R-010-203.3

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ENGINEERING EVALUATION/COST ANALYSIS WASTE PIT AREA STORM WATER RUNOFF CONTROL AUGUST 1990

DOCUMENT DATE 05-01-90

293 [redacted]

Engineering Evaluation/Cost Analysis
Waste Pit Area
Storm Water Run-Off Control

FEED MATERIALS PRODUCTION CENTER
Fernald, Ohio

May 1990

U. S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

293

DRAFT

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Waste Pit Area
Storm Water Runoff Control

FEED MATERIALS PRODUCTION CENTER
Fernald, Ohio

Prepared for
U.S. Department of Energy
Oak Ridge Operations Office

Prepared by

Advanced Sciences, Inc.
International Technology Corporation

May 1990

FMPC-0002-4

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ACRONYM LIST

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ASI/IT	Advanced Sciences, Inc./International Technology Corp.
AWQC	Ambient Water Quality Criteria
AWWT	Advanced Wastewater Treatment
BAT	best available technology
BDN	biodenitrification
BMP	Best Management Practices
BSL	biodenitrification surge lagoon
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COE	U.S. Corps of Engineers
CRP	chlorosulfanated reinforced polyethylene
DCGs	derived concentration guides
DOE	Department of Energy
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
GPM	gallons per minute
HI	Hazard Index
HSL	Hazardous Substance List
MCL	maximum contaminant level
MCLGs	Maximum Contaminant Level Goals
NCP	National Contingency Plan
NEPA	National Environmental Policy Act of 1969
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
O&M	Operations and Maintenance
OAC	Ohio Administrative Code
OSHA	Occupational Safety and Health Administration
PFD	Process Flow Diagram

RFD	Reference Dose
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMCL	secondary maximum concentration level
SOWC	Southwest Ohio Water Company
TDS	total dissolved solids
TOC	total organic carbon
TOX	total organic halogens
TSS	total suspended solids
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
Weston	Roy F. Weston, Inc.
WMCO	Westinghouse Materials Company of Ohio

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EXECUTIVE SUMMARY

The U.S. Atomic Energy Commission (AEC), predecessor to the U.S. Department of Energy (DOE), established a production complex in the early 1950s for processing uranium and its compounds from natural uranium ore concentrates. This complex, known as the Feed Materials Production Center (FMPC), is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. The villages of Fernald, Ross, New Haven, and Shandon are all located within a few miles of the plant.

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the DOE and the U.S. Environmental Protection Agency (EPA) pertaining to environmental impacts associated with the extended years of operation at the FMPC. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented.

In response to the FFCA and consistent with the modifications agreed to in March 1990, a Remedial Investigation/Feasibility Study (RI/FS) is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The technical strategy adopted for the RI/FS is to issue distinct RI/FS reports for each of five identified operable units at the FMPC.

One of the operable units (Operable Unit 1) includes those facilities utilized for the storage/disposal of radiological and chemical wastes from FMPC operations. Related facilities that now contain similar waste types are also included. These facilities include Waste Pits 1, 2, 3, 4, 5, and 6; the burn pit; and the Clearwell. Analytical results indicate that elevated concentrations of uranium are present in the storm water runoff from the waste pit area. Because of the associated potential threat to human health and the environment, DOE is pursuing a removal action to control the storm water runoff from this area pending the outcome of the RI/FS and the implementation of a final remedial action for the waste storage units.

Removal actions, as described in the National Contingency Plan (NCP) of April 1990 (40 Code of Federal Regulations [CFR] 300.415), are primarily intended to abate, prevent, minimize, stabilize, mitigate, or eliminate a release or a threat of release prior to a final action if there is a threat to

public health or welfare or the environment. Whenever a planning period of at least six months exists before on-site activities must be initiated and it is determined that a removal action is appropriate, an engineering evaluation/cost analysis (EE/CA) is performed to analyze removal action alternatives and to support the selection of a preferred alternative. This document represents the EE/CA for the waste pit area removal action at the FMPC and will be used by DOE as the basis for selection of the removal action.

The scope for this removal action can be broadly defined as management of radioactively contaminated storm water runoff from the waste pit area. The area includes six waste pits, a burn pit, four concrete silos, the Clearwell, and surrounding areas of approximately 20 acres. Storm water data collected to date from the site drainage ditches in this area indicate the presence of radionuclides and inorganic metals in the storm water runoff from the waste pits and perimeter areas. Most of the radionuclides are found at natural background concentrations. Several of the parameters exceed established concentration guidelines or limits, but most exceedances are sporadic and within the range of uncertainty in the data. Based on the data results, uranium has been designated as the contaminant of concern for the waste pit area removal action.

The fundamental objective of the removal action is to protect public health and the environment by controlling the release of storm water runoff with uranium concentrations exceeding the proposed DOE-derived concentration guides (DCGs) for surface water discharge. Related objectives, founded on other risk-based levels for various potential exposure scenarios, include the protection of biotic environments in Paddys Run and the mitigation of contaminants from surface water to the underlying aquifer.

Based on the study objective of controlling the release of contaminated storm water runoff from the waste pit area to Paddys Run, the following five alternatives were developed as the initial set of alternatives for the waste pit area removal action:

- Alternative 1 - No Action
- Alternative 2 - Surface Capping
- Alternative 3 - Surface Capping with Lateral Drainage Sump Collection
- Alternative 4 - Runoff Collection and Treatment
- Alternative 5 - Source Removal

A brief description of each proposed removal action is provided in the following paragraphs.

Alternative 1 - No Action

Under the no-action alternative, no additional abatement, remediation, treatment, or security activities would occur at the waste pit area. Any reduction in contamination would be brought about by natural phenomena such as radioactive decay and removal of contaminated soil through erosion.

Alternative 2 - Surface Capping

This alternative consists of constructing a cap over surface areas to minimize the contact of rainwater with the contaminated soil. These areas include Waste Pits 1, 2, 3, 5, and 6; the burn pit; and surface areas southeast of the pits. The site will be graded to provide proper drainage. The majority of the water would be routed away from the waste pit area for direct discharge into Paddys Run. In order to maximize the effectiveness of this alternative, three subalternatives were considered: 1) a compacted clay cap, 2) a synthetic liner cap, and 3) a Resource Conservation and Recovery (RCRA) cap. Based on technical and cost decision factors, the synthetic liner cap was selected as the capping alternative of choice.

Alternative 3 - Surface Capping with Lateral Drainage Sump Collection

The surface capping with lateral drainage incorporates the components of Alternative 2 with a lateral drainage collection sump. This alternative would intercept all subsurface lateral flow resulting from infiltration through the cap from rainfall. The flow would be collected in a six-inch trench downgradient from the cap. The trench would be sloped to a central collection sump. Lateral flow would be pumped out of the sump on a semiannual basis from a riser pipe to the biodenitrification surge lagoon. Suspended solids would settle here prior to treatment through the biodenitrification towers and effluent water treatment system. The treated water would then be discharged to the Great Miami River through Manhole 175. The use of the combined cap and collection sump would eliminate the potential release of contaminated infiltrated rainwater from reaching Paddys Run.

Alternative 4 - Runoff Collection and Treatment

This alternative incorporates planned separation of drainage areas within the waste pit storage area, thus isolating contaminated from noncontaminated storm water runoff. Contaminated water will be collected in the existing Clearwell and in a new collection sump and pumping station that will be located south of the Clearwell. Drainage flow control devices will be installed in upstream drainage channels located in the waste pit area to restrict peak flows to the new pumping station.

The new system will pump the collected runoff to the biodenitrification surge lagoon where suspended solids would be allowed to settle prior to treatment through the biodenitrification towers and effluent water treatment system and before discharge to the Great Miami River through Manhole 175.

Alternative 5 - Source Removal

This source removal alternative would consist of removing all disposed waste and contaminated berm and cover soils and regrading the site with clean fill. An estimated 444,500 cubic yards of waste and 58,900 cubic yards of contaminated soil would have to be excavated, packaged in waste disposal boxes, and disposed of at an approved facility. The removal of the source would eliminate the threat of contaminated runoff entering Paddys Run via the waste pit area.

These five alternatives for the storm water runoff removal action were subjected to a screening to ascertain if any could be eliminated from further consideration prior to the detailed evaluation phase. The no-action alternative had to be retained to achieve compliance with the requirements of CERCLA. Of the remaining four alternatives, only the capping alternative and the runoff collection and treatment alternative were judged to be effective and implementable as removal actions and to warrant further evaluation in this EE/CA. The increased effectiveness introduced by the lateral drainage collection system in Alternative 3 was not considered sufficient to offset the increased cost and time required for its implementation. Also, while fully effective in meeting the removal action objectives, Alternative 5 far exceeds the scope of the other removal action alternatives that would satisfy the objectives to a comparable extent.

Alternatives 1, 2, and 4 were then evaluated according to the following criteria:

- Effectiveness
- Implementability
- Cost

The components of the effectiveness criterion include public health protection; environmental protection; the degree to which the toxicity, mobility, or volume of the contaminants in the storm water runoff will be reduced; the consistency of the alternative with the final remedial action alternatives under consideration for the waste pit area; and other miscellaneous factors important to the overall effectiveness of the action.

Factors of implementability considered for the detailed evaluation include technical feasibility, including the availability of applicable technologies, and administrative feasibility. A third evaluation component, timeliness, was also considered due to the strong preference for removal actions that can be designed and implemented in a minimum amount of time to satisfy both the desires and commitments of the involved agencies.

The total cost of an alternative is the final factor considered. This factor includes direct capital costs, indirect capital costs, and any postremoval operation and maintenance costs. A summary of this evaluation is presented in Table ES-1.

As shown in Table ES-1, the no-action alternative is a deficient response action in relation to several factors. First and foremost is the continued release of storm water runoff with uranium concentrations exceeding DOE DCGs, resulting in noncompliance with the guidelines to be considered (TBC) that establish the concentration of uranium that provides protection for a hypothetical maximally exposed individual. Also, the no-action alternative would prolong any environmental impacts associated with the release. The contribution of uranium to the regional aquifer via leakage from Paddys Run will also remain at its current level if no action is taken to reduce the uranium loading to Paddys Run. For these reasons, the no-action alternative is eliminated from further consideration.

Both Alternatives 2 and 4 are shown to satisfy the important public health protection criterion. Both alternatives also satisfy the objective of reducing the uranium loadings to Paddys Run for purposes of protecting the aquatic environment of the stream, with the collection and treatment option providing a higher level of protection since no residual loadings are associated with this alternative. However, overall environmental improvement is better satisfied by the capping alternative since it also protects the local environments downstream from the waste pit area and upstream from Paddys Run. The capping alternative also has the advantage of preventing the contamination of the storm water runoff rather than providing for its treatment after the contamination occurs.

The collection and treatment alternative is consistent with the final remedial actions for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5). This CERCLA-based requirement for a removal action is not, however, satisfied by the capping alternative.

TABLE ES-1

SUMMARY OF EVALUATION OF ALTERNATIVES

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Effectiveness: Public Health	Does not meet TBC for max. exposed individual; no imminent & substantial risk	All exposure pathways within acceptable risk limits	All exposure pathways within acceptable risk limits
Effectiveness: Environmental	No decrease in uranium loading to Paddys Run; continuation of any current impacts	Significant reduction in uranium loading to Paddys Run; overall improvement elsewhere; potential wetlands impact	Total reduction in uranium loading to Paddys Run; little improvement elsewhere; potential wetlands impacts
Effectiveness: Reduction In Toxicity, Mobility, Volume	No reduction in toxicity, mobility, or volume	Significant reduction in uranium concentration and loading in runoff	No reduction in volume of contaminants runoff; "End of Pipe" treatment varies with time
Effectiveness: Consistency with final action	No effect on final action	Not consistent with final actions for Operable Units 1 and 5 unless capping is selected.	Consistent with final actions for Operable units 1 and 5
Effectiveness: Other factors	None	Reduction in infiltration and leaching potential; damage has little effect	No reliance on source of contaminants in runoff

TABLE ES-1 - CONTINUED

SUMMARY OF EVALUATION OF ALTERNATIVES

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Implementability: Technical Feasibility	Not Applicable	Straightforward, with readily available labor and materials; special conditions require consideration	Straightforward, with readily available labor and materials; special conditions require consideration
Implementability: Administrative Feasibility	Maintains conditions exceeding DOE limits; inconsistent with previous commitment	Requires permit to install from Ohio; no other permits for on-site actions; however, requirements for wetlands must be met; would require reversal of previous commitment	No permits required for on-site actions; however, requirements for wetlands must be met
Implementability: Timeliness	No time element involved	Longer design period; longer construction period	Shorter design period; shorter construction period
Cost (Present Worth)	$0	$6,610,000	$3,325,000

Neither alternative represents a significant public health or environmental concern due to temporary system failures or disruptions.

Conditions that will require special attention during both the engineering and construction activities are associated with both the capping and the collection and treatment alternatives. Again, however, none of these conditions are insurmountable constraints to the technical feasibility of the alternative and are not considered to represent a critical decision factor.

The collection and treatment alternative is preferential from an administrative feasibility standpoint due to the lack of administrative constraints to project approval. The current NPDES permit incorporates the addition of the storm water runoff from the waste pit area.

The collection and treatment alternative is also preferential from a timeliness standpoint. This option has been considered as part of the Best Management Practices (BMP) Plan at the site and design is already completed. In addition, the construction time is less than that estimated for the capping option.

The present worth cost of the capping alternative has been estimated to be approximately $6,610,000 while the cost of the collection and treatment alternative is estimated to be $3,325,000. This factor favors the collection and treatment alternative since the costs are one-half those of the capping option.

Based on the comparative evaluation of the capping and the collection and treatment alternatives, there are several factors that favor the collection and treatment alternative as the preferred removal action for the storm water runoff from the waste pit area. First, the collection and treatment alternative is consistent with all final remedies being considered for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5). Second, the time for completion of the alternative is shorter than the capping alternative. Third, this alternative provides an effective solution for one-half the cost of the capping alternative.

1.0 INTRODUCTION

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (U.S. EPA) for DOE's Feed Materials Production Center (FMPC) in Fernald, Ohio. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented.

In response to the FFCA and consistent with the modifications agreed to in March 1990, a Remedial Investigation/Feasibility Study (RI/FS) is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The technical strategy adopted for the RI/FS is to issue distinct RI/FS reports for each of five identified operable units for the FMPC. By accommodating separate schedules for each operable unit, the remedial action decision process is proceeding to completion for the most problematic units while data collection and analysis continue for other operable units.

One of the operable units (Operable Unit 1) includes those facilities utilized for the storage/disposal of radiological and chemical wastes from FMPC operations. Related facilities that now contain similar waste types are also included. These facilities include Waste Pits 1, 2, 3, 4, 5, and 6; the burn pit; and the Clearwell. Analytical results indicate that elevated concentrations of uranium are present in the storm water runoff from the waste pit area. Because of the associated potential threat to human health and the environment, DOE is pursuing a removal action to control the storm water runoff from this area pending the outcome of the RI/FS and the implementation of a final remedial action for the waste storage units.

Removal actions, as described in the National Contingency Plan (NCP) of April 1988 (40 Code of Federal Regulations [CFR] 300.415), are primarily intended to abate, prevent, minimize, stabilize, mitigate, or eliminate a release or a threat of release prior to a final action if there is a threat to public health or welfare or the environment. A second reason for implementing a removal action is to mitigate contaminant migration pending final action if site conditions permit a straightforward mitigative action, and significant migration would occur in the interim if no action is taken. Additionally, removal actions are to be consistent with the anticipated long-term remedial action and to contribute to the efficient performance of the long-term remedy to the extent practicable.

Once a non-time-critical removal action (i.e., a period of greater than six months is available before on-site activities must begin) is deemed appropriate, an engineering evaluation/cost analysis (EE/CA) is performed to analyze removal action alternatives and to support the selection of a preferred alternative. This document represents the EE/CA for the waste pit area removal action at the FMPC. The National Environmental Policy Act of 1969 (NEPA) requires that federal agencies include in their decision-making processes appropriate and careful consideration of all environmental effects of proposed actions. Therefore, this EE/CA has been prepared so as to integrate the requirements of both CERCLA and NEPA and will be used by DOE as the basis for selection of the removal action.

2.0 SITE CHARACTERIZATION

2.1 SITE BACKGROUND

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

The FMPC site is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. The production area is limited to an approximate 136-acre tract near the center of the FMPC site. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant (Figure 2-1).

A variety of chemical and metallurgical processes are utilized at the FMPC for the manufacture of uranium products. High-quality uranium compounds are introduced into the manufacturing process at several points. Impure feed materials are dissolved in nitric acid and the uranium is purified through solvent extraction to yield a solution of uranyl nitrate. Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced with hydrogen to uranium dioxide (UO_2) and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined reduction vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot. Various uranium metal-working processes also exist.

Large quantities of liquid and solid wastes are generated by the various operations at the FMPC. Solid waste materials associated with uranium metals production are presently stored on site in steel drums awaiting further processing or off-site disposal at approved facilities. These wastes include oils, sludges, contaminated combustibles, filter cake, off-spec UF_4 or thorium tetrafluoride (ThF_4), and reject UO_3. The drums sit on various pads and/or in warehouses and are inspected on a

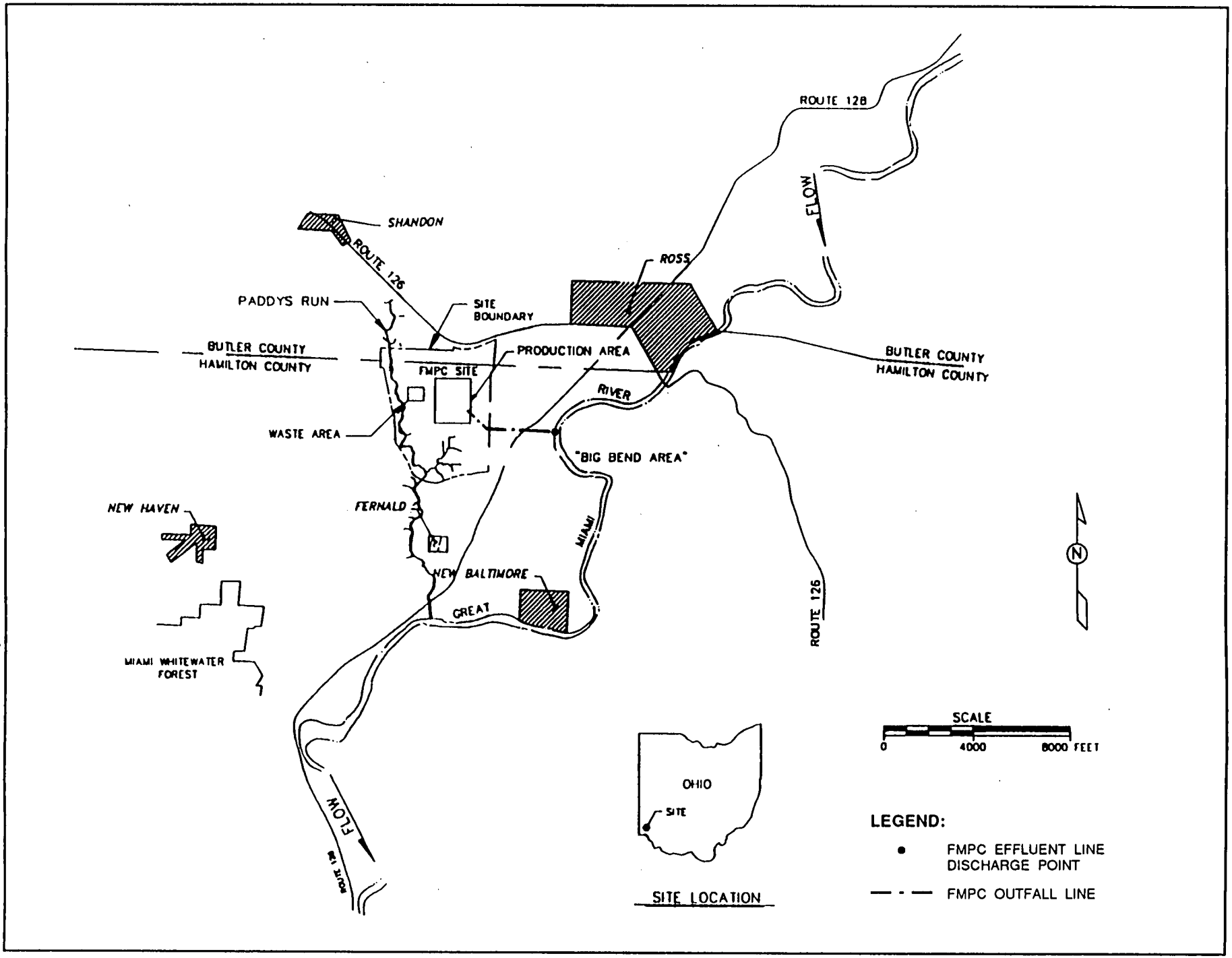

FIGURE 2-1. FMPC SITE AND VICINITY

weekly basis. Contents of deteriorated drums are repackaged. Other stored waste materials include spent degreasing solvents and PCB-contaminated material.

Prior to 1985, solid and slurried wastes from FMPC processes were disposed of in the on-site Waste Storage Area (Figure 2-2). This area, which is located west of the production facilities, includes six low-level radioactive waste storage pits, a burn pit, two earthen-bermed concrete silos containing K-65 residues (i.e., high specific activity and low-level radium-bearing residues resulting from the pitchblende refining process), a concrete silo containing metal oxides, two lime sludge ponds, and a sanitary landfill.

Waste Pit 1 has been out of service since 1959 when it was backfilled, covered with clean soil, and graded to provide surface drainage away from the waste pit area. Pit 1 was constructed in 1952 into existing native clay and then lined with an additional four feet of clay. The maximum depth of the pit is 17 feet. It has an 80,000 square foot surface area with an estimated 40,000 cubic yards of buried waste. This pit contains neutralized waste filter cake, fly ash, scrap graphite, brick scraps, sump liquor/cake, depleted slag, and an estimated 115,000 pounds of uranium.

Waste Pit 2 has been out of service since 1964 when it was backfilled and covered with clean soil. Pit 2 was constructed in 1957 into native clay with a 17-foot maximum depth. It has a 48,215 square foot surface area with an estimated 13,000 cubic yards of buried waste. This pit contains neutralized waste filter cake, scrap graphite, brick scrap, concrete, construction rubble, sump liquor/cake, depleted slag, an estimated 2,700,000 pounds of uranium, and approximately 900 pounds of thorium.

Waste Pit 3 was constructed in 1959 and has been out of service since 1977 when it was backfilled and covered with clean soil. The pit was constructed into an existing clay layer and was lined with an additional foot of clay. The maximum depth of the pit is 27 feet. It has a 238,500 square foot surface area with an estimated 227,000 cubic yards of buried waste. This pit contains lime-neutralized raffinate, raffinate concentrate, slag leach residues, filter cake, and fly ash, with an estimated 290,000 pounds of uranium and approximately 900 pounds of thorium.

