uncertainty in the analysis. The attenuation and retardation factors of every constituent except uranium were determined after an extensive literature search. The use of site-specific values are assumed to result in lower uncertainty than using literature values. The impact on risk could overestimate or underestimate risks up to one order of magnitude.

- The organic decay rates at the FEMP were determined after an extensive literature search. The actual decay rates may or may not follow the assumed literature values because of site-specific conditions. The use of site data to determine organic decay rates is assumed to result in lower uncertainty than that resulting from the use of literature values. The variation could impact risk, potentially causing their overestimation or underestimation by up to one order of magnitude.

- Transport through the vadose zone is approximated by using a one-dimensional model and assuming that each of the two zones is homogeneous. The unsaturated seepage flow rate is a function of several parameters, such as porosity, residual saturation, and pore size distribution index. Due to the heterogeneous nature of the till, these parameters change from location to location and from depth to depth. This uncertainty could cause the overestimation or underestimation of risks by up to one order of magnitude.

- The total mass of each contaminant is calculated by multiplying the UCL by the volume of the entire waste area, except for U-238 which was kriged, thus assuming the UCL concentration is uniformly distributed through the entire source. This uncertainty could overestimate or underestimate risks by one to two orders of magnitude because the UCL is often much greater than the mean concentration.

- The fate and transport modeling uses a "70-year rule" for these constituents where no or inadequate leachate data exist. This "rule" assumes all the chemical leaches from a particular waste unit in 70 years. This method is considered very conservative for compounds that are insoluble but may underestimate the maximum exposure for soluble compounds. Although it may underestimate maximum exposure concentration for soluble compounds, it also overestimates exposure time. This uncertainty could overestimate the risk due to certain constituents by more than one order of magnitude.

- Air modeling is based on a number of conservative assumptions. In combination these assumptions appear to overestimate the exposure point concentrations for air based on site air monitoring data and according to a literature search for typical ambient air PM_{10} measurements for EPA Region V. The long-term average PM_{10} concentrations calculated are comparable to measured dust concentrations on constructions. This uncertainty is expected to moderately overestimate risk (i.e., overestimate risks by 1 to 2 orders-of-magnitude.

- The future configuration of the Operable Unit 2 subunits is uncertain at this time; thus, a reasonable worst-case configuration is used to determine source concentrations for both air and surface water modeling. If the actual configuration differs from that used in this evaluation, the future source concentrations may change and the models will have incorrectly estimated the exposure point concentrations. This uncertainty could cause an overestimation or underestimation of risks by up to one order of magnitude.

- The transport models individually made assumptions regarding the fate of individual constituents within source media. However, these models were not combined or linked to consider assumptions made regarding depletion of chemicals from one model and the effect of that assumption on another model (i.e., the leaching models did not consider source depletion from volatilization or fugitive emissions and the air emissions models did not consider losses via leaching). Furthermore, the direct exposure pathways to a particular source (i.e., incidental ingestion of surface soil) did not consider source depletion by leaching, surface water transport, or air emissions. Consequently, this assumption is considered very conservative, causing an overestimation of one to two orders of magnitude for the pathways impacted.

These uncertainties for modeling collectively are assumed to moderately overestimate the concentrations expected in groundwater and for aerial deposition (i.e., overestimate concentration and risk by a factor of one to two orders of magnitude) based on the above discussion. Models were also used to calculate chemical concentrations in plants and animals. Each time concentrations at one level in the food chain are extrapolated from a lower level, uncertainty is introduced into the result. For example, soil-to-plant transfer factors (B_{iv} values) generally represent the maximum amount of contaminant transfer that may occur. In reality, the contaminant transfer is quite dependent on the form of the constituent (e.g., metal species) and other site-related physical conditions (e.g., soil type). Thus actual site transfer factors are unknown. The values chosen are intended to be conservative and they are likely to overestimate risk.

6.4.4 Uncertainty as a Result of Land Use, Receptors, and Exposure Factors

A major uncertainty associated with predicting future exposures at the FEMP is the future disposition of the property itself. Because it is not possible to accurately predict what the future uses of the land may be the most conservative (rather than the most likely) land use is evaluated, as stipulated by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The receptors selected for evaluation in this assessment have been generally selected to reflect and encompass those types of activities which may produce the reasonable maximum exposure individual. Uncertainty associated with the selection of receptors in the current land use scenario is assumed to be low (over- or underestimate risks by a one order of magnitude or less) because the current site environmental setting and configuration was the basis for selection of these receptors. Uncertainty associated with receptors identified in the future land use scenario is high (i.e., potential to overestimate risk by two or more orders-of-magnitude) due to the low probability of the site being used as a residence or for agricultural purposes.

Each exposure factor selected for use in this risk assessment has some uncertainty associated with it. Generally these factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid the underestimation of exposure, this risk assessment followed EPA's recommendation and used the 95th percentile for most of the exposure parameters used in this risk assessment. In other words, the values selected represent the observed or expected habits of a small percentage of the population (usually the upper 5 or 10 percent). For example, the resident farmer scenarios were assumed to inhale air at the location of the highest annual average concentration for 350 days per year for 70 years. Seventy years represents the maximum exposure duration and is not based on a statistical assessment of local or regional residence time for farm families. This factor tends to overestimate risk.

Few intake parameters have high uncertainty associated with them. In the risk assessment for Operable Unit 2, the particular exposure parameters with the greatest uncertainty are judged to be those associated with time (combination of frequency and duration on the site). The particular exposure pathway with the combination of exposure parameters with the highest uncertainty is dermal contact, which is assumed to result in moderate uncertainty (over- or underestimate actual exposure by one to two orders of magnitude) for exposure.

6.4.5 Toxicity Assessment

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for CPCs. The hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will induce adverse effects in humans. Uncertainty in hazard assessment arises from the nature and quality (sensitivity and selectivity) of the animal and human data. Uncertainty is decreased when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when pharmacokinetic data indicate a similar fate in animals and humans; when postulated mechanisms of toxicity are similar for humans and animals; and when the CPC is structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation includes the determination of a slope factor for the carcinogenic assessment and derivation of an RfD or RfC for the noncarcinogenic assessment. Uncertainty is introduced from interspecies (animal-to-human) extrapolation, which, in the absence of quantitative pharmacokinetic, dosimetric, or mechanistic data, is usually based on consideration of interspecies differences in basic metabolism. Uncertainty also results from intraspecies, or individual, variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal. However the human population of concern may reflect a great deal of heterogeneity including unusual sensitivity or tolerance to the CPC. Even toxicity data from human occupational exposures reflect a bias because only those individuals sufficiently healthy to attend work regularly and those not unusually sensitive to the CPC, are likely to be occupationally exposed.

For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for noncancer effects arises from use of an effect level in the estimation of an RfD or RfC, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an additional uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises from estimation of an RfD or RfC for chronic exposure from less than chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less than chronic study. Uncertainty in the derivation of reference doses is mitigated by the use of uncertainty and

modifying factors that normally range between three and ten. Uncertainty factors (UF) and modifying factors (MF) are assigned as follows:

- A UF of ten is used to account for sensitive subpopulations.
- A UF of ten is used when extrapolating from animals to humans to account for interspecies variability.
- A UF of ten is applied to a NOAEL (no observed adverse effect level) derived from a subchronic study rather than a chronic study.
- A UF of ten is applied to a LOAEL (lowest observed adverse effect level) to estimate a NOAEL.
- An MF from zero to ten is applied to data to reflect the quality of the data from the critical study used to derive the reference dose.

As a result, a combination of uncertainty and modifying factors may exceed 100, 1000, or more for a particular compound. These uncertainty factors are discussed in Section B.2.5 for the CPCs in Operable Unit 2. Other toxicity information used in the Operable Unit 2 risk assessment that introduces uncertainty include:

- The EPA inhalation slope factor of 7.7×10^{-12} pCi^{-1} for Rn-222 plus its daughters is used to calculate risks resulting from indoor inhalation of radon gases. The EPA bases this slope factor on a 50% equilibrium ratio between Rn-222 and its short-lived daughters. Studies cited in NCRP Report No. 78 (NCRP, 1984) report a lower value for this equilibrium ratio in indoor air (i.e.: 100/50/30/20/20 for Ra-222, Po-218, Pb-214, Bi-214, and Po-214, respectively). Since the concentration of daughters expected in indoor air is lower than the EPA assumption, the slope factor is probably conservative in this respect.
- PAHs that are classified as B2 probable human carcinogens for which no toxicity data were available are evaluated using benzo(a)pyrene toxicity data. This assumption likely leads to an overestimation of the carcinogenicity of those PAHs because conservative assumptions were used to relate their carcinogenicity to that of benzo(a)pyrene. However, when toxicity equivalency factors were used in this assessment to evaluate their carcinogenicity, this may either underestimate or overestimate the carcinogenic risks. Overall, this increased conservatism does not significantly impact the overall risks from Operable Unit 2 since the majority of risks are posed by other CPCs.
- The only PCB with positive carcinogenicity results is Aroclor-1260. The carcinogenicity of all PCB isomers were assumed to be equal to the carcinogenicity of Aroclor-1260 because the dose-response data for other isomers are inconclusive. Statistically significant cancer results were not seen for Aroclors with lower percentages of chlorine atoms. The

conservatism introduced in the evaluation of PCBs is not anticipated to impact the selection of CPCs for final risks because they did not exceed the concentration-toxicity screen.

- As with PAHs, the carcinogenicity of dioxins and furans other than the 2,3,7,8-isomer were determined using EPA's revised Toxicity Equivalency Factors (TEFs) in the absence of toxicity values for the different isomers (Clement International, 1990). The TEFs are based on the assumption that all dioxin and furan congeners are carcinogenic. This may introduce a large positive bias to the results of the assessment.

A significant source of uncertainty for calculating risks from radionuclides in surface soil is the use of EPA slope factors for external radiation exposure. In deriving these slope factors, EPA has assumed that an individual continuously stands on an infinitely thick slab of soil with a uniform radionuclide concentration. To manage complicated calculations for photon attenuation and scattering in soil, EPA has assumed that the activity in the slab source is present on an infinite plane with uniform surface concentration. The slope factors for external radiation exposure are, therefore, based on calculated exposures (and associated risks of cancer incidence) from the hypothetical plane source. In addition, EPA calculates slope factors for ingestion of many radionuclides using the maximum value for the GI absorption factor. The actual chemical form(s) that influence the magnitude of the GI absorption factor have not been considered.

6.4.6 Risk Characterization

Uncertainty in risk characterization results from assumptions made regarding additivity of effects from exposure to multiple compounds from various exposure routes. High uncertainty exists when summing cancer risks or hazard indices for several substances across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the body where additivity is not appropriate. However, the assumption of additivity is made to provide a conservative estimate of risk. This particular source of uncertainty is insignificant for Operable Unit 2 because the majority of cancer risks and hazard index is due to a few constituents of potential concern (CPCs).

Risk characterization does not consider antagonistic or synergistic effects. Little to no information is available to determine the potential for antagonism or synergism for CPCs. Therefore, this uncertainty cannot be discussed based on the impact on the risk assessment since it has the potential to either over-or under-estimate potential human health risks. The additivity of risks from radionuclides and chemical carcinogens is the subject of considerable debate. EPA guidance (EPA 1989a) indicates

that the two sets of estimates should be considered separately because 1) chemical CSFs are developed using laboratory experiments and radionuclide toxicity values are based on human epidemiological data, and 2) chemical CSFs represent an upper bound limit value while radionuclide slope factors are "best estimates." Therefore, cancer risks from exposure to radionuclides are presented separately from those from chemical CPCs.

6.5 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

CERCLA §121(d)(2) states that for wastes left on site, remedial actions must comply with federal and state environmental laws that are legally applicable or are relevant and appropriate under the circumstances of the release. Off-site actions must comply only with requirements that are legally applicable.

The definition of Applicable or Relevant and Appropriate Requirements (ARARs) are:

- Applicable Requirements - Cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and Appropriate Requirements - Cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

EPA has also created another category of requirements known as "to be considered" (TBCs) that include non-promulgated criteria, advisories, and guidance issued by federal or state governments.

Identification of potential ARARs is initiated during scoping and continually refined during site characterization activities, analysis of alternatives and then finalized with the selection of the preferred remedial alternatives.

The EPA document "Overview of ARARs" (Publication 9234.2-03/FS) directs that chemical- and location-specific ARARs be identified early in the process, generally during the site investigation,

while action-specific ARARs are usually identified during the detailed analysis of alternatives in the FS. The three types of ARARs are defined as:

- Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies used to determine acceptable concentrations of chemicals that may be found in or discharged to the environment [e.g., Maximum Contaminant Levels (MCLs) that establish safe levels in drinking water].

- Location-specific ARARs restrict actions or contaminant concentrations in certain environmentally sensitive areas. Examples of areas regulated under various federal laws include floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

- Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions or conditions involving special substances.

The initial Operable Unit 2 list of potential ARARs was submitted to EPA and OEPA on October 12, 1990. On February 7, 1991, EPA acknowledged receipt of the potential list and commented that their review would be an iterative process with their final approval at the time of remedy selection.

During the Operable Unit 2 RI, sufficient data has been developed to make initial judgments concerning the COCs in Operable Unit 2 and special location characteristics that may require special protection or action. The Operable Unit 2 pertinent chemical- and location-specific potential ARARs are identified in the following sections.

6.5.1 Potential Chemical-Specific ARARs

The chemical-specific ARARs for the Operable Unit 2 COCs are arranged in this section according to the following categories:

- ARARs and TBC Guidance for Drinking Water and Groundwater
- ARARs and TBC Guidance for Surface Water
- ARARs for Air Emissions
- ARARs and TBC Guidance for Waste Classification
- ARARs and TBC Guidance for Radiation

6.5.1.1 Potential ARARs and TBC Guidance for Drinking Water and Groundwater

There are no applicable requirements for drinking water or groundwater for Operable Unit 2. The National Contingency Plan (40 CFR §300.430 (e)(2)(i)B-D) states that non-zero Maximum Contaminant Level Goals (MCLGs) and MCLs, are considered to be relevant and appropriate for any aquifer that is a potential drinking water source. The Great Miami Aquifer beneath the Fernald site is considered a potential drinking water source.

If attainment of a non-zero MCLG or MCL is impossible because the background level of the chemical subject to CERCLA authority (e.g., man-made chemical) is higher than that of the MCLG or MCL, attainment of the MCLG or MCL would not be relevant and appropriate [CERCLA Compliance with the CWA and Safe Drinking Water Act (SDWA), Publication 9243.2-06/FS, January 1990].

The relevant and appropriate or TBC (proposed) MCLG and MCL values for the Operable Unit 2 COCs are provided in Table 6-31.

6.5.1.2 Potential ARARs and TBC Guidance for Surface Water and Sediment

CERCLA §121 states that hazardous substances, pollutants, or contaminants left on site at the conclusion of the remedial action shall attain Federal Water Quality Criteria where they are relevant and appropriate under the circumstances of the release or threatened release. CERCLA §121(d)(2)(B)(i) requires this determination to be based on the designated or potential use of the water, the media affected, the purpose of the criteria, and the current information. OEPA has promulgated Water Quality Standards specific to state waters and their actual or potential uses. The designated uses of the Great Miami River and its tributaries are for a warm water aquatic life habitat, agricultural, and industrial water supply and primary contact recreation [Ohio Administrative Code (OAC) 3745-1-21].

The OEPA-promulgated standards are considered potentially applicable for the direct discharge of wastewater generated during a CERCLA action and potentially relevant and appropriate for use in determining clean-up goals for soils or groundwater that is or has the potential to impact the surface waters. The OEPA standards are provided in Table 6-32.

TABLE 6-31

MCLGs AND MCLs FOR OPERABLE UNIT 2 CONTAMINANTS OF CONCERN

Contaminant of Concern	Requirement	Citation	Remarks
METALS			
Arsenic	0.05 mg/L	40 CFR § 141.11(b)	Promulgated MCL
Beryllium	0.004 mg/L	40 CFR §141.51, §141.62	both MCL and MCLG
Chromium	0.05 mg/L	OAC 3745-81-11	Promulgated MCL
Benzo(a)pyrene	0.0002 mg/L	40 CFR § 141.61	Promulgated MCL
RADIONUCLIDES			
Radium-226	20 pCi/L	56 FR 33050 7/18/91	Proposed MCL
Radium-228	20 pCi/L	56 FR 33050 7/18/91	Proposed MCL
Radium-226 and -228	5 pCi/L	40 CFR §141.15(a)	Promulgated MCL
Uranium-Total	20 μg/L (30 pCi/L)	56 FR 33050 7/18/91	Proposed MCL
Gross alpha particle activity (including Radium-226 ,but excluding Radon and Uranium)	15 pCi/L	40 CFR §141.15(a)	Promulgated MCL; Includes Np-237 and Th-228
Beta and photon radioactivity	4 mrem per year	40 CFR §141.16(a)	Promulgated MCL; Includes Tc-99

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TABLE 6-32

OEPA WATER QUALITY STANDARDS (OAC 3745-1-07)

Contaminant of Concern	Outside Mixing Zone (μg/L)				Inside Mixing Zone (μg/L)
	Warm Water Habitat		Human Health	Agriculture Water Supply	Warm Water Habitat
	Maximum	Average	Average	Average	Maximum
Arsenic	360	190	-[a]	100	1300
Beryllium (total)[b]	520	23	1.17	100	1000
Chromium (total)[b]	1,800	210	3,433,000	100	3,600
Level of Protection (Q-flow)[c]	7Q10	30Q10	Harmonic Mean Flow	Harmonic Mean Flow	-

[a]There is no requirement for this parameter.
[b]Assume a hardness of 100 mg/L as $CaCO_3$.
[c]For example: 7Q10 is the 7 day, 10 year low flow of the receiving stream.

The values provided in the table are the acceptable instream levels. The level of protection is defined as the low flow during which the water quality standards must still be met. Discharge levels are based on the designated level of protection and the upstream concentration of the contaminant of concern. Acceptable discharge levels are governed by the most stringent level based on the protection of the designated uses.

6.5.1.3 Potential ARARs and TBC Guidance for Air Emissions

EPA regulations for National Emission Standards for Hazardous Air Pollutants (NESHAP; 40 CFR §61.92) provide a potentially applicable air emission standard for remedial activities in Operable Unit 2. This regulation limits the effective dose from airborne radionuclide emissions to 10 mrem per person. In addition, radon-222 emissions are limited to 20 pCi/s/m^2 from each Operable Unit 2 source (40 CFR §61.192).

6.5.1.4 Potential ARARs on Waste Classification

To determine the regulatory classification of the wastes in Operable Unit 2, the concentrations of contaminants found in the wastes and soils are compared to the levels defining a regulatory classification. The two waste classifications that are important in defining the Operable Unit 2 wastes are the RCRA Subtitle C Toxicity Characteristic list and the OEPA Nontoxic Policy (OEPA Policy Number 4.07). The COCs with the associated concentration levels for these waste characteristics are listed in Table 6-33.

TABLE 6-33

WASTE CONCENTRATION STANDARDS

Parameter	RCRA Toxic Characteristic (mg/L)	Ohio Exempt Waste Standard (30 Times the Ohio Drinking Water Standard) (mg/L)
Arsenic	5.0	1.5
Chromium	5.0	1.5

6.5.1.5 Potential ARARs and TBC Guidance for Radiation

The Nuclear Regulatory Commission (NRC), EPA regulations, and DOE Orders control radiological emissions from all sources to all media. The NRC and EPA regulations are not applicable but may

be relevant and appropriate to the wastes and remedial activities in Operable Unit 2. While DOE Orders 5400.1 and 5820.2A contain requirements for the control of radiological releases from DOE facilities, these orders are not promulgated and are used as TBC requirements. For the purposes of the Operable Unit 2 assessment of remedial alternatives in the FS, relevant and appropriate NRC and EPA regulations will be supplemented with DOE Order requirements, where the DOE requirements are more stringent. These requirements are outlined in Table 6-34.

6.5.2 Potential Location-Specific ARARs

The RI identifies special characteristics (e.g., presence of wetlands and habitat of endangered species) of the operable unit that allows the identification of statutes and regulatory requirements that may prohibit activities or require the existing conditions to be rectified. While no areas were identified in the Operable Unit 2 battery limits, the final decision whether any statutes are prohibitory or retroactive will be made during the FS. Supplemental investigations have been performed or are currently underway to determine sensitive areas affected by Operable Unit 2 and/or by Operable Unit 2 potential remedial activities. The potential location-specific ARARs identified for Operable Unit 2 are presented in Table 6-35.

