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August, 1988

DECONTAMINATION AND DECOMMISSIONING FACILITY ENVIRONMENTAL ASSESSMENT

FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

OAK RIDGE OPERATIONS OFFICE

Department of Energy
Oak Ridge, Tennessee

Environmental Assessment Decontamination and Decommissioning Facility

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1.0 PURPOSE AND NEED FOR ACTION

The Feed Materials Production Center (FMPC) is a U.S. Department of Energy (DOE) uranium metal production facility located on a 425-hectare site near Fernald, Ohio, about 33 kilometers northwest of downtown Cincinnati (Figure 1-1). Most of the site is located within Hamilton County, although approximately 81 hectares are situated in Butler County. The villages of Fernald, New Baltimore, Ross, and Shandon are all located within a few kilometers of the plant.

Currently under management of the Westinghouse Materials Company of Ohio (WMCO), the FMPC has been in operation since 1954. It consists of nine separate production plants and 47 support buildings and facilities, including radioactive waste treatment and storage facilities. The primary mission of the FMPC is the production of purified uranium metal and uranium compounds for use at other DOE defense facilities. A small amount of thorium processing has also been conducted at the FMPC.

Operations at the FMPC result in radioactive contamination of tools, scrap materials, equipment and vehicles used in materials transport. Items requiring decontamination range from small hand tools to large pieces of machinery and bulk containers used for transporting uranium-bearing powders. At the present time, only a small decontamination and decommissioning (D&D) facility is in operation at the FMPC. The existing facility was constructed in the mid-1950's and utilizes technologies, such as nitric acid baths and low-pressure steam-cleaning, which have become outdated. The existing facility is inadequate to handle current and future operational needs in an environmentally acceptable manner. In recognition of the inadequacy of the existing facility and in anticipation of expanded future requirements, the DOE proposes to construct a new D&D facility at the FMPC as part of the Environmental, Health and Safety Improvements project (87-D-159). The proposed location for this new facility is shown on Figure 1-2.

The proposed facility is intended to provide for a variety of cleaning and decontamination processes. The types of materials expected to be treated in the facility include the following:

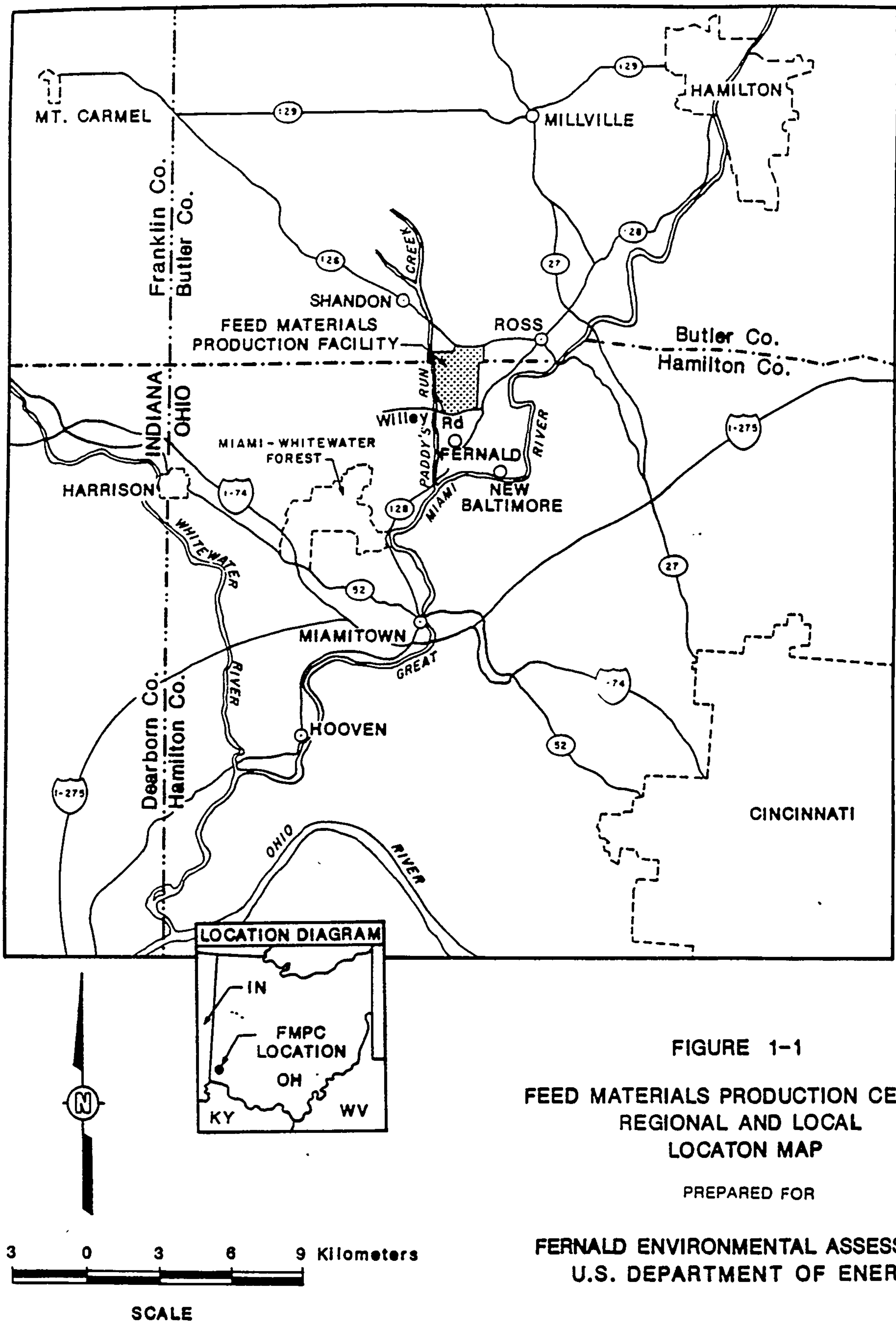

FIGURE 1-1

FEED MATERIALS PRODUCTION CENTER
REGIONAL AND LOCAL
LOCATON MAP

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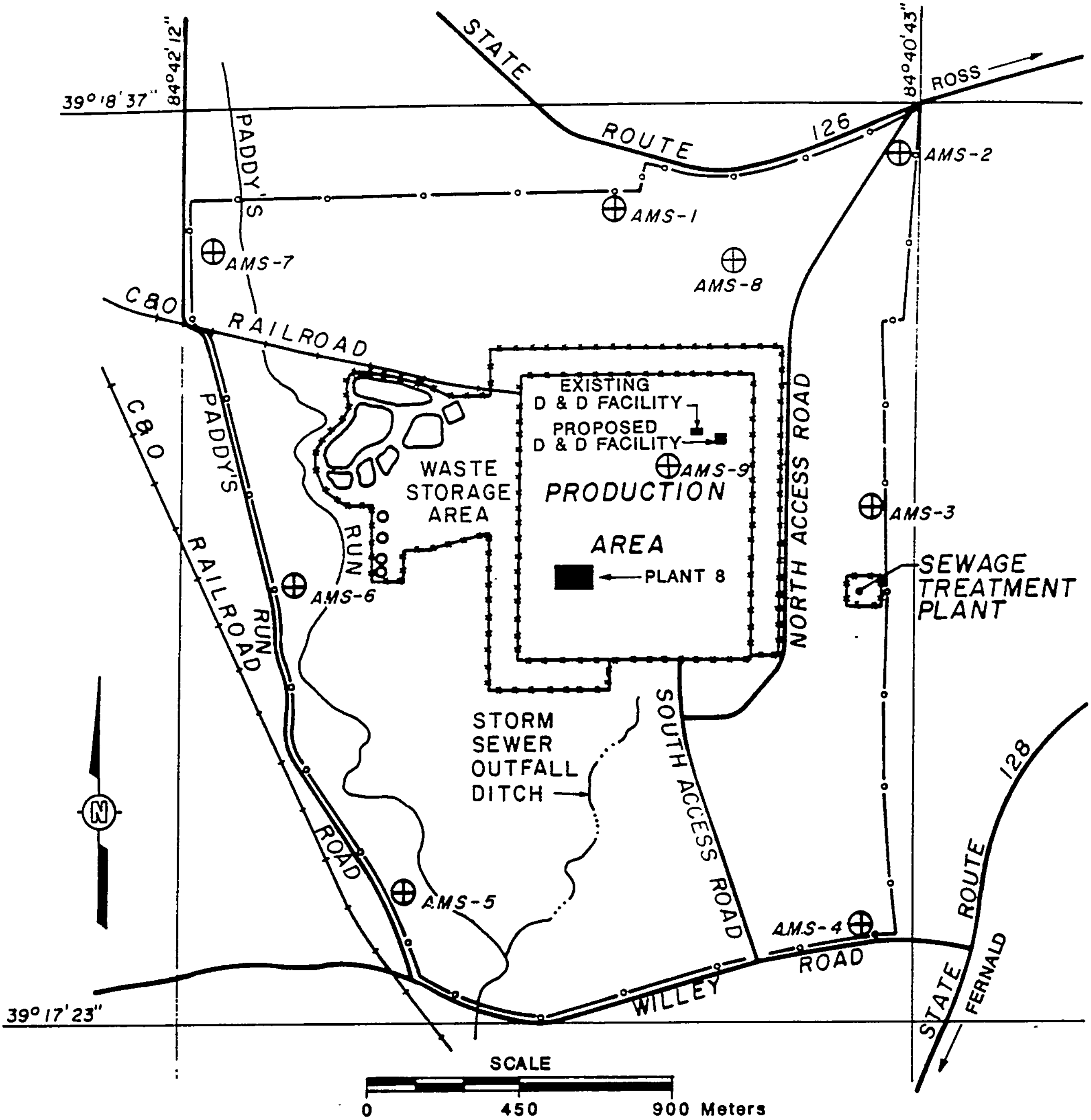