Waste Pit 4 has been out of service since 1986 when it was backfilled and covered with clean soil. Recently, an interim cap providing an additional cover of compacted clay overlain by a 45-mil-thick Hypalon chlorosulfanated reinforced polyethylene (CRP) liner was installed to further ensure

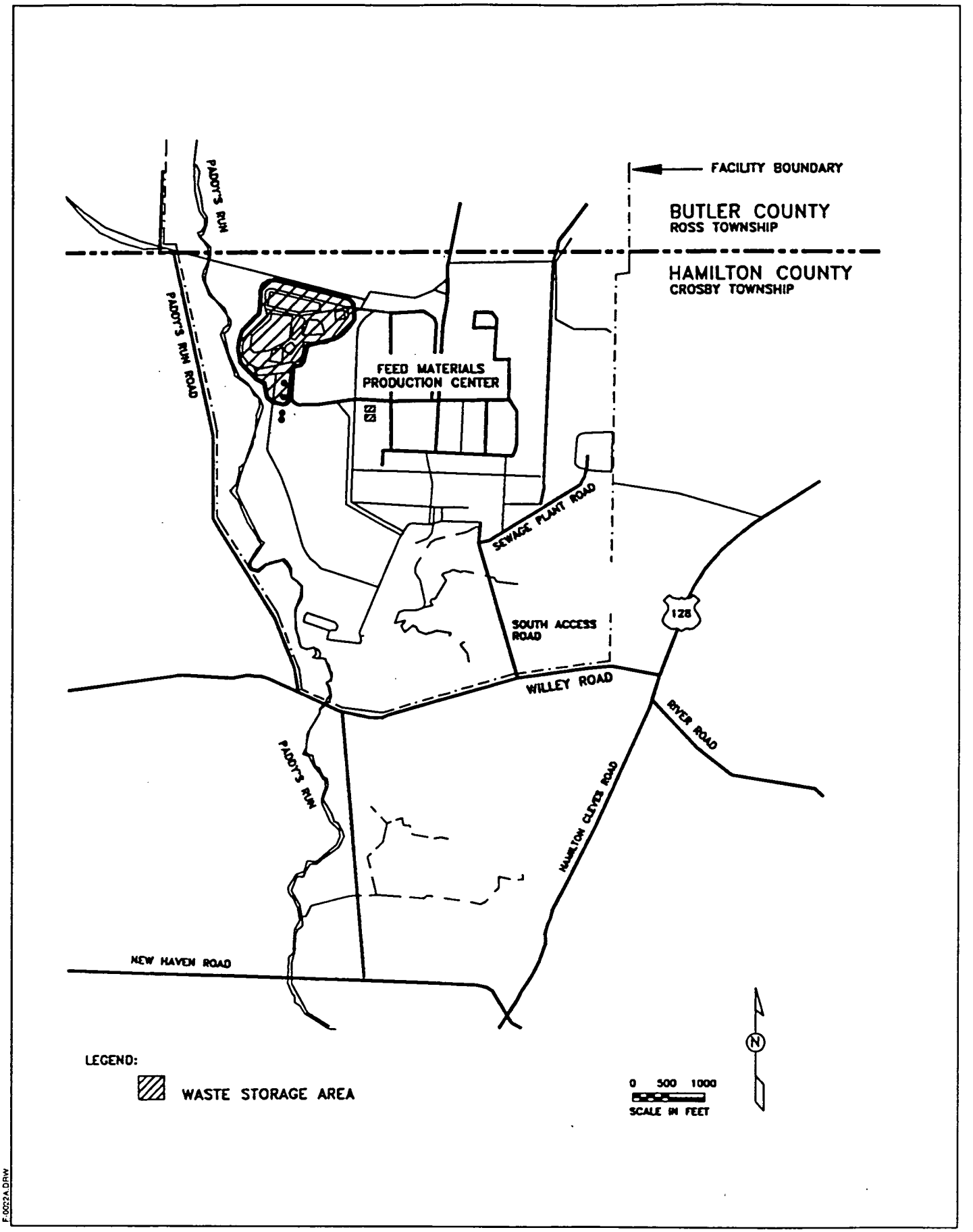

FIGURE 2-2. FMPC GENERAL LAYOUT

segregation of encapsulated materials from surface water during the interim period prior to implementation of a final remedial action under the Record of Decision (ROD). This is a clay-lined pit and was constructed in 1960 with a 24-foot maximum depth. It has an 85,685-square-foot-surface area with an estimated 53,000 cubic yards of buried waste. This pit contains process residues, raffinates, slurries, filter cake, lime sludge, 23,500 pounds of barium chloride, scrap graphite, noncombustible trash, asbestos, and construction rubble, with an estimated 1,400,000 pounds of uranium and 140,000 pounds of thorium.

Waste Pit 5 has been out of service since 1987 although it has not yet been dewatered and covered. It is a 183,737-square-foot, 30-foot-deep pond lined with a 60-mil-thick Royal-Seal ethylene rubber elastomeric membrane. The pit was constructed in 1968 and served as a settling pond for slurried waste from various production processes. It contains an estimated 102,500 cubic yards of settled waste material consisting of neutralized raffinate, slag leach slurry, sump slurry, lime sludge, and some construction debris, with an estimated 110,000 pounds of uranium and 38,000 pounds of thorium. Only rainfall currently enters Waste Pit 5, which flows by gravity from the pit and is released to the Clearwell. Therefore, no storm water runoff of concern to this removal action originates from Waste Pit 5.

Waste Pit 6 has been out of service since 1985 although it has not been covered. It is a 32,400-square-foot, 24-foot-deep pond lined with a 60-mil-thick Royal-Seal ethylene rubber elastomeric membrane. The pit was constructed in 1979 and contains an estimated 9000 cubic yards of waste material consisting of green salt, filter cake, depleted slag, and process residues, with an estimated 950,000 pounds of uranium. Standing water remains trapped within the berms of the pit. As with Waste Pit 5, no storm water runoff originates from Waste Pit 6.

The burn pit was excavated in 1957 as a clay borrow pit for lining Waste Pits 1 and 2. The depth and size of the pit are not precisely known, but it is believed to be approximately 20 feet deep. The pit was subsequently used to dispose of and burn laboratory chemicals, including pyrophoric and reactive chemicals, waste oils, and other low-level contaminated materials such as wooden pallets. The residual waste quantities are not known.

The Clearwell served as a settling basin for process water and storm water runoff from the waste pits. Most recently, the Clearwell was used as a final settling basin for process water that passed through Waste Pit 5 prior to its discharge to the Great Miami River via Manhole 175, a National Pollutant Discharge Elimination System (NPDES) discharge point. This use was terminated in

March 1987 when Pit 5 was removed from the process water treatment scheme. The Clearwell currently receives surface water runoff from the majority of the surfaces of Pits 1, 2, and 3 and from the entire surface of Pit 5. Water of varying depth remains in the Clearwell at all times. The sediments resulting from material deposition were removed on at least one occasion during the period of operation. The depth of sediment remaining in the Clearwell is unknown.

Surface water runoff from a portion of the waste pit area and other affected areas within the western portion of the FMPC enters Paddys Run, a tributary of the Great Miami River. Paddys Run originates just north of the FMPC and flows south-southeast along the western edge of the site and, for a part of the year, is a dry streambed with occasional rainfall-induced flows.

Leachate from these same areas can potentially migrate vertically to the regionally important Great Miami Aquifer which underlies the site. This aquifer serves as a principal source of domestic, municipal, and industrial water throughout the region. A portion of the flow in Paddys Run is also known to enter this aquifer downstream from the waste pit area as a result of leakage through the stream bottom.

Liquid waste effluent generated from FMPC process operations is pumped to a general plant for treatment and analysis prior to release to the Great Miami River through the main effluent line discharge point (Figure 2-1). Storm water runoff from the production area is collected in storm water retention basins to allow solids to settle and is monitored during release through the same effluent line to the Great Miami River. During major storm events, if the storm water retention basins overflow, storm water may be discharged through a storm sewer outfall ditch into Paddys Run.

The main effluent line to the Great Miami River, which is a permitted discharge for wastewater from the FMPC and the storm water presently collected in the Clearwell, would also be the discharge facility for waste pit area storm water runoff under one removal action alternative. The discharge is regulated by an NPDES permit and DOE orders, with compliance monitoring performed at Manhole 175 before the effluent leaves the site boundary. The effluent line is a 4200-foot-long, 16-inch-diameter cast-iron pipe constructed in 1952. Because the lower reaches of the effluent pipeline would be submerged under high water conditions in the Great Miami River, the pipeline was designed to accommodate pressure flow in these lower reaches. The flow capacity of the pipeline has been computed to be about 6.5 million gallons per day (mgd) or 10 cubic feet per second (ft^3/s). This greatly exceeds the value that would be realized under gravity flow only.

In 1987, the average rate of discharge from the pipeline was 0.576 mgd or 0.89 ft^3/s (WMCO 1988), far below the design capacity.

One requirement of the NPDES permit for the FMPC specifies that the following effluent characteristics be monitored at Manhole 175: flow rate, BOD, pH, suspended solids, ammonia, oil and grease, residual chlorine, and nitrate. DOE orders also require daily sampling for radionuclides, with the daily samples composited on a weekly basis for laboratory analysis. Based on the analytical data from the weekly composites, the average concentration of total uranium in the FMPC effluent discharge in 1987 was found to be 660 picocuries per liter (pCi/L). This was about the same as the average value of 661 pCi/L measured in 1985 and more than the average value of 450 pCi/L measured in 1986 (WMCO 1986, 1987).

To ensure compliance with the NPDES limits for nitrate, a demonstration biodenitrification (BDN) facility was constructed and placed into operation in 1986. This treatment system includes a biodenitrification surge lagoon (BSL) and biodenitrification towers. The BSL is used to equalize and settle process wastewater and storm water runoff flows before processing for nitrate removal in the downstream towers. The BDN is currently being upgraded to full production status.

Additionally, an Advanced Wastewater Treatment (AWWT) Facility is proposed to treat FMPC wastewater discharge to Manhole 175 for the removal of radioactivity. DOE Order 5400.5 requires best available technology (BAT) as the required level of treatment for liquid wastes containing radioactive material. The facility will be designed to comply with this order. The streams targeted for treatment are the general sump, biodenitrification facility (of which the waste pit area storm water flows will be part), sewage treatment plant, and storm water retention basin. Preliminary designs target the use of ion exchange, reverse osmosis, or a combination of both, whichever provides BAT treatment. The final design will be based on treatability studies that are presently being conducted.

2.2 SITE SETTING

The following description of the physical setting of the FMPC and surrounding area was derived from various existing reports. Two documents were relied on substantially (IT 1988; DOE 1987) and are not specifically referenced in the text. Other documents used to support individual statements are appropriately cited within the text.

2.2.1 Climate

Data from the Greater Cincinnati International Airport has been shown to satisfactorily characterize the climatic regime of the FMPC area. Wind-flow data from the Dayton Airport have been utilized as a secondary data source.

The regional climate is defined as continental, with temperatures ranging from a monthly average of 29°F in January to 75°F in July. The highest temperature recorded from 1950 through 1984 was 102°F in August 1962 and the lowest was -25°F in January 1977. The average number of days per year with a minimum temperature of 32°F or less is 110 days, and the average number of days with a maximum temperature of 90°F or above is 20 days per year. Frost depth ranges from 30 to 36 inches.

The average annual precipitation for the period 1955 through 1984 was 37.75 inches and ranged from 29.22 to 40.64 inches. The highest precipitation occurs during the spring and early summer; precipitation is lowest in late summer and fall. The average annual snowfall for the same period was 24.0 inches, with heaviest snowfall in January.

2.2.2 Surface Water Hydrology

The FMPC is located within the Great Miami River Basin drainage but above the river's present-day floodplain. The Great Miami River is the receiving stream for the FMPC effluent discharge and represents the main surface water feature in the vicinity of the FMPC. The river flows generally to the southwest and has a drainage area of approximately 3360 square miles at the Hamilton gage, which is located about 10 miles upstream from the FMPC discharge outfall. The average discharge of the Great Miami River at Hamilton, based on 55 years of records, is 3305 ft^3/s. Using drainage area scaling, the corresponding average flow at the FMPC point of discharge has been estimated to be 3460 ft^3/s. The minimum daily discharge of 155 ft^3/s was recorded on September 27, 1941. This value is approximately one-half of the 7-day, 10-year low-flow value (Q_{7-10}) of 267 ft^3/s, as computed by the U.S. Geological Survey (USGS) for the Hamilton gage. This translates to 280 ft^3/s at the site reach.

Natural surface drainage from the FMPC is primarily to Paddys Run. Paddys Run originates north of the site, drains southward through the western portion of the FMPC, and eventually enters the Great Miami River approximately 1.5 miles south of the FMPC (Figure 2-1). This stream loses flow to the groundwater along much of its course due to its highly permeable channel bottom and limited elevation above the regional groundwater table. Paddys Run is an ungaged, intermittent

stream that flows primarily between January and May, with an estimated discharge for this period ranging between 0.2 and 4.0 ft^3/s. Its floodplain does not encompass any portion of the waste pit area.

A principal drainage feature of the FMPC is a tributary to Paddys Run known as the storm sewer outfall ditch. This drainage course originates south of the production area, flows southwest across the southern portion of the site, and enters Paddys Run downstream from the waste pit area near the southwest corner of the property. Much of the stream bottom of this drainage course, which also collects runoff from an area east of the plant, is composed of sand and gravel. Vertical seepage rates through the stream bottom may be high. This drainage course is generally dry throughout most of the year, with flows occurring during and immediately after precipitation.

The storm sewer outfall ditch historically conveyed surface water runoff from the production area directly to Paddys Run when the capacity of the storm sewer lift station, which diverts low flow to Manhole 175, was exceeded. Two storm water retention basins were recently constructed at the head of the storm sewer outfall ditch. Storm water runoff from the production area is now conveyed to these retention basins. The basins, designed to retain the runoff from a 10-year, 24-hour rainfall event, essentially eliminate the contribution of storm water from the production area to the outfall ditch and thus to Paddys Run. After at least a 24-hour retention period to allow for settling of suspended solids, the water is pumped out of the retention basins to the Great Miami River via the FMPC's main effluent line.

2.2.3 Groundwater Hydrology

The FMPC is located within a two- to three-mile-wide subterranean valley known as the New Haven Trough, a valley that formed as a result of Pleistocene glaciation and subsequent filling with glacial outwash materials and till. The FMPC lies on top of terrace remnants left after the establishment of the present-day Great Miami River channel. The lower portions of Paddys Run have cut through this till and lie directly on the sands and gravels of the buried channel.

Flat-lying, olive-gray Ordovician shale with thin, interbedded layers of limestone form the floor and valley walls of the New Haven Trough. The trough ranges from 60 to more than 200 feet deep in the vicinity of the FMPC and is filled with approximately 150 feet of Pleistocene glacial valley fill deposits, generally composed of sand and gravel outwash deposits. The buried valley is about one-half to over two miles wide and is U-shaped, having a broad, relatively flat bottom and steep valley walls. Interbedded glacial till deposits occur within the outwash deposits, but in most cases are of

limited lateral extent. The till deposits are composed primarily of poorly sorted pebbles, cobbles, and boulders in a predominantly clay matrix.

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

Large groundwater supplies of regional significance occur in the outwash deposits (buried channel aquifer) and are recharged by three principal sources: recharge from bedrock, precipitation recharge, and recharge by stream infiltration. Under natural conditions, the gradient of groundwater flow is from the aquifer to the Great Miami River, except during dry periods when the gradient is reversed. Intermittent recharge to the aquifer also occurs along Paddys Run. The groundwater in the regional aquifer beneath the FMPC flows from the buried valleys west, north, and east towards the center of the FMPC study area and subsequently south-southeast through the branch of the buried channel aquifer west of New Baltimore. However, large pumping wells of the Southwest Ohio Water Company (SOWC) in the "Big Bend" (Figure 2-1) meander of the Great Miami River east of the FMPC produce a pronounced cone of depression that, due to bedrock geometry, extends more in the east-west direction than in the north-south direction. This results in a groundwater divide and in an eastward groundwater flow component across portions of the FMPC, including the waste pit area. Consequently, infiltration into the regional aquifer beneath the waste pits would tend to move eastward, while storm water runoff from the same area could enter Paddys Run and subsequently be lost to the regional aquifer in an area with a southern flow component.

2.2.4 Soils

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

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

2.2.5 Vegetation and Wildlife

The FMPC is in a region containing beech and mixed deciduous forests. Generalized habitats on the FMPC have been described as grazed and ungrazed pastures, the reclaimed fly ash pile, pine plantations, and deciduous and riparian woodlands (Facemire et al. 1990). Grasses and herbs dominate the pasture areas and covered waste pit areas. Deciduous woodlands occur mainly north of the production area and contain a variety of species, including ash, elm, hickory, and sugar maple.

Jurisdictional wetlands on the FMPC are being delineated as part of the RI/FS. Wetlands identified in the waste pit area include the riparian woodland along Paddys Run, the drainage ditches along the railway north of Waste Pit 5, and other drainage ditches in the waste pit area (Figure 2-3). The dominant tree species in the riparian woodland are eastern cottonwood, American elm, hackberry, and boxelder. Cattails and rushes grow in the drainage ditches in the waste pit area and in portions of Paddys Run. The most common fish in Paddys Run are bluntnose and stoneroller minnows, creek chubs, shiners, and darters (Facemire et al. 1990). Fifty-six benthic macroinvertebrate taxa have been identified in Paddys Run. The most common of these are nonbiting midges, riffle beetles, mayflies, and stoneflies. Ecological diversity in Paddys Run is considered typical for area streams (Facemire et al. 1990).

Common fish species in the Great Miami River include carp, gizzard shad, and sunfish (WMCO 1988). Fish populations in the Great Miami River remain healthy and have not changed appreciably since 1984 (WMCO 1988).

A study to assess the acute and chronic toxic effects of effluent from the FMPC on algae, invertebrates, and fish is being conducted for the environmental media operable unit. The potential effects of FMPC contaminants on the macroinvertebrate community structure in the Great Miami River and Paddys Run are also being examined as part of the RI/FS.

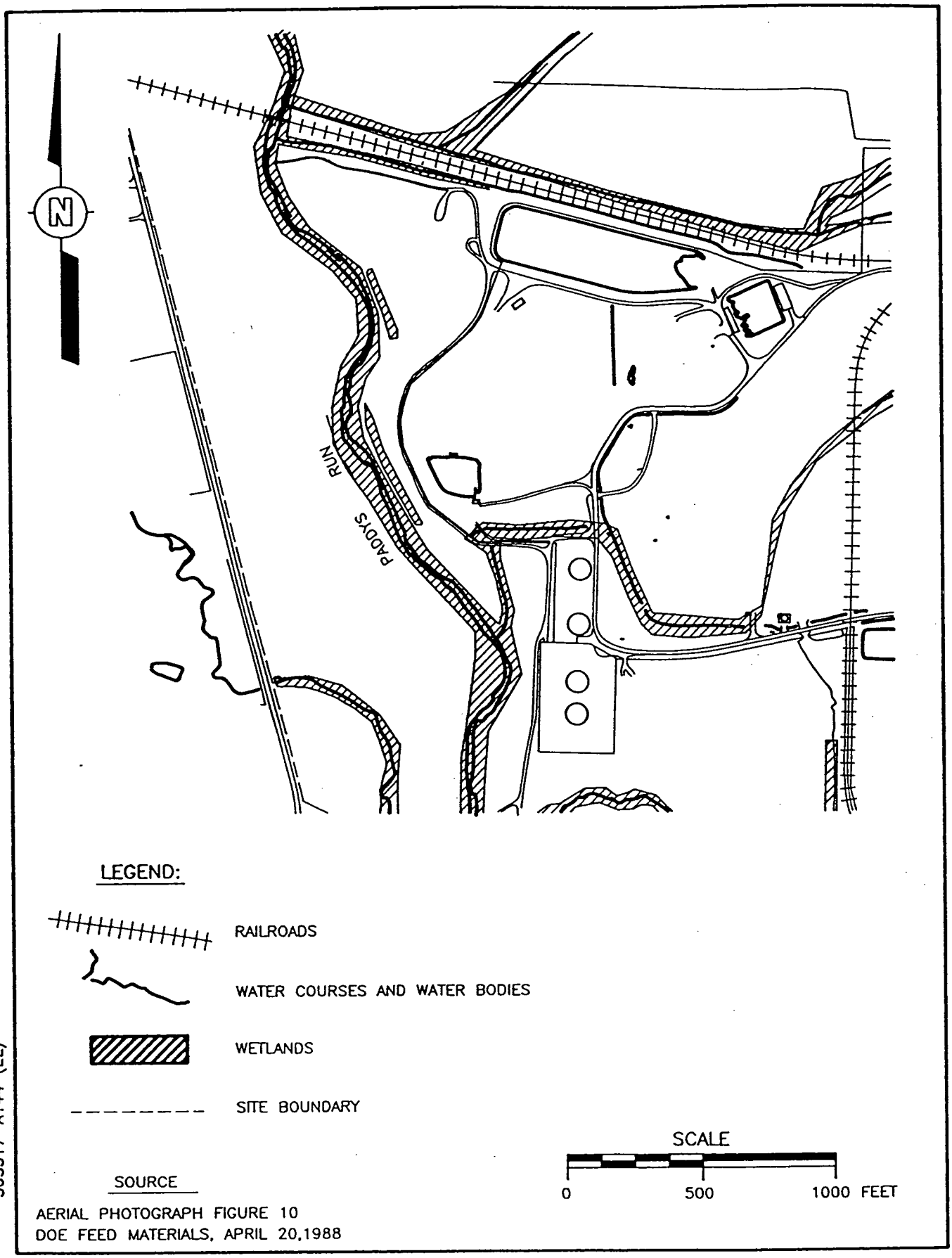

FIGURE 2-3

WETLANDS DELINEATED
IN WASTE PIT AREA

Mammals in the FMPC area predominantly include the whitetail deer, eastern cottontail, fox squirrel, eastern chipmunk, woodchuck, and raccoon. Birds requiring open pasture, wooded, and shrubby field habitats have been observed on the site. These include the red-winged blackbird, mourning dove, blue jay, tufted titmouse, song sparrow, and common yellowthroat.

The FMPC is within the geographic ranges of several species determined by the U.S. Fish and Wildlife Service to be endangered or threatened. These include the Indiana bat, bald eagle, peregrine falcon, and northern wild monkshood (50CFR17.11 and 17.12). The cave salamander is recognized as state endangered (ODNR 1974). There are no critical habitats in the vicinity of the FMPC. The bald eagle and peregrine falcon do not nest in the counties surrounding the FMPC site and would occur only as rare transients along the Great Miami River. The northern wild monkshood has not been observed in the FMPC area.

During RI/FS biological sampling, Indiana bats were not found on or adjacent to the FMPC, but were netted at a monitoring site three miles northeast of the FMPC boundary. Potential habitat for the Indiana bat along Paddys Run ranges in quality from poor to excellent, with over 50 percent fair. The cave salamander was not found within FMPC boundaries during RI/FS sampling. Marginal habitat for this species was identified along Paddys Run.

A study to assess the acute and chronic toxic effects of effluent from the FMPC on algae, invertebrates, and fish is being conducted for the environmental media operable unit. The effects of the effluent on the macroinvertebrate community structure in the Great Miami River and Paddys Run are also being examined as part of the RI/FS.

2.2.6 Land Use and Population

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

Scattered residences and several villages, including Fernald, New Baltimore, Ross, and Shandon, are located near the FMPC. The city of Cincinnati and its suburbs are 10 to 15 miles southeast of the FMPC and the town of Hamilton is 8 miles to the northeast. There is an estimated population of over 14,000 within a five-mile radius of the site.

The area surrounding the FMPC contains several sites of historical interest, but none are within the immediate waste pit study area. The National Register of Historic Places lists four prehistoric Indian sites within a three-mile radius. These include the Adena Circle, the Demoret Mound, the Colerain Work, and the Dunlap Work. The closest site, the Colerain Work, is situated approximately one mile east of the FMPC. The State Historical Preservation Officer reports that there are no known sites of archaeological significance on the FMPC site. There are also no known archaeological sites in the immediate vicinity of the waste pit area.

2.3 ANALYTICAL DATA

2.3.1 Introduction

The waste storage area at the FMPC has undergone storm water runoff samplings by four contractors: 1) WMCO; 2) Roy F. Weston, Inc. (Weston); 3) Advanced Sciences, Inc./International Technology (ASI/IT); and 4) Dames and Moore.

The sampling performed by WMCO and Weston was accomplished using standard techniques as described in "Sampling Plan for the Characterization of Storm Water Runoff at the Feed Materials Production Center," October 1987, and "Quality Assurance and Quality Control Plan for Preparation of Best Management Practices (BMP) Plan for the Feed Materials Production Center," October 30, 1987. The sampling performed by ASI/IT was accomplished using standard techniques as described in the "Surface Water and Sediment Sampling Plan" (Section 5.0 of the "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Volume I - Sampling Plan," Rev. 3) and the RI/FS "Quality Assurance Project Plan."