6.5.3 Use of ARARs

The potential chemical- and location-specific ARARs identified for Operable Unit 2 will be finalized during the Feasibility Study/Proposed Plan. The action-specific ARARs and additional location-specific ARARs (e.g., siting criteria) will be identified and analyzed in the Feasibility Study/Proposed Plan based on the selection of alternatives. The pertinent chemical-specific ARARs will be used in conjunction with the risk assessment to determine PRG for Operable Unit 2. The ROD will contain the final list of ARARs and remedial goals that will direct the Operable Unit 2 Remedial Design and Remedial Action.

TABLE 6-34

POTENTIAL RADIATION PROTECTION REQUIREMENTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Citation	Requirement
Effluent Concentrations 10 CFR §20.106	Radioactive licensed material shall not be possessed, used, or transferred so as to release to an unrestricted area radioactive material in concentrations which exceed the effluent concentration limits provided in this regulation. As an example, specified levels for uranium are provided in the table below. Concentrations may be averaged over a period of not greater than 1 year. μCi/mL Air / Water Uranium-234: $5x10^{-14}$ / $3x10^{-7}$ Uranium-235: $6x10^{-14}$ / $3x10^{-7}$ Uranium-236: $6x10^{-14}$ / $3x10^{-7}$ Uranium-237: $2x10^{-9}$ / $3x10^{-5}$ Uranium-238: $6x10^{-14}$ / $3x10^{-7}$ Natural Uranium: $9x10^{-14}$ / $3x10^{-7}$
Protection of the General Population from Releases of Radioactivity 10 CFR § 61.41	Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ of any member of the public. Reasonable measures should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable (ALARA).
Protection of Sedimentation from Effluent DOE Order 5400.5 Chapter II (3)(a)(3)	Liquid process waste streams containing radioactive material in the solid present in the waste stream does not exceed 5 pCi/g above background level of settleable solids for alpha-emitting radionuclides, or 50 pCi/g above background of settleable solids for beta-gamma-emitting radionuclides.
Interim Dose Limit for Native Aquatic Animal Organisms DOE Order 5400.5 Chapter II (3)(a)(3)	The absorbed dose to these organisms shall not exceed 1 rad per day from exposure to the radiological material in the liquid wastes discharged to natural water ways.

001011

TABLE 6-34
(Continued)

Citation	Requirement
Basic Dose Limits DOE Order 5400.5 Chapter IV (3)	The exposure of members of the public, to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem. Dose evaluations should reflect realistic exposure conditions, including remedial actions and naturally occurring radionuclides released by DOE processes and operations. If unusual circumstances affect a DOE activity in such a manner that the potential public dose could exceed an effective dose equivalent of 100 mrem in a year, DOE may authorize a temporary increase of the dose limit up to 500 mrem.
Guidelines for Residual Radioactive Material DOE Order 5400.5 Chapter IV (4)(a)	Guidelines for residual concentrations of radionuclides other than thorium and radium shall be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these derivations are given in DOE/CH-8901. Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 m^2.
Hot Spots DOE Order 5400.5 Chapter IV (4)(a)(1)	If the average concentration in any surface or below surface area less than or equal to 25 m^3, exceeds the limit or guideline by a factor of$(100/A)^{0.5}$ [where A is the area (in square meters) of the region in which the concentrations are elevated], limits for "hot spots" shall also be developed and applied. Procedures for calculating these hot spots limits, which depend on the extent of the elevated local concentrations, are given in DOE/CH-8901. In addition, reasonable efforts shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit in the soil, irrespective of the average concentration in the soil.
Generic Guidelines DOE Order 5400.5 Chapter IV (4)(a)(2)	The generic guidelines for residual concentrations of Ra-226, Ra-338, Th-230 and Th-232 are: • 5 pCi/g, averaged over the first 15 cm of soil below the surface; and • 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.
External Gamma Radiation DOE Order 5400.5 Chapter IV (4)(c)	External gamma radiation levels on open lands shall comply with the basic limit [dose] and the "as low as reasonably achievable" (ALARA) process, considering appropriate-use scenarios for the area.

001012

TABLE 6-35

POTENTIAL OPERABLE UNIT 2 LOCATION-SPECIFIC ARARs
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Citation	Requirement	Remarks
Endangered Species and Critical Habitat 50 CFR §17.21, §17.94 50 CFR §402.01 40 CFR §6.302 (h)	All Federal agencies must insure that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of the constituent elements essential to the conservation of a listed species within a defined critical habitat.	Baseline Ecological survey conducted by Miami University in 1986 and 1987 found no federal or state endangered species at the Fernald site. The Miami University Study and others have identified suitable habitats for three endangered species.
Antiquity Preservation 16 U.S.C. §431	No person may appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity situated or controlled by the Government of the United States.	A survey of the Operable Unit 2 areas was performed in March, 1993 and it was determined that it had already been sufficiently disturbed that there would be no requirement to consult the State Historic Preservation Officer (SHPO). Any other proposed areas of disturbance for Operable Unit 2 remedial actions will be surveyed and the SHPO consulted as necessary.
Archaeological Recovery and Preservation 16 U.S.C. §408(a), 16 U.S.C. §470ff(a), 43 CFR Part 7, 40 CFR §6.301 (c)	No person may excavate, remove, damage, or otherwise alter or deface any archaeological resource located on public lands unless such activity is pursuant to a permit.	See above remark.
Safe Drinking Water Act 42 U.S.C. §1424(e)	All Federal financially assisted projects constructed in the area of a sole source aquifer and its principal recharge zone will be subject to EPA's review to insure that these projects are designed and constructed so that they do not create a significant hazard to public health.	53 FR 15876 (May 4, 1988) designated the Buried Valley Aquifer System of the Great Miami/Little Miami River Basins of Southwestern Ohio as a sole or principal source of drinking water.

TABLE 6-35
(Continued)

Citation	Requirement	Remarks
Wetlands Executive Order 11990	Federal agencies must take action to avoid adversely impacting wetlands whenever possible, to minimize wetlands destruction, and to preserve the values of wetlands. 40 CFR §6, Appendix A describes EPA's policy for complying with this order. 10 CFR § 1022 contains DOE regulations implementing the order.	An updated site-wide delineation of Fernald wetlands, performed in accordance with the U.S. Army Corps of Engineers Wetland Delineation Manual, was completed in March 1993. While no wetlands were located in Operable Unit 2, some nearby wetlands may be affected during Operable Unit 2 remedial action.
Floodplains Executive Order 11988	This order requires federal agencies undertaking actions within a floodplain to evaluate the potential the action has for adverse impact on the floodplain. If it is determined that adverse impacts could occur, the effects of the action must be minimized to the extent practical. 10 CFR §1022 contains DOE's regulation implementing the order.	An updated floodplain determination was performed for Paddys Run in October 1993 using the Corps of Engineers' standard HEC2 water surface profile analysis program. The 100 year flood elevations reach the western slope of the Inactive Flyash Pile and the toe of slope of the South Field.

001014

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7.0 SUMMARY AND CONCLUSIONS

This section provides a summary of the RI report for Operable Unit 2 and states the major conclusions of the investigation.

7.1 FACILITY DESCRIPTION AND RELEVANT HISTORY

The FEMP is a DOE facility located near Fernald, Ohio, which operated from 1952 to 1989 to provide high purity uranium metal products in support of United States defense programs. In 1989, the mission of the facility was changed to one of environmental restoration. Also in 1989, the facility was placed on the National Priorities List ("Superfund List"). The RI/FS for the FEMP is executed according to an Amended Consent Agreement between DOE and the EPA, under authority of CERCLA. OEPA is also participating in the FEMP RI/FS process through direct involvement in review meetings, public meetings, and technical review of project documentation.

The FEMP occupies about 1,050 acres and is located about 17 miles northwest of downtown Cincinnati near Fernald, Ohio, a small farming community. The site lies on the boundary of Hamilton and Butler counties. The primary mission of the FEMP during its 37 years as an operating production facility was to process, refine, and machine high-grade natural uranium ores into high purity uranium metal. The high purity metals were shipped to other DOE or U.S. Department of Defense facilities for use as "feed materials" in the nuclear weapons program. These uranium production activities generated large quantities of waste materials. The storage and disposal of wastes at the site and their potential for impacting human health led to the site being placed on the National Priorities List.

EPA approved the FEMP RI/FS Work Plan in May 1988. The work plan provided the overall technical approach, identified areas to be investigated, and presented the objectives and data evaluation criteria for the planned investigations. The work plan identified 27 specific areas, or units, within the FEMP for investigation. Subsequent evaluations increased the number of units to 39. It soon became apparent that for purposes of effective management, the 39 units should be categorized and grouped. The resultant groupings formed the five operable units of the FEMP. These operable units are:

- Operable Unit 1 - Waste Pit Area
- Operable Unit 2 - Other Waste Areas
- Operable Unit 3 - Former Production Area
- Operable Unit 4 - Silos 1 through 4
- Operable Unit 5 - Environmental Media

Operable Unit 2 is comprised of five subunits: (1) Solid Waste Landfill, (2) Lime Sludge Ponds, (3) Active Flyash Pile, (4) Inactive Flyash Pile, and (5) South Field. Large volumes of conventional industrial wastes, assumed to have small amounts of hazardous chemicals and radionuclides, were placed in these subunits during the period of production operations. These subunits are briefly described below.

7.1.1 Solid Waste Landfill

The Solid Waste Landfill is located in the northeast corner of the Waste Storage Area and is a flat, rectangular area of about one acre. The landfill has been inactive since 1986 and is covered with a layer of fill. The operational history of the landfill is not well documented; however, a review of historical site aerial photographs indicates that disposal activities may have occurred as early as 1954. Available documentation and interviews indicate that the landfill was intended to be used for "nonburnable wastes". Field investigations have revealed a variety of waste materials including medical wastes, rubbish, wastes from areas other than the former Production Area, and on-site construction/demolition wastes.

7.1.2 Lime Sludge Ponds

The Lime Sludge Ponds are two (North and South) unlined, rectangular ponds, each measuring approximately 125 by 225 feet, located in the southeast corner of the Waste Storage Area. The sludge is confined by earthen dikes of unknown origin. The operational history of the ponds is well understood based on documentation and process knowledge. Wastes disposed of in the ponds originated from water plant operations, coal pile storm water runoff, and boiler plant blowdown. The South Pond is full, has been inactive since the mid-1960s, and is now overgrown with grasses and shrubs. The North Pond currently remains in use. The west side of the North Pond usually is covered with one to two feet of water, mainly depending on precipitation. The remainder of the pond is dry and sparsely covered with vegetation.

The waste from water plant operations is generated from a water softening process. About one cubic yard of waste sludge is generated each day and is pumped to Tanks 6 and 7 of the General Sump. Coal pile runoff is treated in a retention basin to settle out the solids, then pumped to Tanks 6 and 7 of the General Sump. The boiler plant blowdown consists of backflush water, generated when the boilers are backflushed to prevent scale buildup. This water is also pumped to Tanks 6 and 7 of the General Sump. Tanks 6 and 7 contain only sludges from these three sources.

Sludge is allowed to accumulate in the tanks for about two weeks. It is then pumped as a slurry to the North Lime Sludge Pond. The bulk of the material comprising the slurry is sludge from the water softening operations. The Lime Sludge Ponds have been operated in this manner since the early 1950s. Based on this process knowledge as well as the results of analytical analysis of the sludge, it appears that the lime sludge is relatively homogenous. The Lime Sludge Ponds are presently classified as SWMUs by OEPA.

7.1.3 Inactive Flyash Pile

The Inactive Flyash Pile is located about 2,000 feet southwest of the former Production Area and covers approximately two acres. Paddys Run forms the western boundary and the South Field lies to the east. The Inactive Flyash Pile and South Field are contiguous and lack a defined physical boundary. In appearance, this subunit resembles a relatively steep hill covered with shrubs and trees. The soil covering the southern half of the Inactive Flyash Pile is of unknown origin.

The operating history of the Inactive Flyash Pile is not well understood. The bulk of the waste material in the pile is reported to be bottom ash and flyash from the facility's boiler plant operations, commonly referred to as flyash. Based on a review of historical aerial photographs, flyash appears to have been taken by truck to an existing slope near Paddys Run and dumped. The photographs indicate that flyash disposal at this subunit had ceased by the mid-1960s. Various other wastes including building rubble, gravel, asphalt, and process waste were also deposited at the Inactive Flyash Pile.

7.1.4 South Field

The South Field is an 11-acre area that lies between the Inactive Flyash Pile and the Active Flyash Pile. A physical boundary with the Inactive Flyash Pile is not distinguishable. Currently, the South Field is relatively flat and is covered with grasses, shrubs, and trees.

The operational history of the South Field is neither well documented nor understood. It is not an engineered disposal site. A review of historical aerial photographs indicates that disposal may have been initiated in 1954 and continued until the mid-1960s. Disposal appears to have taken place in a random manner. Available documentation indicates that a number of wastes were disposed in the South Field, including construction and demolition materials, flyash, soils that may have been contaminated with low levels of radioactive materials, and possibly process wastes.

7.1.5 Active Flyash Pile

The Active Flyash Pile is bounded to the east and north by the Storm Sewer Outfall Ditch, and is separated from the South Field to the west by an unpaved road. The Active Flyash Pile appears as a large, steep pile of black flyash, and covers about three acres. Wind screens and silt fences have been installed to prevent wind and water erosion, and a crusting agent has been applied to minimize dust. The operational history of the subunit is well understood based on documentation and process knowledge.

Flyash from the site's coal-fired boiler plant was disposed at the Active Flyash Pile from the mid-1960s until December 1992. Flyash presently being generated at the FEMP is disposed at an approved, off-site facility. The waste at the Active Flyash Pile is comprised of about 70 percent bottom ash and 30 percent flyash. Small quantities of unburned coal and rock are present, as is typical of boiler ashes. Previous investigations have discussed the possibility that waste oils, which theoretically could contain PCBs or uranium, might have been applied to the Active Flyash Pile as a dust control measure; however, attempts to document this possibility have not been successful.

7.2 OPERABLE UNIT 2 INVESTIGATIONS

The potential for contamination at Operable Unit 2 subunits has been established through several environmental investigations. The investigations most relied on in this report are the CERCLA RI, the CIS, and the Environmental Survey (ES). The evaluation of the nature and extent of contamination in this report was based primarily on RI data. The CIS and ES primarily were focused on site-wide issues and were not intended to provide a detailed analysis of contamination due to Operable Unit 2 subunits. Data from the CIS was not validated, and therefore, were used only in a supplementary manner and for descriptive purposes. Neither ES nor CIS data were used in fate and transport modeling for the baseline risk assessment.

The RI field investigations were implemented in two phases (Phase I and Phase II). Phase I investigation activities occurred between 1988 and 1992, and Phase II occurred during 1993. These combined efforts collected over 2,000 samples of environmental media in order to evaluate the potential for contamination. All RI data were validated, and only RI contaminant concentration data were used in the fate and transport modeling for the baseline risk assessment.

The RI data collection was for two specific purposes: (1) to determine the nature and extent of contamination in a manner adequate to determine the future impacts on human health if the site were not to be remediated, and (2) to provide a basis for the development and evaluation of a range of feasible remedial action alternatives. The specific objectives of the RI field investigation were to:

- Characterize the nature and extent of contamination in surface soil, subsurface soil and fill, surface water and sediment, perched water, and the Great Miami Aquifer that could be expected to have been impacted by Operable Unit 2 subunits.
- Characterize specific waste materials, (e.g., lime sludge).
- Provide the data necessary to evaluate the potential for human exposure to contaminants through the air, surface water, groundwater, dermal contact, external radiation, and ingestion pathways.

7.3 PHYSICAL CHARACTERISTICS

The physical characteristics of the site include the natural and man-made factors affecting meteorology, geology, hydrology, and hydrogeology. The prevailing winds at the FEMP are generally from the southwest and west-southwest. The most frequent adverse weather conditions in the region occur from severe thunderstorms and tornados. The annual probability of a tornado occurring per square mile in Ohio is estimated to be 1.25 in 10,000.

The average annual precipitation for the Greater Cincinnati area for the period of 1960 to 1989 was 40.56 inches, and ranged from 27.99 inches in 1963 to 52.76 inches in 1979. The seasons having the most precipitation are spring and early summer; the least precipitation occurs in late summer and fall. The highest 24-hour rainfall event on record, 5.21 inches, occurred in March 1964. The average annual snowfall for the 1960 to 1989 time period was 23.5 inches. The heaviest snowfall usually occurs in January; the maximum monthly snowfall, 31.5 inches, occurred in January 1978. The maximum recorded 24-hour snowfall event, 9.8 inches, occurred in March 1968.

Maximum elevation at the FEMP is along the northern boundary and is slightly more than 700 feet above MSL. The former Production Area and Waste Storage Area (Operable Units 3 and 1, respectively) are on a relatively flat plain at about 580 feet above MSL. The plain slopes gently from about 600 feet above MSL along the eastern boundary of the FEMP to approximately 550 feet above MSL at Paddys Run. Surface water drainage on the FEMP is generally from east to west toward Paddys Run. The storm water drainage from the former Production Area and the Waste Storage Area is controlled and discharged to the Great Miami River.

Paddys Run originates north of the FEMP and flows intermittently southward along the western boundary of the site. The stream is about 8.8 miles long and drains an area of about 15.8 miles. Flow in Paddys Run is lost to the underlying Great Miami Aquifer in the vicinity of the site. Paddys Run usually flows throughout its entire length between January and May of each year.

The other flowing body of water at the FEMP is the Storm Sewer Outfall Ditch. The drainage area originates east of the former Production Area, and surface flow becomes channeled within a culvert until it reaches the Storm Sewer Outfall Ditch at a point near the parking lot south of the former Production Area. The outfall ditch then flows southwest across the southern portion of the site and enters Paddys Run near the southwestern boundary of the FEMP. Throughout the year, this ditch generally is dry, with flows occurring only during and after precipitation events. Much of the ditch's bottom is composed of sand and gravel, and loss of flow to the underlying aquifer may occur.

The FEMP is situated on an area of glacial overburden deposits; the overburden primarily is composed of till, a dense silty clay that may contain lenses of poorly sorted fine to medium grained sand and gravel, silty sand, and silt. Undisturbed glacial till has relatively low permeability. The thickness of the till varies from 0 to 50 feet on the site, and the till tends to be thicker in the northern part of the site (the Solid Waste Landfill, for example, is sited in thick till) and pinches out completely in the South Field area in the southern part of the site. Areas not covered with till may exhibit higher infiltration rates than those covered with glacial till.

Erratically distributed pockets of sand and gravel within the till contain zones of perched groundwater. Perched groundwater is separated from the underlying aquifer by the surrounding relatively impermeable till materials. Depth to perched groundwater at the FEMP ranges from 1 to 15

feet below ground surface. The depth may fluctuate seasonally by up to 10 feet at a given location, with the highest levels occurring in the early spring and the lowest in the late fall.

The FEMP is sited above a major aquifer system, the Great Miami Aquifer. The Great Miami Aquifer is designated a Sole-Source Drinking Water Aquifer and sustains numerous industrial, municipal, and private drinking water wells.

7.4 PROCESS FOR DETERMINING NATURE AND EXTENT, FATE AND TRANSPORT, AND BASELINE RISK ASSESSMENT

This section summarizes the succession of work performed to determine the Operable Unit 2 COCs and to obtain sufficient information to develop and evaluate remedial alternatives under the Operable Unit 2 FS. This process consists of three major steps: (1) nature and extent, (2) fate and transport, and (3) a baseline risk assessment.

Nature and Extent

The data collected during the RI was analyzed in Section 4.0 to describe the specific constituents and concentration levels found in each environmental media within the Operable Unit 2 battery limits. This analysis included the identification of the horizontal and vertical extent of these constituents within the battery limits of Operable Unit 2.