NOTE:
COORDINATES AT CENTER OF PRODUCTION AREA:
LONGITUDE 84° 41' 19", LATITUDE 39° 17' 58"

LEGEND

- SECURITY FENCE
- PROPERTY LINE FENCE
- GRID LINE
- ⊕ AMS-5 AIR QUALITY MONITOR SITES

FIGURE 1-2

FEED MATERIALS PRODUCTION CENTER
DETAILED LOCATION MAP

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- Contaminated Scrap Metal - Approximately seven million kilograms of contaminated scrap metal will be generated through planned demolition projects at the FMPC. A portion of this scrap will be classified as low-level radioactive waste and disposed of off site. The remainder will include both recyclable and nonrecyclable materials which will be treated at the proposed D&D facility.

- Vehicles - Normal operations at the FMPC include use of a variety of vehicles that include forklift trucks, automobiles and transport trucks, as well as heavy construction equipment. Uranium products and supplies are transported to and from the site via flatbed and tractor-trailer vehicles. The potential exists for any of these vehicles to become contaminated. These vehicles require periodic decontamination to reduce occupational doses to personnel performing vehicle maintenance.

- Reusable Equipment - Reusable equipment ranging in size from hand tools and small motors to large machines will require decontamination. Many small items can be decontaminated simultaneously as a load. Larger equipment (weighing more than 2,700 kilograms or greater than 3.7 by 2.4 by 1.8 meters in dimension) will be broken down into smaller pieces or decontaminated in the proposed D&D facility vehicle decontamination station.

- T-Hoppers - T-hoppers are large bulk containers used for transporting uranium-bearing powders to the FMPC from the DOE's Puducah, Kentucky and Hanford, Washington sites. FMPC is responsible for decontamination and repair of each of 434 T-hoppers prior to off-site shipment. The T-hoppers are on a three-year refurbishment cycle. Currently, approximately 200 hoppers labeled "out-of-service" are awaiting decontamination and repair.

- Furnace Pots - FMPC production processes utilize furnace pots which become contaminated during normal operations and may suffer erosion when contacted by molten uranium metal. Contamination consists of tightly adhering unconverted greensalt (uranium tetraflouride) and metallic uranium that becomes fused to furnace pot surfaces. An estimated 400 such pots per year require decontamination prior to off-site refurbishment or disposal as scrap.

In summary, there is a critical need at the FMPC to replace the existing inadequate D&D facility with a totally new facility offering greatly enlarged capacity and efficiency. The amount of newly generated scrap metal, in addition to vehicles, equipment, T-hoppers, and furnace pots, cannot be accommodated by the existing D&D facility. The proposed new facility will provide for D&D needs projected over the next 25 years. Once the operational capability of the new facility has been proven, the existing D&D facility will be decommissioned and evaluated for alternative uses.

2.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

This section discusses the proposed action and alternative actions which constitute decontamination and decommissioning activities required at the FMPC site. The proposed action is to:

> Construct a new D&D facility on a previously unused tract of land within the FMPC process area, at the northeast corner of the FMPC. The new facility will have the capacity to decontaminate various items including vehicles, furnace pots, T-hoppers, large equipment, and scrap. The design will accommodate the D&D needs associated with contaminated process equipment and vehicles, and newly generated scrap resulting from ongoing and future environmental improvement projects. The facility is intended to utilize state-of-the-industry, commercially available technology in an environmentally safe manner (A. M. Kinney, 1988).