Sample locations are identified in Figure 2-4. The analytical results of the storm water runoff sampling data are summarized in Tables 2-1 through 2-4. Only the sample locations which relate to the waste pit area are tabulated; therefore, the results presented in the tables are actually subsets of each contractor's sampling data.

Table 2-1 is a tabulation of WMCO data indicating analytical results of total uranium in storm water runoff reported in total milligrams per liter (mg/L). The data was taken between April 23, 1987 and November 9, 1989; 12 sample locations are identified as being within the waste pit area. Table 2-2 is a tabulation of data, taken by Weston, indicating the analytical results for drainage ditch samples collected on July 20 and July 21, 1988. An asterisk (*) indicates the parameter was

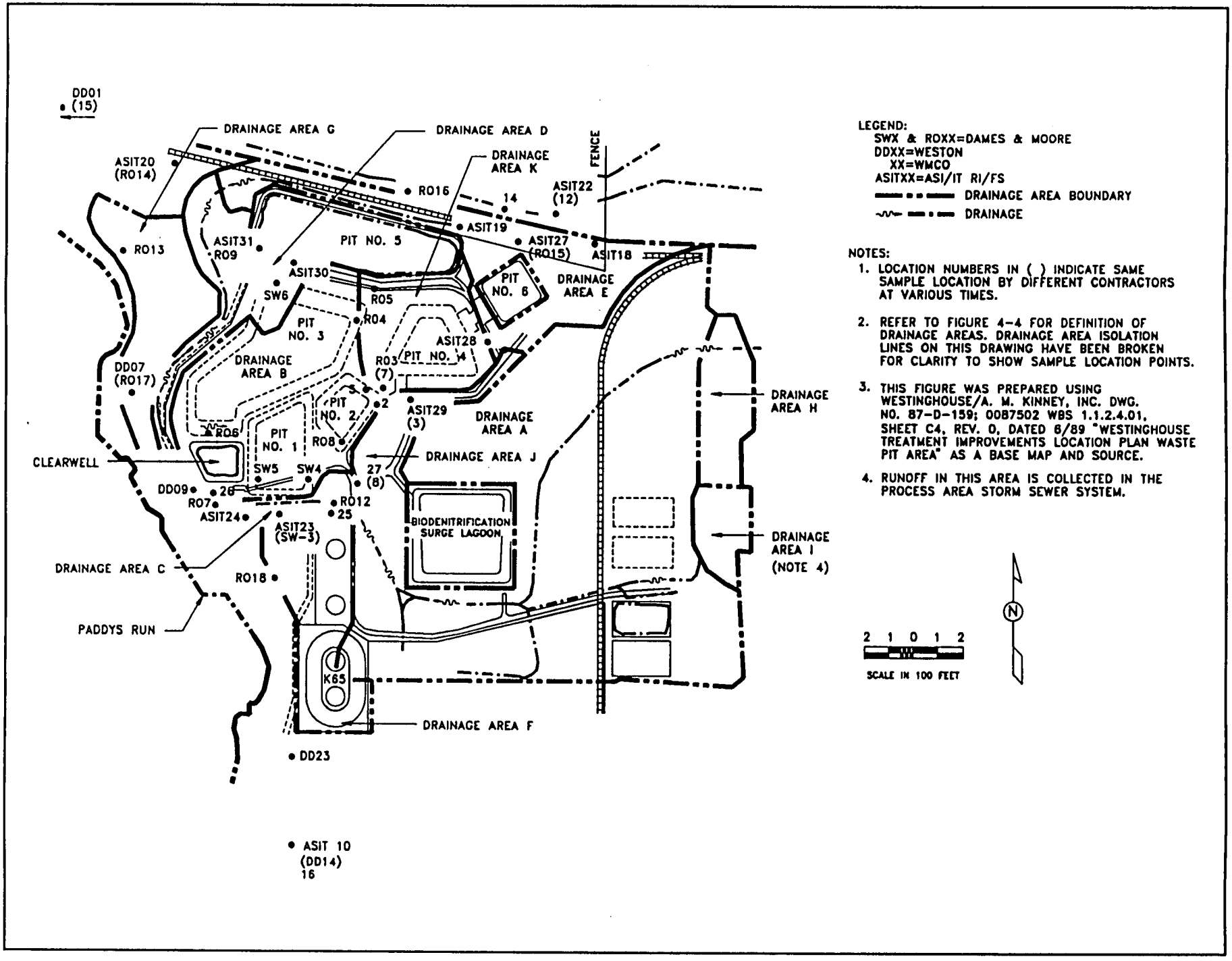

FIGURE 2-4. STORM WATER RUNOFF SAMPLE LOCATIONS

TABLE 2-1
WMCO DATA FOR SURFACE WATER RUNOFF

Sample Point Location	Total Uranium (mg/l) By Sampling Date (Unfiltered)									
	4/23/87	7/28/87	1/20/88	2/1/88	3/2/88	3/3/88	3/25/88	3/21/89	9/14/89	11/8/89
2	-	-	-	-	-	-	-	-	2.00	8.3
3	-	-	-	-	-	-	-	-	4.70	15.2
5	-	-	-	-	-	-	-	0.800	1.74	14.9
7	-	-	-	-	-	-	-	-	1.56	3.4
8	-	-	-	-	-	-	-	0.770	2.52	6.6
14	DRY	0.163	0.320	0.128	0.043	0.096	0.042	-	0.027	-
15	0.052	0.028	0.200	0.047	0.046	0.078	0.050	-	0.051	15N-0.265 15S-0.224
16	0.007	0.256	0.160	0.071	0.801	0.32	0.28	-	0.16	0.226
25	-	-	-	0.793	2.38	1.64	0.70	0.440	0.28	0.249
26	-	-	-	1.013	2.24	1.54	0.72	0.340	0.32	0.449
27	-	-	-	0.454	11.30	2.70	6.44	-	-	-

SOURCE: Site Environmental Monitoring Data

TABLE 2-2
WESTON DATA FOR SURFACE WATER RUNOFF

Analyte	Drainage Ditch Samples Collected July, 1988				
	DD-07	DD-09	DD-14	DD-23	DD-01
Aluminum, µg/L	456	964	14,400	11,700	869
Barium, µg/L	320	209	387	226	217
TOC, mg/L	118	7.6	16.6	9.4	14.4
TOX, µg/L	260	37	39	43	41
TDS, mg/L	1190	414	358	155	692
TSS, mg/L	20.0	148	2150	385	266
Chloride, mg/L	28.1	39.3	227	2.5*	11.3
Fluoride, mg/L	1.2	1.3	0.68	0.32	0.24
Nitrate, mg/L	0.20*	2.6	1.8	0.20*	1.0*
Gross Alpha pCi/L	850±50	420±30	450±60	100±20	8±5
Gross Beta pCi/L	560±20	380±10	370±30	110±10	13±3
Thorium-228 pCi/L	NR	0.1±0.3	NR	NR	NR
Thorium-230 pCi/L	NR	1.4±0.5	NR	NR	NR
Thorium-232 pCi/L	NR	0.1±0.2	NR	NR	NR
Uranium-234 pCi/L	160±30	57±30	120±10	14±4	0.6±0.5

TABLE 2-2 (Continued)
WESTON DATA FOR SURFACE WATER RUNOFF

Analyte	Drainage Ditch Samples Collected July, 1988				
	DD-07	DD-09	DD-14	DD-23	DD-01
Uranium-235 pCi/L	5±10	1.0±8.6	21±5	2.0±1.3	0.3±0.2
Uranium-238 pCi/L	740±60	310±40	220±20	64±6	2.4±0.5
Radium-226 pCi/L	NR	NR	7.0±0.6	NR	NR
Radium-228 pCi/L	NR	NR	4.5±1.8	NR	NR
Chromium, µg/L	10.0*	10.0*	12.8	18.5	10.0*
Sulfate, mg/L	38.3	89.9	48.4	14.3	317

* The value reported is the laboratory detection limit. The sample was analyzed, but the specified contaminant was not detected.

NR - An analysis for the parameter was not requested.

SOURCE: Addendum to Best Management Practices Plan: Stormwater Sampling Program Results prepared by Roy F. Weston, Inc., October 18, 1988

TABLE 2
ASI/IT DATA FOR SURFACE WATER RUNOFF

Parameter	Sample Location and Sample Date												
	ASIT-001 S 1133 3/29/89	ASIT-010 S 1118 3/10/89	ASIT-18 S 1155 3/21/89	ASIT-19 S 1157 3/21/89	ASIT-20 S 1159 3/21/89	ASIT-22 S 1163 3/21/89	ASIT-23 S 1151 3/21/89	ASIT-24 S 1153 3/21/89	ASIT-27 S 1203 5/9/89	ASIT-28 S 1205 5/9/89	ASIT-29 S 1112 3/10/89	ASIT-30 S 1166 3/21/89	ASIT-31 S 1168 3/21/89
Aluminum µg/L	---	---	---	---	232	---	---	---	---	---	---	383	395
Barium µg/L	---	---	---	---	47.2	---	---	---	---	---	---	57.2	54.6
TOC mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---
TOX µg/L	---	---	---	---	15.0	---	---	---	---	---	---	29.2	16.1
TDS mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---
TSS mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---
Chloride mg/L	---	---	---	---	7	---	---	---	---	---	---	60	49
Fluoride mg/L	---	---	---	---	0.44	---	---	---	---	---	---	0.85	0.85
Nitrate mg/L	---	---	---	---	2.3	---	---	---	---	---	---	9.73	10.9
Gross Alpha pCi/L	21	232	---	---	---	---	---	---	---	---	362	---	---
Gross Beta pCi/L	---	67	---	---	---	---	---	---	---	---	193	---	---
Thorium-228 pCi/L	---	---	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	---	---	---	<1.0	<1.0
Thorium-230 pCi/L	---	---	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	---	---	---	<1.0	<1.0
Thorium 232 pCi/L	---	---	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	---	---	---	<1.0	<1.0
Uranium-234 pCi/L	---	---	62.9	72.6	40.6	10.3	76.9	85.8	---	---	---	653	597
Uranium-235 pCi/L	---	---	5.3	5.6	3.4	<1.0	6.0	6.7	---	---	---	51.5	38.3
Uranium 238 pCi/L	---	---	244	364	183	18.0	165	195	---	---	---	2840	2506
Radium-226 pCi/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	3.4	<1.0	<1.0
Radium-228 pCi/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	10.9	4.2	<3.0	<3.0
Chromium µg/L	---	---	---	---	19.9	---	---	---	---	---	---	52.5	45.2
Sulfate mg/L	---	---	---	---	129	---	---	---	---	---	---	120	123
Total Uranium mg/L	0.02	0.2	0.7	0.9	0.5	0.05	0.4	0.6	9.3	5.8	1.0	8.4	7.4

Source: Fernald RI/FS data base

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TABLE 2-4
DAMES AND MOORE DATA FOR SURFACE WATER RUNOFF

Sample Point Location	Date Collected	Total Uranium, mg/L
SW-3	8/11/86	3.76
SW-4	8/11/86	16.42
SW-5	8/11/86	26.55
SW-6	8/11/86	1.21
RO-3	3/85	0.007
RO-4	3/85	28.0
RO-5	3/85	24.0
RO-6	3/85	4.6
RO-7	3/85	0.31
RO-8	3/85	34.0
RO-9	3/85	3.0
RO-12	3/85	0.34
RO-13	3/85	0.54
RO-14	3/85	0.48
RO-15	3/85	0.71
RO-16	3/85	0.62
RO-17	3/85	11.0
RO-18	3/85	0.53

SOURCE: WMCO, Aug. 25, 1986, Letter EH (EC): 86-0365.

analyzed but not detected. The minimum detection limit, not the method detection limit for the sample, is reported preceding the asterisk. Five drainage ditch sample locations are considered applicable for this removal action. For all samples collected by Weston, analyses included uranium and other chemical and radiological parameters as indicated in Table 2-2.

Table 2-3 is a tabulation of ASI/IT data indicating the analytical results for chemical and radiological parameters in the surface water samples collected on the dates indicated in the table.

Table 2-4 is a tabulation of data collected by Dames and Moore, indicating the analytical results of surface water runoff samples collected on August 11, 1986 and samples collected in March 1985 from the waste pit area. The surface water samples collected in 1986 are designated as "SW" and those collected in 1985 are designated as "RO." Eighteen sample locations are identified on the table.

The sample locations are mapped in Figure 2-2. Some locations have been sampled by more than one contractor. These locations are identified in Figure 2-2.

2.3.2 Analytical Results

2.3.2.1 Metals

Only two of the four contractors tested for metals, Weston and ASI/IT. Hazardous Substance List (HSL) metals analyses were not included in the analysis of background surface water samples at the site. Therefore, the determination of above background concentrations is not possible at this time.

The highest level for aluminum was 14,400 µg/L which was from the Weston DD-14 sample location south of the K-65 silos. The highest level for aluminum from the ASI/IT data was 395 µg/L from location ASIT-31 (sample 1168) along the western edge of the pits. The samples were not filtered. There are no regulatory limits set for aluminum.

Barium has an established maximum contaminant level (MCL) of 1.0 mg/L as established by the EPA Safe Drinking Water Act (SDWA) interim primary drinking water standards. The limit was not exceeded in any of the samples. The highest detected concentration was 387 µg/L from Weston DD-14. The lowest detected concentration was 47.2 µg/L from ASIT-20 (sample 1159).

The MCL for chromium is 50 µg/L (EPA 1988) and the laboratory detection limit is 10.0 µg/L. Only one sample from the five Weston sample locations had detectable levels of chromium, which was DD-23 at 18.5 µg/L. Of the relevant ASI/IT data, three sample locations were tested for chromium, with all three having detectable levels of chromium. The highest concentration of chromium detected was 52.5 µg/L at sample location ASIT-30, which slightly exceeded the MCL for chromium. Sample location ASIT-30 is between Pits 3 and 5; no other surface water samples had concentrations exceeding the MCL. The lack of pervasiveness of the chemical throughout the area of interest indicates that chromium is not a principal chemical of concern to this study.

2.3.2.2 Other Water Quality Parameters

Only the Weston samples were analyzed for total organic carbon (TOC). The highest concentration reported was 118 mg/L from location DD-07. No MCLs or any other standard are available for comparison of TOC concentrations.

All samples collected by Weston and ASI/IT were analyzed for total organic halogens (TOX). The highest concentration of TOX was detected at Weston DD-07 with a concentration of 260 µg/L. The highest concentration of TOX at the ASI/IT sample locations was 29 µg/L. No standards or MCLs are available for comparison to the TOX levels detected.

Only Weston performed an analysis for total dissolved solids (TDS). The highest concentration was found at sample location DD-07 at 1190 mg/L, which exceeds the EPA Secondary Drinking Water Standards secondary maximum concentration level (SMCL) of 500 mg/L and the Ohio Administrative Code (OAC) standard for TDS, set at 500 mg/L (monthly average) and 700 mg/L (transient).

For total suspended solids (TSS), only the Weston study provided test results. For the five sample locations given in Table 2-2, the concentrations of TSS ranged from 20 mg/L to 2150 mg/L, with the highest concentration measured at location DD-14. Using the NPDES limits for FMPC discharge, TSS are set at 20 mg/L (daily average) and 40 mg/L (daily maximum). However, there is no MCL for TSS. Four of the sample locations (DD-01, DD-09, DD-14, and DD-23) exceeded the daily average limit of 20 mg/L and one location (DD-07) equalled the limit.

Both the Weston and ASI/IT samples were analyzed for chloride. The highest chloride concentration was found in the Weston sample location, DD-14 at 227 mg/L, which does not exceed the SMCL for chloride set at 250 mg/L. The lowest detectable chloride concentration was

found in the ASI/IT data at sample location ASIT-20 with a concentration of 7 mg/L. Chlorides were found in one sample from Weston location DD-23 at a concentration less than the detection limit of 2.5 mg/L.

Both the Weston and ASI/IT data were analyzed for fluoride. The MCL for fluoride is 1.4 mg/L, while the OAC standard for fluoride is 1.0 mg/L. The highest fluoride concentration found was 1.3 mg/L at sample location DD-09, which slightly exceeds the 1.0 mg/L standard. The concentration of fluoride from one other Weston sample location, DD-07, exceeds the 1.0 mg/L limit with a concentration of 1.2 mg/L. Samples from three ASI/IT sample locations (ASIT-20, ASIT-30, and ASIT-31) did not exceed the 1.0 mg/L concentration for fluoride.

For sulfate, the highest observed concentration was 317 mg/L at Weston sample location DD-01, which is somewhat in excess of the OAC standard of 250 mg/L. The highest sulfate concentration for the three ASI/IT samples analyzed for sulfate was 129 mg/L. The lowest concentration was 14.3 mg/L at Weston sample location DD-23.

The highest concentration for nitrate was 10.9 mg/L at ASI/IT sample location ASIT-31, which slightly exceeds the primary MCL and the OAC standard for nitrate set at 10 mg/L. The second highest concentration level was 9.7 mg/L at ASI/IT sample location ASIT-30. The lowest detectable nitrate concentration was 1.8 mg/L at Weston sample location DD-14.

2.3.2.3 Radionuclides and Gross Radioactivity

Samples collected from a total of 18 sample locations (5 from Weston and 13 from ASI/IT) were analyzed for the concentration of multiple radionuclides including thorium -222, -228, and -230; uranium -234, -235, and -238; radium -226 and -228; and gross alpha and gross beta radioactivity. The Weston surface water samples were not filtered prior to analysis, whereas the surface water samples collected by ASI/IT were analyzed prior to and following filtration. For proper comparison with Weston data, the unfiltered analysis for each ASI/IT sample will be used in this section. The differences in radionuclide concentrations between filtered and unfiltered samples is an important factor in the evaluation of alternatives, however, and will be discussed in Chapter 5.0.

DOE Order 5400.5 sets guidelines now in effect for the FMPC for the discharge of radionuclides. Concentrations established from these guidelines are called derived concentration guides (DCGs).

The DCG is the concentration of a radionuclide in air or water (in this case water) that, under conditions of exposure for one year by one exposure mode (i.e., ingestion of water), would result in an effective dose equivalent of 100 milirems (mrem).

The DCG for thorium-228 is 400 pCi/L. The concentration for thorium-228, -230, and -232 was not requested for four of the five Weston sample locations. The sample from location DD-09 was analyzed for thorium-228, -230, and -232, with readings of 0.1 pCi/L, 1.4 pCi/L, and 0.1 pCi/L, respectively. These values are well within the limits set by DOE Order 5400.5. DOE DCGs for thorium-230 and -232 are 300 pCi/L and 50 pCi/L, respectively. For those samples from ASI/IT sample locations which were analyzed for thorium, the results indicate concentrations less than 1.0 pCi/L, which are well within the DOE guidelines.

Samples from all locations, except Weston, were analyzed for total uranium. The highest concentrations of total uranium from the WMCO data were found in the samples collected November 8, 1989 for sample locations 3 and 5, with 15.2 mg/L and 14.9 mg/L, respectively. The highest concentrations of total uranium from the ASI/IT data were found at sample locations ASIT-27 (sample 1203), ASIT-30 (sample 1166), and ASIT-31 (sample 1168), with concentrations of 9.4 mg/L, 8.4 mg/L, and 7.4 mg/L, respectively. The total uranium concentration levels for the remaining ASI/IT sample locations ranged from 0.02 mg/L to 5.8 mg/L.

The highest concentration of total uranium in surface water from the Dames and Moore data occurred at sample location SW-5, with a concentration of 26.6 mg/L. The total uranium concentration of the remaining sample locations ranged from 1.2 mg/L to 16.4 mg/L. Dames and Moore also analyzed surface water samples from drainage ditches in which sample location RO-8 had the highest concentration of total uranium of 34.0 mg/L. Sample location RO-8 is within drainage basin C. The uranium concentration of surface water of the remaining sample locations ranged from 0.007 mg/L to 28.0 mg/L.

The DOE DCG for uranium-234 is 500 pCi/L. Concentrations of uranium from two ASI/IT sample locations exceed this limit. Samples from locations ASIT-30 (sample 1166) and ASIT-31 (sample 1168) have measured concentrations of 653 pCi/L and 597 pCi/L, respectively. Concentrations measured for all other ASI/IT samples ranged between 10.3 pCi/L and 85.6 pCi/L and were well within the guidelines. All of the Weston sample results are within the DOE guideline. The Weston concentrations ranged from 0.6 pCi/L to 160 pCi/L.

The uranium 235/236 DCG set by DOE is 600 pCi/L. All of the Weston sample concentrations for uranium-235/236 are well within this limit, ranging from 0.3 pCi/L to 21.0 pCi/L. Also, the ASI/IT uranium-235/236 sample concentrations are well within the DOE guideline, ranging from less than 1.0 pCi/L to 51.5 pCi/L.

The DOE DCG for uranium-238 is 600 pCi/L. Concentrations in excess of this limit were observed in a surface water sample from Weston sample location DD-07 at 740 pCi/L and in ASI/IT surface water samples from sample locations ASIT-30 (sample 1166) and ASIT-31 (sample 1168) with readings of 2840 pCi/L and 2506 pCi/L, respectively. The remaining Weston samples had uranium concentrations ranging from 2.4 pCi/L to 310 pCi/L. The uranium-238 concentrations for the remaining ASI/IT samples ranged from 18 pCi/L to 364 pCi/L.

The DOE DCG for radium-226 and -228 is 30 pCi/L. Radium concentrations were measured at only one Weston sample location. The radium-226 and -228 concentrations for Weston sample location DD-14 were 7.0 pCi/L and 4.5 pCi/L, respectively, and are well within DOE guidelines. The radium-226 and -228 concentrations for samples from the ASI/IT sample locations are also well within the DOE guidelines. Detected concentrations for Ra-226 at ASI/IT sample locations were 3.4 pCi/L (ASIT-29) and 1.1 pCi/L (ASIT-28). Concentrations found above the detection limit for Ra-228 are 10.0 pCi/L (ASIT-28) and 4.2 pCi/L (ASIT-29). All other ASI/IT sample locations indicate concentrations of less than 1.0 pCi/L for Ra-226 and less than 3.0 pCi/L for Ra-228.

The highest gross alpha and gross beta concentrations in surface water were observed at the Weston sample location DD-07 and were 850 pCi/L and 560 pCi/L, respectively. Gross alpha measurements in the other Weston samples ranged from 8 pCi/L to 450 pCi/L and the gross beta ranged from 13 pCi/L to 380 pCi/L. The gross alpha measurements for the ASI/IT samples ranged from 21 pCi/L to 362 pCi/L and the gross beta measurements ranged from 67 pCi/L to 362 pCi/L.

2.3.3 Summary

A review of the analytical data on storm water runoff within the waste pit area reveals a high degree of variability in concentration patterns. However, three sample locations are generally more heavily contaminated than the other sample locations: Weston sample location DD-07 and ASI/IT sample locations ASIT-30 and ASIT-31. Sample location DD-07 had the highest concentration of TDS, at 1190 mg/L, which exceeded the applicable limit. Location DD-07 also had the highest concentrations of TOX and TOC. No limit is set for these parameters. Although location DD-07 did not have the highest concentrations of fluoride and uranium, the concentrations of 1.3 mg/L and

740 pCi/L, respectively, exceeded the applicable limits. This sample location had the highest concentration of gross alpha and gross beta, 850 pCi/L and 520 pCi/L, respectively. This sample location is located within drainage area G, downgradient from any likely contributions from the waste pits.

Sample location ASIT-30 had the highest concentration of chromium at 52.5 µg/L, which exceeds the MCL of 50 µg/L for chromium, and had the highest concentration of chloride at 60 mg/L, which did not exceed the applicable limit. This location had the highest concentration of uranium-234 at 653 pCi/L and uranium-238 at 2840 pCi/L, both of which exceed the DOE DCG of 500 pCi/L and of 600 pCi/L, respectively. This ASI/IT sample location is in drainage area D, between Waste Pits 3 and 5.

Sample location ASIT-31 had the highest concentration of nitrate at 10.9 mg/L, which exceeds the limit of 10 mg/L. Sample location ASIT-31 also had high concentration levels of uranium-234 at 597 pCi/L and uranium-238 at 2506 pCi/L, both of which exceeded the DOE DCGs of 500 pCi/L and 600 pCi/L, respectively. This sample location is also in drainage area D.