Fate and Transport

Results of the site physical characteristics, source characteristics, and extent of contamination analyses were combined in the analyses of constituent fate and transport. The observed extent of contamination was used to assist in assessing the transport pathway's rate of migration and the fate of contaminants over the 40 year span from the suspected contaminant release to the time of the RI. A source term was developed for each subunit based on the 95th percent UCL of the mean of the concentration for all constituents except uranium. The source term for uranium was developed through solid block modeling of the RI data. This solid block modeling produced a mean level of uranium present in each subunit based on geostatistical evaluation of the uranium data. A screening procedure was used to identify CPCs for Operable Unit 2. This process eliminated constituents of a source term that were below background levels, of nutrient value, and less than 1.0×10^{-7} potential carcinogenic risk or a HI of less than 0.1 from EPA Region III guidance. Computer modeling, using the ISCLT2, HELP, ODAST, and SWIFT models, were used to predict the future concentrations of

these CPCs in air, groundwater, and surface water. Groundwater transport was modeled for 1000 years. These simulation models have been approved by EPA and calibrated to site conditions.

Baseline Risk Assessment

An Operable Unit 2 baseline risk assessment was performed to evaluate the current and future potential threat to human health from the Operable Unit 2 subunits in the absence of any remedial actions. The baseline risk assessment was performed in two stages to determine the risk from each subunit as well as the cumulative risk from Operable Unit 2.

The assessment accomplished the following for each subunit:

- Determination of CPCs for Operable Unit 2.
- Assessment of the potential for and magnitude of constituent transport from Operable Unit 2 sources to potential points of human exposure.
- Quantification of potential exposures to human receptors under current and future land use scenarios.
- Characterization of the nature and magnitude of potential risks associated with Operable Unit 2, assuming there were no remedial action in the future.
- Evaluation of the uncertainty associated with the risk estimations.

The baseline risk assessment results are used to determine the need for remedial action in Operable Unit 2; identify specific media and areas for which cleanup is appropriate; present a baseline of potential risk for the no action alternative in the FS; and provide criteria for determining cleanup levels.

The Operable Unit 2 baseline risk Assessment addresses only potential risks associated with waste subunits within the battery units of Operable Unit 2. It does not consider existing sources or contamination in soil, surface water, and sediment outside the boundaries of Operable Unit 2, nor does it consider groundwater contamination. Therefore risk quantified in the baseline risk assessment represents a portion of the total risk posed by the FEMP site. Total cumulative risk from all operable units will be addressed in the final Comprehensive Response Action Risk Evaluation (CRARE) prepared for Operable Unit 5. These risks will be evaluated in the Operable Unit 5 RI. Risks due to groundwater in this and other operable unit risk assessments are based on estimates of future concentrations which are based on modeling. This risk assessment does not consider the potential

impacts on flora and fauna (ecological risks). Evaluation of site-wide ecological risks will take place in the Operable Unit 5 RI/FS; areas likely to be remediated on the basis of human health protection will not be evaluated.

Operable Unit 2 includes five subunits for which remedial decisions must be made. In order to facilitate the decisions, risk was quantified separately for each subunit. The specific risk assessment methodology followed for the risk assessment was consistent across all subunits as well as for the cumulative risk from Operable Unit 2 that was calculated.

Potential human exposure to risk is evaluated in the context of four and use scenarios: (1) current land use assuming DOE ownership with access control, (2) current land use without access controls, (3) future land use assuming federal ownership, and (4) future land use assuming private ownership. For all scenarios, it is assumed that no additional cleanup of Operable Unit 2 occurs beyond that which already has taken place.

The postulated human receptors of incremental risk for the current land use scenario with access controls include a trespassing youth, off-property residents, on-property groundskeeper, and users of the Great Miami River. Receptors of the current land use scenario without access controls include the user of meat and milk products from livestock grazing on Operable Unit 2. For the future land use scenario assuming federal ownership. the receptors are expanded trespasser, off-property farmers (evaluated under both federal and private ownership), and users of the Great Miami River. For the future land use scenario assuming private ownership, the receptors are on-property farmers, homebuilders (for South Field and Solid Waste Landfill only), and users of "perched" groundwater [isolated bodies of groundwater within the glacial till] (for Solid Waste Landfill and Lime Sludge Ponds only). Users of the Great Miami River (both current and future scenarios) were evaluated under three exclusive uses: (1) recreational, (2) agricultural, and (3) residential. For the future land use scenarios, the contaminant concentrations at the specific geographical and temporal points of human exposures were determined by the application of approved air dispersion and surface water and groundwater transport computer simulation models.

Epidemiological evidence indicates that the typical human being has a risk of developing cancer of about one in three, or 3.3×10^{-1}. EPA has established a range of incremental lifetime cancer risk from 1×10^{-6} to 1×10^{-4}. This range is referred to as the target range and provides a point of reference for the risk estimates presented in the Operable Unit 2 baseline risk assessment. Accordingly, this baseline risk assessment presents the risks due to exposure to carcinogens in terms of ILCR; that is, the additional risk to a given person, given a lifetime of exposure to wastes and impacted media within the Operable Unit 2 battery limits. Hazards due to exposure to noncarcinogenic constituent also are evaluated. Noncarcinogenic risks are reported as a HI. HIs of greater than 1.0 or "above unity" indicate a concern for potential health effects. Constituents which resulted in risks to a receptor of greater than 1×10^{-6} or which yielded an HI greater than 0.2, were designated as COCs. The media-specific COCs that contributed greater than one percent total medium risk for each subunit are identified in Table 7-0.

To ensure that the most sensitive or most exposed individuals in the population are protected, EPA guidance provides for calculation of RME, which is the maximum reasonable exposure a person could receive from the waste site being evaluated. For example, in the Operable Unit 2 future land use scenario having private ownership, the on-property RME farmer (adult and child) builds a home on (where physically feasible) and actively farms the unremediated Operable Unit 2 waste units, and is exposed to the following for each contaminant of potential concern:

- Inhalation of fugitive dust, volatile organic compounds, and gases
- Incidental ingestion, inhalation, and dermal contact while using groundwater (separate evaluations for Great Miami Aquifer and perched groundwater) in the home.
- Consumption of foodstuffs grown on the waste site, including fruits and vegetables, and meat and milk
- Incidental ingestion of, external radiation from, and dermal contact with soil
- Inhalation of indoor radon.

Thus, the RME receptors usually will have the highest estimated risks in a risk assessment. Risk and hazard results are also presented for a CT receptor, whose exposures are thought to be more typical of the average individual in the exposed population. For all subunits, future risks to off-property farmers (adult and child) were evaluated for federal or private ownership. A summary of the results of the risk assessment are presented in Table 7-1. Figures 7-1, 7-2, and 7-3 illustrate the total current

FIGURE 7-1
CURRENT - TOTAL CARCINOGENIC RISK

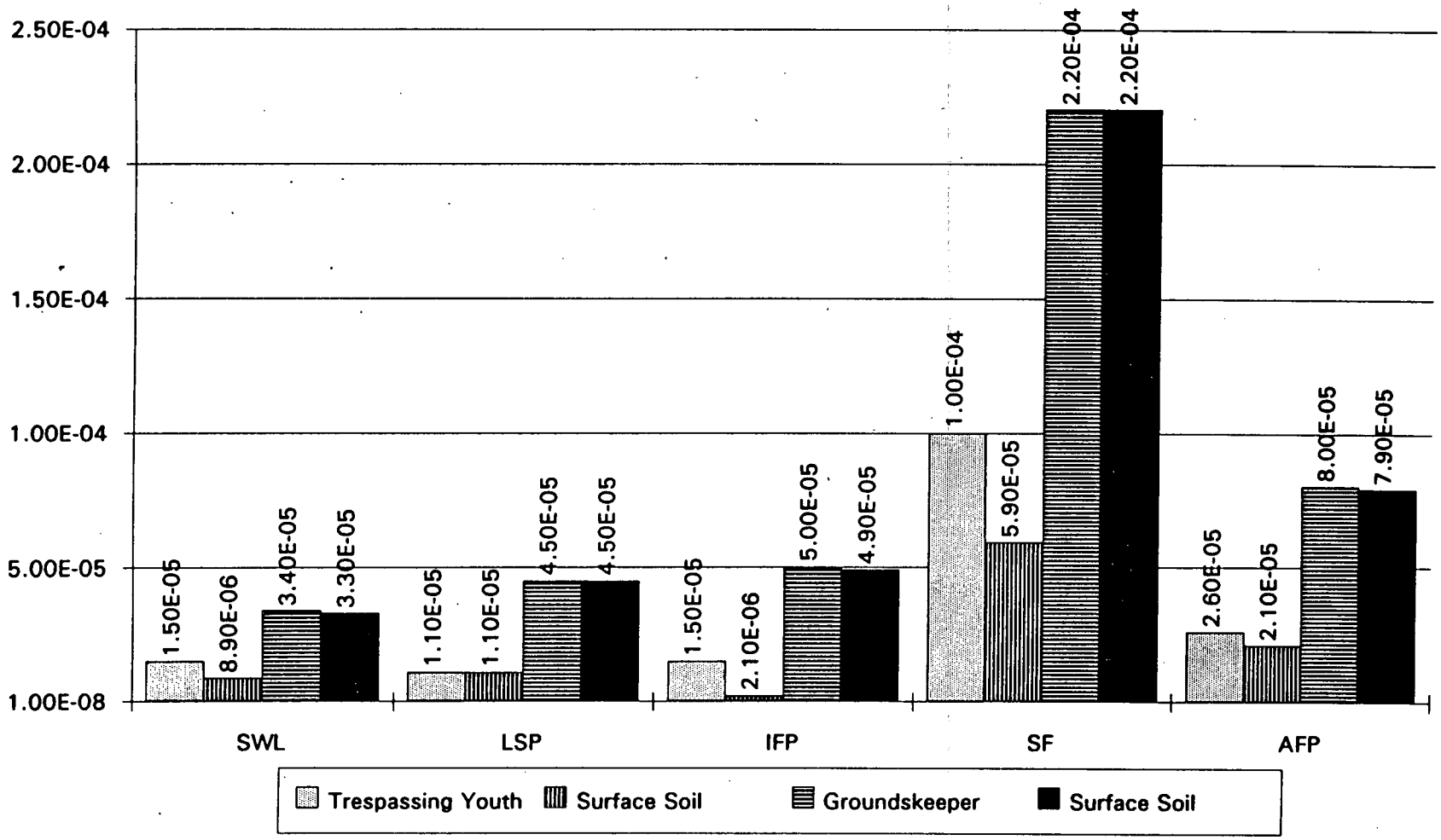

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FIGURE 7-2
FUTURE - TOTAL CARCINOGENIC RISK
FEDERAL OWNERSHIP

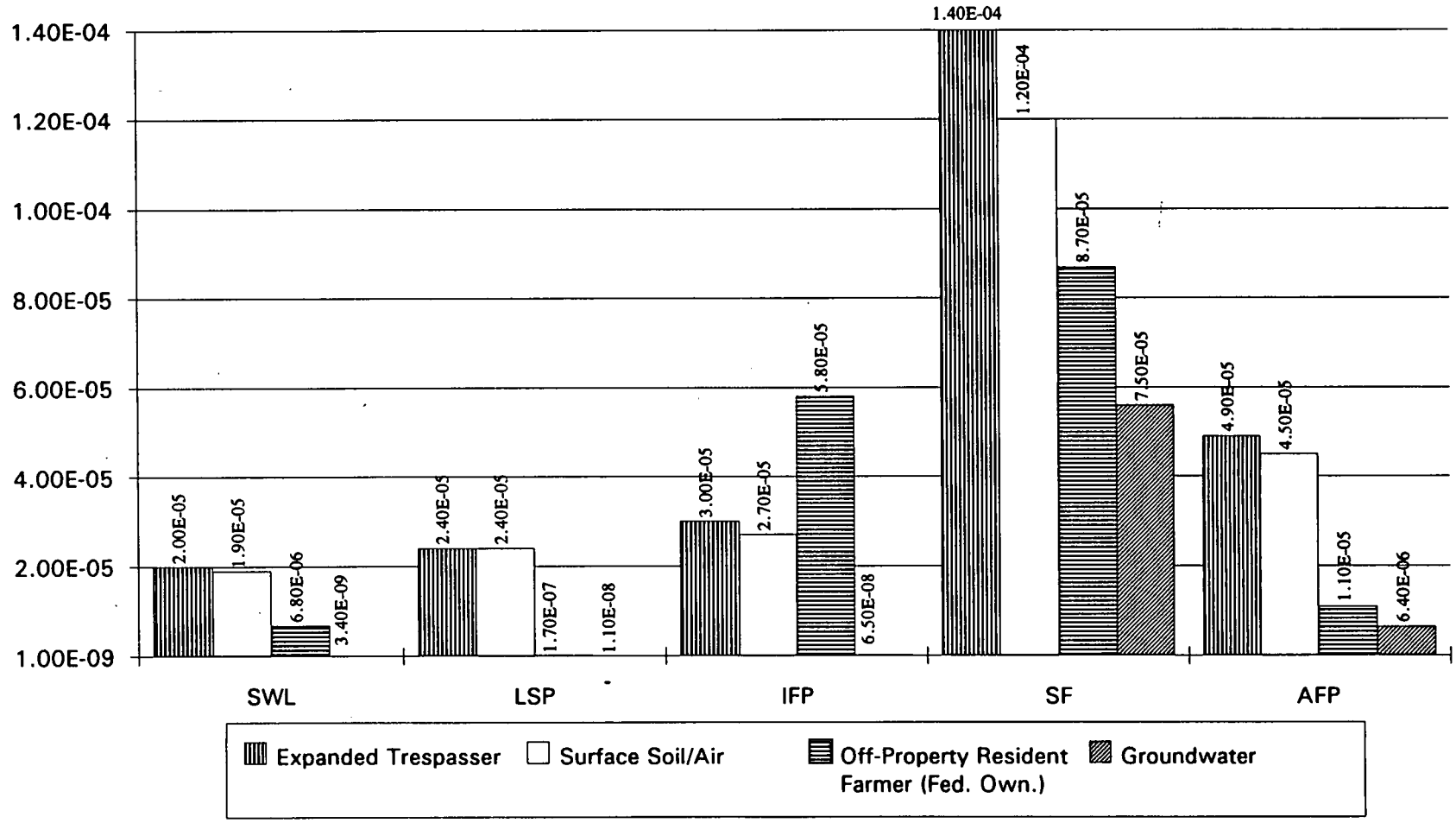

FIGURE 7-3
FUTURE - TOTAL CARCINOGENIC RISK
PRIVATE OWNERSHIP

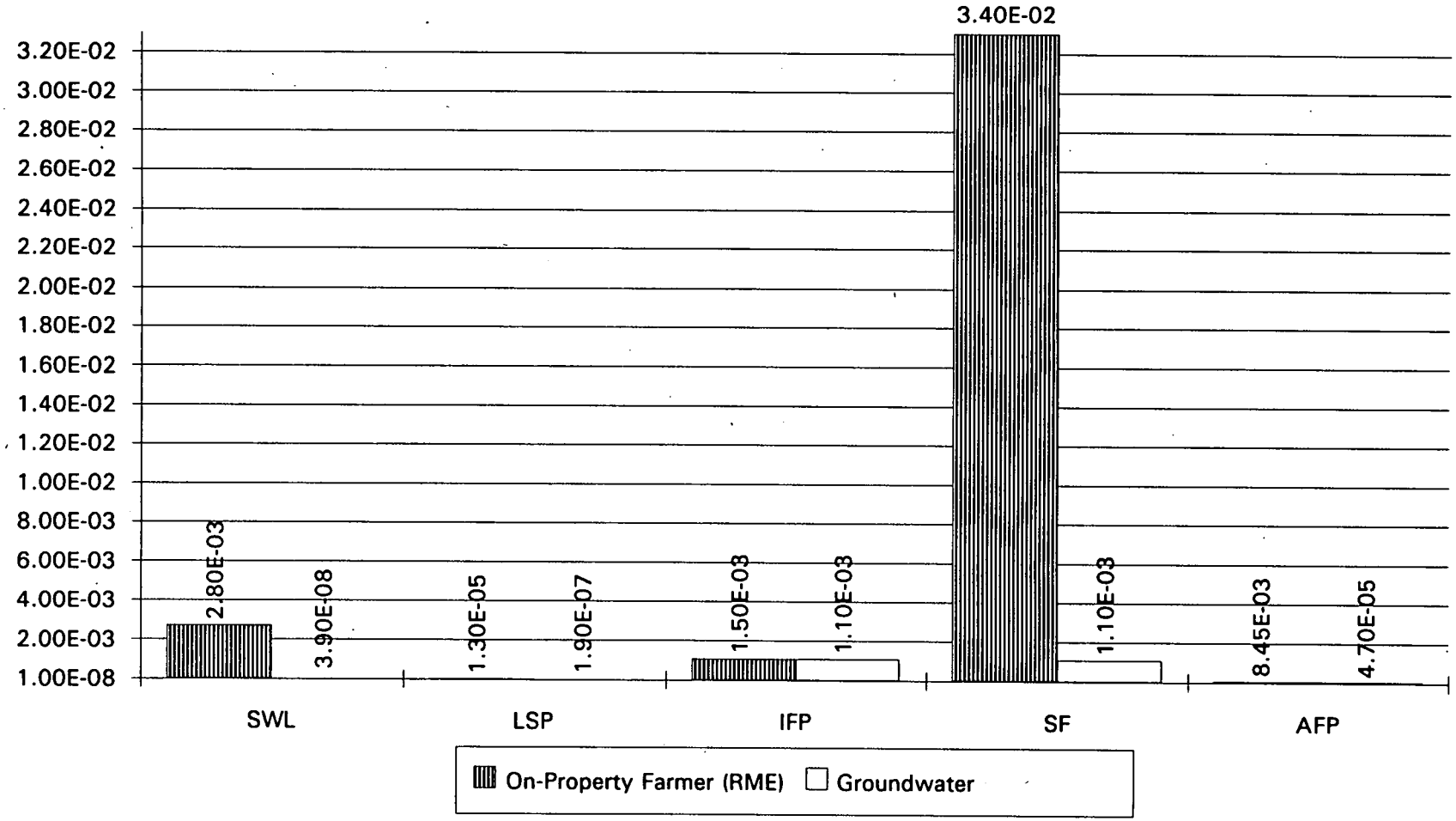

TABLE 7-0

OPERABLE UNIT 2 CONTAMINANTS OF CONCERN ABOVE ONE PERCENT TOTAL MEDIUM RISK

Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
SURFACE SOIL				
neptunium-237 radium-226 radium-228 thorium-228 thorium-230 thorium-232 uranium-235/236 uranium-238 antimony arsenic beryllium benzo(a)pyrene dibenzo(a,h)anthracene	cesium-137 radium-226 radium-228 thorium-228 thorium-230 thorium-232 uranium-238 uranium-total	radium-226 radium-228 thorium-228 thorium-232 arsenic dibenzo(a,h)anthracene	radium-226 radium-228 thorium-228 thorium-230 thorium-232 uranium-238 arsenic benzo(a)pyrene dibenzo(a,h)anthracene	cesium-137 neptunium-237 radium-226 radium-228 thorium-228 thorium-232 arsenic beryllium
CROSS-MEDIA IMPACT ON SURFACE WATER				
uranium-total arsenic	no COCs	no COCs	uranium-total arsenic dieldrin	no COCs
CROSS-MEDIA IMPACT ON SEDIMENT				
uranium-total	no COCs	no COCs	radium-226	radium-226 arsenic
CROSS-MEDIA IMPACT ON GROUNDWATER				
no COCs	no COCs	uranium-234 uranium-235/236 uranium-238 uranium-total	uranium-234 uranium-235/236 uranium-238 uranium-total	uranium-234 uranium-238 uranium-total
CROSS-MEDIA IMPACT ON PERCHED GROUNDWATER				
technetium-99 carbazole	neptunium-237 strontium-90 technetium-99	no COCs	no COCs	no COCs

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TABLE 7-0
(continued)

Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
CROSS-MEDIA IMPACT FROM DUST ON BEEF/MILK AND HOMEGROWN PRODUCE				
neptunium-237 radium-226 strontium-90 uranium-234 uranium-238 arsenic beryllium benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene dibenzo(a,h)anthracene indeno(1,2,3-cd)pyrene	no COCs	dibenzo(a,h)anthracene	radium-226 strontium-90 technetium-99 arsenic Aroclor-1254 Aroclor-1260 benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene benzo(k)fluoranthene dibenzo(a,h)anthracene dieldrin indeno(1,2,3-cd)pyrene	arsenic
CROSS-MEDIA IMPACT FROM GROUNDWATER ON BEEF/MILK AND HOMEGROWN PRODUCE				
no COCs	no COCs	uranium-234 uranium-235/236 uranium-238 uranium-total	uranium-234 uranium-235/236 uranium-238 uranium-total	radium-226 strontium-90 uranium-235/236 uranium-total
GREAT MIAMI RIVER SURFACE WATER CROSS-MEDIA IMPACT				
no COCs	no COCs	no COCs	radium-226 technetium-99	no COCs