Other alternatives considered are:

> Upgrade the technology of the existing D&D facility to accommodate site process/equipment decontamination requirements and to upgrade facility exhaust filtration and contamination control.
>
> Ship contaminated material off site for disposal as low-level radioactive waste without decontamination or recycling of reusable material.
>
> No Action [an alternative which must be addressed in all National Environmental Policy Act (NEPA) documentation]. This alternative would provide for continued operation of the existing D&D facility.

The overall purpose of this section is to describe the proposed action and alternatives in sufficient detail to allow for a reasoned comparative evaluation of possible impacts. The evaluation of impacts is contained in Section 4.0.

2.1 PROPOSED ACTION

The preferred alternative is to construct a new D&D facility which will adequately meet FMPC needs for decontamination of: tools and auxiliary equipment (e.g., vehicles) for recycle, maintenance or resale; production equipment to meet process specifications; and scrap material to meet criteria for unrestricted use to allow recycling or sale. Radioactive contamination present on such equipment and articles is made up of surface residue primarily consisting of uranium metal or uranium compounds. Other radioactive materials present are thorium and thorium compounds, traces (less than ten parts per billion by weight) of plutonium in the total residue, and traces of pitchblende ore materials (Click, 1987). The physical form of this residual contamination will range from loosely adhering to tightly bonded and fused.

The design basis for of the new D&D facility is to process (Tope, 1987):

- 272,000 kilograms of currently generated construction scrap metal per year,
- 50 vehicles per year including trailers, tractors, forklifts, cars, trucks, and heavy equipment,
- 1,000 pieces of reusable equipment per year,
- T-Hoppers at the rate of two to three per day, and
- 400 furnace pots per year.

Decontamination processes to be utilized in the new facility consist of dry abrasive blasting, high and ultra-high pressurized water spray, and freon/ultrasonic cleaning. The types of processes to be used and their specific applications are summarized in Table 2-1. These processes have been identified as being cost-effective, flexible, and consistent with FMPC safety and environmental protection requirements.

2.1.1 Site Preparation

The site for the proposed new D&D facility is relatively flat, previously unused, and within the fenced production area at the northeast side of the FMPC. The location of the D&D facility in relation to its neighboring buildings is shown in Figure 2-1. Surface water drains to existing catch basins and inlets connected to the plant storm sewer. Vegetation consists of mowed grasses. Site development activities would consist of grading and road construction activities.

Prior to construction, soils in the disturbed area will be sampled and analyzed for uranium contamination. Where required by FMPC operational procedures, any soil determined to be contaminated will be stripped and boxed for disposal as low-level waste.

TABLE 2-1

DECONTAMINATION PROCESSES FOR THE PROPOSED DECONTAMINATION AND DECOMMISSIONING FACILITY

	DRY ABRASIVE BLAST	PRESSURIZED WATER SPRAY	FREON/ULTRASONIC CLEANING
Type of Decontamination	Fixed: film and base metal removal	Fixed and smearable: film and base metal removal	Smearable: loosely adhering films
Application	Recoverable Scrap Metal Furnace Pots	Vehicles T-hoppers Reusable Equipment Furnace Pots Recoverable Scrap Metal	Reusable Equipment Electrical Equipment