Concentrations from four other sample locations should be highlighted. Weston sample location DD-14 had the highest concentrations of TSS, at 2150 mg/L, which exceeds the applicable limits. Location DD-14 is located south of drainage area F and the K-65 silos. Surface water from Weston sample location DD-01 had a sulfate concentration of 317 mg/L, and a TSS concentration of 266 mg/L, both of which exceed the limits. This sample location is north of the railroad tracks, away from the waste storage area. The TSS loading may be the result of the cleared borrow area for Waste Pit 4 cover material located just upstream from this point. Also, Weston sample location DD-23 had high concentrations of TSS (although not as high as location DD-14) at 385 mg/L, which exceeds the applicable limit. In addition, Weston sample location DD-09 had high concentrations of TSS at 148 mg/L and fluoride at 1.3 mg/L, both of which exceed the applicable limits. Location DD-09 is located at the south end, downstream of drainage area D.

Since some of the highest values for many parameters analyzed occurred around drainage area D, it can be concluded that this area and the corresponding surface water runoff and drainage ditches would be the most contaminated. This is an expected result since drainage area D is downgradient from the waste pits, considered to be the principal source of contaminants to storm water runoff. The concentration of uranium increases in samples downstream of the pits, and the measured uranium isotopic content of surface water samples indicates that the uranium is depleted (i.e., less

than 0.7 percent uranium-235 by weight). It is not possible, however, to conclusively differentiate any loadings resulting from direct surface water contributions and those from seeps from the pits. Sampling points ASIT-30 and ASIT-31 along Pit 5 indicate the increased potential for contaminant releases via seeps.

2.4 SITE CONDITIONS THAT JUSTIFY A REMOVAL ACTION

The threats posed by the off-site migration of uranium in the storm water runoff from the waste pit area are of a non-time-critical nature; i.e., based on the site evaluation there is a planning period of greater than six months available before on-site activities must begin. The site conditions, however, do meet certain criteria listed in the NCP for categorization of specific cleanup efforts as removal actions. The eight factors to be considered in determining the appropriateness of a removal action, as listed in Section 300.415 of the NCP, are:

1. Actual or potential exposure to hazardous substances or pollutants or contaminants by nearby populations, animals, or food chains
2. Actual or potential contamination of drinking water supplies or sensitive ecosystems
3. Hazardous substances or pollutants or contaminants--in drums, barrels, tanks, or other bulk storage containers--that may pose a threat of release
4. High levels of hazardous substances or pollutants or contaminants in soils, largely at or near the surface, that may migrate
5. Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released
6. Threat of fire or explosion
7. Availability of other appropriate federal or state response mechanisms to respond to the release
8. Other situations or factors that may pose threats to public health or welfare and the environment

Of the eight factors to be considered, the off-site migration of radiological or hazardous substances or pollutants as a result of uncontrolled storm water runoff from the waste pit area, as reflected in 4. and 5. above, establishes the justification for a removal action. The potential resulting contamination of drinking water supplies or sensitive ecosystems from this migration, and the associated potential exposure to these contaminants by various receptors (1. and 2.), are also relevant to the waste pit area storm water runoff control removal action.

Natural drainage from the waste pit area is primarily westward toward Paddys Run. Storm water runoff from this area carries concentrations of uranium in excess of the DOE DCG for surface water releases. Upon entering Paddys Run, the potential exists for these contaminants to migrate to the Great Miami Aquifer. This aquifer is within the buried valley aquifer of the Great Miami River Basin, which has been designated as a Sole-Source Aquifer by the EPA under Section 1424(e) of the SDWA (EPA 1988). Under this designation, the Regional Administrator of Region V of the EPA has determined that this aquifer is the sole or principal source of drinking water for this area. Contamination of Paddys Run and/or the underlying aquifer may pose potential exposure risks to public health and the environment.

2.4.1 Release Mechanisms

If left uncontrolled, contaminants from the surface of the waste pit area could migrate via storm water runoff westward toward Paddys Run. This migration of radionuclides to Paddys Run is a direct function of the amount of storm water runoff from this area. The flow of storm water runoff from the waste pit area, if averaged over an annual cycle, is estimated to be 23 gallons per minute (gpm) (WMCO 1987). Water from Paddys Run can directly enter the regional aquifer through the highly permeable sediments of the creek. Additionally, surface waters in the waste pit area itself may leach into the underlying till and eventually reach the regional aquifer. However, only the control of surface water runoff to Paddys Run is being considered under this removal action. The infiltration of surface waters within the waste pit area may be concomitantly reduced depending on the removal action alternative selected, but this is not an explicit objective of the removal action. Groundwater issues are being addressed under the RI/FS for both the waste storage units (Operable Unit 1) and the environmental media (Operable Unit 5).

2.4.2 Environmental Fate

As described in the previous section, contaminated storm water runoff from the waste pit area migrates toward Paddys Run. Upon release to the stream, the uranium concentrations would be less than at the site boundary due to dilution by the stream. In addition, some of the contaminants in Paddys Run surface water may adhere to the stream sediments. Surface water contaminants may also be transferred to the groundwater, again at lesser concentrations due to dispersion and dilution within the aquifer.

2.4.3 Potential Risks

Risks of potential health effects for off-site personnel require the presence of contaminants that pose either a radiological or chemical hazard, pathways for potential exposure, and human and

environmental receptors. Each of these components is summarized in the following sections for the contaminated storm water runoff from the waste storage area.

2.4.3.1 Contaminants of Concern

Storm water data collected to date from the site drainage ditches indicate the presence of radionuclides and metals in the storm water runoff from the waste pit area. Most of the radionuclides are found at natural background concentrations. Several of the parameters exceed established concentration guidelines or limits, but most exceedances are sporadic and within the range of uncertainty in the data. Only uranium represents a potential concern to public health or the environment. For this reason, uranium has been designated as the contaminant of concern for the storm water runoff control removal action. All considered actions that account for public health and environmental protection against uranium will also provide protection against other radionuclides and chemicals, due to the low levels present.

Uranium is a potential radiocarcinogen and a chemical toxin. Insoluble uranium compounds primarily pose a radiological hazard resulting from inhalation. Soluble uranium compounds pose both chemical and radiological hazards from ingestion. If ingested at sufficiently high rates, these compounds can lead to kidney damage and arterial lesions. Other potential adverse health effects that can result from ingestion of soluble uranium compounds are damage to the cardiovascular, hematopoietic, endocrine, and immunological systems.

2.4.3.2 Exposure Pathways

Exposure to the contaminants in the storm water runoff can occur as a result of the release of these contaminants to Paddys Run. The contaminants may then be discharged from Paddys Run to the Great Miami River or the underlying sand and gravel aquifer. Paddys Run is not used as a drinking water supply; however, the associated potential pathways for hypothetical receptors include ingestion of surface water or sediments from the stream. The ingestion of groundwater from the aquifer underlying Paddys Run is an additional potential exposure pathway. Other exposure pathways associated with the groundwater include ingestion of crops irrigated by the water, ingestion of beef from cattle exposed to uranium through water and crops, and ingestion of milk from cows exposed to uranium through water and crops.

The potential exposure pathways associated with the surface waters of the Great Miami River include direct ingestion as drinking water, ingestion of plants after use of the water for irrigation, and ingestion of meat or milk from livestock exposed to the surface water through direct intake or

from irrigated crops. This secondary pathway is not considered in detail for the storm water runoff removal action since the current releases from Paddys Run to the river do not constitute an unacceptable level of risk.

2.4.3.3 Potential Receptors

Contaminated storm water runoff from the waste storage area currently enters Paddys Run. The surface waters of Paddys Run are not used as a drinking water supply; however, the potential exists for an off-site individual to ingest these waters or stream sediments. Additionally, there is no known use of groundwater for drinking water, feedstock watering, or crop irrigation from the portion of the aquifer immediately underlying Paddys Run. However, persons may, in the future, pump groundwater from this area for these uses. A concurrent removal action for the south plume, an area of elevated uranium concentrations in groundwater south of the FMPC, is addressing receptors located further downgradient from the stream.

3.0 REMOVAL ACTION OBJECTIVES

The principal objective of the removal action for storm water runoff control in the waste storage area is to reduce or mitigate the release of uranium and other contaminants to Paddys Run, thereby reducing the potential threat to the public and the environment from those exposure pathways associated with such releases. This and other objectives are further defined in Sections 3.1 through 3.3 in terms of response authority scope and purpose and compliance with ARARs and other criteria, advisories and guidance to be considered (TBCs).

3.1 RESPONSE AUTHORITY

Authority for responding to releases or threats of releases from a hazardous waste site is addressed in Sections 104 and 106 of CERCLA. Executive Order 12580 delegates Section 104 response authority to the Secretary of Energy for DOE sites. However, EPA maintains response authority if an action is carried out in response to a Section 106 enforcement order. In accordance with the FFCA, the waste pit area removal action is being conducted under EPA's enforcement authorities. Section 300.415 of the NCP contains the CERCLA removal action authorities.

3.2 SCOPE AND PURPOSE

The scope of the proposed removal action can be broadly defined as management of radioactively contaminated storm water runoff from the waste storage area. The area includes six waste pits, a burn pit, the Clearwell, four concrete silos, and surrounding areas including approximately 20 acres. As discussed in Section 2.4.3.1, the only contaminant of concern for the storm water runoff control removal action is uranium.

The fundamental objective of the removal action for the storm water runoff control is to protect public health and the environment by controlling the release of storm water runoff with uranium concentrations exceeding the DOE DCG values for surface water discharge of 600 pCi/L for uranium-238 and -235, and 500 pCi/L for uranium-234. The sum of the ratios of the observed concentration of each radionuclide to its corresponding DCG must not exceed 1.0. Related objectives, founded on other risk-based levels for various potential exposure scenarios, include the protection of biotic environments in Paddys Run and the mitigation of contaminants from surface water to the underlying aquifer.

As will be discussed in Chapter 5.0, the removal action alternatives being considered for the storm water runoff control will satisfy these objectives to varying degrees; therefore, the final selection of

the preferred removal action will balance the effectiveness of each alternative in satisfying these objectives against other decision factors judged to be of particular importance for the problem-specific conditions. Potential adverse impacts of each alternative will also be considered. This selection strategy is being executed so as not to hinder or foreclose viable options for a long-term remedial action for the waste storage area that will fully satisfy all ARARs established for the corresponding operable unit.

3.3 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED

Section 300.415 (i) of the NCP requires that removal actions attain, to the extent practicable considering the exigencies of the situation, a level or standard of control which is applicable or relevant and appropriate to any hazardous substances, pollutants, or contaminants that will remain on site. Other federal and state criteria, advisories, and guidance shall, as appropriate, be considered in formulating the removal action.

Three classifications of ARARs are considered. These include: 1) contaminant-specific ARARs, 2) location-specific ARARs, and 3) action-specific ARARs. Contaminant-specific ARARs address the acceptable amount or concentration of a specific pollutant that may be found in or discharged to soil, water, and air. Location-specific ARARs are based on the specific setting and nature of the site, and action-specific ARARs relate to technology- or activity-based requirements or limitations on the specific response actions taken with respect to the type of wastes. Additionally, three types of TBCs are considered and include: 1) health effects information with a high degree of credibility, 2) technical information on how to perform or evaluate site investigations or remedial actions, and 3) policy.

The identification of potential ARARs and TBCs for the storm water runoff control removal action will be based on the nature of the contamination (radioactively contaminated runoff), the location of the site (within a populated groundwater usage area and within 1.5 miles of the Great Miami River), and the technical scope of the identified removal action alternatives. A summary of these ARARs and TBCs and a discussion of their pertinence to the proposed alternatives are included in Chapter 5.0.

4.0 REMOVAL ACTION ALTERNATIVES

4.1 DEVELOPMENT OF INITIAL ALTERNATIVES

The objective of the subject removal action is to control the release of contaminated storm water runoff from the waste pit area into Paddys Run. While numerous technologies can be identified as potentially applicable and appropriate to at least partially satisfy this objective, the overall response actions are limited to the following: remove the source of the contaminants; leave the source in place but prevent the release of contaminants into the storm water runoff; and allow the runoff to be contaminated but prevent its release into Paddys Run. The most applicable and appropriate technology for preventing the release of contaminants into the surface runoff is to cap the source materials so that the necessary contact between surface runoff and the contaminants is eliminated. A responsive remedy for preventing the release of contaminated runoff to Paddys Run is to collect the runoff at the downstream end of the drainage area and to provide for adequate treatment prior to discharge to a receiving stream.

In addition to these three baseline alternatives for the storm water runoff removal action, two other alternatives were considered necessary to satisfy the full range of technical and program issues. One is an augmentation of the capping alternative to include a lateral drainage collection sump. This alternative is formulated to more proactively control all the contaminated water; in this case, the subsurface lateral flow resulting from residual infiltration through the cap. The other alternative is the no-action alternative, the inclusion of which is a requirement under CERCLA since it provides a baseline condition against which other alternatives can be compared.

Based on this discussion, the following five alternatives form the initial set of alternatives for the storm water runoff control removal action:

- Alternative 1: No Action
- Alternative 2: Surface Capping
- Alternative 3: Surface Capping with Lateral Drainage Sump Collection
- Alternative 4: Runoff Collection and Treatment
- Alternative 5: Source Removal

4.2 DESCRIPTION OF REMOVAL ACTION ALTERNATIVES

A description of each proposed removal action is provided in the following sections.

4.2.1 Alternative 1 - No Action

Under the no-action alternative, no additional abatement, remediation, treatment, or security activities would occur at the waste pit area. The relative risk to the public and the environment would remain relatively constant to what is currently present. Any reduction in contamination would be brought about by natural phenomena such as radioactive decay and removal of contaminated soil through erosion. This alternative is being considered as a baseline for comparison with the other alternatives.

4.2.2 Alternative 2 - Surface Capping

This alternative consists of constructing a cap over the surface of the waste pit area to minimize the contact of rainwater with the contaminated soil. The majority of the water would be routed away from the waste pit area for direct discharge into Paddys Run. A small volume of water would be introduced to the contamination via continued infiltration through the cap. The capping system will cover the portions of the waste pit areas designated as Drainage Areas B, C, D, E, F, J, and K. These drainage areas are shown in Figure 2-3. The basic reasons for this are that the grading of the area and construction of the liners over the entire area would be easier as one continuous placement instead of several separate areas, and would cover unidentified contaminated areas. The site will be graded at a slope of approximately 5 percent to provide proper drainage (Figure 4-1). Waste Pit 4 was covered with an interim cap in 1988. The interim cap consisted of a compacted clay layer and a synthetic liner. This design is adequate for the prevention of runoff contacting contaminated soil; therefore, a new cap will not be placed over Waste Pit 4 as part of this removal action. Before capping Waste Pits 5 and 6, sludge in these pits will be stabilized using a fixative agent such as fly ash. In order to reduce the potential for worker exposure and to minimize waste generation, no soil will be excavated; rather, grading will consist of additional soil placed on the existing surface.

In order to maximize the effectiveness of this alternative, three subalternatives were considered. They are presented below:

1. Compacted clay cap - this type of cap consists of a 24-inch-thick clay cap compacted in 6-inch layers. The desired compaction is to a permeability of 10^{-7} cm/s. This cap will be overlain with 12 inches of topsoil (local soil from the Fincastle series) to protect the clay cap moisture content and to provide an evaporative zone and root structure system. This layer of soil will be planted with native grass such as Kentucky bluegrass and fescue. The cap will be graded to promote drainage.

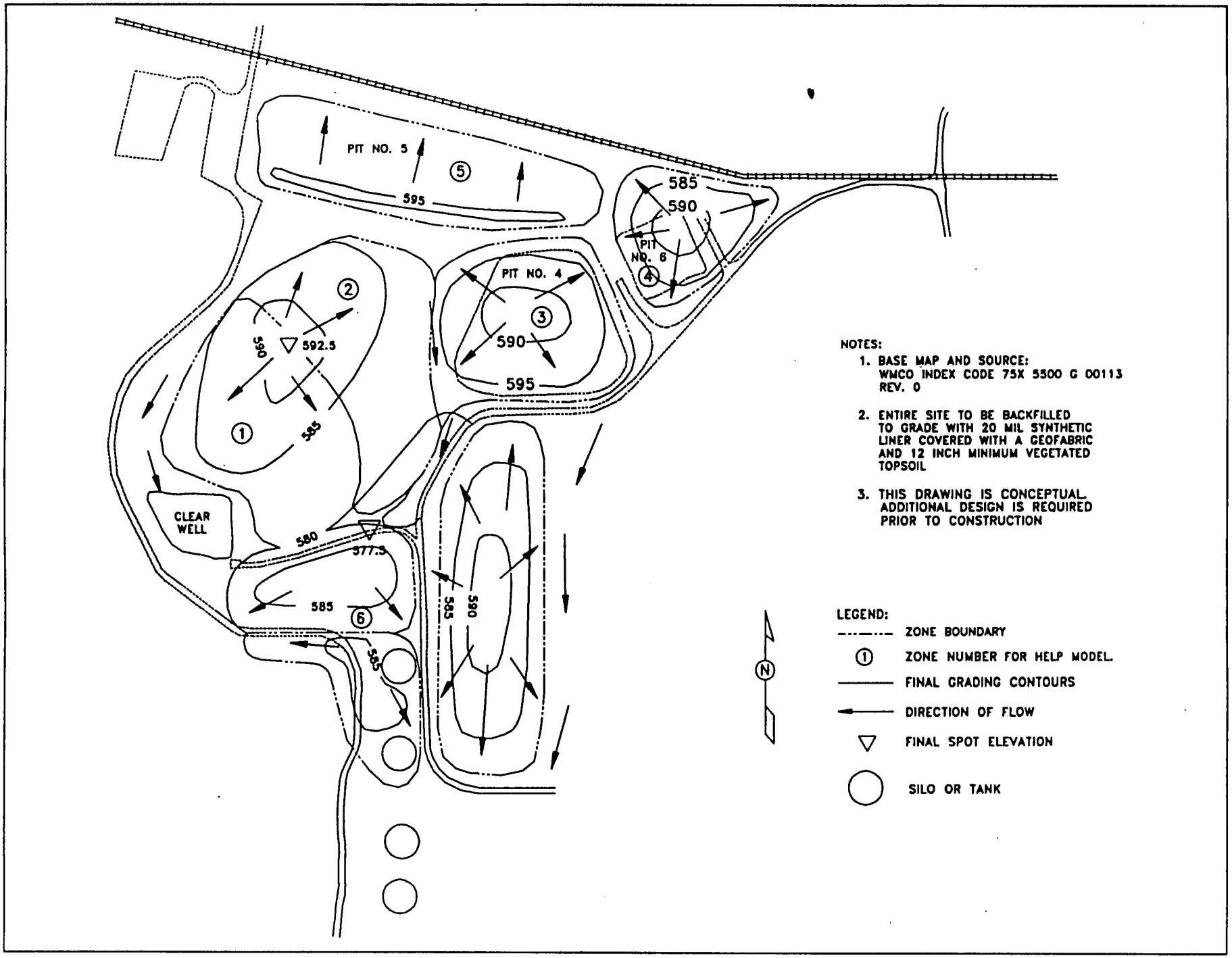


FIGURE 4-1. ALTERNATIVE 2 - SURFACE CAPPING

2. Synthetic liner cap - this type of cap consists of a 20-mil synthetic liner in place of the 24-inch-thick clay cap. The liner will have heat-welded seams and be anchored in place. A layer of geotextile will be placed beneath and above the synthetic liner. This will be covered with a minimum of 12 inches of local topsoil. A vegetation cover, similar to subalternative 1, will be provided.

3. RCRA cap - this type of cap has a construction profile similar to caps designed to satisfy RCRA closure requirements. The cap generally consists, from bottom to top, of a 24-inch-thick compacted clay layer, a 20-mil synthetic liner, a 12-inch sand layer for lateral drainage, a geofabric, and a 12-inch layer of vegetation topsoil.

Each of the subalternatives were evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) model to quantitate the amount of infiltration to the contaminated soil. This infiltration is assumed to contact the soil and travel laterally to Paddys Run. In order to properly evaluate the flow, the waste pit area was broken into separate drainage zones. Zone 1 is an area of approximately 1.67 acres consisting of Pit 1, the southern section of Pit 2, and the southern section of Pit 3. All drainage is designed to drain via natural topographic features. Since this cap, as well as other cap areas, will be overlain with vegetated topsoil, no increase in net runoff volume will be expected. Zone 2 consists of the northern sections of Pits 2 and 3 and the burn area and comprises approximately 1.8 acres. Drainage is based on existing natural contours, so drainage is north and southeast. Southeast drainage is discharged to the Clearwell. Zone 3 (1.12 acres) is the outline of Pit 4 which was properly capped in a previous interim corrective action. Zone 4 consists of Pit 6 and the area northeast of Pit 6 and is approximately 2.1 acres. Waste Pit 5 (1.6 acres) comprises Zone 5. The area south of the waste pit area comprises Zone 6 (2.2 acres). The zones are illustrated in Figure 4-1. The RCRA cap had the least amount of annual volume of infiltration (513 ft^3 cumulative), followed by the liner cap (16,117 ft^3 cumulative), and the clay cap (37,843 ft^3 cumulative).

In evaluating which subalternative was the most desirable, several factors were considered. Clay soil with little sand material and appropriate permeability characteristics would be required to construct the clay cap. This material would most likely have to be brought in from an off-site source which would greatly increase the cost and would require costly decontamination for trucks leaving the facility, as was encountered with the Pit 4 cap. Additionally, more infiltration would occur than with the synthetic liner.

The synthetic liner cap could use on-site soil for grading since the permeability of the cap is based on the liner properties. This subalternative is superior to the clay cap in removing infiltration and

would require the least construction time of the three subalternatives. A detail of this capping system is shown in Figure 4-2.

The RCRA cap would provide an effective solution to infiltration, but would have the highest cost since it would be a combination of the costs of the other subalternatives. As an interim measure, it was determined that the additional costs could not be justified. Therefore, the synthetic liner cap was chosen. Additionally, if a final remedial action option was removal, the only contaminated material would be the synthetic liner, which would comprise a small (<1 percent) percentage of the total material removed. Additionally, it would enhance any final remedial action which involved capping.

4.2.3 Alternative 3 - Surface Capping with Lateral Drainage Sump Collection

The surface capping with lateral drainage consists of the use of Alternative 2 with a lateral drainage collection sump. This alternative, shown in Figure 4-3, would intercept all subsurface lateral flow resulting from infiltration through the cap from rainfall. The flow would be collected in an accumulation trench downgradient from the cap. The trench would be sloped to a central collection sump. Lateral flow would be pumped out of the sump on a routine basis from a riser pipe to the biodenitrification surge lagoon. Suspended solids would settle here prior to treatment through the biodenitrification towers and effluent water treatment system. The treated water would then be discharged to the Great Miami River through Manhole 175. The use of the combined cap and collection sump would eliminate the potential release of contaminated infiltrated rainwater from reaching Paddys Run.

4.2.4 Alternative 4 - Runoff Collection and Treatment

This alternative incorporates planned separation of drainage areas within the waste pit area, thus isolating contaminated from noncontaminated storm water runoff, as shown in Figure 4-4. Contaminated water will be collected in the existing Clearwell and in a new collection sump and pumping station that will be located south of the Clearwell. Drainage flow control devices will be installed upstream of drainage channels located in the waste pit storage area to restrict peak flows to the new pumping station. The new system will pump the collected runoff to the biodenitrification surge lagoon, where suspended solids would be allowed to settle prior to treatment through the biodenitrification towers and effluent water treatment system and before discharge to the Great Miami River through Manhole 175. A Process Flow Diagram (PFD) for this alternative is shown in Figure 4-5.