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TABLE 7-1

BASELINE RISK ASSESSMENT SUMMARY
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Subunit	Risk Type[a]	Current Land Use						Future Land Use Assuming Federal Ownership		
		Trespassing Youth	On-Property Groundskeeper	Off-Property Resident Farmer	Off-Property Resident Child	User of Meat and Milk	Great Miami River Recreational User	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child
Solid Waste Landfill	Carcinogenic	$1.5x10^{-5}$	$3.4x10^{-5}$	$6.0x10^{-8}$	$2.7x10^{-9}$	$9.0x10^{-9}$	$2.8x10^{-10}$	$2.0x10^{-5}$	$6.7x10^{-8}$	$3.5x10^{-9}$
	Noncarcinogenic	8.6	$4.3x10^{-3}$	$1.8x10^{-6}$	$6.4x10^{-6}$	$5.8x10^{-7}$	$1.1x10^{-7}$	$2.7x10^{-1}$	$1.8x10^{-6}$	$6.4x10^{-6}$
Lime Sludge Ponds	Carcinogenic	$1.1x10^{-5}$	$4.5x10^{-5}$	$1.5x10^{-7}$	$1.4x10^{-8}$	$1.4x10^{-6}$	NA[b]	$2.4x10^{-5}$	$1.7x10^{-7}$	$1.6x10^{-8}$
	Noncarcinogenic	$2.1x10^{-1}$	$1.3x10^{-1}$	$2.0x10^{-5}$	$9.3x10^{-5}$	$4.3x10^{-4}$	NA	$2.2x10^{-1}$	$2.0x10^{-5}$	$9.3x10^{-5}$
Inactive Flyash Pile	Carcinogenic	$1.5x10^{-5}$	$5.0x10^{-5}$	$6.1x10^{-7}$	$7.9x10^{-8}$	$1.1x10^{-7}$	$8.4x10^{-9}$	$3.0x10^{-5}$	$7.5x10^{-5}$	$4.0x10^{-6}$
	Noncarcinogenic	$1.0x10^{-1}$	$2.0x10^{-2}$	$5.5x10^{-5}$	$2.0x10^{-4}$	$1.4x10^{-5}$	$1.9x10^{-6}$	$1.0x10^{-1}$	1.2	2.5
South Field	Carcinogenic	$1.0x10^{-4}$	$2.2x10^{-4}$	$6.4x10^{-7}$	$2.4x10^{-7}$	$4.5x10^{-6}$	$4.2x10^{-6}$	$1.4x10^{-4}$	$8.7x10^{-5}$	$4.2x10^{-6}$
	Noncarcinogenic	$5.3x10^{-1}$	ND[c]	$2.0x10^{-5}$	$7.2x10^{-5}$	$3.0x10^{-5}$	$8.0x10^{-07}$	$8.0x10^{-2}$	1.1	3.1
Active Flyash Pile	Carcinogenic	$2.6x10^{-5}$	$8.0x10^{-5}$	$4.7x10^{-7}$	$6.6x10^{-8}$	$4.7x10^{-7}$	$1.37x10^{-9}$	$4.9x10^{-5}$	$1.1x10^{-5}$	$7.2x10^{-7}$
	Noncarcinogenic	$3.6x10^{-2}$	$5.9x10^{-2}$	$6.2x10^{-4}$	$2.1x10^{-3}$	$3.7x10^{-3}$	$6.1x10^{-6}$	$4.2x10^{-2}$	$1.9x10^{-1}$	$7.9x10^{-1}$

See footnotes at end of table

TABLE 7-1
(Continued)

Waste Subunit	Risk Type[a]	Future Land Use Assuming Private Ownership							
		On-Property Resident Farmer (RME)[d]	On-Property Resident Farmer (CT)[e]	On-Property Resident Child	Home Builder	Perched Groundwater User	Great Miami River Recreational User	Great Miami River Residential User	Great Miami River Agricultural User
Solid Waste Landfill	Carcinogenic	$2.8x10^{-3}$	$2.0x10^{-4}$	$6.4x10^{-4}$	$9.0x10^{-6}$	$2.8x10^{-3}$	$2.8x10^{-10}$	$4.2x10^{-9}$	$6.5x10^{-7}$
	Noncarcinogenic	$2.9x10^{-1}$	$1.2x10^{-1}$	1.0	$4.8x10^{-1}$	ND	$1.1x10^{-7}$	$2.2x10^{-6}$	$1.1x10^{-4}$
Lime Sludge Ponds	Carcinogenic	$1.3x10^{-5}$	$9.3x10^{-7}$	$1.2x10^{-6}$	NA	$7.7x10^{-5}$	NA	NA	NA
	Noncarcinogenic	$1.7x10^{-3}$	$7.3x10^{-4}$	$7.9x10^{-3}$	NA	$3.1x10^{-3}$	NA	NA	NA
Inactive Flyash Pile	Carcinogenic	$1.5x10^{-3}$	$8.6x10^{-5}$	$7.7x10^{-5}$	NA	NA	$8.4x10^{-9}$	$3.0x10^{-9}$	$5.4x10^{-10}$
	Noncarcinogenic	22	9.8	65	NA	NA	$1.9x10^{-6}$	$4.2x10^{-6}$	$3.6x10^{-5}$
South Field	Carcinogenic	$3.4x10^{-2}$	$2.0x10^{-3}$	$9.2x10^{-3}$	$1.1x10^{-5}$	NA	$4.2x10^{-6}$	$6.3x10^{-8}$	$4.2x10^{-6}$
	Noncarcinogenic	23	11	63	$5.4x10^{-1}$	NA	$2.5x10^{-6}$	$1.4x10^{-4}$	$4.0x10^{-5}$
Active Flyash Pile	Carcinogenic	$8.4x10^{-5}$	$4.8x10^{-6}$	$5.7x10^{-6}$	NA	NA	$1.4x10^{-9}$	$7.7x10^{-9}$	$3.5x10^{-9}$
	Noncarcinogenic	$9.9x10^{-1}$	$4.5x10^{-1}$	2.8	NA	NA	$6.1x10^{-6}$	$1.5x10^{-5}$	$6.7x10^{-6}$

[a]The carcinogenic risk value is the Incremental Lifetime Cancer Risk (ILCR) and the noncarcinogenic hazard value is the Hazard Index (HI).

[b]NA = The indicated land use is not applicable to the waste subunit

[c]ND = Not determined because toxicity data are not available

[d]RME = Reasonable Maximum Exposure

[e]CT = Central Tendency

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and future carcinogenic risks for each subunit and the major media/exposure scenarios associated with the total risk. The following sections discuss these risks and exposure scenarios in more detail. Full details of the risk assessment are presented in Appendix B. A discussion of this process for each subunit is presented in the following subsections.

7.4.1 Solid Waste Landfill

Trenching and boring activities in the Solid Waste Landfill have determined that cafeteria, laboratory, construction/maintenance, and manufacturing wastes were disposed in the landfill. One waste disposal cell and an evaporation pond were identified in historical photographs and trench observations, but waste was observed in numerous other areas within the battery limits. The depth of waste is generally 10 feet and the maximum depth is the southeastern corner of the landfill of 15 feet.

Nature and Extent

Table 7-2 presents a summary of the nature of COCs for the Solid Waste Landfill determined through the fate and transport modeling and baseline risk assessment processes. Nineteen COCs have been identified for the Solid Waste Landfill that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides, three metals, and six organic compounds. The table identifies the number of samples detected above background compared to the number of samples in a particular medium. This comparison has been provided for all media even though a parameter may be a COC for only one medium.

The extent of COCs in the Solid Waste Landfill is distributed throughout the surface and subsurface fill materials with the maximum levels in the southeastern corner of the landfill. The COCs were also detected in the glacial till beneath the landfill and in the perched groundwater near the southeast corner of the subunit. While uranium was detected above background in the Great Miami Aquifer, the levels were similar in upgradient and downgradient wells indicating that there is not a significant impact on the Great Miami Aquifer from the Solid Waste Landfill. The number of COCs detected in the surface water, sediment, and perched groundwater are fewer than those detected in the surface and subsurface soils.

Fate and Transport

Future maximum on-site and off-site modeled COC concentrations for each media are listed in Table 7-3. The media pathways considered significant for the Solid Waste Landfill as a result of the

TABLE 7-2

COCs DETECTED IN THE SOLID WASTE LANDFILL[a]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

COC/Phase	Surface Soil	Subsoil		Surface Water		Sediment		Groundwater 1000-series		Groundwater 2000-series	
	II	I	II	I	II	I	II	I	II	I	II
Neptunium-237	8/8[b]	0/21	25/25	N/A[c]	0/2	N/A	1/2	1/8	2/4	0/11	1/5
Radium-226	2/12	2/22	2/35	N/A	0/2	0/1	0/2	1/8	1/6	1/9	1/8
Radium-228	5/12	5/22	7/35	N/A	0/2	0/1	0/2	0/8	0/6	0/9	1/8
Technetium-99	0/12	0/19	3/33	N/A	0/2	N/A	0/2	0/8	0/6	0/11	0/8
Thorium-228	1/9	9/23	7/30	N/A	0/1	N/A	0/1	1/8	1/6	0/11	0/8
Thorium-232	1/9	3/19	7/30	N/A	0/1	N/A	0/1	1/8	2/6	0/11	0/8
Uranium-235/236	9/12	9/23	14/35	N/A	2/2	N/A	1/2	0/8	3/6	0/11	3/8
Uranium-238	12/12	18/23	22/35	N/A	2/2	N/A	2/2	6/8	5/6	4/10	3/8
Antimony	0/12	11/16	0/32	N/A	0/2	N/A	0/2	0/1	0/8	0/6	0/11
Arsenic	1/12	4/16	3/37	0/1	0/2	N/A	0/2	1/9	0/8	0/12	0/11
Beryllium	4/12	13/16	23/37	1/1	0/2	N/A	0/2	0/3	1/8	1/8	0/11
Benzo(a)anthracene	6/12	8/16	18/37	0/1	0/2	N/A	1/2	N/A	0/4	0/4	0/7
Benzo(a)pyrene	6/12	6/16	17/37	0/1	0/2	N/A	1/2	N/A	0/4	0/4	0/7
Benzo(b)fluoranthene	5/12	7/16	17/37	0/1	0/2	N/A	1/2	N/A	0/4	0/4	0/7
Carbazole	1/12	N/A	11/37	N/A	0/2	N/A	1/2	N/A	0/4	N/A	0/7
Dibenzo(a,h)anthracene	2/12	5/15	11/37	0/1	0/2	N/A	0/2	N/A	0/4	0/4	0/7
Indeno(1,2,3-cd)pyrene	5/12	5/15	16/37	0/1	0/2	N/A	1/2	N/A	0/4	0/4	0/7

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.
[b]Number refers to detections above background relative to number of analyses.
[c]N/A signifies not analyzed.

TABLE 7-3

MAXIMUM MODELED COC CONCENTRATIONS IN THE[a] SOLID WASTE LANDFILL OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

COC	Air Maximum Modeled Concentration		Perched Groundwater Maximum Modeled Concentration	Groundwater Maximum Modeled Concentrations				Surface Water Maximum Modeled Concentrations
	On Site[b]	Off Site[c]	On Site	On Site	Year	Off Site	Year	On Site
Neptunium-237	1.08E-04 pCi/m³	1.78E-06 pCi/m³	1.11E-05 pCi/L	NOT CPC		NOT CPC		5.25E-01 pCi/L
Radium-226	1.78E-04 pCi/m³	2.07E-06 pCi/m³	0.00 pCi/L	NOT CPC		NOT CPC		4.86E-02 pCi/L
Radium-228	1.53E-04 pCi/m³	2.52E-06 pCi/m³	0.00 pCi/L	NOT CPC		NOT CPC		5.85E-02 pCi/L
Technetium-99	NA[d]	NA	2.89E+01 pCi/L	0.61 pCi/L	60	0.054 pCi/L	70	NA
Thorium-228	1.48E-04 pCi/m³	2.44E-06 pCi/m³	0.00 pCi/L	NOT CPC		NOT CPC		6.79E-03 pCi/L
Thorium-232	1.38E-04 pCI/m³	2.27E-06 pCi/m³	0.00 pCi/L	NOT CPC		NOT CPC		6.30E-03 pCi/L
Uranium-235/236	2.58E-04 pCi/m³	4.26E-06 pCi/m³	0.00 pCi/L	NOT CPC		NOT CPC		9.14E-01 pCi/L
Uranium-238	7.02E-03 pCi/m³	1.16E-04 pCi/m³	0.00 pCi/L	NOT CPC		NOT CPC		2.50E+01 pCi/L
Antimony	NA	NA	0.00	NOT CPC		NOT CPC		NA
Arsenic	6.07E-07 mg/m³	1.00E-08 mg/m³	0.00 μg/L	NOT CPC		NOT CPC		8.09E-01 μg/L
Beryllium	6.35E-08 mg/m³	1.05E-09 mg/m³	0.00 μg/L	NOT CPC		NOT CPC		1.30E-02 μg/L
Benzo(a)anthracene	3.35E-08 mg/m³	5.42E-10 pCi/m³	0.00 μg/L	NOT CPC		NOT CPC		3.38E-03 μg/L
Benzo(a)pyrene	3.09E-08 mg/m³	5.10E-09 pCi/m³	0.00 μg/L	NOT CPC		NOT CPC		1.31E-03 μg/L
Benzo(b)fluoranthene	6.46E-08 mg/m³	1.07E-09 pCi/m³	0.00 μg/L	NOT CPC		NOT CPC		7.03E-04 μg/L
Carbazole	NA	NA	9.61E+00 μg/L	NOT CPC		NOT CPC		NA
Dibenzo(a,h)anthracene	1.82E-08 mg/m³	3.00E-10 mg/m³	0.00 μg/L	NOT CPC		NOT CPC		7.90E-04 μg/L
Indeno(1,2,3-cd)pyrene	4.37E-08 mg/m³	7.20E-10 mg/m³	0.00 μg/L	NOT CPC		NOT CPC		3.87E-05 μg/L

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.
[b]On site refers to a location on the subunit of concern.
[c]Off site refers to the location at the FEMP fenceline.
[d]NA = not applicable

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modeling include air, surface water, groundwater, and perched water. Perched water was modeled under the Solid Waste Landfill because of a potential for household use of the perched water.

Solid Waste Landfill Baseline Risk Assessment

For the current land use scenario, a total carcinogenic risk to a trespassing youth is 1.5×10^{-5} due to external radiation from radium-226, radium-228, thorium-228, and thorium-232 in surface soil. HI was 8.6 due primarily to the presence of uranium-total in surface water. Total risk to the on-property groundskeeper is within the same order of magnitude as the trespassing youth. Major contributors to risk for this receptor are the same as those to the trespassing youth with the addition of uranium-238 in soil. HI was less than 1.0. Off-property farmers have carcinogenic risks on the order of 10^{-8} and HIs of less than 1.0.

For the future land use scenario assuming private ownership, total carcinogenic risk to the on-property RME farmer was 2.8×10^{-3}. Total HI was less than 1.0. Major contributors to risk for this receptor were from radium-226, radium-228, thorium-228, and thorium-232 in surface soil via external radiation. Risks exceeded the 1.0×10^{-3} level for perched groundwater users due primarily to radium-226, radium-228, thorium-228, thorium-232, and uranium-238 in surface soil.

For the future scenario having federal ownership, the expanded trespasser had a combined carcinogenic risk of 2.0×10^{-5} due mostly to external radiation from radium-226, radium-228, thorium-228, thorium-232, and uranium-238 in soil. Total HI is less than 1.0. Combined carcinogenic risk for off-property farmers (private and federal ownership) range from 10^{-6} to 10^{-9}. The off-property farmer under private ownership slightly exceeded 1.0×10^{-6} due primarily to the cumulative presence of various radionuclides in soil; no single radionuclide exceeded 1.0×10^{-6}.

Risks to the users of the Great Miami River (recreational, agricultural, and residential) were in the 1.0×10^{-7} to 1.0×10^{-10} range and HIs were below 1.0.

Table 7-4 lists the COCs contributing greater than one percent total medium risk for each medium relating to the future scenarios. Approximately 64 percent of the total risk to the on-property resident farmer is derived from four COCs: radium-226, radium-228, thorium-228, and thorium-232 in surface soil.

TABLE 7-4
SOLID WASTE LANDFILL FUTURE LAND USE
SUMMARY OF COC CARCINOGENIC RISK CONTRIBUTIONS[a,b]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	Great Miami River User	% Total Receptor Risk
Soil:								
Neptunium-237	-[c]	-	2.3E-05	0.82%	1.9E-06	0.95%	N/A[d]	
Plutonium-238	-	-	-	-	-	-	N/A	
Radium-226	3.8E-06	18.96%	3.5E-04	12.91%	2.9E-05	15.03%	N/A	
Radium-228	2.2E-06	10.92%	2.0E-04	7.41%	1.7E-05	8.66%	N/A	
Thorium-228	41.E-06	20.43%	3.8E-04	13.89%	3.2E-05	16.40%	N/A	
Thorium-230	-	-	-	-	-	-	N/A	
Thorium-232	5.8E-06	28.74%	5.4E-04	19.33%	4.5E-05	22.86%	N/A	
Uranium-234	-	-	1.5E-05	0.53%	-	-	N/A	
Uranium-235/236	-	-	2.9E-05	1.05%	2.4E-06	1.24%	N/A	
Uranium-238	1.4E-06	6.76%	1.7E-04	6.03%	1.3E-05	6.76%	N/A	
Arsenic	-	-	3.0E-05	1.09%	-	-	N/A	
Benzo(a)anthracene	-	-	-	-	-	-	N/A	
Beryllium	-	-	-	-	-	-	N/A	
Benzo(b)-fluoranthene	-	-	-	-	-	-	N/A	
Dibenzo(a,h)-anthracene	-	-	-	-	-	-	N/A	
Indeno(1,2,3-cd)pyrene	-	-	-	-	-	-	N/A	
Perched Groundwater:								
Technetium-99	N/A		N/A		N/A		N/A	
Carbazole	N/A		N/A		N/A		N/A	

See footnotes at end of table

TABLE 7-4
(Continued)

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	Great Miami River User	% Total Receptor Risk
Home Grown Produce (Dust Affected):								
Neptunium-237	N/A		3.4E-06	0.12%	-	-	N/A	
Radium-226	N/A		2.1E-06	0.08%	-	-	N/A	
Strontium-90	N/A		1.1E-05	0.40%	-	-	N/A	
Uranium-234	N/A		3.5E-06	0.13%	-	-	N/A	
Uranium-238	N/A		1.1E-05	0.40%	-	-	N/A	
Arsenic	N/A		5.1E-06	1.82%	2.8E-06	1.42%	N/A	
Benzo(a)anthracene	N/A		4.0E-06	0.14%	-	-	N/A	
Benzo(a)pyrene	N/A		2.1E-05	0.74%	1.1E-06	0.58%	N/A	
Benzo(b)fluoranthene	N/A		4.2E-06	0.15%	-	-	N/A	
Beryllium	N/A		3.3E-06	0.12%	-	-	N/A	
Dibenzo(a,h)anthracene	N/A		4.5E-06	0.17%	-	-	N/A	
Indeno(1,2,3-cd)pyrene	N/A		1.5E-06	0.06%	-	-	N/A	
Beef/Milk (Dust Affected):								
Radium-226	N/A		-	-	-	-	N/A	
Strontium-90	N/A		5.0E-05	1.80%	2.3E-06	1.16%	N/A	
Uranium-234	N/A		-	-	-	-	N/A	
Uranium-238	N/A		9.6E-06	0.34%	-	-	N/A	
Arsenic	N/A		6.7E-05	2.42%	3.8E-06	1.94%	N/A	
Benzo(a)anthracene	N/A		1.1E-05	0.39%	-	-	N/A	
Benzo(a)pyrene	N/A		2.0E-04	7.04%	9.9E-06	5.03%	N/A	
Benzo(b)fluoranthene	N/A		4.2E-05	1.51%	2.1E-06	1.08%	N/A	
Beryllium	N/A		-	-	-	-	N/A	
Dibenzo(a,h)anthracene	N/A		4.2E-04	15.17%	2.1E-05	10.85%	N/A	
Indeno(1,2,3-cd)pyrene	N/A		6.2E-05	2.24%	3.1E-06	1.61%	N/A	
Ambient Radon	-	-	1.4E-06	0.05%	-	-	N/A	

See footnotes at end of table

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TABLE 7-4
(Continued)

Medium/ Parameter	On-Property Resident Child	% Total Receptor Risk	Home-builder	% Total Receptor Risk	Perched Groundwater user	% Total Receptor Risk	Perched Groundwater Child	% Total Receptor Risk
Soil:								
Neptunium-237	1.7E-06	0.27%	-	-	2.3E-05	0.083%	N/A	
Plutonium-238	-	-	-	-	-	-	N/A	
Radium-226	2.7E-05	4.18%	-	-	3.5E-04	12.73%	N/A	
Radium-228	1.5E-05	2.39%	-	-	2.4E-04	7.30%	N/A	
Thorium-228	2.9E-05	4.48%	1.1E-06	12.25%	3.8E-04	13.70%	N/A	
Thorium-230	-	-	-	-	-	-	N/A	
Thorium-232	4.0E-05	6.30%	1.8E-06	19.83%	5.4E-04	19.28%	N/A	
Uranium-234	-	-	-	-	-	-	N/A	
Uranium-235/236	2.2E-06	0.04%	-	-	2.9E-05	1.05%	N/A	
Uranium-238	1.0E-05	1.62%	-	-	1.7E-04	6.02%	N/A	
Arsenic	1.3E-05	2.04%	-	-	3.0E-05	1.09	N/A	
Benzo(a)anthracene	-	-	-	-	-	-	N/A	
Benzo(b)-fluoranthene	-	-	-	-	-		N/A	
Beryllium	6.6E-06	1.03%	-	-	-	-	N/A	
Benzo(a)pyrene	5.4E-06	0.86%	2.7E-06	30.05%	-	-	N/A	
Dibenzo(a,h)-anthracene	3.2E-06	0.50%	-	-	-	-	N/A	
Indeno(1,2,3-cd)pyrene	-	-	-	-	-	-	N/A	
Perched Groundwater:								
Technetium-99	N/A		N/A		1.8E-06	0.07%	N/A	
Carbazole	N/A		N/A		5.3E-03	0.19%	N/A	
Home Grown Produce (Dust Affected):								
Neptunium-237	-	-	N/A		3.4E-06	0.12%	N/A	
Radium-226	-	-	N/A		2.1E-06	0.08%	N/A	
Strontium-90	-	-	N/A		1.1E-05	0.40%	N/A	
Uranium-234	-	-	N/A		3.5E-06	0.13%	N/A	
Uranium-238	-	-	N/A		1.1E-05	0.40%	N/A	
Arsenic	1.7E-05	2.61%	5.1E-05	1.82%	N/A		N/A	
Benzo(a)anthracene	1.7E-06	0.21%	4.0E-06	0.14%	N/A		N/A	
Benzo(a)pyrene	1.3E-06	1.06%	2.1E-05	0.74%	N/A		N/A	
Benzo(b)fluoranthene	6.8E-06	0.22%	4.2E-06	0.15%	N/A		N/A	

See footnotes at end of table

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TABLE 7-4
(Continued)

Medium/ Parameter	On-Property Resident Child	% Total Receptor Risk	Home-builder	% Total Receptor Risk	Perched Groundwater user	% Total Receptor Risk	Perched Groundwater Child	% Total Receptor Risk
Beryllium	1.4E-06	0.17%	3.3E-06	0.12%	N/A		N/A	
Dibenzo(a,h)anthracene	1.1E-06	0.23%	4.5E-06	0.16%	N/A		N/A	
Indeno(1,2,3-cd)pyrene	-	-	1.5E-06	0.06%	N/A		N/A	
Beef/Milk (Dust Affected):								
Radium-226	-	-	N/A		-	-	N/A	
Strontium-90	9.3E-06	1.46%	N/A		5.0E-05	1.79%	N/A	
Uranium-234	-	-	N/A		-	-	N/A	
Uranium-238	-	-	N/A		9.6E-06	0.34%	N/A	
Arsenic	1.6E-05	2.48%	N/A		6.7E-05	2.42%	N/A	
Benzo(a)anthracene	6.6E-06	0.98%	N/A		1.1E-05	0.39%	N/A	
Benzo(a)pyrene	1.1E-04	17.63%	N/A		2.0E-04	7.02%	N/A	
Benzo(b)fluoranthene	2.4E-05	3.80%	N/A		4.2E-05	1.51%	N/A	
Beryllium	-	-	N/A		-	-	N/A	
Dibenzo(a,h)anthracene	2.4E-04	3.99%	N/A		4.2E-04	15.13%	N/A	
Indeno(1,2,3-cd)pyrene	3.6E-05	5.62%	N/A		6.2E-05	2.24%	N/A	
Ambient Radon	-	-	N/A		1.4E-06	0.05%	N/A	

[a]Off-Property Resident Farmer and Child receptors did not have any COCs associated with them, therefore, were not included in this table.

[b]Sediment, groundwater, surface water, home grown produce (groundwater affected), perched groundwater, beef/milk (groundwater and surface water affected) pathways did not have any COCs associated with them, therefore, were not included in this table.

[c]No risk greater than the threshold level of 1×10^{-6}.

[d]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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7.4.2 Lime Sludge Ponds

Field investigations of the Lime Sludge Ponds indicate that the sludge within the subunit is homogeneous. Sampling in the berm soils and glacial till beneath the ponds has determined that the soils have higher concentrations of most constituents than the sludge. This means that future impacts from the sludge upon the soil are not likely. Elevated concentrations of uranium and thorium were detected in downgradient perched groundwater wells, but samples collected from the K-65 Trench (outside of Operable Unit 2 boundaries) detected elevated radioisotope activities. The K-65 Trench is believed to be the source for the perched groundwater contamination.

Nature and Extent

Table 7-5 presents a summary of the nature of COCs within each medium for the Lime Sludge Ponds determined through the fate and transport modeling and baseline risk assessment processes. Ten COCs have been identified for the Lime Sludge Ponds that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides. The table identifies the number of samples detected above background compared to the number of samples in a particular medium.

As described in Section 4.3, the extent of COCs in the Lime Sludge Ponds is limited mostly to the berm soils surrounding the ponds. Beryllium is the only COC that is believed to have originated in the lime sludge. Radionuclides and organics appear to have originated in the surface and berm soils. The COCs were also detected in the perched groundwater downgradient of the subunit, but the source of these contaminants is believed to be the K-65 Trench. No impact has been observed on the Great Miami Aquifer.

Fate and Transport

Future maximum on-site and off-site modeled COC concentrations for each medium are listed in Table 7-6. The media pathways considered significant for the Lime Sludge Ponds as a result of the modeling include the air and groundwater pathways. No surface water pathway exists near the Lime Sludge Ponds and all surface water is contained within the subunit. Perched water was modeled under the Lime Sludge Ponds because of a potential for household use of the perched water.

Baseline Risk Assessment

For the current land use scenario, a total carcinogenic risk to a trespassing youth was 1.1×10^{-5} due primarily to exposure to surface soil containing radium-226, radium-228, thorium-228, and thorium-

TABLE 7-5

COCs DETECTED IN THE LIME SLUDGE PONDS[a]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

COC/Phase	Surface Soil	Subsoil		Surface Water		Groundwater 1000-series		Groundwater 2000-series	
	II	I	II	I	II	I	II	I	II
Cesium-137	1/14[b]	0/6	11/33	N/A[c]	0/1	N/A	0/7	N/A	0/5
Neptunium-237	14/14	0/4	23/24	N/A	0/1	0/11	2/5	0/5	2/4
Radium-226	6/14	0/6	3/33	N/A	0/1	0/11	1/7	0/5	0/5
Radium-228	7/14	0/6	7/33	N/A	0/1	0/11	0/6	0/5	0/5
Strontium-90	2/13	1/6	3/33	N/A	0/1	0/11	1/7	0/5	0/5
Technetium-99	2/14	0/3	1/33	N/A	0/1	0/1	0/7	0/5	0/5
Thorium-228	4/13	1/6	1/30	N/A	0/1	2/11	2/7	1/5	0/5
Thorium-230	11/13	2/6	14/31	N/A	1/1	0/11	2/7	0/5	0/5
Thorium-232	1/12	2/6	2/30	N/A	0/1	0/11	3/7	0/5	0/5

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.

[b]Number refers to detections above background relative to number of analyses.

[c]N/A indicates not analyzed.

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TABLE 7-6

MAXIMUM MODELED COC CONCENTRATIONS IN THE[a] LIME SLUDGE PONDS OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

COC	Air Maximum Modeled Concentration		Perched Groundwater Maximum Modeled Concentration	Groundwater Maximum Modeled Concentrations			
	On Site[b]	Off Site[c]	On Site	On Site	Year	Off Site	Year
Cesium-137	1.05E-05 pCi/m³	1.24E-07 pCi/m³	0.0 pCi/L	NOT CPC		NOT CPC	
Neptunium-237	1.08E-05 pCi/m³	1.28E-07 pCi/m³	5.06E+00 pCi/L	NOT CPC		NOT CPC	
Radium-226	2.88E-05 pCi/m³	3.40E-07 pCi/m³	0.0 pCi/L	NOT CPC		NOT CPC	
Radium-228	2.46E-05 pCi/m³	2.90E-07 pCi/m³	0.0 pCi/L	NOT CPC		NOT CPC	
Strontium-90	1.18E-05 pCi/m³	1.37E-07 pCi/m³	1.91E+00 pCi/L	NOT CPC		NOT CPC	
Technetium-99	NA[d]	NA	8.23E+01 pCi/L	2.96 pCi/L	40	0.17 pCi/L	40
Thorium-228	4.37E-05 pCi/m³	5.15E-07 pCi/m³	0.0 pCi/L	NOT CPC		NOT CPC	
Thorium-230	6.72E-04 pCi/m³	7.93E-06 pCi/m³	0.0 pCi/L	NOT CPC		NOT CPC	
Thorium-232	1.96E-05 pCi/m³	2.31E-07 pCi/m³	0.0 pCi/L	NOT CPC		NOT CPC	

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.

[b]On site refers to a location on the subunit of concern.

[c]Off site refers to the location at the FEMP fenceline.

[d]NA = not applicable

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232 in soil via external radiation. Total risk to the current on-property groundskeeper was 4.5 x 10^{-5} due mostly to the presence of cesium-137, radium-226, radium-228, thorium-228, thorium-232, and uranium-238 in surface soil. Total HIs for these receptors were less than 1.0. Carcinogenic risks to off-property residents were on the order of 10^{-7} to 10^{-8} and the total HI was less than 1.0.

For the future land use scenario assuming private ownership, the RME farmer has a total risk of 1.3 x 10^{-5} due primarily to the presence of thorium-230 and uranium-238 in surface soil which accounted for approximately 66 percent of the total receptor risk.

For the future land use scenario with federal ownership, the expanded trespasser had a total risk of 2.2 x 10^{-5} due to radium-226, radium-228, thorium-228, and thorium-232 in surface soil which accounted for 88 percent of the total receptor risk. HI was less than 1.0. Off-property farmers (private and federal ownership) have carcinogenic risks on the order of 10^{-7} or less and HIs of less than 1.0.

Risks from the Lime Sludge Ponds to the Great Miami River users was not quantified because the Lime Sludge Ponds pose no significant risk.

Table 7-7 lists the COCs contributing greater than one percent total medium risk to receptor of the future scenarios for the Lime Sludge Ponds. No COCs were determined for perched groundwater even if perched groundwater is used for a household drinking water source. Approximately 77 percent of the total risk to the on-property resident farmer is derived from five COCs in surface soil: thorium-228, thorium-230, thorium-232, and uranium-238. Pathways contributing most to risk include external radiation and inhalation of surface soil.

7.4.3 Inactive Flyash Pile

Field investigations of the Inactive Flyash Pile indicate that waste other than flyash were disposed of in the subunit. Sludge, clay tile drain pipe, wood, nails, wire, construction debris, and small amounts of organic waste were found in addition to flyash. Field measurements with an alpha-beta meter indicated that all materials except for flyash had elevated levels of radioactivity. The identified waste materials appear to be resting on or near the interface between the flyash and the native glacial overburden.

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TABLE 7-7

LIME SLUDGE PONDS
FUTURE LAND USE
SUMMARY OF COC TOTAL CARCINOGENIC RISK CONTRIBUTIONS[a,b]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Soil:			-	-		
Cesium-137	-[c]	-	-	-	-	-
Radium-226	5.2E-06	21.66	-	-	-	-
Radium-228	2.1E-06	8.88%	-	-	-	-
Thorium-228	7.3E-06	30.44%	-	-	-	-
Thorium-230	-	-	-	-	2.3E-06	16.94%
Thorium-232	5.0E-06	20.81%	-	-	-	-
Uranium-238	1.5E-06	6.37%	-	-	6.4E-06	48.39%
Perched Groundwater:						
Neptunium-237	-	-	-	-	-	-
Strontium-90	-	-	-	-	-	-
Technetium-99	-	-	-	-	-	-

[a]Perched Groundwater User, Off-property Resident Child, and Perched Groundwater Child receptors do not have any COCs and are not included in this table.

[b]Sediment, groundwater, surface water, perched groundwater, home grown produce (dust and groundwater affected), and beef/milk (dust and groundwater affected) pathways do not have any COCs associated with them, therefore, not included in this table.

[c]No risk greater than the threshold level of 1×10^{-6}.

The occurrence of uranium contamination in the perched groundwater appears to be related to waste materials buried within or near this subunit. The perched groundwater appears to discharge through seeps into the Paddys Run drainage channel or directly into the Great Miami Aquifer through regions where the glacial overburden has been eroded. This means that a mechanism exists to transport uranium contamination vertically into the Great Miami Aquifer. Uranium contamination in the Great Miami Aquifer was not detected upgradient or from the northern part of the subunit. Uranium contamination was detected in two wells downgradient from the central part of the subunit. This suggests that a source of uranium contamination to the Great Miami Aquifer exists beneath the central part of the Inactive Flyash Pile.

Nature and Extent

Table 7-8 presents a summary of the nature of COCs within each medium for the Inactive Flyash Pile determined through the fate and transport modeling and baseline risk assessment processes. Nine COCs have been identified for the Inactive Flyash Pile that contribute greater than one percent of the total risk for a medium. These COCs consist of seven radionuclides, one metal, and one organic compound. The table identifies the number of samples detected above background compared to the number of samples in a particular medium. This comparison has been provided for all media even though a parameter may be a COC for only one medium.

The extent of COCs in the Inactive Flyash Pile covers most of the surface and subsurface soils, surface water, sediment, and perched water sampled within the subunit. Radionuclides appear to be connected to non-flyash waste such as sludge, wood, and construction debris, whereas organics appear to be intermixed with the flyash, possibly from dust control spraying. The COCs were also detected in the perched groundwater beneath of the subunit. Uranium is the only COC detected in the Great Miami Aquifer downgradient of the subunit.

Fate and Transport

Future maximum on-site and-off site modeled COC concentrations for each medium are listed in Table 7-9. The media pathways considered significant for the Inactive Flyash Pile as a result of the modeling include air, surface water, and groundwater pathways.

TABLE 7-8

COCs DETECTED IN THE INACTIVE FLYASH PILE[a]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Surface Soil	Subsoil		Surface Water		Sediment		Groundwater 1000-series		Groundwater 2000-series	
COC/Phase	II	I	II	I	II	I	II	I	II	I	II
Radium-226	1/7[b]	12/19	15/24	0/2	1/6	0/5	0/4	0/3	0/1	0/7	0/3
Radium-228	2/7	10/19	14/24	0/3	0/6	0/5	0/4	0/3	1/1	0/10	0/3
Thorium-228	1/2	12/18	11/23	0/2	1/6	N/A[c]	0/4	0/3	0/1	0/11	0/3
Thorium-232	1/2	9/18	12/23	0/2	0/6	N/A	0/4	0/3	0/1	0/10	1/3
Uranium-234	6/7	14/18	18/24	2/2	6/6	N/A	1/4	3/3	1/1	10/11	3/3
Uranium-235/236	4/7	7/18	15/24	0/2	3/6	N/A	0/4	0/3	0/1	0/10	3/3
Uranium-238	6/7	21/25	18/24	2/2	6/6	N/A	1/4	3/3	1/1	9/10	3/3
Arsenic	1/7	6/12	11/22	0/3	1/6	0/1	0/6	0/4	0/1	0/16	0/6
Dibenzo(a,h)anthracene	1/7	0/16	1/31	N/A	0/6	0/1	0/6	N/A	0/1	0/1	0/4

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.

[b]Number refers to detections above background relative to number of analyses.

[c]N/A signifies not analyzed.

TABLE 7-9

MAXIMUM MODELED COC CONCENTRATIONS IN THE[a] INACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

COC	Air Maximum Modeled Concentration		Groundwater Maximum Modeled Concentrations				Surface Water Maximum Modeled Concentrations
	On Site[b]	Off Site[c]	On Site	Year	Off Site	Year	On Site
Radium-226	1.1E-05 pCi/m³	7.11E-07 pCi/m³	8.90E-03 pCi/L	1000	1.13E-09 pCi/L	1000	3.60E-01 pCi/L
Radium-228	1.26E-05 pCi/m³	8.07E-07 pCi/m³	NOT CPC		NOT CPC		3.63E-01 pCi/L
Thorium-228	1.52E-05 pCi/m³	9.76E-07 pCi/m³	NOT CPC		NOT CPC		1.45E-02 pCi/L
Thorium-232	1.31E-05 pCi/m³	8.39E-07 pCi/m³	NOT CPC		NOT CPC		1.25E-02 pCi/L
Uranium-234	4.85E-05 pCi/m³	3.11E-06 pCi/m³	4.69E+02 pCi/L	160	2.40E+01 pCi/L	220	1.63E+02 pCi/L
Uranium-235/236	3.38E-06 pCi/m³	2.12E-07 pCi/m³	2.50E+01 pCi/L	160	1.28E+00 pCi/L	220	1.10E+01 pCi/L
Uranium-238	4.98E-05 pCi/m³	3.19E-06 pCi/m³	5.17E+02 pCi/L	160	2.65E+01 pCi/L	220	1.62E+02 pCi/L
Arsenic	1.86E-07 mg/m³	1.20E-08 mg/m³	3.35E-04 μg/L	1000	8.56E-05 μg/L	1000	3.23E+00 μg/L
Dibenzo(a,h)anthracene	1.23E-08 mg/m³	7.74E-10 mg/m³	6.66E-04 μg/L	1000	NA[d]		2.22E-02 μg/L

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.
[b]On site refers to a location on the subunit of concern.
[c]Off site refers to the location at the FEMP fenceline.
[d]NA = not applicable

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Baseline Risk Assessment

Because of the contiguous nature of the Inactive Flyash Pile and South Field, the complexity of the geology and lithology, and the patterns of groundwater flow in the area, it was not possible to completely separate these potential groundwater contaminant sources on other than an arbitrary basis. Therefore, the groundwater modeling for these subunits included simultaneous inputs from the entire area of these combined subunits. Hence, the risk contribution of the groundwater pathway is based on the combined effects of these subunits.

For the current land use scenario, total carcinogenic risks range from slightly greater than 10^{-5} for the trespassing youth to about 10^{-7} for off-property receptors. Total risk to the trespassing youth is 1.3 x 10^{-5} mostly due to the presence of radium-226, radium-228, and thorium-232 in surface soil which accounted for 74 percent of the total receptor risk. Risk to the on-property groundskeeper are on the same order of magnitude as the trespassing youth. Major contributors to risk for the on-property groundskeeper include radium-226, radium-228, and thorium-232 which accounted for approximately 87 percent of the total receptor risk. HIs for all current scenario receptors are less than 1.0.

For the future land use scenario assuming private ownership, the on-property RME farmer had a total risk of 1.5 x 10^{-3} and HI of 18. The major contributors of risk were from the estimated presence of uranium-234 and uranium-238 in groundwater, and consequently in irrigated milk and beef products from livestock that are watered with groundwater contaminated from the combined Inactive Flyash Pile/South Field source area. The most significant contributors of the elevated HI was due to total uranium in groundwater.