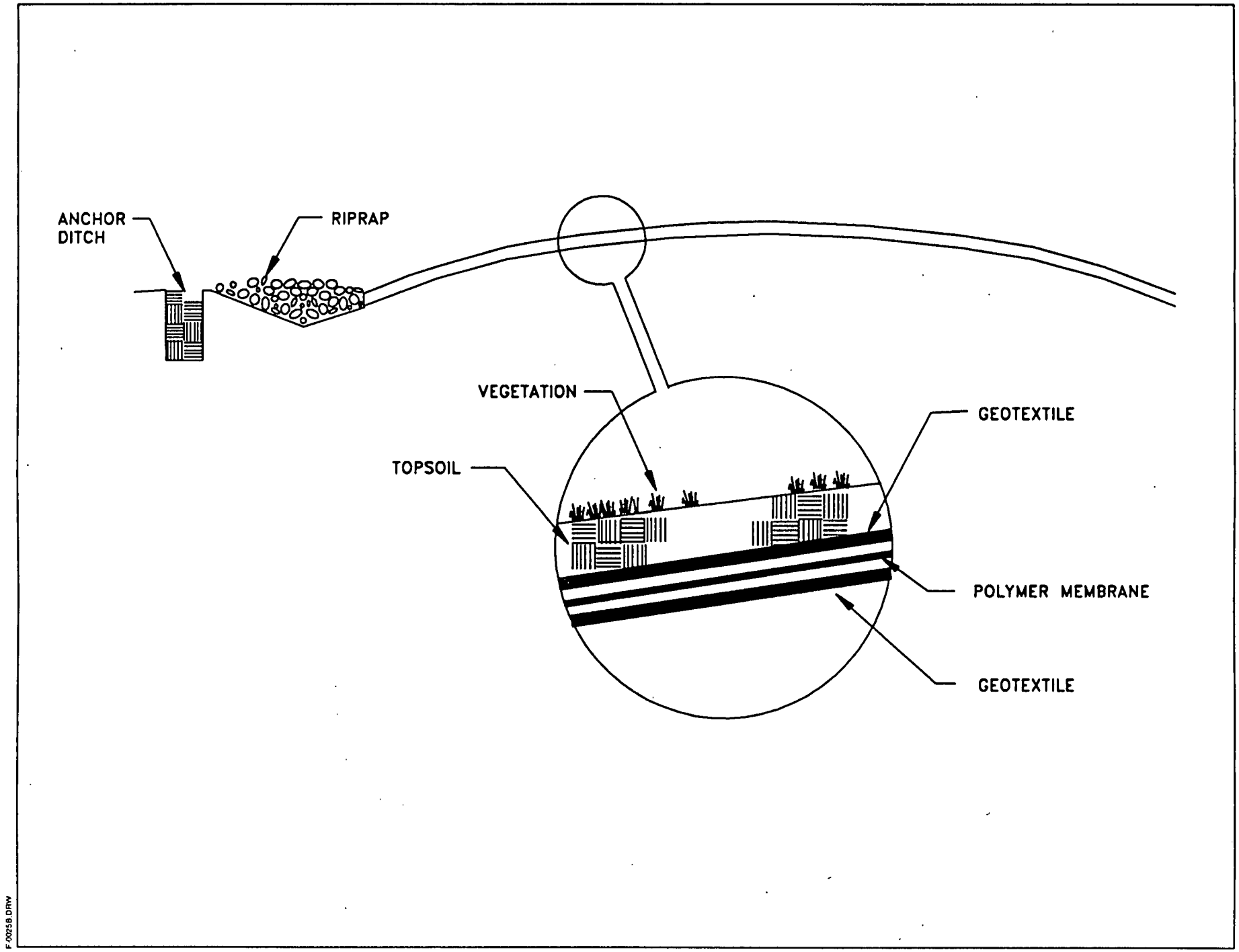


FIGURE 4-2. ALTERNATIVE 2 - COVER PROFILE

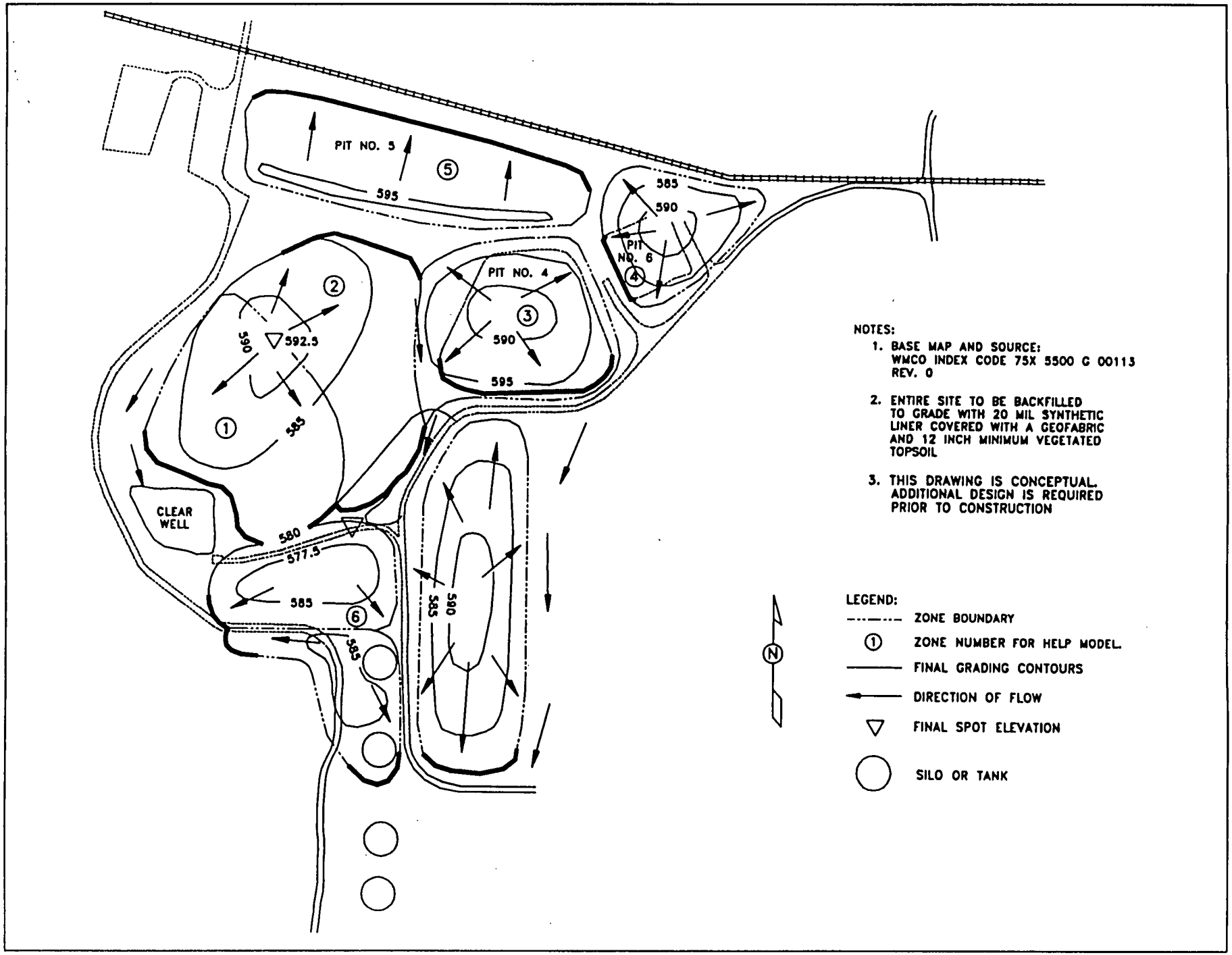


FIGURE 4-3. ALTERNATIVE 3 - CAPPING WITH SUBSURFACE DRAINAGE COLLECTION

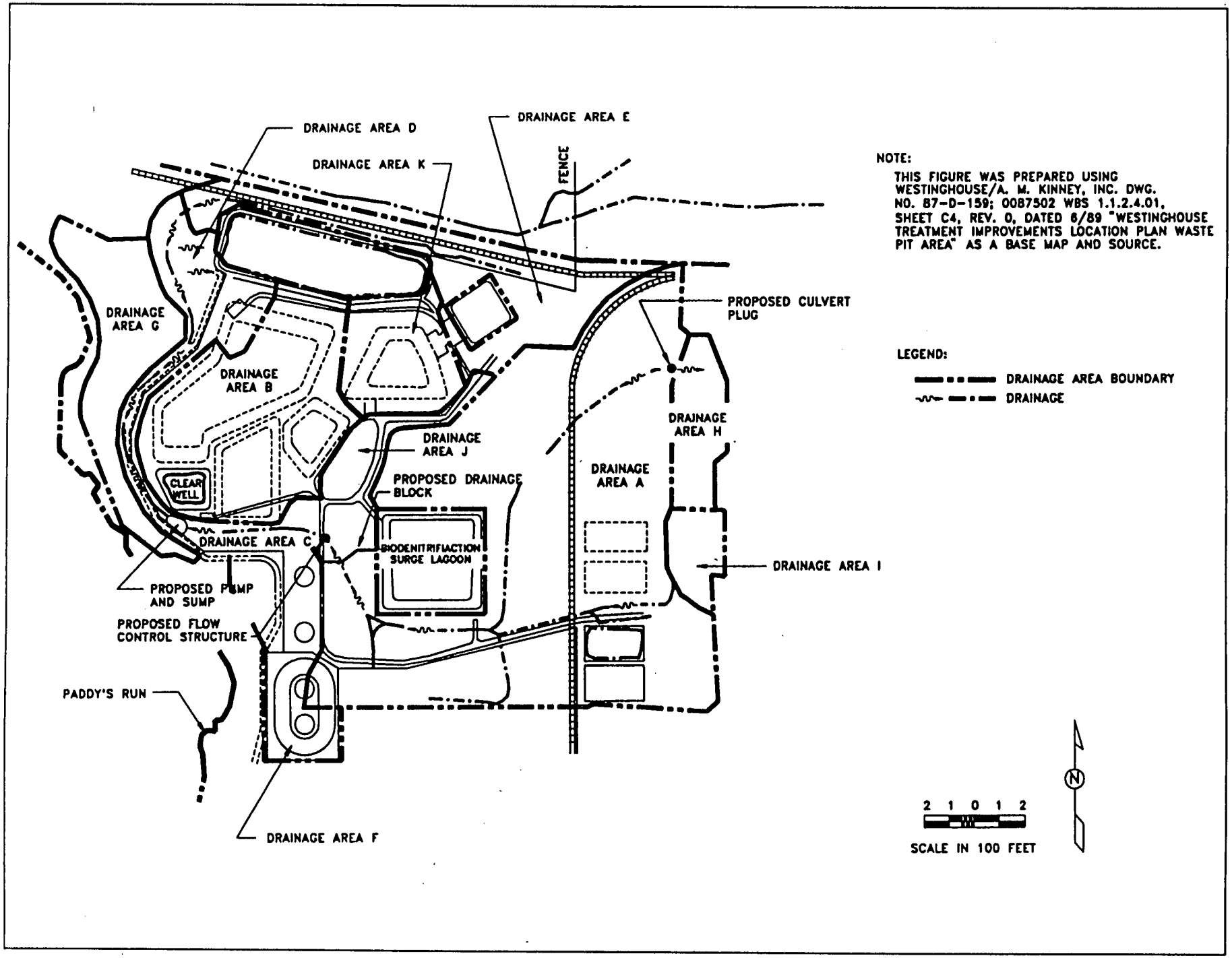
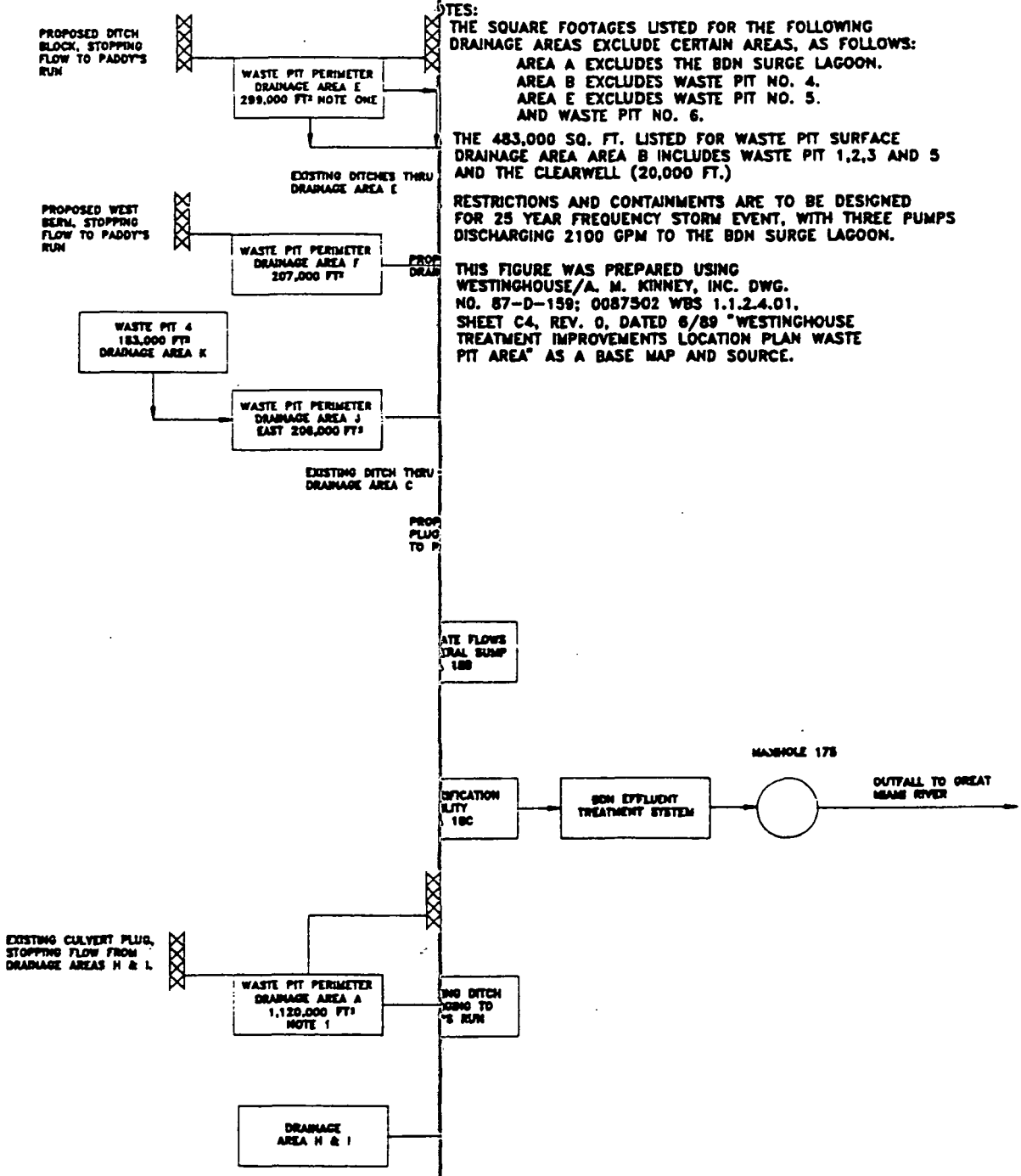


FIGURE 4-4. ALTERNATIVE 4 - RUNOFF COLLECTION AND TREATMENT



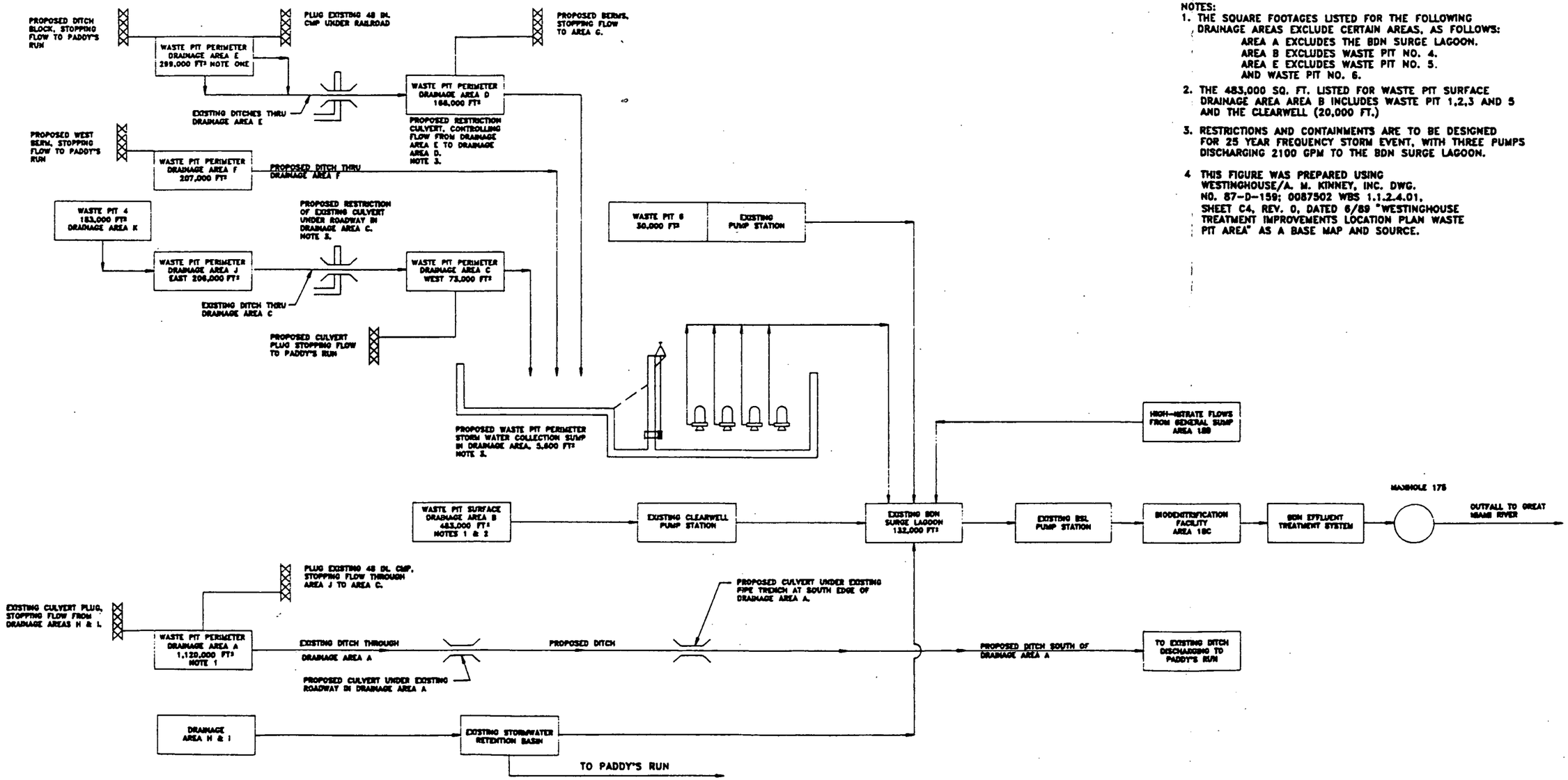
TES:
THE SQUARE FOOTAGES LISTED FOR THE FOLLOWING DRAINAGE AREAS EXCLUDE CERTAIN AREAS, AS FOLLOWS:

AREA A EXCLUDES THE BDN SURGE LAGOON.
AREA B EXCLUDES WASTE PIT NO. 4.
AREA E EXCLUDES WASTE PIT NO. 5. AND WASTE PIT NO. 6.

THE 483,000 SQ. FT. LISTED FOR WASTE PIT SURFACE DRAINAGE AREA AREA B INCLUDES WASTE PIT 1,2,3 AND 5 AND THE CLEARWELL (20,000 FT.)

RESTRICTIONS AND CONTAINMENTS ARE TO BE DESIGNED FOR 25 YEAR FREQUENCY STORM EVENT, WITH THREE PUMPS DISCHARGING 2100 GPM TO THE BDN SURGE LAGOON.

THIS FIGURE WAS PREPARED USING WESTINGHOUSE/A. M. KINNEY, INC. DWG. NO. 87-D-159; 0087502 WBS 1.1.2.4.01, SHEET C4, REV. 0, DATED 6/89 "WESTINGHOUSE TREATMENT IMPROVEMENTS LOCATION PLAN WASTE PIT AREA" AS A BASE MAP AND SOURCE.



NOTES:

1. THE SQUARE FOOTAGES LISTED FOR THE FOLLOWING DRAINAGE AREAS EXCLUDE CERTAIN AREAS, AS FOLLOWS:
   AREA A EXCLUDES THE BDN SURGE LAGOON.
   AREA B EXCLUDES WASTE PIT NO. 4.
   AREA E EXCLUDES WASTE PIT NO. 5.
   AND WASTE PIT NO. 6.
2. THE 483,000 SQ. FT. LISTED FOR WASTE PIT SURFACE DRAINAGE AREA AREA B INCLUDES WASTE PIT 1,2,3 AND 5 AND THE CLEARWELL (20,000 FT.)
3. RESTRICTIONS AND CONTAINMENTS ARE TO BE DESIGNED FOR 25 YEAR FREQUENCY STORM EVENT, WITH THREE PUMPS DISCHARGING 2100 GPM TO THE BDN SURGE LAGOON.
4. THIS FIGURE WAS PREPARED USING WESTINGHOUSE/A. M. KINNEY, INC. DWG. NO. 87-D-159; 0087502 WBS 1.1.2.4.01, SHEET C4, REV. 0, DATED 6/89 "WESTINGHOUSE TREATMENT IMPROVEMENTS LOCATION PLAN WASTE PIT AREA" AS A BASE MAP AND SOURCE.

FIGURE 4-5. ALTERNATIVE 4 - PROCESS FLOW DIAGRAM

Drainage Area A is expected to be a noncontaminated area if isolated from storm water runoff from adjacent areas. Isolation of Drainage Area A will require modification of existing drainage structures and topography. Prevention of channelized flows from Areas H and I from entering Area A has been accomplished by plugging existing culverts and ditches and diverting this flow to the existing underground process area storm sewer. Flow from Areas C and E will be diverted from Area A by plugging existing ditches and culverts. Diverting overland flow of Area F from entering Area A will require a combination of berms and ditches. A fill area and earthen berm will be required in the area between the metal oxide tanks and the biodenitrification surge lagoon to prevent flow from Area A into Area C. The south end of Area A has an existing utility pipe trench. Storm water runoff from Area A will be diverted under this utility trench. A culvert will be constructed under this trench to direct runoff from Area A southward to an unnamed tributary of Paddys Run.

Drainage Area B is presently collected in the Clearwell. There is some channelized flow along the west side of Area B that enters the northwest corner of the Clearwell through a 12-inch pipe. Present plans are to leave Area B as it exists. Any of the waste pit area that is not presently collected in the Clearwell will be collected in the new perimeter area collection system and sump.

Drainage Area C is the perimeter area on the southeast side of the waste pits. A new sump will be located at the low point of Area C south of the Clearwell. Runoff from Areas D, E, and F will run through Area C and collect in the new sump. The required isolation of Area C is accomplished by existing topography. An outlet culvert discharging to Paddys Run will be plugged and flow will be diverted by a ditch to the new sump. A culvert within Area C currently drains the area west of the biodenitrification surge lagoon under a roadway and directs flow west to Paddys Run. The existing culvert will be modified to provide watershed storage east of the roadway. The restriction will be designed to detain the peak of an anticipated 25-year design frequency storm event. The restriction culvert will be designed to release at a determined maximum rate and be equipped with overflow considerations to protect against upstream flooding.

Drainage Area D is the waste pit perimeter area to the west of the waste pits. Existing topography of Area D allows a large portion of runoff to enter Area G. Correcting this problem will require a combination of berms and ditches along the west side of Area D. The new ditch in Area D will discharge to the main sump at the downstream end of Area C.

Drainage Area E is the perimeter area to the north of the waste pits. Existing topography of Area E allows channelized flow from east to west along the north side of Pit 5. A ditch block will be installed at the west end of Area E in order to direct the flow into Area D and then to the new sump. A ditch plug and flow diversion will be installed at some point along the railroad at the east end of Area E to direct flow to the northwest.

At the western portion of Drainage Area E, where flow will be directed to Area D, a restriction culvert will be placed. In an effort to keep the volume of the new sump and size of the new pumps to a minimum, some watershed storage will be required to reduce the peak discharge for an anticipated 25-year storm event. The restriction culvert will be designed to release at a maximum determined rate as well as be equipped with overflow consideration for upstream flooding protection.

Drainage Area F is the perimeter area of the K-65 silos. A perimeter collection system composed of a combination of ditches and berms will be required around Area F on all sides but the north. Runoff on the north side will be allowed to flow directly to Area C. The perimeter ditch and berm collection system will direct flow along both sides of the silos from the high point on the east side of Area F near the pipe trench.

Drainage Area G is the area west of Area D. Area G covers a section of Paddys Run. By controlling the runoff from the waste pit area, no additional contamination will be discharged into Area G.

Drainage Areas H and I lie within the production area fence line. Grab samples of this runoff indicate levels of uranium that are greater than the DOE DCGs. Drainage Areas H and I have been diverted into the existing production area storm sewer system and no longer affect Drainage Area A. The remaining runoff from Area A will be acceptable for discharge to Paddys Run.

Drainage Area J currently drains to Area C through a culvert under a roadway. The existing culvert will be modified to provide detention east of the roadway. Part of the K-65 silo mound originally in Drainage Area F is now included in this area, due to existing topographical features.

Drainage Area K is a new drainage area for Waste Pit 4. Existing topography of Area K directs runoff into Drainage Area J. No modifications are required for Drainage Area K.

In addition to the above required modifications, ongoing and scheduled upgrades of associated on-site wastewater treatment systems will be required to implement this alternative. These upgrades include the addition of a high-nitrate tank to accommodate volumes of high-nitrate wastewater from the general sump. These high-nitrate wastewaters will be proportionally mixed with wastewaters stored in the biodenitrification surge lagoon. The current biotreatment tower operation of the biodenitrification facility is being upgraded from a two- to a four-tower operation that will accommodate the increased flows from the storm water collection in the waste pit area. An effluent water treatment system will also be implemented that will allow effluent to be sent directly to Manhole 175 and not to the FMPC Sewage Treatment Plant. The effluent treatment for the biodenitrification facility will be a stand-alone, pre-engineered packaged activated sludge treatment system capable of reducing the effluent concentrations of both five-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) below 30 mg/L daily average and 45 mg/L daily maximum. The system will be sized to treat low, normal, and high flows (70, 110, and 200 gpm) for the biodenitrification facility. Current flows contributing to the BDN facility are shown in the Block Flow diagram, Figure 4-6. The expected flows resulting from additional storm water collection for Alternative 4 and associated upgrades to the facility are shown in the Block Flow diagram, Figure 4-7.

In addition to the upgrades associated with the BDN facility, the addition of the AWWT is proposed to treat FMPC wastewater discharge to Manhole 175 for removal of radioactivity. The facility will be designed to meet BAT as specified by DOE Order 5400.5 as the required level of treatment for liquid wastes containing radioactive material. The streams targeted for treatment through the AWWT are the general sump, the biodenitrification facility (of which the waste pit area storm water flows will be a part), the sewage treatment plant, and the storm water retention basin. Preliminary designs target the use of ion exchange, reverse osmosis, or a combination of both, whichever provides BAT treatment.

4.2.5 Alternative 5 - Source Removal

The final alternative to minimizing the release of contaminated runoff from the waste pit area into Paddys Run is the source removal alternative. This alternative would consist of removing all disposed waste and contaminated soil and regrading the site with clean fill. An estimated 444,500 cubic yards of waste and 58,900 cubic yards of contaminated soil would have to be excavated, packaged in waste disposal boxes, and disposed at an approved facility. The removal of the source would eliminate the threat of contaminated runoff entering Paddys Run via the waste pit area.

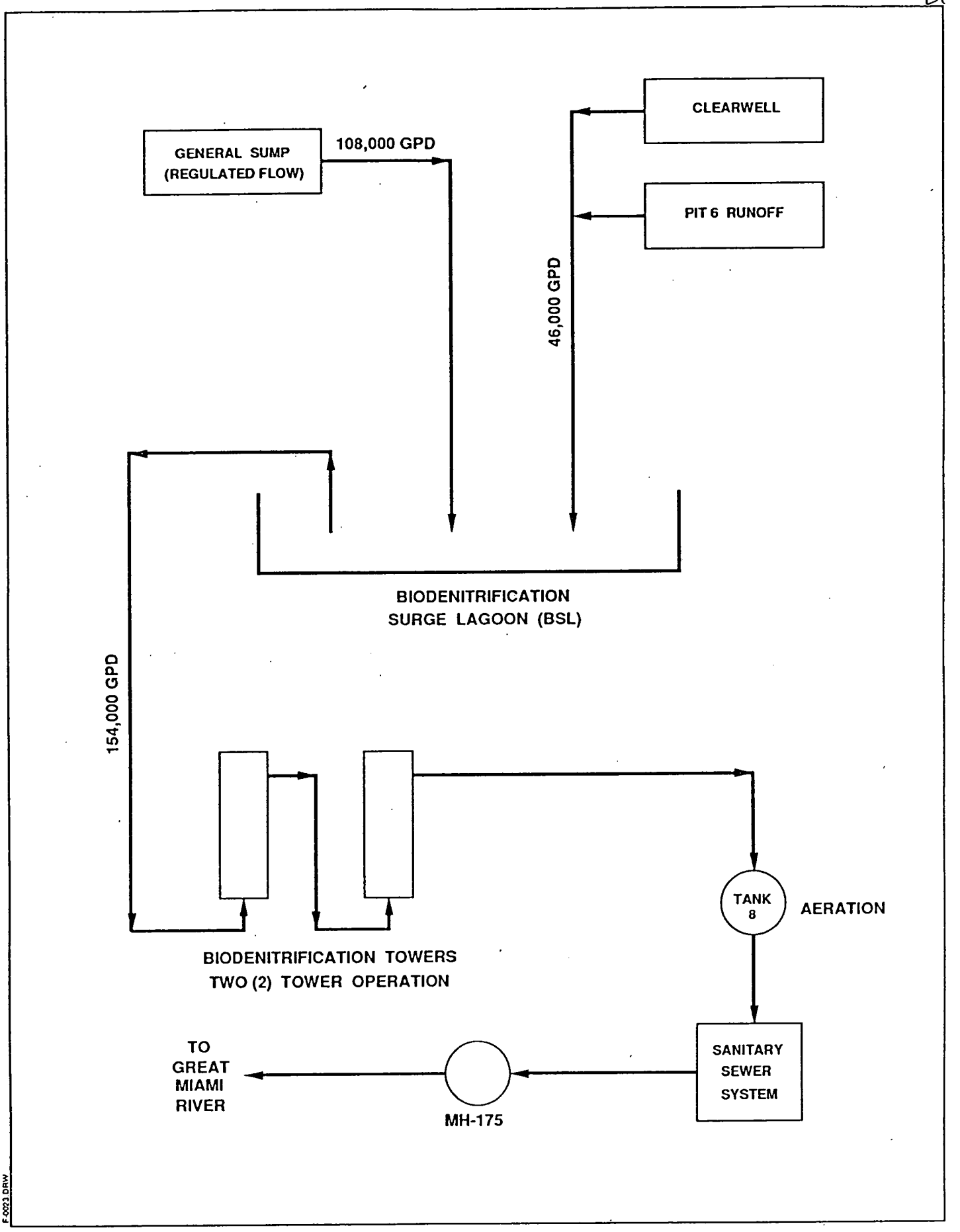


FIGURE 4-6. BLOCK FLOW DIAGRAM - EXISTING FLOW CONFIGURATION THROUGH DEMONSTRATION BIODENITRIFICATION FACILITY

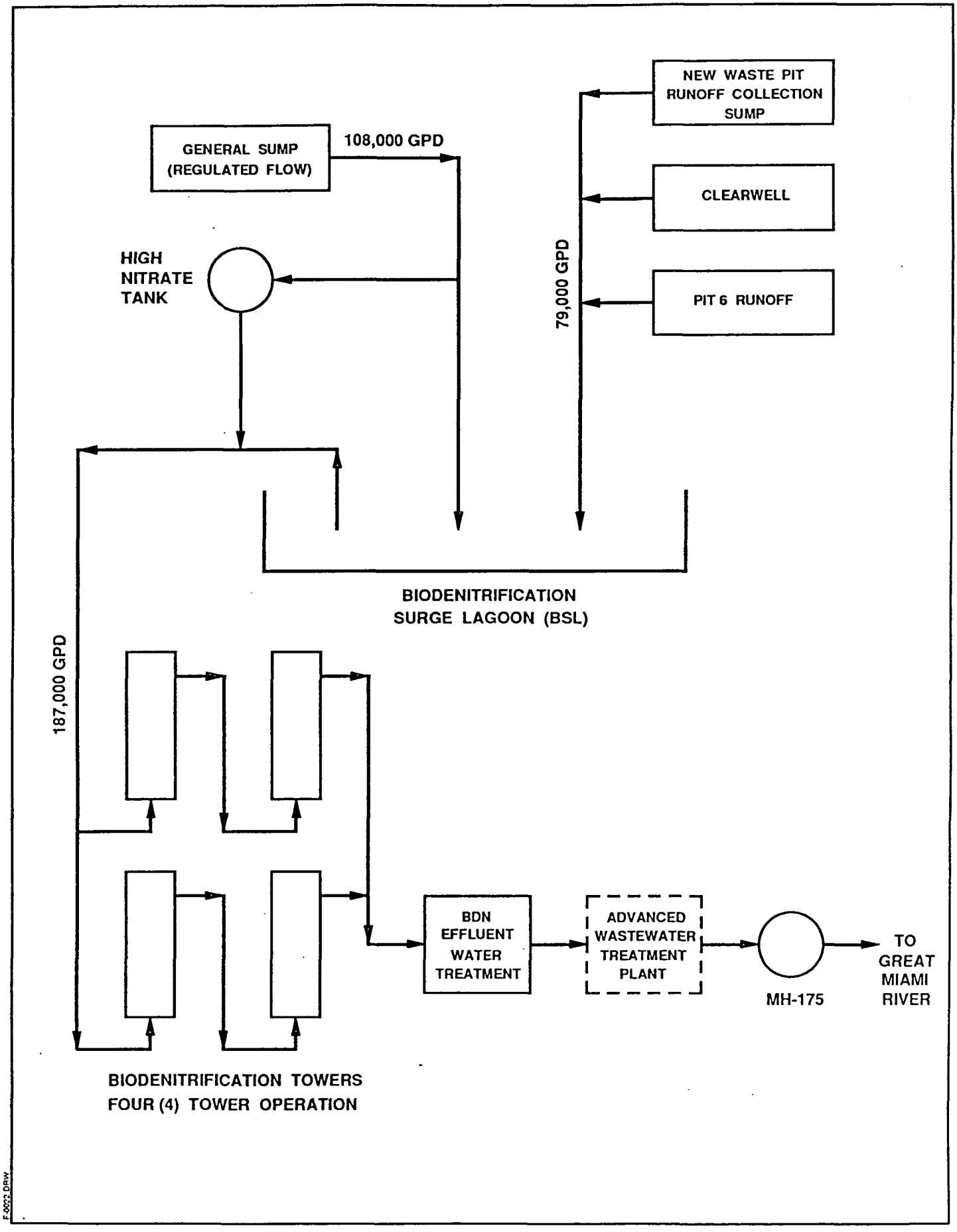


FIGURE 4-7. BLOCK FLOW DIAGRAM - ALTERNATIVE 4 - PROPOSED FLOW CONFIGURATION THROUGH PRODUCTION BIODENITRIFICATION FACILITY

4.3 SCREENING OF ALTERNATIVES

The five alternatives for the storm water runoff removal action were subjected to an initial screening to ascertain if any could be eliminated from further consideration prior to the detailed evaluation phase. The no-action alternative had to be retained to achieve compliance with the requirements of CERCLA. Of the remaining four alternatives, only the capping alternative and the runoff collection and treatment alternative were judged to be sufficiently effective and implementable as removal actions to warrant further evaluation in this EE/CA.

The increased effectiveness introduced by the lateral drainage collection system in Alternative 3 was not considered sufficient to offset the increased cost and time required for its implementation. In particular, there is no assurance that all infiltration through the cap would move horizontally to the collection system. The implementation of this additional component could, therefore, be very inefficient in satisfying its primary objective of collecting the infiltrating water. Such flows will be addressed under Operable Unit 1 and possibly under Operable Unit 3 if a particular subsurface flow condition calls for a local action not affecting the final action at other locations. It is also noteworthy that construction of the collection trench would require the excavation of a large volume of material that could be contaminated. Current uncertainty in relation to the actual geographical limits of Waste Pits 1 through 3 and the burn pit would increase this concern since actual waste materials could be encountered, resulting in concern about meeting DOE's as low as reasonably achievable (ALARA) standards.

While fully effective in meeting the removal action objectives, the waste removal alternative exceeds the scope of the other removal action alternatives that would satisfy the objectives to an acceptable extent. Waste removal would also introduce far-reaching technical implications (e.g., removal technologies, stabilization technologies, storage facilities, etc.), public health and environmental implications (e.g., transportation and disposal requirements, worker exposure, etc.), administrative implications (e.g., impacts on the final remedial action decision process, significant permitting and other administrative requirements, etc.), and high cost of implementation (Appendix A). Although being eliminated from further consideration as a removal action, this same alternative remains a candidate for the long-term remediation of the waste storage area under the Operable Unit 1 feasibility study.

As a result of this initial screening, only Alternatives 1, 2, and 4 are retained for detailed evaluation in Chapter 5.0.

5.0 EVALUATION OF ALTERNATIVES

The evaluation of the removal action alternatives is presented in this chapter. Section 5.1 describes the evaluation criteria. Evaluations of the individual alternatives are presented in Sections 5.2 through 5.4, respectively. A separate discussion of the ARARs and TBCs is presented in Section 5.5.

5.1 EVALUATION CRITERIA

The three alternatives described in Chapter 4.0 are evaluated according to the following criteria:

- Effectiveness
- Implementability
- Cost

To achieve consistency with the removal action objectives identified in Chapter 3.0 and to accommodate the selection of a preferred alternative in Chapter 6.0, the effectiveness and implementability criteria are subdivided into several evaluation components. Each is described in the following sections.

5.1.1 Effectiveness

For purposes of this evaluation of the removal action alternatives, the effectiveness criterion has been subdivided into five components. These include: public health protection; environmental protection; the degree to which the toxicity, mobility, or volume of the contaminants in the storm water runoff will be reduced; the consistency of the alternative with the final remedial action alternatives under consideration for the waste pit area; and other miscellaneous factors important to the overall effectiveness of the action.

Public Health

The first component of the effectiveness of an alternative is defined by its ability to ensure the protection of and to minimize impacts to public health. The evaluation of this factor will focus on the extent to which the completed action reduces or mitigates identified threats, as well as compliance with contaminant-specific ARARs or TBCs. This component also involves an assessment of the potential for future exposure to postaction conditions at the site, as well as the potential for failure of the alternative and any resulting threats.

As described in Section 2.4, uranium is the only constituent of the waste pit storm water runoff that could present a public health risk from radiological or chemical exposures through environmental pathways. Therefore, assessment of public health risks to off-site populations will be limited to the radiation doses from, and chemical toxicity of, uranium.

Any exposure pathways associated with the storm water runoff prior to its discharge into Paddys Run are considered to be of low risk potential for purposes of this analysis. The reasons are twofold. First, the entire waste storage area is a controlled entry area and it is assumed that established DOE/WMCO health and safety programs are sufficient to protect individuals from exposure and that the health and safety programs will be followed. Second, the only potential exposure pathway would be associated with isolated events (e.g., the accidental ingestion of contaminated sediment from the drainageways) and would not be easily quantifiable due to its infrequent and stochastic nature.

A related issue is the potential exposure of workers to direct radiation and radon from the nearby K-65 silos and fugitive emissions from Waste Pits 5 and 6 during construction of the selected removal action. Again, because it is assumed that adequate personnel protection will be provided to the workers, it is not necessary or practical to quantitatively address this potential exposure pathway. Rather, the potential for exposure will be directly related to the estimated time of construction and will be reflected in the cost estimates by adjustments to the estimated expenses to achieve adequate worker protection.

Three environmental pathways will be quantitatively evaluated as potentially nontrivial contributors to the exposure of the public in relation to the storm water runoff from the waste pit area. These pathways come into play only when the runoff reaches Paddys Run and include direct ingestion of contaminated water, ingestion of sediments contaminated as a result of the contaminated runoff, and ingestion of groundwater contaminated by aquifer recharge from Paddys Run in off-site areas beyond the southern boundary of the FMPC.

Both the direct ingestion of contaminated water and the ingestion of sediments will be evaluated against a total annual committed effective dose equivalent (CEDE) (50-year CEDE) limit of 25 mrem. All on-site activities may not create a CEDE of greater than 100 mrem per year via all environmental transport pathways. The 25 percent value is consistent with the target value established for each operable unit in the RI/FS; that is, a value less than 25 mrem for each operable unit is considered to provide a factor of safety against exceeding the 100 mrem limit from

all pathways. In all cases, the radiation dose (50-year CEDE) was calculated by multiplying the annual intake rate of uranium by the respective dose conversion factors for isotopes of uranium (DOE 1988).

The conservatism of this value in protecting public health is obvious when one considers that the uranium concentration limit derived from the dose limit established in DOE Order 5400.5 is based on a hypothetical maximally exposed individual who consumes two liters of contaminated water directly from the discharge point on a daily basis, 365 days a year. In the case of Paddys Run, which is dry over a portion of the year, one can conjecture that the storm water discharge is equivalent to the flow in the stream; thus, the receptor can be assumed to be ingesting the water directly from Paddys Run. This conjecture does not influence the conservatism in the TBC, however, since Paddys Run is not used as a drinking water source and it is inconceivable that a storm water discharge would occur concurrent with a no-flow condition in Paddys Run.

For the groundwater pathway, a more stringent TBC is used due to the known use of the regional aquifer as a potable water source. In this case, the selected TBC is a 50-year CEDE limit of 4 mrem from an annual intake of radioactive materials in drinking water. The concentration of uranium in drinking water that corresponds to the 4 mrem dose limit is derived to be equal to 22 pCi/L, (or 33 µg/L, assuming equal activity concentrations of uranium-234 and uranium-238).

The calculated annual intake rate was also used to evaluate the potential for chemical toxicity from uranium. The recently published reference dose (RFD) describing an acceptable daily intake of uranium based on its chemical toxicity is 3 µg/kg body weight/day (EPA 1989). The acceptable daily intake corresponds to a uranium concentration in water of approximately 100 µg/L, assuming a 70 kg person ingests two liters of water per day. To calculate the acceptable risk to an individual, a Hazard Index (HI) is calculated by dividing the estimated daily intake by the acceptable daily intake. An HI greater than or equal to unity implies that exposure at this level is potentially detrimental to human health and, conversely, an HI less than unity implies that exposure is acceptable with respect to an individual's risk of chemical toxicity.

Environmental Protection

The evaluation of environmental protection will focus on the degree to which the mass loading of uranium to Paddys Run will be reduced, thereby limiting the potential for exposure to environmental receptors such as fish and macroinvertebrates. Additionally, the environmental evaluation will qualitatively consider the extent to which the actions would impact, both beneficially

and adversely, the local ecology of the drainageways and any environmentally sensitive areas controlled by location-specific ARARs (e.g., wetlands). The environmental protection component will include the consideration of environmental impacts that may occur during and as a result of the implementation of the removal action.

Reduction in Toxicity/Mobility/Volume

Although not required for a removal action, the preference stipulated in SARA for remedies that permanently eliminate or reduce the toxicity, mobility, or volume of waste will be considered in the evaluation of effectiveness. In the case of contaminated storm water runoff, this factor comes into play in two ways. The first involves reductions in the volume of the storm water runoff that becomes contaminated, while the second involves reductions in the mobility of a contaminant or providing for treatment once contaminated runoff is produced. Each is considered to be consistent with the intent of SARA.

Consistency with Final Action

The NCP requires that a removal action be consistent with the anticipated final action for the site. In the case of the FMPC, the most direct concern is consistency with the remedial action alternatives currently being evaluated for Operable Unit 1, which includes the waste pits, burn pit, and the Clearwell. A lesser concern is consistency with those clean-up alternatives being considered for the environmental media under Operable Unit 5, since any removal action taken in the waste pit area would simply represent a partial source control rather than an action directly involving the environmental media.

5.1.2 Implementability

The implementability of an alternative is typically defined by its technical feasibility, including the availability of applicable technologies, and its administrative feasibility. Each is discussed in more detail below. For purposes of this removal action, a third evaluation component, timeliness, is added due to the strong preference for removal actions that can be designed and implemented in a minimum amount of time.

Technical Feasibility

Evaluation factors regarding the technical feasibility of an alternative include the ability to construct and operate the alternative, the ability to meet the required process efficiencies or performance goals, compliance with action-specific ARARs, and the previously demonstrated performance of the underlying technologies.

In addition, the technical feasibility criterion is used to evaluate the availability of necessary equipment, materials, and personnel, as well as adequate storage or disposal capacity, if appropriate. Availability also considers any measures that may be required at the completion of the action, including monitoring and the availability of a responsible party to assume these activities.

Administrative Feasibility

The evaluation of administrative feasibility of an alternative includes the likelihood of public acceptance, activities necessary for coordination with other agencies, and the ability to obtain necessary approvals or permits.

5.1.3 Cost

The total cost of an alternative is the final factor considered. This factor includes direct capital costs, indirect capital costs, and any postremoval site control costs. The cost estimates are intended to provide an accuracy between +25 percent and -25 percent. A present-worth analysis is conducted to provide a common basis for comparison.

A discount rate of 10 percent is used over a five-year project duration. The five-year period is used in all alternatives as the expected duration of the removal action. Even though the associated activities or structures may continue to function beyond this period, it has been assumed that they will be incorporated into the final remedial action after five years and that the continuing costs will be accounted for under the evaluation of the final actions in the corresponding feasibility study.

The cost criterion is applied differently than the effectiveness and implementability criteria. The objective of the cost evaluation is to eliminate removal action alternatives for which the present-worth cost greatly exceeds that of other alternatives while providing only a marginal increase in the degree to which the removal action objectives are satisfied.

5.2 ALTERNATIVE 1 - NO ACTION

5.2.1 Effectiveness: Public Health

Under the no-action alternative, it is assumed that off-site receptors have unrestricted access to the discharged runoff and any affected surface water or groundwater regime. Based on ongoing analyses of existing conditions in Paddys Run and the regional aquifer being performed under the RI/FS, it has been concluded that no imminent and substantial endangerment currently exists for

any off-site receptor under the most plausible exposure scenarios. Therefore, the contribution of contaminants to Paddys Run and the aquifer from storm water runoff from the waste storage area does not represent an imminent and substantial endangerment.

It is also necessary to evaluate the radiological and chemical exposures associated with potential (i.e., hypothetical) exposure scenarios. For purposes of this analysis, the hypothetical maximally exposed individuals are considered to be: 1) an individual directly ingesting the runoff at the point of discharge from the waste pit area to Paddys Run; 2) an individual ingesting sediments from Paddys Run at the point of maximum observed uranium concentration upstream of the storm sewer outfall ditch; and 3) an individual consuming groundwater from the regional aquifer immediately below Paddys Run. All input data to the exposure models are based on actual field observations under the assumption that previously observed conditions are representative of both current and future conditions if no action is taken. An exception is the concentration in groundwater at the point of concern; the value used in the analysis is calculated from a groundwater flow and solute transport model assuming that the contaminated storm water runoff is the only flow in Paddys Run (i.e., no dilution water is available prior to leakage into the aquifer).

Measured concentrations of uranium in surface water runoff from the waste pit area have been extremely variable, ranging from less than 100 µg/L to more than 2000 µg/L. For the purposes of the assessment, a concentration of 1700 µg/L is used (valued based on 95 percent confidence level). Ingestion of surface water at a rate of 730 L/year (2 L/day) by a hypothetical receptor yields a calculated radiation dose (50-year CEDE) of approximately 200 mrem and a chemical hazard index exceeding 1.0, which exceed the specified TBCs for radiation doses and chemical toxicity, respectively. It is important to note that the exposure scenario from which these results were calculated is based on the unrealistic assumption that Paddys Run is used continuously throughout the year as a drinking water source.