For the future land use assuming federal ownership, the expanded trespasser has a total carcinogenic risk of 3.0 x 10^{-5} due primarily to the ingestion of surface soil containing radium-226, thorium-228, thorium-232, and arsenic which accounted for 86 percent of the total risk. Total HI was less than 1.0. The off-property farmers (private and federal ownership) exceeded 1.0 x 10^{-6} risk level. The major contributors of risk to the off-property farmers were from uranium-234 and uranium-238 in groundwater contaminated from the combined Inactive Flyash Pile/South Field source area which accounted for approximately 95 percent of the total farmer receptor risk and 85 percent of the total child receptor risk. Total HIs for the farmers were below 1.0, but for the child it was 2.2 due mostly to uranium-total in the groundwater.

Total estimated risk to future Great Miami River users are in the range of 1.0×10^{-6} to 1.0×10^{-5}. For the adult and youth receptors, thorium-228, uranium-235/236, and radium-228 in sediment were the major contributors to total risk. Total HIs are below 1.0.

Table 7-10 lists the COCs which contribute greater than one percent total medium risk to the future scenarios. Approximately 75 percent of the total risk to the on-property RME farmer is derived from three COCs in groundwater: uranium-234, uranium-235/236, and uranium-238. Pathways contributing most to risk included ingestion, inhalation, and dermal contact with groundwater.

7.4.4 South Field

Test trenches uncovered a range of waste materials including concrete, steel pipe, sheet steel, wood, and clay tile. The results of wipe samples taken from these materials indicate that they represent a potential source of the leaching of radionuclides to groundwater.

Nature and Extent

Table 7-11 presents a summary of the nature of COCs within each medium for the South Field determined through the fate and transport modeling and baseline risk assessment processes. Twenty COCs have been identified for the South Field that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides, one metal, and nine organic compounds. The table identifies the number of samples detected above background compared to the number of samples in a particular medium. This comparison has been provided for all media even though a parameter may be a COC for only one medium.

The extent of COCs in the South Field covers most of the surface and subsurface soils, surface water, sediment, perched groundwater, and groundwater sampled within the subunit. Radionuclides and organics were detected in higher concentrations in the northern portion of the South Field. The COCs were also detected in the perched groundwater beneath the subunit and in the Great Miami Aquifer downgradient of the subunit.

TABLE 7-10

INACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF COC CARCINOGENIC RISK CONTRIBUTIONS[a,b]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer[c]	% Total Receptor Risk	Great Miami River User	% Total Receptor Risk
Soil:						
Radium-226	5.4E-06	17.88%	-[c]	-	N/A	
Radium-228	2.9E-06	9.71%	-	-	N/A	
Thorium-228	6.8E-06	22.65%	-	-	N/A	
Thorium-232	8.9E-06	29.58%	-	-	N/A	
Arsenic	2.0E-06	6.52%	-	-	N/A	
Groundwater:						
Uranium-234	N/A[d]		1.9E-05	24.98%	N/A	
Uranium-235/236	N/A		1.0E-06	1.33%	N/A	
Uranium-238	N/A		3.6E-05	48.26%	N/A	
Homegrown Produce (Groundwater Affected)						
Uranium-234	N/A		5.7E-06	7.53%	N/A	
Uranium-238	N/A		1.1E-05	14.54%	N/A	
Beef/Milk (Dust Affected)						
Dibenzo(a,h)anthracene	N/A		-	-	N/A	
Beef/Milk (Groundwater Affected):						
Uranium-234	N/A		-	-	N/A	
Uranium-238	N/A		1.1E-06	1.42%	N/A	
Ambient Radon:	-	-	-	-	N/A	

See footnotes at end of table

TABLE 7-10
(Continued)

Medium/ Parameter	Off-Property Resident Child[f]	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk
Soil:								
Radium-226	-	-	-	-	-	-	-	-
Radium-228	-	-	-	-	-	-	-	-
Thorium-228	-	-	-	-	-	-	-	-
Thorium-232	-	-	-	-	-	-	-	-
Arsenic	-	-	-	-	-	-	-	-
Groundwater:								
Uranium-234	-	-	3.7E-04	25.06%	2.2E-05	25.67%	1.6E-05	20.34%
Uranium-235/236	-	-	2.0E-05	1.34%	1.2E-06	1.37%	-	-
Uranium-238	1.6E-06	39.01%	7.1E-04	48.33%	4.3E-05	49.53%	3.0E-05	39.23%
Homegrown Produce (Groundwater Affected)								
Uranium-234	N/A		1.1E-04	7.55%	6.1E-06	7.07%	7.8E-06	10.09%
Uranium-238	N/A		2.1E-04	14.57%	1.2E-05	13.63%	1.5E-05	19.46%
Beef/Milk (Dust Affected):								
Dibenzo(a,h)anthracene	-	-	-	-	-	-	1.06E-06	1.29%
Beef/Milk (Groundwater Affected):								
Uranium-234	-	-	1.1E-05	0.74%	-	-	2.0E-06	2.54%
Uranium-238	-	-	2.1E-05	1.42%	-	-	3.8E-06	4.90%
Ambient Radon	-	-	4.2E-06	5.48%	-	-	-	-

[a]Sediment, surface water, home grown produce (dust and groundwater affected), and beef/milk (dust affected) pathways do not have any COCs associated with them, therefore, were not included in this table.
[b]Great Miami River User (Adult) and Great Miami River (Youth) receptors did not have any COCs associated with them, therefore, were not included in this table.
[c]No risk greater than the threshold level of 1×10^{-6}.
[d]N/A signifies that exposure of the receptor to the indicated medium is not applicable.
[e]The Off-Propery farmer under both federal and private ownership has the same risk.
[f]The Off-Property child under both federal and private ownership has the same risk.

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TABLE 7-11

COCs DETECTED IN THE SOUTH FIELD[a]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Surface Soils	Subsoil		Surface Water	Sediment	Groundwater 1000-Series		Groundwater 2000-Series	
COC/Phase	II	I	II	II	II	I	II	I	II
Radium-226	8/21[b]	10/71	10/45	0/2	3/3	0/4	3/7	1/16	0/11
Radium-228	6/21	11/70	11/45	0/2	1/3	0/4	0/8	0/18	0/11
Technetium-99	1/21	43/78	0/43	0/2	0/3	0/6	0/10	0/18	0/11
Thorium-228	2/16	16/112	5/34	0/2	1/3	1/6	4/9	0/18	0/10
Thorium-230	8/16	26/112	15/34	0/2	2/3	0/6	3/9	1/18	1/10
Thorium-232	2/6	11/112	6/34	0/2	1/3	0/6	4/9	1/18	1/10
Uranium-234	21/21	62/102	33/44	2/2	3/3	4/6	9/10	17/19	8/10
Uranium-235/236	20/21	53/102	19/44	2/2	3/3	1/6	9/10	7/19	8/10
Uranium-238	21/21	61/102	31/44	2/2	3/3	4/6	8/10	17/19	9/10
Arsenic	3/21	0/18	4/43	0/2	1/3	0/8	0/13	0/22	0/14
Aroclor-1254	1/21	7/19	12/43	0/2	1/3	N/A[c]	0/7	0/2	0/9
Aroclor-1260	2/21	0/19	1/43	0/2	0/3	N/A	0/7	0/2	0/9
Benzo(a)anthracene	12/21	5/14	5/42	0/2	1/3	N/A	0/7	0/3	0/9
Benzo(a)pyrene	12/21	3/14	6/41	0/2	1/2	N/A	0/7	0/3	0/9
Benzo(b)fluoranthene	12/21	5/14	4/41	0/2	1/2	N/A	0/7	0/3	0/9
Benzo(k)fluoranthene	13/21	0/14	5/41	0/2	2/2	N/A	0/7	0/3	0/9
Dibenzo(a,h)anthracene	7/21	0/14	1/41	0/2	0/2	N/A	0/7	0/3	0/9
Dieldrin	1/21	0/19	1/43	0/2	0/3	N/A	0/7	0/2	0/9
Indeno(1,2,3-cd)pyrene	10/21	1/14	3/41	0/2	1/2	N/A	0/7	0/3	0/9

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.
[b]Number refers to detections above background relative to number of analyses.
[c]N/A signifies not analyzed.

Fate and Transport

Future maximum on-site and off-site modeled COC concentrations for each medium are listed in Table 7-12. The media pathways considered significant for the South Field as a result of the modeling include air, surface water, and groundwater pathways.

Baseline Risk Assessment

For the current land use scenario, total carcinogenic risks ranged on the order of 10^{-4} for the trespassing youth and on-property groundskeeper to about 10^{-7} for off-property receptors. Major contributors to total risk to the trespassing youth and on-property groundskeeper were mostly due to radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Total HI for the trespassing youth was 53 due primarily to the presence of uranium-total in surface water. HIs for all other current receptors were below 1.0.

For the future land use scenario assuming private ownership, the on-property RME farmer had a total carcinogenic risk of 3.4×10^{-2} while the resident child had a risk of 9.2×10^{-3}. The largest components of risk to the on-property farmers are from dust-affected beef and milk products containing technetium-99, benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene. Total hazards for the on-property farmer and child were 23 and 63, respectively, due mostly to the presence of uranium-total in groundwater.

For the future land use assuming federal ownership, the expanded trespasser had a total carcinogenic risk of about 1.4×10^{-4} and HI of less than 1.0. The major contributor to risk was from radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Off-property farmers (private and federal ownership) had carcinogenic risks in the range of 10^{-6} to 10^{-4}. The largest component of risk to the off-property farmers was from uranium-234 and uranium-238 in groundwater which accounted for approximately 52 percent of the total receptor risk. For the off-property farmer child under private ownership, the primary contributors to total risk were from ingestion of beef and milk products affected by dust containing dibenzo(a,h)anthracene, benzo(a)pyrene, and Aroclor-1260. For the off-property child under federal ownership, the primary contributors to risk were from uranium-234 and uranium-238 in groundwater. Total HIs for the off-property farmers exceeded 1.0 due to the estimated presence of uranium-total in groundwater.

TABLE 7-12

MAXIMUM MODELED COC CONCENTRATIONS IN THE[a] SOUTH FIELD OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

COC	Air Maximum Modeled Concentration		Groundwater Maximum Modeled Concentrations				Surface Water Maximum Modeled Concentrations
	On Site[b]	Off Site[c]	On Site	Year	Off Site	Year	On Site
Radium-226	1.10E-02 pCi/m³	8.01E-04 pCi/m³	8.90E-03 pCi/L	1000	1.13E-09 pCi/L	1000	5.46E+00 pCi/L
Radium-228	1.38E-03 pCi/m³	1.01E-04 pCi/m³	NOT CPC		NOT CPC		6.90E-01 pCi/L
Technetium-99	5.07E-02 pCi/m³	3.69E-03 pCi/m³	1.03E+01 pCi/L	40	2.86E+00 pCi/L	40	1.67E+04 pCi/L
Thorium-228	1.57E-03 pCi/m³	1.15E-04 pCi/m³	NOT CPC		NOT CPC		2.59E-02 pCi/L
Thorium-230	4.93E-03 pCi/m³	3.59E-04 pCi/m³	NOT CPC		NOT CPC		8.15E-02 pCi/L
Thorium-232	1.42E-03 pCi/m³	1.04E-04 pCi/m³	NOT CPC		NOT CPC		2.35E-02 pCi/L
Uranium-234	5.09E-03 pCi/m³	2.25E-04 pCi/m³	4.69E+02 pCi/L	160	2.40E+01 pCi/L	220	1.40E+02 pCi/L
Uranium-235/236	3.17E-04 pCi/m³	2.31E-05 pCi/m³	2.50E+01 pCi/L	160	1.28E+00 pCi/L	220	1.23E+01 pCi/L
Uranium-238	3.30E-03 pCi/m³	2.42E-04 pCi/m³	5.17E+02 pCi/L	160	2.65E+01 pCi/L	220	1.51E+02 pCi/L
Arsenic	2.59E-06 mg/m³	1.89E-07 mg/m³	3.35E-04 μg/L	1000	8.60E-05 μg/L	1000	6.84E-01 μg/L
Aroclor-1254	3.18E-08 mg/m³	2.31E-09 mg/m³	NOT CPC		NOT CPC		8.62E-04 μ/L
Aroclor-1260	1.86E-08 mg/m³	1.35E-09 mg/m³	NOT CPC		NOT CPC		4.17E-04 μg/L
Benzo(a)anthracene	1.96E-06 mg/m³	1.43E-07 mg/m³	3.84E-03 μg/L	1000	NA		1.42E-01 μg/L
Benzo(a)pyrene	3.36E-06 mg/m³	2.44E-07 mg/m³	2.75E-03 μg/L	1000	NOT CPC		1.02E-01 μg/L
Benzo(b)fluoranthene	2.21E-06 mg/m³	1.61E-07 mg/m³	NOT CPC		NOT CPC		1.72E-02 μg/L
Benzo(k)fluoranthene	2.61E-06 mg/m³	1.90E-07 mg/m³	NOT CPC		NOT CPC		1.09E-02 μg/L
Dibenzo(a,h)anthracene	6.78E-07 mg/m³	4.94E-08 mg/m³	6.66E-04 μg/L	1000	NA[d]		2.10E-02 μg/L
Dieldrin	3.57E-09 mg/m³	2.60E-10 mg/m³	8.47E-04 μg/L	1000	NA		3.13E-02 μg/L
Indeno(1,2,3-cd)pyrene	2.14E-06 mg/m³	1.56E-07 mg/m³	NOT CPC		NOT CPC		1.36E-03 μg/L

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.
[b]On site refers to a location on the subunit of concern.
[c]Off site refers to the location at the FEMP fenceline.
[d]NA = not applicable

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For the users of the Great Miami River, the total risk calculated for the recreational user was 4.2 x 10^{-6} with the risk due primarily to ingestion of fish contaminated with radium-226 and technetium-99 via the Great Miami River surface water pathway. For the Great Miami River agricultural user, total risk was 4.4 x 10^{-6} due primarily to the ingestion of beef and milk products affected by dust containing technetium-99 which accounts for 97 percent of the total receptor risk. Total receptor risk to the residential user was 6.3 x 10^{-8}. Total HIs for all of the Great Miami River user were below 1.0.

Table 7-13 lists the COCs which contribute greater than one percent total medium risk. Approximately 60 percent of the risk to the on-property resident farmer is derived from five COCs: radium-226, radium-228, thorium-232 in surface soil and beef and milk products affected by dust containing technetium-99, benzo(a)pyrene, and dibenzo(a,h)anthracene. Pathways posing risk include external radiation, inhalation, and ingestion with surface soil, and ingestion of dust-affected beef and milk products.

7.4.5 Active Flyash Pile

The Active Flyash Pile contains only flyash from field observations and historical documentation. Interviews with former processing personnel indicated that organic compounds could have been sprayed on the flyash to reduce dust. The analytical results of the RI field investigation do not support such speculation.

Nature and Extent

Table 7-14 presents a summary of the nature of COCs within each medium for the Active Flyash Pile determined through the fate and transport modeling and baseline risk assessment processes. Twelve COCs have been identified for the Active Flyash Pile that contribute greater than one percent of the total risk for a medium. These COCs consist of ten radionuclides and two metals. The table identifies the number of samples detected above background compared to the number of samples in a particular medium. This comparison has been provided for all media even though a parameter may be a COC for only one medium.

The extent of COCs in the Active Flyash Pile covers most of the surface and subsurface soils, and sediment within the subunit. The COCs uranium-234, uranium-235/236, and uranium-238 were

TABLE 7-13

SOUTH FIELD
FUTURE LAND USE
SUMMARY OF COC CARCINOGENIC RISK CONTRIBUTIONS[a,b]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	Off-Property Resident Child	% Total Receptor Risk	Great Miami River Recreational User	% Total Receptor Risk	Great Miami River Agricultural User	% Total Receptor Risk
Soil:										
Radium-226	8.3E-05	59.89%	-	-	-	-	N/A		N/A	
Radium-228	5.0E-06	3.62%	-	-	-	-	N/A		N/A	
Thorium-228	1.1E-05	7.94%	1.0E-06	0.97%	-	-	N/A		N/A	
Thorium-230	-	-	1.2E-06	1.13%	-	-	N/A		N/A	
Thorium-232	1.5E-05	10.91	1.3E-06	1.24%	-	-	N/A		N/A	
Arsenic	-	-	-	-	-	-	N/A		N/A	
Benzo(a)pyrene	3.3E-06	2.36%	-	-	-	-	N/A		N/A	
Sediment:										
Radium-226	1.3E-05	9.51%	N/A		N/A		N/A		N/A	
Groundwater:										
Uranium-234	-	-	1.9E-05	17.55%	-	-	N/A		N/A	
Uranium-235/236	-	-	1.0E-06	0.94%	-	-	N/A		N/A	
Uranium-238	-	-	3.6E-05	33.91%	1.6E-06	10.39%	N/A		N/A	
Surface Water:										
Radium-226	N/A		N/A		N/A		1.3E-06	30.40%	N/A	
Technetium-99	N/A		N/A		N/A		2.0E-06	46.33%	N/A	
Uranium-238	N/A		N/A		N/A		4.1E-06	97.31%	N/A	
Home Grown Produce (Dust Affected):										
Benzo(a)pyrene	N/A		1.5E-06	1.42%	-	-	N/A		N/A	
Home Grown Produce (Groundwater Affected):										

See footnotes at end of table

TABLE 7-13
(Continued)

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	Off-Property Resident Child	% Total Receptor Risk	Great Miami River Recreational User	% Total Receptor Risk	Great Miami River Agricultural User	% Total Receptor Risk
Uranium-234	N/A		5.7E-06	5.29%	-	-	N/A		N/A	
Uranium-238	N/A		1.1E-05	10.22%	-	-	N/A		N/A	
Beef/Milk (Dust Affected):										
Aroclor-1260	N/A		1.8E-06	1.71%	1.1E-06	7.03%	N/A		N/A	
Benzo(a)pyrene	N/A		6.1E-06	5.73%	3.5E-06	23.57%	N/A		N/A	
Dibenzo(a,h)anthracene	N/A		6.8E-06	6.32%	3.9E-06	26.00%	N/A		N/A	
Indeno(1,2,3-cd)pyrene	N/A		1.2E-06	1.08%	-	-	N/A		N/A	
Beef/Milk (Groundwater Affected):										
Technetium-99	N/A		N/A		N/A		4.3E-06	97.31%	4.3E-06	97.31%
Uranium-238	N/A		1.1E-06	1.00%	-	-	N/A		-	-
Ambient Radon	1.9E-06	1.39%	4.4E-06	5.06%						

See footnotes at end of table

TABLE 7-13
(Continued)

Medium/ Parameter	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk	Home-Builder	% Total Receptor Risk
Soil:								
Radium-226	7.8E-03	23.18%	6.5E-04	31.68%	5.9E-04	6.34%	2.6E-06	22.44%
Radium-228	4.7E-04	1.40%	3.9E-05	1.92%	3.5E-05	0.38%	1.6E-06	13.85%
Thorium-228	1.0E-03	3.10%	8.7E-05	4.25%	7.7E-05	0.84%	2.1E-06	18.66%
Thorium-232	1.4E-03	4.25%	1.2E-04	5.84%	1.1E-04	1.15%	1.1E-06	9.46%
Arsenic	3.3E-05	0.11%	1.7E-06	0.08%	1.4E-05	0.15%	-	-
Beryllium	2.0E-05	0.06%	-	-	8.9E-06	0.10%	-	-
Chromium	1.3E-05	0.35%	-	-	1.1E-06	0.25%	-	-
Benzo(a)pyrene	3.4E-04	1.03%	1.6E-05	0.80%	1.5E-04	1.63%		
Dibenzo(a,h)-anthracene	6.9E-05	0.21%	3.2E-06	0.16%	3.0E-05	0.33%		
Sediment:	N/A		N/A		N/A			
Groundwater:								
Uranium-234	3.7E-04	1.09%	2.2E-05	1.08%	1.6E-05	0.17%		
Uranium-235/236	2.0E-05	0.06%	1.2E-06	0.06%	-	-		
Uranium-238	7.1E-04	2.11%	4.3E-05	2.09%	3.0E-05	0.33%		
Home Grown Produce (Dust Affected):								
Radium-226	4.7E-05	0.14%	2.6E-06	0.13%	3.3E-06	0.04%		
Strontium-90	1.9E-05	0.06%	1.0E-06	0.05%	1.3E-06	0.01%		
Technetium-99	3.6E-04	1.06%	2.0E-05	0.96%	2.5E-05	0.27%		
Arsenic	5.5E-05	0.16%	3.0E-06	0.15%	1.8E-05	0.20%		
Benzo(a)anthracene	6.0E-05	0.18%	3.0E-06	0.16%	2.0E-05	0.21%		
Benzo(a)pyrene	5.7E-04	1.70%	3.1E-05	1.53%	1.9E-04	2.02%		
Benzo(b)fluoranthene	3.7E-05	0.11%	2.0E-06	0.10%	1.2E-05	0.13%		
Dibenzo(a,h)anthracene	4.3E-05	0.13%	2.4E-06	0.12%	1.4E-05	0.15%		
Dieldrin	2.5E-04	0.75%	1.4E-05	0.68%	8.3E-05	0.90%		

See footnotes at end of table

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TABLE 7-13
(Continued)

Medium/ Parameter	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk	Home-Builder	% Total Receptor Risk
Indeno(1,2,3-cd)pyrene	1.9E-05	0.06%	1.1E-05	0.05%	6.3E-06	0.07%		
Home Grown Produce (Groundwater Affected):								
Uranium-234	1.1E-04	0.33%	6.1E-06	0.30%	7.8E-06	0.08%		
Uranium-235/236	5.9E-06	0.02%	-	-	-	-		
Uranium-238	2.1E-04	0.64%	1.2E-06	0.57%	1.5E-05	0.16%		
Beef/Milk (Dust Affected):								
Benzo(a)pyrene	1.2E-05	0.31%	-	-	6.7E-06	1.50%		
Benzo(b)-fluoranthene	3.7E-06	0.10%	-	-	2.1E-06	0.47%		
Benzo(k)-fluoranthene	3.7E-06	0.10%	-	-	2.2E-06	0.48%		
Dibenzo(a,h)-anthracene	2.6E-06	0.07%	-	-	1.5E-06	0.33%		
Indeno(1,2,3-cd)pyrene	9.8E-05	2.60%	5.9E-06	1.89%	5.6E-05	12.54%		
Beef/Milk (Groundwater Affected):								
Uranium-234	6.4E-06	0.17%	-	-	1.2E-06	0.26%		
Uranium-238	1.2E-05	0.33%	-	-	2.3E-06	0.50%		

[a]Homebuilder, Great Miami River User (Adult), and Great Miami River User (Youth) receptors did not have any COCs associated with them, therefore, were not included within this table.
[b]Surface water pathway did not have any COCs associated with carcinogenic risk, therefore, were not inlcuded in this table.
[c]No risk greater then the threshold level of 1×10^{-6}.
[d]C/A signifies that exposure of the receptor to the indicated medium is not applicable.