The observed concentration of uranium in the sediments of Paddys Run north of the storm sewer outfall ditch on FMPC property is approximately 5 pCi/g. Assuming that an individual consumes 0.2 grams of this sediment every day for a year, the resultant 50-year CEDE would be 0.09 mrem. Since this calculated radiation dose is such a small fraction of the dose limit, the exposure pathway of sediment ingestion is not considered to be a concern even under the no-action alternative. Additionally, the HI calculated for this exposure scenario is less than 0.01. Note that this analysis conservatively assumes that all the uranium in the sediments of Paddys Run north of the storm sewer outfall ditch are attributable to storm water runoff from the waste pit area.

The groundwater exposure pathway was analyzed by comparing the 33 µg/L derived concentration limit to the estimated concentration of uranium that would be extracted by a hypothetical receptor from a well immediately adjacent to Paddys Run. The latter value accounted for contributions from waste pit area runoff (via leakage from Paddys Run) and was based on the following assumptions:

- The concentration of uranium entering the aquifer from Paddys Run remains unchanged from the annual average concentration entering the stream from storm water runoff (1700 µg/L). This value is extremely conservative for two reasons: 1) the 1700 µg/L is greater than both the mean and median concentration values observed at representative sampling locations in the waste storage area, and 2) it does not account for any dilution in Paddys Run between the point of discharge and the assumed off-site location (i.e., a no-flow condition is assumed in Paddys Run, even though storm water runoff is occurring from the waste storage area).

- The rate of leakage is equal to 14 inches per year, which is equal to the recharge value used in the groundwater flow model.

- The contaminated recharge completely mixes with the groundwater passing through the zone of interest.

- Recharge and mixing occur within one 125-by-125-foot model cell, which is commensurate with assuming that the well would have a radius of influence of approximately 125 feet. The conservatism in this assumption is that the recharge is also assigned across the 125-by-125-foot surface area, thereby representing a stream width many times greater than the actual width of Paddys Run under low-flow conditions.

- The groundwater is pumped from a depth of 40 feet.

The resulting concentration value is 80 µg/L, which indicates that the hypothetical maximally exposed individual would be ingesting water that exceeds the 33 µg/L limit. The radiation dose (50-year CEDE) calculated for all pathways from groundwater having a concentration of 80 µg/L is approximately 21 mrem, of which the radiation dose for the drinking water pathway contributes 9.7 mrem. The chemical hazard index for all pathways from groundwater having a concentration of 80 µg/L is less than 1.0.

5.2.2 Effectiveness: Environmental

Under the no-action alternative, the principal objective of reducing the uranium loading to Paddys Run for purposes of improving the environmental community would not be satisfied. The current level of loading would be expected to continue until a final action was implemented in the waste pit area.

Decreases in macroinvertebrate diversity in those reaches of Paddys Run subject to discharges from the FMPC have been observed by both Miami University in 1986 to 1987 and ASI/IT in 1989. This provides circumstantial evidence of an environmental impact associated with site releases. In addition, several fish samples from Paddys Run were found to contain low but detectable levels of uranium.

Jurisdictional wetlands have been delineated along Paddys Run and within most of the drainageways that form an integral part of the storm water runoff collection and conveyance system within the waste pit area (Figure 2-3). These areas include the drainageway between Waste Pit 5 and the railroad tracks to the north, the drainageway running southwest through Drainage Area A, and the ditch from Drainage Area C into Paddys Run. Under the no-action alternative, contaminated discharges would continue to flow through these areas and could represent a long-term threat to the wetlands communities.

No data are available on the local biotic resources within each of the drainageways to substantiate whether the existing flows are causing an adverse impact. Any adverse conditions that do exist would be continued and no improvement would occur under the no-action alternative.

The no-action alternative would have no impacts on noise or air quality, and there would be no change in existing land use practices or waste management requirements. No cultural resources would be affected.

5.2.3 Effectiveness: Reduction in Toxicity/Mobility/Volume

The no-action alternative would result in no reduction to the amount of runoff being contaminated by the various sources of radionuclides and chemicals within the drainage areas. Likewise, no reduction in contaminant mobility or toxicity would be provided.

5.2.4 Effectiveness: Consistency with Final Action

If no action is selected as the preferred removal action alternative, the feasibility studies for Operable Units 1 and 5 would proceed under the same baseline conditions as currently assumed. The selection of a no-action alternative would have no effect on the selection process for the final, long-term action.

5.2.5 Effectiveness: Other Factors

There are no other factors related to the effectiveness of the no-action alternative.

5.2.6 Implementability: Technical Feasibility

The evaluation of technical feasibility and availability factors related to implementability is not appropriate for the no-action alternative. No construction or monitoring activities over and above those currently practiced are associated with this alternative.

5.2.7 Implementability: Administrative Feasibility

Acceptance of the no-action alternative by the public and the agencies is not likely. No action would maintain conditions that exceed derived discharge limits established under draft DOE Order 5400.5. In addition, to take no action at this time would represent an inconsistency with the commitments made by DOE to reduce the release of radionuclides and chemicals to surface waters under the Best Management Practices (BMP) Plan for the FMPC.

5.2.8 Implementability: Timeliness

There is no time element involved with the no-action alternative.

5.2.9 Cost

There are no capital or incremental operation and maintenance costs associated with the no-action alternative.

5.3 ALTERNATIVE 2 - CAPPING

5.3.1 Effectiveness: Public Health

There is evidence that a large percentage of the uranium in storm water runoff from the waste storage area is introduced from the waste pits and the perimeter areas. Not only does the concentration in the runoff increase downstream from the pits, but the measured uranium isotopic content of the surface water samples indicates that the uranium is depleted (i.e., less than 0.7 percent uranium-235 by weight) and suggests the source to be materials in the pits. Considering this condition, it can be conjectured that the concentration of uranium in the storm water runoff will decrease to below the DOE-derived concentration limit if the source, the waste pit area, is eliminated by a protective cap. This conclusion is supported by the available data on uranium concentrations upstream from the waste pits (less than 10 μg/L) (Section 2.3), which can be considered representative of residual concentrations once the capping alternative is implemented.

This anticipated residual condition would result in an acceptable level of risk to the hypothetical maximally exposed individual ingesting water directly from the point of discharge. Consequently, the most stringent exposure pathway for public health protection is within acceptable risk limits, and the alternative of capping would meet the objective of providing adequate protection to public health.

The other two exposure pathways, the ingestion of sediments from Paddys Run and the ingestion of groundwater from the regional aquifer below Paddys Run, would remain within acceptable limits. The resultant concentration of uranium in both media would be reduced from its existing value upon completion of the capping alternative.

The potential for public health risk could increase if the cover is damaged at some point in the future since contaminants could once again enter the runoff. However, such a condition would be of short duration until maintenance is provided. The resultant level of risk would be insignificant since the continuous, long-term exposure underlying the dose calculations would not be applicable.

Direct exposure to contaminants during construction should be minimal although some excavation into the contaminated area may be necessary for anchoring the cover material. The exposure of workers to direct radiation and radon from the K-65 silos and fugitive emissions from Waste Pits 5 and 6 during the period of field construction would be of more concern. As indicated in Section 5.1, appropriate health and safety protection to minimize this risk would be provided.

5.3.2 Effectiveness: Environmental

By reducing the amount of contaminants entering storm water runoff, the implementation of the capping alternative would satisfy the principal environmental objective of reducing the mass loading of uranium to Paddys Run. A residual loading would continue under this alternative, but in general the environmental conditions within Paddys Run would be gradually improved. The same gradual improvement in environmental conditions would occur in any wetland areas downstream from the waste pit area. The wetland area north of Pit 5 may not be improved since no cover is planned for the area adjacent to Pit 5.

Construction of a cap would impact wetlands within the waste pit area itself. The wetland area just west of the metal oxide silos could be disturbed or eliminated, depending on the final boundaries of the cap (Figures 2-3, 4-1). The wetland occupying the drainageway to the east of the metal oxide silos and running between the silos and the wastepit area would be eliminated by capping, and the

wetland in the drainageway running southwest through Drainage Area A could be disturbed by construction activities. However, these areas are relatively small, with a total area of approximately 5.5 acres, and are not considered critical habitat. It is expected that wetland communities would become reestablished in any areas not permanently altered. Paddys Run would not be directly affected by construction activities.

5.3.3 Effectiveness: Reduction in Toxicity/Mobility/Volume

The capping option will not decrease the volume of storm water runoff discharged to Paddys Run from the waste storage area. However, by eliminating the contact between the runoff and the contaminated surficial materials, the potential for contaminant desorption into the runoff is eliminated. The potential for the resuspension of contaminated soils into the runoff as suspended solids is also eliminated.

The result is a significant reduction in both the concentration and mass loading of uranium and any other contaminants in the runoff stream. This condition of eliminating the formation of contaminated surface water can be viewed as both a reduction in waste volume and a reduction in the mobility of the waste materials that exist in the surficial cover of the pits.

5.3.4 Effectiveness: Consistency with Final Action

The alternative of capping is inconsistent with most of the potential alternatives under consideration for the final action, but does not eliminate any alternatives from consideration in the feasibility study. Several remedial action alternatives still under consideration would require the removal of the capping materials from the waste pits. Therefore, the addition of any cover material as a removal action would increase the amount of material requiring removal and disposition during the final action. Due to contact with contaminated material during the intervening years, the cover materials added under the removal action may have to be treated as waste material at the time of removal. Future testing would be required to confirm this condition.

5.3.5 Effectiveness: Other Factors

Two other factors are noteworthy when comparing the effectiveness of the capping option with that of the other two alternatives. First, any future disruption of the cap would not significantly affect the long-term effectiveness of the alternative. Any release of contaminants that would result from damage to the cap would be limited to the area of damage and would occur only until maintenance is provided. Second, although protection of the perched groundwater is not a primary objective of this removal action, a capping of the pits would concomitantly reduce infiltration into the pit. This,

in turn, would reduce the rate of leakage of contaminated water from the pits into the underlying till and groundwater.

5.3.6 Implementability: Technical Feasibility

Construction of a temporary cap over Waste Pits 1 through 3, the burn pit, and areas near the silos would be straightforward and would utilize only widely practiced and proven technologies. The recent construction of an interim cap over Pit 4 demonstrates the technical feasibility of this option and provides direct evidence that suitable borrow material for a natural cover is available on site. Since no special properties would be required for a synthetic cover, this material would also be generally available. However, construction of a cap over Waste Pits 5 and 6 would require stabilization of pit contents before covering. Suitability of stabilizing agents would need to be determined.

Construction of the cap would require trained operators and craftsmen, but these are readily available locally and have performed work at the FMPC in the past.

5.3.7 Implementability: Administrative Feasibility

A permit to install may be required for cap installation. Additionally, it may be necessary to meet the substantive permitting requirements of the U.S. Corps of Engineers (COE) if any jurisdictional wetlands are destroyed by channel construction. Since the affected wetland area is under 10 acres in size and would not be characteristically unique, requirements of a simplified Nationwide Permit should be appropriate.

5.3.8 Implementability: Timeliness

Due to the aforementioned need for a change in course, the selection of a capping alternative at this point in time would require the initiation of a complete design process and would extend the design time (relative to Alternative 4) by several months. The design would, however, be straightforward.

The construction time (excluding design and bid and award phases) for the capping alternative is estimated to be 12 months, which is somewhat greater than the estimated 10-month construction time for Alternative 4. The highest potential for construction delays would be adverse weather conditions.

The capping alternative would be fully effective immediately upon completion of construction.

5.3.9 Cost

Capital, annual, and present-worth costs were estimated for the capping alternative. Capital costs for this alternative include labor costs and the cost of materials necessary to stabilize waste materials and to install the cap. Indirect costs for engineering, subcontracting, and contingencies are also included. The total capital cost for this alternative is estimated to be $5,556,000 (Appendix A).

Annual costs for this alternative include only the cost of cap maintenance and have been estimated at 5 percent of the direct capital costs, or $278,000 annually. Based on a 10 percent discount factor and a five-year project period, the present-worth value of this alternative is estimated to be approximately $6,610,000.

5.4 ALTERNATIVE 4 - RUNOFF COLLECTION AND TREATMENT

5.4.1 Effectiveness: Public Health

Three environmental pathways have been quantitatively evaluated as potential contributors to public health risk in relation to storm water runoff from the waste pit area. Alternative 4, which involves the collection of runoff from the waste storage area, eliminates the public health exposure scenario of direct ingestion of the contaminated discharge. This scenario represented the principal public health concern under the no-action case. The remaining exposure pathways, which include the ingestion of sediment from Paddys Run and the ingestion of groundwater from the regional aquifer underlying Paddys Run, did not present an unacceptable level of risk even under the no-action alternative and would be improved if the storm water collection and treatment alternative is implemented.

The eventual discharge of the contaminated runoff to the Great Miami River via Paddys Run was not considered as a principal exposure pathway under a no-action alternative in comparison with the three pathways already under consideration. However, under Alternative 4, the direct discharge of the storm water runoff into the Great Miami River after treatment within the biodenitrification system introduces a need to reconsider this pathway. Table 5-1 presents total uranium concentrations in both filtered and unfiltered samples for these locations collected by ASI/IT from the drainageways within the waste pit area (unfiltered data are presented in Table 2-3). Within the range of uncertainty of the data, one can conclude that the concentrations in the filtered and unfiltered samples are the same and that little (if any) uranium is bound up in suspended solids in

TABLE 5-1
URANIUM CONCENTRATIONS: FILTERED VERSUS UNFILTERED SAMPLES

	Total Uranium (µg/L)	
Sample Location	Filtered Sample	Unfiltered Sample
ASIT-001	21 ± 3	18 ± 3
ASIT-010	282 ± 46	231 ± 38
ASIT-018	700 ± 112	667 ± 106
ASIT-019	944 ± 156	930 ± 152
ASIT-020	538 ± 87	530 ± 86
ASIT-022	92 ± 15	54 ± 9
ASIT-023	465 ± 82	433 ± 72
ASIT-024	517 ± 83	576 ± 93
ASIT-027	8148 ± 1360	9318 ± 1499
ASIT-028	5067 ± 835	5779 ± 943
ASIT-029	1228 ± 201	1005 ± 163
ASIT-030	7030 ± 1127	8363 ± 1338
ASIT-031	6853 ± 1144	7380 ± 1210

the storm water runoff. This finding is generally consistent with the low values of total suspended solids observed in the same samples. The important point is that solids removal via settling would not be expected to correlate with uranium removal. Recent data collected by WMCO also indicates that less than 10 percent of the uranium in storm water runoff from the production area is tied up with filterable solids. Consequently, one can assume that at least 90 percent of the current uranium loading from the waste pit area storm water runoff will escape treatment via settling in the biodenitrification surge lagoon. The uranium removal efficiency of the biodenitrification towers and effluent water treatment system remains an unknown.

Under a worst-case assumption that no uranium removal is achieved, no incremental public health concerns exist for those pathways associated with usage of the Great Miami River. Although the additional loading from the storm water runoff (averaged over the year) would represent a 10 percent increase in loading through the main effluent line to the Great Miami River, the concentration of the uranium in the combined flow would not be significantly increased.

The alternative of runoff collection and treatment would increase the potential for direct contact with contaminated runoff because of the provision for temporary storage within the collection system. However, the entire system will be located within a controlled access area and the associated risk will be minimal. A future risk is associated with system breakdown since contaminated runoff could once again enter Paddys Run. However, as with the capping option, such a condition would be short-lived until maintenance is provided and would not result in continuous, long-term exposure.

Under this option, the potential exists for direct exposure to contaminants during construction due to the management of contaminated runoff throughout the period of construction and excavation into the contaminated area during construction of the new ditches. It is assumed that appropriate worker protection will be provided to negate any associated risk. Protection is also assumed against any exposure related to the K-65 silos or fugitive emissions from the waste pits during field construction.

5.4.2 Effectiveness: Environmental

By eliminating the discharge of runoff from the waste pit area to Paddys Run, Alternative 4 would totally satisfy the objective of reducing uranium loadings to the stream. The environmental conditions within Paddys Run would gradually improve as a result. On the other hand, there would be no environmental improvement in any areas upstream from the final collection sump until a final

action is taken, since no control of the contaminant sources (e.g., the waste pits and perimeter areas) is being implemented under this alternative.

Any disruption of the local ecological communities during construction would be temporary and reestablishment of the communities would be expected. Construction of the collection ditches would disrupt the areas delineated as jurisdictional wetlands (Figure 2-3). However, these areas, excluding Paddys Run, are relatively small, with a total area of approximately eight acres, and are not considered critical habitat. It is expected that wetland communities would become reestablished in the areas not permanently altered and would develop in the newly constructed drainageways. Paddys Run would not be directly affected by construction activities and environmental conditions would gradually improve, as described above.

Any noise or air quality impacts associated with the collection and treatment alternative would be minimal and limited to on-site populations. There would be no changes in land use practices, no effect on cultural resources, and no discernable effects on property values or other socioeconomic factors. The construction of the channels and sumps will generate waste material that would be disposed of in accordance with approved site procedures. This does not represent a significant environmental concern.

5.4.3 Effectiveness: Reduction in Toxicity/Mobility/Volume

Although the collection and treatment alternative will eliminate the mass loading of uranium from the waste pit area to Paddys Run, the total system may do little to reduce the volume and mobility of the contaminated runoff until the advanced wastewater treatment plant is on-line. As previously cited, only a maximum 10 percent uranium removal efficiency can be expected as a result of settling in the biodenitrification surge lagoon. The degree of uranium removal in subsequent treatment units is unknown. Rather than actually being treated, the uranium is essentially being routed to the Great Miami River without first passing through Paddys Run. Once the advanced wastewater treatment system is operating, however, uranium removal will be effected and the reduction in volume and mobility will be a significant benefit of the proposed collection and treatment system.

5.4.4 Effectiveness: Consistency with Final Action

A major advantage of the collection and treatment alternative is its consistency with the final remedial program at the FMPC. It is expected that any alternative for final remediation of the waste storage area under Operable Unit 1 will require an upgrade of the storm water collection and

control system; therefore, the system proposed under Alternative 4 would likely become a necessary and integral part of the final remedy.

By cutting off contaminated runoff to Paddys Run, a source of continuing release to both the surface water and groundwater beneath Paddys Run is eliminated. Therefore, Alternative 4 can also be considered as supportive of the long-term remedial action program for the regional environmental media under Operable Unit 5.

5.4.5 Effectiveness: Other Factors

One additional factor that favors the alternative of runoff collection and treatment is that the effectiveness of the remedy has no reliance on the source of the contaminants in the runoff. Therefore, the effectiveness is not affected by any remaining uncertainties as to whether all significant sources are known and accounted for, as is the case under the capping alternative.

There are other factors, however, that work against the long-term effectiveness of this alternative in relation to the capping alternative. First, the disruption of a system component (e.g., the pumping system) would result in the ineffectiveness of the entire system, although this potential problem is minimized by the inclusion of a standby pump and emergency power supplied by a diesel generator. Second, any operational problems with the biodenitrification system, whether or not caused by the proposed surface water contribution, would also compromise system performance. Finally, the long-term performance of this alternative relies on the future construction of the advanced wastewater treatment facility.

5.4.6 Implementability: Technical Feasibility

Construction of the storm water collection and pumping systems would utilize only widely practiced and proven technologies. All necessary labor and materials are readily and locally available.

Emphasis will need to be placed on storm water management during the construction of two particular components of the system. First, the collection system will consist of a combination of new drainageways with modifications to existing ditches. Good construction planning is required to minimize discharges during the change over from the old to the new system. Second, available data on perched groundwater conditions in the waste storage area indicate that the main collection sump will be constructed within a perched groundwater zone. Again, storm water management is necessary to prevent the direct communication between surface water and perched groundwater that could result in an increased discharge of uranium to groundwater.

5.4.7 Implementability: Administrative Feasibility

The transfer of the runoff into the main effluent line from the FMPC is not likely to require a modification of the existing NPDES permit for this discharge point. The addition of stormwater runoff from the waste pit area is incorporated under the current permit application.

As with the capping alternative, it may be necessary to obtain approval from COE if any jurisdictional wetlands are significantly disrupted or destroyed by channel construction.

5.4.8 Implementability: Timeliness

The collection and treatment of storm water runoff from the waste pit area has been an ongoing consideration of the BMP plan at the FMPC; therefore, design time required for this alternative is minimal.

The construction time for the collection and treatment alternative is estimated to be 10 months. Adverse weather conditions, particularly wet conditions involving considerable storm water runoff, represent the greatest potential for construction delays.

The collection and treatment alternative would be fully effective immediately upon completion of construction.

5.4.9 Cost

The total capital cost for Alternative 4 is $2,798,000 (Appendix A). This cost includes direct capital costs for equipment, labor costs, and the cost of materials necessary for the installation of the collection and pumping systems. Indirect capital costs for engineering, subcontracting, and contingencies are also included. The biodenitrification treatment system is already in place, and no costs of the advanced wastewater treatment plant are accounted for under this alternative.

The annual costs for this alternative include only maintenance of the collection and pumping systems and have been estimated at 5 percent of the direct capital costs, or $139,900 annually. Based on a 10 percent discount factor and a five-year project period, the present-worth value of this alternative is estimated to be $3,325,000.

5.5 REQUIREMENTS POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE TO THE PROPOSED ACTIONS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED

The ARARs and TBCs for the proposed actions for the waste pit area storm water runoff control are listed in Table 5-2. The potential ARARs follow EPA-recommended classifications: contaminant-specific ARARs, location-specific ARARs, and action-specific ARARs. A discussion of each group and its relation to the proposed actions is given below.

5.5.1 Contaminant-Specific ARARs

The contaminant-specific ARARs apply to all of the proposed removal actions since the contaminant concentration drives the action level for the implementation of the removal action. However, the application of the contaminant-specific ARARs listed in Table 5-2 is complicated by the fact that radionuclides (particularly uranium) have been exempted from most environmental regulations. DOE has been primarily self-regulating for environmental activities and established its own policies for environmental monitoring, waste disposal, and limits of exposure to employees and the public. EPA regulations regarding the handling and disposal of wastes containing radionuclides are regulated under programs set up by the Uranium Mill Tailings Act and the NRC.

Regulations concerning the management and disposal of radioactive waste materials have been generally separated from other hazardous waste regulations. Uranium is excluded from the definition of solid waste (and therefore also from the definition of hazardous waste) under 40CFR261.4(a)(4) "Source, special nuclear, or by-product material as defined by the Atomic Energy Act . . . ." Source is defined under 10CFR20.3(a)(15) as "uranium . . . in any physical or chemical form . . . ." Uranium is also specifically excluded under federal and Ohio water quality standards, drinking water standards, and NPDES discharge criteria. Federal MCLs for uranium are mandated for promulgation but none have yet been proposed by EPA. Thus, where radionuclides are concerned, the process of coordinating DOE regulations with mainstream state and federal environmental regulations is required.

5.5.2 Location-Specific ARARs

The location-specific ARARs are applicable for each alternative regarding the actions' impacts on wetlands and wildlife. The implementation of any action should be conducted in a manner such that minimal disturbance or destruction to wetlands, protected habitats, and/or endangered species is caused by the action.