See footnotes at end of table

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TABLE 7-14

COCs DETECTED IN THE ACTIVE FLYASH PILE[a]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

	Surface Soil[b]	Flyash[b]		Subsoil[b]		Surface Water		Sediment		Groundwater 1000-series		Groundwater 2000-series	
COC/Phase	II	I	II	I	II	I	II	I	II	I	II	I	II
Cesium-137	1/14[c]	0/10	0/6	0/8	0/6	N/A[d]	0/1	N/A	0/1	N/A	0/2	0/2	0/3
Neptunium-237	6/6	0/6	5/5	0/6	6/6	N/A	1/1	N/A	1/1	0/2	1/2	0/15	0/2
Radium-226	12/14	10/10	6/6	0/8	1/6	0/2	0/1	0/2	0/1	0/2	0/2	0/13	0/2
Radium-228	13/14	10/10	6/6	0/7	1/6	0/2	1/1	0/2	0/1	0/2	0/2	0/15	0/2
Strontium-90	7/14	7/10	2/6	4/7	0/6	N/A	0/1	N/A	0/1	0/2	1/2	0/13	0/2
Thorium-228	11/14	10/10	6/6	3/9	1/6	N/A	0/1	N/A	0/1	0/2	0/2	1/14	0/3
Thorium-232	12/14	10/10	6/6	0.9	1/6	N/A	0/1	N/A	0/1	0/24	1/2	2/14	0/3
Uranium-234	14/14	10/10	6/6	1/9	0/6	N/A	1/1	N/A	1/1	2/2	1/2	10/14	2/3
Uranium-235/236	9/14	2/10	4/6	0/9	0/6	N/A	1/1	N/A	1/1	0/2	1/24	7/14	2/3
Uranium-238	14/14	12/12	6/6	2/9	3/6	N/A	1/1	N/A	1/1	2/2	2/2	10/14	2/3
Arsenic	14/14	7/8	6/6	0/3	4/6	1/2	1/1	N/A	1/1	0/4	0/3	0/15	0/5
Beryllium	14/14	8/8	6/6	2/3	5/6	N/A	0/1	N/A	1/1	N/A	0/3	N/A	0/5

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.

[b]These results are compared to subsurface soil background concentrations.

[c]Number refers to detections above background relative to number of analyses.

[d]N/A signifies not analyzed.

detected in the Great Miami Aquifer downgradient of the subunit but are probably related to releases from the Inactive Flyash Pile and the South Field.

Fate and Transport

Future maximum on-site and off-site modeled COC concentrations for each medium are listed in Table 7-15. The media pathways considered significant for the Active Flyash Pile as a result of the modeling include air, surface water, and groundwater pathways.

Baseline Risk Assessment

For the current land use scenario, total carcinogenic risk to a trespassing youth was 2.6×10^{-5} due to the presence of radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Total risk to the groundskeeper was 8.0×10^{-5} due mostly to external radiation from radium-226, radium-228, thorium-228, and thorium-232 in surface soil and dermal contact with arsenic in surface soil which accounted for a combined 99.69 percent of the total receptor risk. Carcinogenic risks to off-property residents did not exceed 10^{-6} risk level. The total HIs for all current receptors are below 1.0.

For the future land use scenario assuming private ownership, the on-property RME farmer and child had total carcinogenic risks of 8.4×10^{-5} and 5.7×10^{-6}, respectively, due mostly to the presence of uranium-234 and uranium-238 in groundwater which accounted for 54 and 34 percent, respectively, of the total receptor risks. Additionally, homegrown produce irrigated with contaminated groundwater containing radium-226, strontium-90, and uranium-235/236 accounted for 28 and 29 percent of the total receptor risk for the RME farmer and child, respectively. The HI for the RME farmer was less than 1.0, but for the child it was 2.8 due to uranium-total in groundwater.

For the future land use assuming federal ownership, the expanded trespasser had a total carcinogenic risk of 4.9×10^{-5} due mostly to the presence of radium-226, radium-228, thorium-228, thorium-232, and arsenic in surface soil. Total HI was less than 1.0. Off-property farmers (private and federal ownership) have carcinogenic risks greater than 1.0×10^{-6} due primarily to estimated future concentrations of uranium-234 and uranium-238 in groundwater and homegrown produce irrigated with contaminated groundwater containing radium-226, strontium-90, and uranium-235/236. HIs were less than 1.0.

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TABLE 7-15

MAXIMUM MODELED COC CONCENTRATIONS[a] IN THE ACTIVE FLYASH PILE OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

COC	Air Maximum Modeled Concentration		Groundwater Maximum Modeled Concentrations				Surface Water Maximum Modeled Concentrations
	On Site[b]	Off Site[c]	On Site	Year	Off Site	Year	On Site
Cesium-137	6.91E-06 pCi/m³	6.87E-07 pCi/m³	NOT CPC		NOT CPC		NA[d]
Neptunium-237	4.13E-05 pCi/m³	4.11E-06 pCi/m³	1.52E+01 pCi/L	160	1.63E-01 pCi/L	280	2.51E+01 pCi/L
Radium-226	3.45E-05 pCi/m³	3.44E-06 pCi/m³	3.37E-01 pCi/L	1000	NA		1.02E+00 pCi/L
Radium-228	2.4E-05 pCi/m³	2.39E-06 pCi/m³	2.34E-01 pCi/L	1000	NA		7.08E-01 pCi/L
Strontium-90	3.38E-05 pCi/m³	3.37E-06 pCi/m³	1.02E+00 pCi/L	100	8.92E-02 pCi/L	160	9.94E-01 pCi/L
Thorium-228	2.85E-05 pCi/m³	2.84E-06 pCi/m³	NOT CPC		NOT CPC		2.81E-02 pCi/L
Thorium-232	2.03E-05 pCi/m³	2.02E-06 pCi/m³	NOT CPC		NOT CPC		1.97E-02 pCi/L
Uranium-234	2.7E-05 pCi/m³	2.69E-06 pCi/m³	1.98E+01 pCi/L	100	2.58E+00 pCi/L	120	5.14E+01 pCi/L
Uranium-235/236	1.20E-06 pCi/m³	1.20E-07 pCi/m³	1.05E+00 pCi/L	100	1.38E-01 pCi/L	120	2.29E+00 pCi/L
Uranium-238	2.7E-05 pCi/m³	2.69E-06 pCi/m³	2.18E+01 pCi/L	100	2.85E+00 pCi/L	120	5.13E+01 pCi/L
Arsenic	6.74E-07 mg/m³	6.72E-08 mg/m³	7.12E-02 μg/L	1000	1.82E-02 μg/L	1000	1.06E+01 μg/L
Beryllium	3.53E-08 mg/m³	3.52E-09 mg/m³	2.75E-03 μg/L	1000	7.08E-04 μg/L	1000	4.41E-01 μg/L

[a]COCs listed in this table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.
[b]On site refers to a location on the subunit of concern.
[c]Off site refers to the location at the FEMP fenceline.
[d]NA = not applicable

Total estimated risk to the future Great Miami River users were on the order of 10^{-9} risk for all these users. Total HIs were below 1.0.

Table 7-16 lists the COCs which present a greater than one percent total medium risk. Over 55 percent of the risk to the on-property resident farmer is derived from two COCs in groundwater: uranium-234 and uranium-238. The pathways which pose the greatest risk to the Active Flyash Pile on-property receptor was ingestion and dermal contact.

7.4.6 Operable Unit 2 Cumulative

Cumulative risk posed by Operable Unit 2 was evaluated for impacts to future land uses and receptors.

Fate and Transport

The fate and transport contributions from all of the Operable Unit 2 subunits were evaluated for a combined impact to the surface water, groundwater, and air pathways. The Operable Unit 2-wide surface water assessment determined that the South Field contributed the major portion of radionuclide and organic constituents and the Active Flyash Pile and the South Field contributed the major portion of metals constituents. Cumulative concentrations were determined for the confluence of the Storm Sewer Outfall Ditch with Paddys Run and the confluence of Paddys Run with the Great Miami River.

The combined assessment of groundwater transport determined that the Inactive Flyash Pile and South Field are the major contributors of uranium isotopes, neptunium-237, technetium-99, and lead, which were the only constituents analogous to more than one subunit. The point of maximum on-site and off-site concentrations for the above constituents did not change significantly from that for the South Field and Inactive Flyash Piles, but the maximum on-site and off-site concentrations increased for the cumulative assessment.

Uranium-238 was the only constituent wide-spread enough to evaluate Operable Unit 2 wide for air modeling. The current source term cumulative maximum on-site concentration location is over the Lime Sludge Ponds and the maximum off-site concentration is over State Route 126 to the northeast of the Lime Sludge Ponds. The future source term maximum on-site concentration lies over the Solid

TABLE 7-16

ACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF COC TOTAL CARCINOGENIC RISK CONTRIBUTIONS[a,b]
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer[c]	% Total Receptor Risk
Soil:				
Neptunium-237	1.1E-06	2.22%	-[d]	-
Radium-226	1.2E-05	25.25%	-	-
Radium-228	4.1E-06	8.33%	-	-
Thorium-228	9.6E-06	19.33%	-	-
Thorium-232	1.0E-05	20.60%	-	-
Arsenic	5.3E-06	10.75%	-	-
Sediment:				
Radium-226	2.0E-06	4.00%	N/A	
Arsenic	1.0E-06	2.11%	N/A	
Groundwater:				
Uranium-234	N/A[e]		2.0E-06	18.74%
Uranium-238	N/A		3.9E-06	36.24%
Home Grown Produce (Dust Affected):				
Arsenic	N/A		-	-
Home Grown Produce (Groundwater Affected):				
Strontium-90	N/A		1.6E-06	14.61%
Ambient Radon	-		-	

See footnotes at end of table

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TABLE 7-16
(Continued)

Medium/ Parameter	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk
Soil:	-	-	-	-		
Neptunium-237	-	-	-	-		
Radium-226	-	-	-	-		
Radium-228	-	-	-	-		
Thorium-228	-	-	-	-		
Arsenic	-	-	-	-		
Beryllium	-	-	-	-		
Sediment:						
Neptunium-237	N/A	-	-	-	-	-
Radium-228	N/A	-	-	-	-	-
Thorium-228	N/A	-	-	-	-	-
Groundwater:						
Uranium-234	1.6E-05	18.58%	-	-	-	-
Uranium-238	3.0E-05	35.81%	1.8E-06	37.25%	1.3E-06	22.41%
Home Grown Produce (Dust Affected):						
Arsenic	1.2E-06	1.43%	-	-	-	-
Home Grown Produce (Groundwater Affected):						
Radium-226	6.5E-06	7.81%	-	-	-	-
Strontium-90	1.2E-05	14.49%	-	-	-	-
Uranium 235/236	5.2E-06	6.17%	-	-	-	-
Beef/Milk (Groundwater Affected):						
Strontium-90	6.0E-06	7.22%	-	-	1.1E-06	19.69%
Ambient Radon	1.5E-06		-		-	

See footnotes at end of table

TABLE 7-16
(Continued)

[a]Surface water, home grown produce (groundwater affected), and beef/milk (dust affected) pathways do not have any COCs associated with it, therefore, was not included in this table.

[b]Great Miami River user (Adult) and Great Miami River user (Youth) receptors did not have any COCs associated with them, therefore, were not included in this table.

[c]Off-property resident private and federal ownership pose the same risk.

[d]No risk greater than the threshold level of 1×10^{-6}.

[e]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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Waste Landfill and the maximum off-site concentration is near the maximum concentration point for the current source term.

Baseline Risk Assessment

Future land use receptors were evaluated for cumulative risk from the presence of contaminants within Operable Unit 2. It is emphasized that the risks and hazards presented are those resulting primarily from the three subunits contributing most to groundwater contamination: the Active Flyash Pile, South Field and Inactive Flyash Pile.

The greatest carcinogenic risk posed was to the RME on-property farmer which had a total risk of 3.3 x 10^{-2}. The major contributors to risk for the on-property receptor were from the ingestion of beef and milk products affected with dust containing technetium-99, benzo(a)pyrene, and dibenzo(a,h)anthracene which contributed a combined 51.6 percent of the total receptor risk. Total HI was 23 due mostly to beryllium in groundwater and homegrown produce irrigated with groundwater contaminated with uranium-total.

Total risk to the off-property farmer was on the order of 1.0 x 10^{-5} due primarily to uranium-234, uranium-235/236, and uranium-238 in groundwater. Total HI for the off-property farmer was 3.7 due primarily to the ingestion of homegrown produce irrigated with groundwater containing uranium-234, uranium-235/236, and uranium-238.

Total risk to the expanded trespasser was 8.5 x 10^{-5} due primarily to external radiation from radium-226, radium-228, thorium-228, and thorium-230 in surface soil which contributed 80.7 percent of the total receptor risk. Total HI for this receptor was below 1.0.

Table 7-17 lists the COCs which present a greater than one percent total medium risk to the future receptors. Approximately 85 percent of the total risk to the on-property farmer is attributed from six COCs in surface soil and dust affected beef and milk products: radium-226, thorium-228, and thorium-232 in surface soil, and technetium-99, benzo(a)pyrene, dibenzo(a,h)anthracene in dust affected beef and milk products.

TABLE 7-17

OPERABLE UNIT 2-WIDE FUTURE LAND USE[a,b]
SUMMARY OF COC TOTAL CONTRIBUTIONS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Soil:						
Cesium-137	-[c]	-	-	-	4.1E-05	1.11%
Neptunium-237	-	-	-	-	-	-
Radium-226	4.5E-05	53.58%	8.9E-06	3.12%	7.8E-03	10.13%
Radium-228	4.0E-06	4.70%	-	-	4.7E-04	0.61%
Thorium-228	9.1E-06	10.72%	-	-	1.0E-03	1.35%
Thorium-230	-	-	-	-	1.7E-05	0.02%
Thorium-232	1.2E-05	13.58%	-	-	1.4E-03	1.86%
Uranium-234	-	-	-	-	1.0E-05	0.01%
Uranium-238	-	-	1.0E-06	0.35%	-	-
Aroclor-1254	-	-	-	-	-	-
Aroclor-1260	-	-	-	-	-	-
Arsenic	1.3E-06	1.51%	-	-	-	-
Beryllium	-	-	-	-	-	-
Benzo(a)pyrene	1.7E-06	2.02%	-	-	3.4E-04	0.44%
Dibenzo(a,h)anthracene	-	-	-	-	-	-
Benzo(a)anthracene	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-
Dieldrin	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	-	-	-	-	-	-
Groundwater:						
Uranium-234	-	-	2.0E-05	6.96%	3.70E-04	0.48%
Uranium-235/236	-	-	1.1E-06	0.37%	2.0E-05	0.03%
Uranium-238	-	-	3.8E-05	13.43%	7.1E-04	0.92%

See footnotes at end of table

TABLE 7-17
(Continued)

Medium/ Parameter	Expanded Trespasser % Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Homegrown Produce (Dust Affected):					
Radium-226	N/A[d]	1.3E-05	4.56%	4.6E-05	0.06%
Strontium-90	N/A	-	-	1.9E-05	0.02%
Technetium-99	N/A	-	-	3.6E-04	0.46%
Uranium-238	N/A	-	-	-	-
Aroclor-1254	N/A	-	-	-	-
Arsenic	N/A	-	-	5.5E-05	0.07%
Benzo(a)anthracene	N/A	-	-	6.0E-05	0.08%
Benzo(a)pyrene	-	-	-	5.7E-04	0.74%
Benzo(b)fluoranthene	N/A	-	-	3.7E-05	0.05%
Benzo(k)fluoranthene	N/A	-	-	-	-
Beryllium	N/A	-	-	-	-
Dibenzo(a,h)anthracene	N/A	-	-	4.3E-05	0.06%
Dieldrin	N/A	-	-	2.5E-04	0.33%
Indeno(1,2,3-d)pyrene	N/A	-	-	1.9E-05	0.02%
Homegrown Produce (Groundwater Affected)					
Uranium-235/236	N/A	6.0E-06	2.10%	1.1E-04	0.14%
Uranium-238	N/A	5.8E-06	3.48%	1.0E-05	0.01%
Beef/Milk (Dust Affected)					
Cesium-237	N/A	-	-	-	-
Radium-226	N/A	2.3E-06	0.81%	-	-
Radium-228	N/A	-	-	-	-
Strontium-90	N/A	-	-	-	-
Technetium-99	N/A	-	-	7.8E-03	10.17%
Uranium-238	N/A	-	-	-	-
Benzo(a)pyrene	N/A	4.0E-06	1.39%	5.4E-03	7.02%

See footnotes at end of table

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TABLE 7-17
(Continued)

Medium/ Parameter	Expanded Trespasser Receptor Risk	% Total	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Benzo(b)fluoranthene	N/A		-	-	3.7E-04	0.48%
Benzo(k)fluoranthene	N/A		-	-	-	-
Aroclor-1254	N/A		-	-	-	-
Aroclor-1260	N/A		1.2E-06	0.41%	2.1E-04	0.27
Arsenic	N/A		-	-	-	-
Benzo(a)anthracene	N/A		-	-	-	-
Beryllium	N/A		-	-	-	-
Dibenzo(a,h)anthracene	N/A		4.4E-06	1.54%	4.0E-03	5.20%
Indeno(1,2,3-cd)pyrene	N/A		-	-	7.8E-04	1.01%
Beef/Milk (Groundwater Affected)						
Uranium-235/236	N/A		-	-	1.1E-05	0.01%
Uranium-238	N/A		-	-	1.0E-06	0.00%
Total Risk	8.7E-05		1.1E-04		3.3E-02	

[a]COCs listed in table are only those contributing greater than one percent total medium risk. Total risk includes the sum of all parameters contributing to risk including those contributing less than one percent.

[b]Surface water pathway did not have any COCs associated with carcinogenic risk, therefore, were not included in this table.

[c]Pose no risk greater than the threshold level of 1.0×10^{-6}.

[d]NA = not applicable

7.4.7 Risk Assessment Uncertainty

Every quantitative risk assessment is subject to sources of uncertainty. To ensure that risk is not underestimated and that human health is protected, CERCLA guidance and the conventions followed in this report address areas of uncertainty through application of conservative (i.e., protective) assumptions. The greatest uncertainty associated with the Operable Unit 2 baseline risk assessment is due to the assumptions made to estimate constituent concentrations at the spatial and temporal points of human exposure. Specifically, the exposure point concentrations in groundwater, air, fruit and vegetable produce, beef and milk for human receptors in the future are the most conservatively estimated. All risk and hazard estimates for future on-property residents are subject to uncertainty, and hence conservatism, because the future site ownership and access controls are unknown. Taken together and interactively, the uncertainties identified with site data, exposure parameters, fate and transport, toxicity assessment, and risk characterization are judged to be high, having the potential to overestimate risk by two orders of magnitude or more.

One way to evaluate the degree of conservatism in the risk assessment methodology is to follow the risk estimation protocol, substituting natural background concentrations for the constituents that were found in place of the values actually measured at the waste site. This was done for the Operable Unit 2 land use and human exposure scenarios. The use of background constituent levels in the Operable Unit 2 risk assessment results in total carcinogenic risk for the on-property RME farmer on the South Field or Solid Waste Landfill of greater than 1.0×10^{-4}. The major contributors to the total background risk are from radium-226, radium-228, thorium-228, and thorium-232 in surface soil. Combined they contribute 90 percent of the total risk.

7.5 DATA LIMITATIONS

This section discusses limitations of the characterization data collected under the Operable Unit 2 RI. The primary objective in characterizing the nature and extent of the contamination was to collect data sufficient to: (1) perform fate and transport modeling/baseline risk assessment and (2) support the development and evaluation of remedial alternatives under the FS for Operable Unit 2. Characterization activities performed under the Operable Unit 2 RI focused on obtaining the quality and quantity of data necessary to meet the objectives of the RI.

Table 7-18 summarizes recognized data limitations, identifies their significance with respect to achieving the RI objectives, and provides recommended actions to resolve the data limitations. As

TABLE 7-18

DATA LIMITATIONS AND RECOMMENDED ACTIONS

Data Limitation	Significance to Alternatives Evaluation	Significance to Baseline Risk Assessment	Recommended Action/Justification
There is no assurance that the RI data identified all localized areas that contain elevated constituent concentrations.	The uncertainty in the level of contaminant concentration present in the soil yields uncertainty in the short-term effectiveness for worker health and safety due to air transport of surface soil contaminants during the remedial action. Further, similar uncertainty would result in establishing residual risk for in situ alternatives and volume and cost estimates for ex situ alternatives.	The uncertainty in soil contaminant concentrations yields uncertainty in the input to the fate and transport model for air and surface water and the exposure point concentrations used in risk characterization.	No additional sampling is warranted. Localized areas of elevated contaminant concentrations are anticipated in preparation of the health and safety plans for workers. Further, localized areas of elevated contaminant concentrations are assumed in the evaluation of remedial action alternatives through the use of the UCLs of the mean to represent contaminant concentration. The baseline risk assessment follows EPA guidance by using the 95 percent UCL of the mean as the exposure point concentration. This method is judged by EPA to compensate for any missed "hot spots" during the soils characterization program. Conservatism is also achieved by assuming that the receptor spends long periods of time in the Operable Unit 2 area. Also, substitution of background values for Operable Unit 2 waste concentrations demonstrates the conservatism of the fate and transport and risk assessment calculations in predicting risks of current and future receptors.

TABLE 7-18
(Continued)

Data Limitation	Significance to Alternatives Evaluation	Significance to Baseline Risk Assessment	Recommended Action/Justification
Uncertainty remains regarding the flow of perched groundwater and its interaction with Paddys Run.	None. Remedial alternatives for perched groundwater will be evaluated under Operable Unit 5.	Uncertainty in the fate and transport calculations related to the flow of perched groundwater and its connection to the Great Miami Aquifer. Exposure point concentrations in perched water are biased high through the use of a dilution model. Risk characterization provides an upper bound estimate by assuming direct ingestion of perched water by the hypothetical on-property farmer under the future land use scenario.	No additional sampling is warranted to support the RI. Additional information relative to perched groundwater flow and its connection to the Great Miami Aquifer will be used in evaluating potential remedial actions under Operable Unit 5. While additional perched groundwater data may refine these calculations, its impacts on fate and transport and risk assessment calculations would be insignificant relative to the total risk and evaluation of the need for Operable Unit 2 remedial actions.

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apparent in Table 7-18, none of the data limitations result in a need for further action to support the Operable Unit 2 RI. However, specific additional data may be necessary to support the Remedial Design based on the preferred remedial alternative identified in the Proposed Plan and selected in the ROD for Operable Unit 2. This identification of data limitations and the recommended actions does not discredit the RI results; rather it highlights that the nature and extent of contamination are determined and the risks are calculated for hypothetical receptors using well-defined and strict methods. Refinements of Operable Unit 2 characterization data, exposure assessment models, or risk characterization information could reduce uncertainties in the RI and in the baseline risk assessment methods; however, no benefit toward the remedial design nor remedial action would be gained.

Characterization activities performed as part of the RI and other site programs successfully characterized the nature and extent of contaminations associated with Operable Unit 2. The Operable Unit 2 baseline risk assessment has succeeded in establishing an upper bound that is sufficient for risk managers to make decisions regarding the need for remedial actions. Based on the results of the investigations and the risk calculations, risks associated with Operable Unit 2 exceeded generally accepted regulatory thresholds, thereby necessitating the implementation of remedial actions. Viable remedial action alternatives will be evaluated in the Operable Unit 2 FS report.

7.6 CONCLUSIONS AND REMEDIAL ACTION OBJECTIVES

7.6.1 Conclusions

This RI presents a detailed understanding of the nature and extent of the contamination of the individual subunits that comprise Operable Unit 2. The contaminant data is used for two major purposes: (1) after the application of rigorous validation and statistical procedures, the data are used to drive the contaminant fate and transport models used in the risk assessment and (2) the types and quantities of contaminants are used in the FS in the screening of appropriate cleanup technologies and the development of specific remedial alternatives. The data collected for the Operable Unit 2 RI are completely adequate for both purposes and no data gaps have been identified.

The Operable Unit 2 baseline risk assessment utilizes a data set in which every data element has been validated for its intended usability. The fate and transport models are approved by EPA and calibrated to the specific site conditions. The risk assessment rigorously follows CERCLA guidance,

the approved Risk Assessment Work Plan Addendum, and specific guidance to the FEMP from EPA Region V.

7.6.2 Remedial Action Objectives

The development of the following general remedial action objectives (RAOs) is based only on the results of the baseline risk assessment. The Operable Unit 2 FS will include a consideration of the ARARs for each subunit, and ARARs have the potential to significantly affect the remedial action objectives. For the Operable Unit 2 subunits requiring remedial action, feasible remedial action alternatives will be developed and evaluated in the FS report to be issued for Operable Unit 2.

The 1991 Amended Consent Agreement defines Operable Unit 2 as other waste units: flyash piles, other south field disposal areas, lime sludge ponds, solid waste landfill, berms, liners and soil within the operable unit boundary. The remediation of existing contamination in the Great Miami Aquifer, perched water, and Paddys Run is not considered here; remediation of these media is within the scope of the Operable Unit 5 remedial actions. During remediation of Operable Unit 2, contaminated perched water will be controlled to prevent the recontamination of the areas being cleaned up. The treatment or disposal of the perched water will be coordinated with the remedial actions for Operable Unit 5. Also, during the remediation of Operable Unit 2, storm water will be controlled to prevent the spread of contaminants. The treatment or disposal of the storm water will be coordinated with the remedial actions for Operable Unit 5.

The RAOs for all subunits in Operable Unit 2 are to prevent the release or migration of contaminants from waste materials and contaminated soils that could potentially: (1) affect future groundwater users (perched and aquifer) on the site, (2) be harmful as sources of external radiation, (3) prevent the availability of harmful waste materials or contaminated soils for inhalation or ingestion by on-property resident farmers, and (4) prevent the availability of harmful waste materials or contaminated soils for plant uptake, disposition on plants, or ingestion by animals raised for meat and milk products.

The COCs for the Operable Unit 2 that pose significant health risks (greater than 10^{-6} or which yield a hazard quotient greater than 0.2) and contribute greater than 1 percent total medium risk are identified in Table 7-0 presented at the beginning of Section 7 (see Table B.4-0 for a list of all COCs, including those that present less than 1 percent total medium risk). Risk-based PRGs for Operable Unit 2 have been calculated for these COCs. Risk based PRGs are chemical-specific, medium-

specific concentration limits necessary to address all contaminants and all pathways found to be of concern during the baseline risk assessment.

Risk-based PRGs for surface soil and groundwater were calculated using the on-property (RME) farmer, off-property farmer, and the expanded trespasser exposure scenarios using intake equations and exposure parameter values consistent with those utilized in the baseline risk assessment for Operable Unit 2 (see Section 6.0 and Appendix B for detail on the baseline risk assessment). The on-property (RME) farmer is used to calculated the risk-based PRGs because it is a reasonably maximized exposure scenario where an individual has unlimited access to the operable unit to farm, live, and do other activities.

Risk-based PRGs are calculated from the results of the baseline risk assessment based on a linear interpolation between concentration of the COC "i" in the source medium (either soil, surface water, or groundwater) and the total risk from all direct and indirect exposure pathways resulting from that source medium, based on the equation:

$$PRG_i = \frac{(ILCR)(C_{si})}{\Sigma risk_i} \qquad (7\text{-}1)$$

where:

PRG_i = Preliminary remediation goal for constituent "i" in source medium

ILCR = Target risk level 10^{-4} to 10^{-6} for carcinogens; or HI<=0.2

Σ $risk_i$ = Sum of risk from all direct and indirect exposure pathways

C_{si} = Concentration of COC "i" in source medium.

Note that the concentration of the COC in the above equation is the source medium concentration and not an individual exposure medium pathway concentration since the risk to a particular source includes exposure to all direct and indirect exposure pathways.

Risk-based PRGs for surface soil and groundwater are presented in Tables 7-19, -20, -21, and -22.

EPA guidance requires that RAOs be developed in the initial phase of the RI/FS and used as the framework for developing remedial alternatives. RAOs are presented in Table 7-23 for waste materials and soil within the Operable Unit 2 boundaries. RAOs serve as the foundation for the evaluation of remedial alternatives in the Operable Unit 2 Feasibility Study.

TABLE 7-19

SUMMARY OF OPERABLE UNIT 2 RISK-BASED SOIL PRELIMINARY REMEDIAL GOALS (PRGs)[a] FOR THE ON-PROPERTY FARMER

COC	NO ADMINISTRATIVE CONTROLS On-Property Farmer (RME)[b] PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th % (pCi/g or mg/kg)
	10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	1.1	1.1E-01	1.1E-02		0.71
Neptunium-237	4.3	4.3E-01	4.3E-02		0.00
Plutonium-238	3.9E+01	3.9	3.9E-01		0.00
Radium-226	3.9E-01	3.9E-02	3.9E-03	5 pCi/g[d]	1.42
Radium-228	8.2E-01	8.2E-02	8.2E-03	5 pCi/g[d]	1.25
Thorium-228	4.2E-01	4.2E-02	4.2E-03		1.43
Thorium-230	7.9E+01	7.9	7.9E-01	5 pCi/g[e]	1.97
Thorium-232	2.8E-01	2.8E-02	2.8E-03	5 pCi/g[e]	1.36
Uranium-234	7.8E+01	7.8	7.8E-01		1.24
Uranium-235/236	8.9	8.9E-01	8.9E-02		0.15
Uranium-238	2.5E+01	2.5	2.5E-01		1.22
Arsenic	4.5	4.5E-01	4.5E-02		8.20
Beryllium	3.3	3.3E-01	3.3E-02		0.60
Benzo(a)anthracene	2.26	2.26E-01	2.26E-02		0.00
Benzo(a)pyrene	1.5E-01	1.5E-02	1.5E-03		0.00
Benzo(b)fluoranthene	1.5	1.5E-01	1.5E-02		0.00
Benzo(k)fluoranthene	4.61	4.61E-01	4.61E-02		0.00
Dibenzo(a,h)anthracene	4.6E-02	4.6E-03	4.6E-04		0.00
Indeno(1,2,3-cd)pyrene	7.3E-01	7.3E-02	7.3E-03		0.00
Aroclor-1254	1.5E-01	1.5E-02	1.5E-03		0.00
Aroclor-1260	2.4E-02	2.4E-03	2.4E-04		0.00
Dieldrin	4.0E-03	4.0E-04	4.0E-05		0.00

[a]Risk-based PRGs in this table represent the minimum PRGs for any of the Operable Unit 2 subunits.
[b]RME - Reasonable Maximum Exposure
[c]ILCR - Incremental Lifetime Cancer Risk
[d]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 5 progeny.
[e]First 15 cm (i.e., 6 inches) depth [DO Order 5400.5 Chapter IX (4)(a)(2), (3)]

TABLE 7-20

SUMMARY OF OPERABLE UNIT 2 RISK-BASED GROUNDWATER PRELIMINARY REMEDIAL GOALS (PRGs) FOR THE ON-PROPERTY FARMER

COC	NO ADMINISTRATIVE CONTROLS				ARAR/ TBC	Background 95th % (pCi/L or µg/L)
	On-Property Farmer (RME)[a] PRG (pCi/g or mg/kg)					
	HI[b] = 0.2	10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR		
Uranium-234		110	11	1.1		1.20
Uranium-235/236		110	11	1.1		0.00
Uranium-238		62	6.2	0.62		0.90
Uranium-Total	1.7E-02	--[d]	--	--	20 ug/L[e]	2.00

[a]RME - Reasonable Maximum Exposure

[b]HI - Hazard Index

[c]ILCR - Incremental Lifetime Cancer Risk

[d]-- Carcinogenic risk not applicable to this parameter

[e]56 Federal Register 33050 (July 18, 1991) TBC

TABLE 7-21

SUMMARY OF OPERABLE UNIT 2 RISK-BASED SOIL PRELIMINARY REMEDIAL GOALS (PRGs)[a] FOR THE EXPANDED TRESPASSER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Expanded Trespasser (pCi/g or mg/kg)			ARAR/ TBC	Background 95th % (pCi/g or mg/kg)
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	1.12E+02	1.12E+01	1.12		0.71
Neptunium-237	4.99E+02	4.99E+01	4.99		0.00
Plutonium-238	1.19E+04	1.19E+03	1.19E+02		0.00
Radium-226	3.69E+01	3.69	3.69E-01	5 pCi/g[c]	1.42
Radium-228	7.7E+01	7.7	7.7E-01	5 pCi/g[c]	1.25
Thorium-228	3.99E+01	3.99	3.99E-01		1.43
Thorium-230	7.23E+04	7.23E+03	7.23E+02	5 pCi/g[d]	1.97
Thorium-232	2.63E+01	2.63	2.63E-01	5 pCi/g[d]	1.36
Uranium-234	7.29E+04	7.29E+03	7.29E+02		1.24
Uranium-235/236	9.21E+02	9.21E+01	9.21		0.15
Uranium-238	5.36E+03	5.36E+02	5.36E+01		1.22
Arsenic	1.69E+03	1.69E+02	1.69E+01		8.20
Beryllium	4.85E+02	4.85E+01	4.85		0.60
Benzo(a)anthracene	2.86E+03	2.86E+02	2.86E+01		0.00
Benzo(a)pyrene	2.86E+02	2.86E+01	2.86		0.00
Benzo(b)fluoranthene	2.86E+03	2.86E+02	2.86E+01		0.00
Benzo(k)fluoranthene	2.86E+04	2.86E+03	2.86E+02		0.00
Dibenzo(a,h)anthracene	2.86E+02	2.86E+01	2.86		0.00
Indeno(1,2,3-cd)pyrene	2.86E+03	2.86E+02	2.86E+01		0.00
Aroclor-1254	1.72E+01	1.72	1.72E-01		0.00
Aroclor-1260	1.72E+01	1.72	1.72E-01		0.00
Dieldrin	1.09E+01	1.09	1.09E-01		0.00

[a]Risk-based PRGs in this table represent the minimum PRGs for any of the Operable Unit 2 subunits.
[b]ILCR - Incremental Lifetime Cancer Risk
[c]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.
[d]First 15 cm (i.e., 6 inches) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC.

TABLE 7-22

SUMMARY OF THE OPERABLE UNIT 2 RISK-BASED SOIL PRELIMINARY REMEDIAL GOALS (PRGs)[a] FOR THE OFF-PROPERTY FARMER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th % (pCi/g or mg/kg)
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	7.64E+05	7.64E+04	7.64E+03		0.71
Neptunium-237	3.69E+04	3.69E+03	3.69E+02		0.00
Radium-226	1.02E+05	1.02E+04	1.02E+03	5 pCi/g[c]	1.42
Radium-228	5.7E+05	5.7E+04	5.7E+03	5 pCi/g[c]	1.25
Thorium-228	1.5E+04	1.5E+03	1.5E+02		1.43
Thorium-230	4.0E+04	4.0E+03	4.0E+02	5 pCi/g[d]	1.97
Thorium-232	1.05E+04	1.05E+03	1.05E+02	5 pCi/g[d]	1.36
Uranium-234	4.5E+04	4.5E+03	4.5E+02		1.24
Uranium-235/236	4.7E+04	4.7E+03	4.7E+02		0.15
Uranium-238	2.3E+04	2.3E+03	2.3E+02		1.22
Arsenic	4.67E+04	4.67E+03	4.67E+02		8.20
Beryllium	2.99E+05	2.99E+04	2.99E+03		0.60
Chromium	5.0E+04	5.0E+03	5.0E+02		15.50
Benzo(a)anthracene	1.0E+05	1.0E+04	1,0E+03		0.00
Benzo(a)pyrene	5.4E+03	5.4E+02	5.4E+01		0.00
Benzo(b)fluoranthene	5.3E+04	5.3E+03	5.3E+02		0.00
Benzo(k)fluoranthene	1.1E+05	1.1E+04	1.1E+03		0.00
Dibenzo(a,h)anthracene	1.25E+03	1.25E+02	1.25E+01		0.00
Indeno(1,2,3-cd)pyrene	2.2E+04	2.2E+03	2.2E+02		0.00
Aroclor-1254	1.1E+03	1.1E+02	1.1E+01		0.00
Aroclor-1260	1.2E+03	1.2E+02	1.2E+01		0.00
Dieldrin	3.4E+03	3.4E+02	3.4E+01		0.00

[a]Risk-based PRGs in this table represent the minimum PRGs for any of the Operable Unit 2 subunits.
[b]ILCR - Incremental Lifetime Cancer Risk
[c]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.
[d]First 15 cm (i.e., 6 inches) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC.

TABLE 7-23

REMEDIAL ACTION OBJECTIVES
OPERABLE UNIT 2

WASTE MATERIAL/CONTAMINATED SOIL
For Human Health
Prevent direct contact with, inhalation, external radiation or ingestion of waste material/contaminated soil in excess of the PRGs identified in Tables 7-19, 7-21, or 7-22.
Prevent leaching of waste material/contaminated soil which would result in soil concentrations in excess of the PRGs identified in Table 7-19, 7-21, or 7-22.
Prevent leaching of waste material/contaminated soil which would result in groundwater concentrations in excess of the PRGs identified in Table 7-20.
Prevent exposures to waste materials and contaminated soil which may cause an individual to exceed an annual dose limits of 25 mrem/yr whole body, 75 mrem/yr to the thyroid or 25 mrem/yr to any other organ.
Prevent exposures to the waste material/contaminated soil which may cause an individual to exceed a 100 mrem/yr effective dose equivalent, above background, form all exposure routes.
For Environmental Protection
Prevent leaching of waste material which would result in groundwater concentrations in excess of the ARARs identified in Section 6.5.
Prevent release or leaching of the waste materials/contaminated soil which would result in surface water concentrations in excess of the ARARs identified in Section 6.5.

In accordance with EPA regulations, the RAOs and associated PRGs will be reevaluated during the course of the feasibility study. The risk-based PRGS will be modified by application of influencing controls which can include administrative controls, cross-media migration, and source controls. These modified PRGS will be used to formulate final remedial goals that will be included in the Record of Decision.

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