TABLE 5-2
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Contaminant-Specific ARARs	
Requirement	Application to the Waste Pit Area
Ohio Water Quality Standards (OAC3745-1)	3745-01-04(D) set the criterion applicable to all waters, 3745-01-05 sets forth the antidegradation policy for waters of the state and 3745-1-21 describes the use designations for the Great Miami River; 3745-1-32(c)(9) specifically excludes uranium from the Ohio River stream criteria
Ohio Drinking Water Rules (OAC3745-81)	3745-81-15 and -16 establishes MCLs for gross alpha and beta particle activity but specifically excludes uranium
Ohio Radiation Protection Standards (OAC3745-38)	3701-38-13(D) provides concentration limits for discharge of radioactive materials into air or water in unrestricted areas
Safe Drinking Water Act (40CFR141)	
a. Maximum Contaminant Levels (MCLs)	Groundwater MCLs for uranium are mandated for promulgation, but not yet proposed
b. Maximum Contaminant Level Goals (MCLGs)	Considered pursuant to SARA Section 121(d)(2)(A(ii)
Clean Water Act (PL92-500) Federal Ambient Existing Source and New Source Water Quality Criteria (AWQC)	Specifically excludes uranium from consideration in discharges to surface water

TABLE 5-2 (Continued)
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Location-Specific ARARs	
Requirement	Application to the Waste Pit Area
Regulation of Activities Affecting Waters of the U.S. (33CFR320-329), for Ohio (OAC3745-32)	COE regulations apply to construction or other disruptive activities in both wetlands and navigable waters
Endangered Species Act of 1978 (16USC1531)	The effects of No Action and the construction and discharge activities must be considered if endangered species are located in an area impacted by the waste pit area
Fish and Wildlife Coordination Act (16USC661)	The effects on wetlands and protected habitats by No Action and by the construction and discharge portions of the alternatives must be considered if any wetlands or protected habitats are located in the waste pit area
Fish and Wildlife Improvement Act of 1978 (16USC742)	The effects on wetlands and protected habitats by No Action and by the construction portions of the alternatives must be considered if any wetlands or protected habitats are located within the waste pit area
Executive Order 11990 Protection of the Wetlands	This order may affect the administrative ability of alternatives which cause disturbance or destruction of wetlands
Ohio Location Standards (OAC3745-54-18)	Governs the location of hazardous waste treatment, storage, or disposal with respect to floodplains
Ohio Conservancy District Rules governing activities within the boundaries of a conservancy district (ORC6109.19)	Erection of obstruction/facilities within the bounds of the Great Miami River Conservancy District will require permit from the Board of Directors

TABLE 5-2 (Continued)
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Action-Specific ARARs	
Requirement	Application to the Waste Pit Area
U.S. EPA Regulations for Environmental Radiation Protection Standards for Nuclear Power Operations (40CFR190)	NRC standards for radiation doses received by members of the public in the general environment and to radioactive materials introduced into the general environment as a result of operations which are part of the nuclear fuel cycle
U.S. EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailing (40CFR192)	Established cleanup standards for inactive uranium mill tailing sites; some standards may be applicable to the FMPC remedial response
CWA NPDES Requirements (40CFR121-125) and Ohio requirements for NPDES permit to discharge wastewater to the waters of the state (OAC3745-33)	Program is mandated to state control; there are no standards for uranium discharge, but other limitations or criteria may be set by a permit (pH, flow, etc.) for alternatives which have a discharge component
Ohio River Quality Standards Antidegradation Policy [OAC3745-1-05(A) and OAC3745-1-05(B)]	Applies to the alternatives which discharge to surface waters
RCRA Requirements (40CFR260-279)	Uranium does not qualify as a solid or hazardous waste
Ohio Solid Waste Management Facility operating rules and permit requirements (OAC3745-27 and 37)	These rules may apply to residuals disposal from groundwater treatment facilities
Ohio Hazardous Waste Management Facility operating rules and permits (OAC3745-50 through 70)	These rules may apply to groundwater treatment plant construction operations and permitting
Ohio Corrective Action Program (groundwater protection) (OAC3745-55)	Includes monitoring requirements for hazardous waste management facilities

TABLE 5-2 Continued
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Action-Specific ARARs	
Requirement	Application to the Waste Pit Area
Ohio restrictions on fugitive dust emissions (OAC-17-08)	Requires dust control during any construction activities which may take place during the remedial response
OSHA Requirements (29CFR1910, 1926, and 1904)	Required worker safety requirements for exposure while engaged in on-site activities
Ohio General Radiation Protection Standards; all facilities that receive, possess, use, store, transfer, install, service, or dispose of any source of radiation require registration by their handlers (OAC3701-70 and 71)	Required worker safety requirements for exposure while engaged in on-site activities
Atomic Energy Act of 1954 (42USC2011)	This act authorizes the conduct of atomic energy activities
DOE Organization Act (42USC7101)	Established powers and responsibilities of DOE
National Environmental Policy Act (NEPA) of 1969 (42USC4341)	Requires consideration of environmental concern by DOE at the FMPC consistent with national environmental policies and goals and provides a method for accomplishing these goals
NRC Rules for Land Disposal of Radioactive Wastes (10CFR61)	NRC standards may apply for exposure limitations at the FMPC
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	Requires DOE to comply with applicable pollution control standards at the FMPC

TABLE 5-2 Continued
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

TBCs	
Requirement	Application to the Waste Pit Area
Doe Order for Radiation Protection of the Public and Environment (DOE 5400.5)	Chapter II.1.d, sets the annual not-to-exceed effective dose limit of 4 mrems for human consumption through drinking water and 100 mrems from all radiation exposure via all environmental transport pathways; the DOE-derived concentration guideline for off-site releases of radioactive materials to surface waters applies to the CEDE of 100 mrems with exposure via ingestion only
DOE Order for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program (5400.4)	Authorizes CERCLA activity by DOE at the FMPC
DOE Order for National Environmental Policy Act (NEPA) (5400.1C)	Establishes environmental policies and goals applicable to DOE and the FMPC
DOE Order for Radiological Effluent Monitoring and Environmental Surveillance (5400.XY)	Monitoring requirements for DOE facilities applicable to all alternatives
DOE Order for Hazardous and Radioactive Mixed Waste Management (5480.2)	Regulations by which FMPC currently operates for waste management
DOE Order for Environmental Protection, Safety, and Health Protection Information Reporting Requirements (5481.1)	Safety requirements for FMPC operations to be followed during remedial response actions
DOE Order for Quality Assurance (5700.6B)	Establishes the level of quality assurance for any work done at the FMPC for remedial response
DOE Order for Radioactive Waste Management (5820.2A)	Policies and guidance for FMPC waste and contaminated facility management
Federal Compliance with Pollution Control Standards Executive Order (12088)	Delegates CERCLA and SARA responsibilities to DOE and EPA
Superfund Implementation Executive Order (12580)	NRC rules may apply to alternatives containing groundwater treatment, disposal, or residual handling components

5.5.3 Action-Specific ARARs

Action-specific ARARs regulate the process and operation of removal actions taken to mitigate the impact of the waste pit area storm water runoff. Any actions taken as a result of releases from the FMPC will be under the supervision of DOE and NRC, and are also subject to EPA pursuant to RCRA and CERCLA/SARA. The powers and responsibilities of DOE and NRC are established by the Atomic Energy Act (42USC2011) and the DOE Organization Act (42USC7101).

The NRC regulation 10CFR20 sets radiation protection requirements for the public and the environment. In general, 10CRF Part 20 is designed to limit radiation hazards caused by NRC-licensed activities. Part 20 contains many substantive requirements including permissible dose levels (in terms of the general public's exposure to radiation), radioactivity concentration limits for effluents, precautionary procedures, and waste disposal requirements. Part 20 establishes a general requirement that radiation exposures should be maintained as low as reasonably achievable (ALARA). Specifically, 10CFR Sections 20.101 - 20.105 establish specific radiation dose limits for the protection of workers and members of the public. Section 20.106 establishes concentrations for radionuclides in airborne and liquid effluents to unrestricted areas. Sections 20.301 and 20.302(a) establish waste treatment and disposal requirements for radioactive wastes.

Additional requirements pertaining to the operation of the FMPC were promulgated under authority of the Atomic Energy Act and set limits on radiation doses received by members of the general public from operations within the uranium fuel cycle. These requirements, as stated in 40CFR190 and regulated by EPA, may be relevant and appropriate to releases of radionuclides and radiation during cleanup actions at the FMPC. Also, cleanup standards for inactive uranium mill tailing sites, as regulated by 40CFR192, may be relevant and appropriate to removal actions at the FMPC.

Monitoring and reporting requirements for DOE operations (including releases) are governed by NRC and EPA requirements listed in 10CFR61.80 and 40CFR300, respectively.

Action-specific ARARs regulating the management of residuals from the treatment and disposal actions at the site are NRC land disposal rules (10CFR61) and RCRA (40CFR, Sections 260 - 279). Worker safety requirements for radiation exposure while handling contaminated wastewater and residuals are governed by Occupational Safety and Health Administration (OSHA) requirements in 29CFR1910, 1926, and 1904. Construction activities in areas unrelated to contamination will be governed under standard OSHA requirements for worker safety in 29CFR.

Discharge of treated or contaminated water to surface water will be regulated under the Clean Water Act NPDES requirements, as delegated to the state of Ohio (40CFR121 - 125 and OAC3745-33). The discharges must meet national and state of Ohio ambient water quality and antidegradation criteria.

5.5.4 TBCs

In addition to legally binding laws and regulations, federal and state environmental and public health programs also develop criteria, advisories, and guidance that are not legally binding but may be useful and appropriate to provide adequate protection for public health and the environment. Since most of DOE's operations are exempt from NRC's licensing and regulatory requirements, DOE's requirements for radiation protection and radioactive waste management are contained in a series of internal DOE orders. These DOE orders are not promulgated requirements and are not potential ARARs. However, to the extent that DOE orders are more stringent or cover areas not addressed by existing ARARs, they are considered where necessary to develop a protective remedy.

Since no contaminant-specific ARARs are identified for uranium, for the purpose of this EE/CA, concentrations of uranium for protection of public health and the environment are derived from DOE Order 5400.5. The exposure limit providing protection for public health and the environment from chemical and radiological constituents in the surface water runoff is the total annual CEDE limit of 100 mrem for off-site individuals for radiation exposure via all environmental transport pathways.

A second exposure limit applicable to the storm water runoff removal action is the CEDE limit of 4 mrem from an annual intake of radioactive materials in drinking water. These limits are discussed in Section 5.1.1 and are used as the basis for the public health evaluations for each alternative.

Other orders to be considered include the Federal Compliance with Pollution Control Standards Executive Order 12088 and Superfund Executive Order 12580, which define the authority and scope of DOE compliance with environmental statutes. DOE Order 5400.4 authorizes CERCLA activity by DOE at the FMPC.

In addition to EPA and NRC requirements, monitoring and reporting requirements for DOE operations are also governed by DOE Orders 5484.1, 5700.6B, and 5400.XY. Waste management activities are governed by DOE Orders 5480.2 and 5820.2A. Additionally, DOE Order 5400.1C establishes environmental policies and goals consistent with NEPA at the FMPC.

6.0 SELECTION OF PREFERRED ALTERNATIVE

In Chapter 5.0, three removal action alternatives were evaluated on an individual basis against nine evaluation factors representing the three principal criteria of effectiveness, implementability, and cost. The results of this evaluation are summarized in Table 6-1. A comparative evaluation of these same nine factors, to support the selection of a preferred alternative, is the subject of this chapter.

6.1 ELIMINATION OF NONRESPONSIVE ALTERNATIVES

Based on the evaluation reported in Chapter 5.0 and summarized in Table 6-1, the no-action alternative is shown to be a deficient response action in relation to several factors. First and foremost is the continued release of storm water runoff with uranium concentrations exceeding DOE DCGs, resulting in noncompliance with the established health protective TBC for a hypothetical maximally exposed individual. Although a direct relationship between observed environmental degradation in Paddys Run and the runoff from the waste pit area has not been established, the relative contribution of releases to Paddys Run from the runoff is substantial and some correlation to the observed effects can be assumed. The no-action alternative would prolong any environmental impacts associated with the release. The contribution of uranium to the regional aquifer via leakage from Paddys Run will also remain at its current level if no action is taken to reduce the uranium loading to Paddys Run. For these reasons, the no-action alternative is eliminated from further consideration.

6.2 COMPARATIVE EVALUATION

This evaluation compares the capping alternative (Alternative 2) and the collection and treatment alternative (Alternative 4) in relation to the five effectiveness factors, the three implementability factors, and the present-worth cost factor identified in Table 6-1. Both alternatives are shown to satisfy the important public health protection criterion. Although some differences exist between the alternatives in relation to specific exposure pathways, neither alternative can be given a significant preference in terms of public health protection.

Both alternatives also satisfy the objective of reducing the uranium loadings to Paddys Run for purposes of protecting the aquatic environment of the stream, with the collection and treatment option providing a higher level of protection since no residual loadings are associated with this

TABLE 6-1

SUMMARY OF EVALUATION OF ALTERNATIVES

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Effectiveness: Public Health	Does not meet TBC for max. exposed individual; no imminent & substantial risk	All exposure pathways within acceptable risk limits	All exposure pathways within acceptable risk limits
Effectiveness: Environmental	No decrease in uranium loading to Paddy's Run; continuation of any current impacts	Significant reduction in uranium loading to Paddy's Run; overall improvement elsewhere; potential wetlands impact	Total reduction in uranium loading to Paddy's Run; little improvement elsewhere; potential wetlands impacts
Effectiveness: Reduction In Toxicity, Mobility, Volume	No reduction in toxicity, mobility, or volume	Significant reduction in uranium concentration and loading in runoff	No reduction in volume of contaminants runoff; "End of Pipe" treatment varies with time
Effectiveness: Consistency with final action	No effect on final action	Not consistent, with final actions for Operable Units 1 and 5 unless capping is selected	Consistent with final actions for Operable Units 1 and 5
Effectiveness: Other factors	None	Reduction in infiltration and leaching potential; damage has little effect	No reliance on source of contaminants in runoff

TABLE 6-1 - (Continued)

SUMMARY OF EVALUATION OF ALTERNATIVES

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Implementability: Technical Feasibility	Not Applicable	Straightforward, with readily available labor and materials; special conditions require consideration	Straightforward, with readily available labor and materials; special conditions require consideration
Implementability: Administrative Feasibility	Maintains conditions exceeding DOE limits; inconsistent with previous commitment	Requires permit to install from Ohio; no other permits for on-site actions; however, requirements for wetlands must be met; would require reversal of previous commitment	No permits required for on-site actions; however, requirements for wetlands must be met
Implementability: Timeliness	No time element involved	Longer design period; longer construction period	Shorter design period; shorter construction period
Cost (Present Worth)	$0	$6,610,000	$3,325,000

alternative. However, overall environmental improvement is better satisfied by the capping alternative since it also protects the local environments upstream from Paddys Run.

The capping alternative also has the advantage of preventing the contamination of the storm water runoff rather than providing for its treatment after the contamination occurs. However, an uncertainty in source definition could compromise the effectiveness of the capping alternative in achieving this condition. The collection and treatment alternative is preferred under a strict interpretation of the SARA stipulation for providing treatment to the maximum extent practicable. The level of treatment provided will vary due to the planned shift from use of the biodenitrification facility to use of the advanced wastewater treatment plant once the latter is constructed and operating.

The collection and treatment alternative is consistent with the final remedial actions for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5). This CERCLA-based requirement for a removal action is not, however, satisfied by the capping alternative. If removal of the waste pits is selected as the final remedial action, interim capping adds additional costs to the project. The latter alternative would not, however, bias the decision process for the final action or eliminate one or more actions from future consideration.

The capping alternative will be less prone to system failure than the collection and treatment alternative, and any disruptions to the cap will have less impact than disruptions to the collection and treatment system. However, neither case represents a significant public health or environmental concern due to the temporary nature of any disruption, and the differences are not considered to be a principal decision factor.

Conditions that will require special attention during both the engineering and construction activities are associated with both the capping and the collection and treatment alternatives. Again, however, none of these conditions are insurmountable constraints to the technical feasibility of either alternative and are not considered to represent a critical decision factor.

The collection and treatment alternative is preferential from an administrative feasibility standpoint due to the lack of administrative constraints to project approval. Storm water runoff from the waste pit area has already been included in the NPDES permit for the main FMPC discharge. Additionally, if the wetlands are affected, requirements necessary to meet substantive permitting

requirements should not be significant due to the small area and nature of the affected wetland areas.

The collection and treatment alternative is also preferential from a timeliness standpoint. This alternative would be implemented in a shorter time frame. This is due primarily to three factors. The design is nearly complete due to prior consideration of this option under the site's BMP plan, the construction time is shorter, and this alternative is currently provided for as a line-item project in the DOE funding system. The entire funding process may need to be reinitiated for the capping alternative, thus delaying its time to completion.

The present-worth cost of the capping alternative has been estimated to be $6,760,000 and the present-worth cost of the collection and treatment alternative is approximately $3,404,000. This factor favors the collection and treatment alternative since the cost of capping is estimated to be approximately twice the cost of Alternative 4. The long-term remediation costs must also be considered. The collection and treatment system will likely be an integral part of a future action within the waste pit area and any expenditures today would offset future costs. The costs of capping, however, may be nonrecoverable once the final action is selected (since a temporary cap is not expected to be part of the final remedy). Also, the costs of the final action would increase if removal and disposal of the capping material is required under the remedial action.

6.3 PREFERRED ALTERNATIVE

Based on the previous discussions of the comparative evaluation of the capping and the collection and treatment alternatives, the collection and treatment alternative has been selected as the preferred alternative. There are several factors that favor the selection of this alternative. First, the collection and treatment alternative is consistent with all final remedies being considered for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5). Second, the estimated time for completion of this alternative is shorter than that for the capping alternative. Finally, this alternative can be implemented for one-half the cost of the capping alternative while providing equal or greater protection for public health and the environment.

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APPENDIX A

Cost Estimates for Alternatives

COST ESTIMATE FOR ALTERNATIVE 2

I. Backfill Site

Assume on-site borrow area

$3.00/cy transport, grading, and compaction

Zone 1	Approximately 1 ft over 72,750 sq ft	=	2,690 cy		
Zone 2	Approximately 1 ft over 78,000 sq ft	=	2,890 cy		
Zone 3	None required				
Zone 4	Backfill Pit 6 (5 ft x 8100 sq ft) and approximately 1 ft over 91,500 sq ft	=	4,880 cy		
Zone 5	Backfill Pit 5 (4 ft x 52,000 sq ft)	=	7,700 cy		
Zone 6	Approximately 1 ft over 71,800 sq ft	=	2,660 cy		
			20,820 cy x $3.00	=	$62,460
	Mobilization/Demobilization				$5,000

II. Solidify Sludge in Pits 4 and 5

$4.00/cu ft labor and material

Volume: Pit 5 (5 ft avg depth x 47,500 sq ft) = 236,250 cu ft

Pit 6 (3 ft avg depth x 8100 sq ft) = 24,300 cu ft

(236,250 + 24,300) x $4.00 = $1,042,200

III. Liner and Geofabric Installation

$3.50/sq ft, material and labor

$10.00/linear ft, anchor material and labor

Area of approximately 10.5 acres or 457,400 sq ft

Liner Cost: 457,400 sq ft x $3.50 = $1,600,800

Anchor Cost: 6,000 ft perimeter x $10.00 = $60,000

COST ESTIMATE FOR ALTERNATIVE 2
-Continued-

IV.	Top Soil	
	Area: 457,400 sq ft x 1 ft avg = 457,400 cu ft = 16,940 cy	
	$3.00/cy x 16,940	= $50,820
	Mobilization/Demolition	$5,000
V.	Vegetation - (Seed, Fertilizer, and Mulch)	
	Area: 457,400 sq ft x $.10/sq ft	= $45,740
	SUBTOTAL	$2,872,020
	CONSTRUCTION MANAGEMENT @ 24%	$689,290
	SUBTOTAL	$3,561,310
	CONTINGENCY @ 30%	$1,068,390
	TOTAL (CONSTRUCTION)	$4,629,700
	DESIGN @ 20%	$925,940
	TOTAL (PROJECT COST)	$5,556,000

COST ESTIMATE FOR ALTERNATIVE 3

I. Excavation of Trench at Lower Elevations

Zone	Volume Required[1]	Length[2]	Profile of Cut[3]
1	3,537	600 ft	4 ft x 5 ft
2	3,792	500 ft	5 ft x 5 ft
3	162	400 ft	2 ft x 2 ft
4	747	125 ft	4 ft x 5 ft
5	3,379	525 ft	4.5 ft x 5 ft
6	4,500	600 ft	5 ft x 5 ft

Total Soil Excavated (length x profile)

Area			
1	600 x 4 x 5	=	444 cy
2	500 x 5 x 5	=	463 cy
3	400 x 2 x 2	=	59 cy
4	125 x 4 x 5	=	93 cy
5	525 x 4.5 x 5	=	438 cy
6	600 x 5 x 5	=	556 cy
			2,053 cy

Cost to excavate using a backhoe, 8 cy/hr x $100/hr

2,053 cy/8 x $100 = $25,660

II. Disposal Costs

2,053 cy/13.3 = 154 Containers

a. Cost of Containers - 154 x $600/each = $92,400

b. Transportation to NTS (4 containers/load) - 154/4 x $6,000 = $231,000

c. Disposal Cost of NTS - 2053 cy x $324/cy = $665,170

[1]Infiltration from HELP output
[2]Length of base
[3]Void ratio estimated at 30%

COST ESTIMATE FOR ALTERNATIVE 3
-Continued-

III.	Trench Fill Material (D_{50}=3")	
	Cost @ $12/cy = 2,053cy x $12 =	$24,640
IV.	Sumps and Riser for Each Trench	
	6 @ $5,000 =	$30,000

SUBTOTAL	$1,068,870
CONSTRUCTION MANAGEMENT @ 24% EXCLUDES DISPOSAL	19,270
SUBTOTAL	$1,088,140
CONTINGENCY @ 30%	326,440
SUBTOTAL	$1,414,580
COST OF CAP (ALTERNATIVE 2)	$4,629,700
TOTAL (CONSTRUCTION)	$6,044,000
DESIGN @ 20% (EXCLUDING DISPOSAL)	$1,011,000
TOTAL (PROJECT COST)	$7,055,000

COST ESTIMATE FOR ALTERNATIVE 4

ESTIMATE SUMMARY	
GENERAL CONTRACTOR - PRIME	$ 699,391
ELECTRICAL SUBCONTRACT	87,185
MECHANICAL SUBCONTRACT	204,401
FENCING SUB-SUBCONTRACT	7,366
INSTRUMENT AND SUB-SUBCONTRACT	24,613
SUBTOTAL	$1,022,956
CONSTRUCTION MANAGEMENT @ 24%	245,504
SUBTOTAL	$1,268,460
WASTE DISPOSAL	525,000
SUBTOTAL	$1,793,460
CONTINGENCY @ 30%	538,040
TOTAL (CONSTRUCTION)	$2,331,500
ENGINEERING & SUBCONTRACT ADMINISTRATION @ 20%	$466,500
TOTAL (PROJECT COST)	$2,798,000

Source: "Cost Estimate Design Review for EH&S Improvements, Phase IV, Vol 3." A.M. Kinney, Inc., 1989.

COST ESTIMATE FOR ALTERNATIVE 5

I.	Excavation Required[1] - 3.5 cy Dragline @ $2.00/cy	
	503,400 cy x $2.00 =	$1,006,800
II.	Disposal Costs	
	503,400 cy/13.3 = 37,850 containers	
	a. Cost of Containers	
	37,850 x $600/each =	22,710,000
	b. Transportation to NTS (4 containers/load)	
	37,850/4 = 9,463 x $6,000 =	56,775,000
	c. Disposal Cost at NTS	
	503,400 cy x $1,485/cy =	$747,549,000
		$828,041,000
III.	Site Backfill	
	-Assume on-site borrow area	
	-$3.00/cy transport, grading, and compaction	$1,510,200
	Mobilization/Demobilization	$5,000
IV.	Vegetation (Seed, Fertilizing & Mulch)	
	284,375 ft^2 0.10 ft^2 =	28,438
	SUBTOTAL	$829,584,600
	CONSTRUCTION MANAGEMENT @ 24%, EXCLUDES DISPOSAL	612,100
	SUBTOTAL	$830,196,700
	CONTINGENCY @ 30%	249,059,010
	TOTAL	$1,079,255,700
	DESIGN @ 20% (EXCLUDING DISPOSAL)	$50,444,300
	TOTAL (PROJECT COST)	$1,129,700,000

[1]See Volume of Waste at Waste Pit Area Calculation