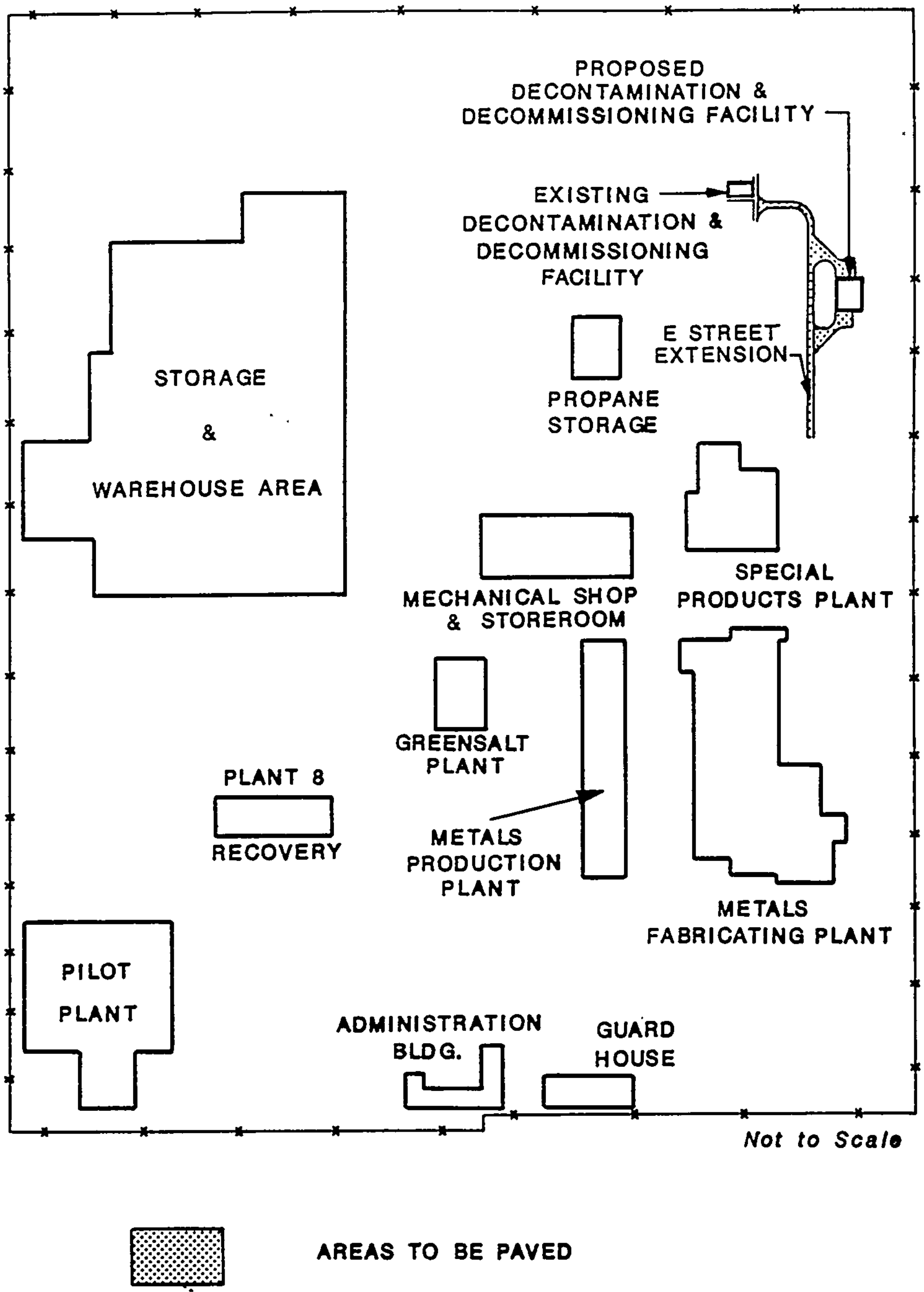

FIGURE 2-1
PROPOSED DECONTAMINATION AND DECOMMISSIONING BUILDING LOCATION ON FMPC SITE

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Topsoil will be stripped and stockpiled and the area will be rough graded. The final grading will be performed so as to channel storm runoff to the existing storm water drainage system at the FMPC. A total of 6,325 square meters will be graded including roads, underground utilities, security fencing, aprons and building area. During construction, silt fences, straw and other erosion control measures will be employed. Topsoil will be replaced and unpaved disturbed areas will be revegetated or covered with gravel after construction activities are complete.

The roads and paved aprons for the new facility have been located to facilitate the desired traffic movement and work flow in the vicinity of the D&D facility. Incoming work will enter from the north side of the new facility and decontaminated material will leave from the south side.

Two existing roads will be extended as shown in Figure 2-1. The "E" street (north-south) extension will require paving of approximately 140 meters of road six meters wide. An extension from "E" street around the west side of the D&D site will require the paving of approximately 55 meters of road six meters wide. Paving will consist of 7.5 centimeters of asphalt over a 25-centimeter aggregate base.

Paved aprons will be constructed as shown in Figure 2-1 north and south of the D&D facility. A total area of approximately 500 square meters will be paved in the same manner as specified for roads.

2.1.2 Physical Description

The new D&D facility will be a rigid metal shell structural steel frame building constructed on a concrete slab. The facility will occupy approximately 743 square meters and includes: an administrative area, change rooms, electrical room, a process area, a staging out area, pump room and an equipment platform. Fire protection coverage will be provided throughout the entire facility with an automatic sprinkler system designed in accordance with NFPA 13 for ordinary hazard occupancy. A dry system will be utilized in the truck staging area and a wet system will be utilized throughout the remainder of the facility. The proposed floor plan for the building is shown in Figure 2-2.

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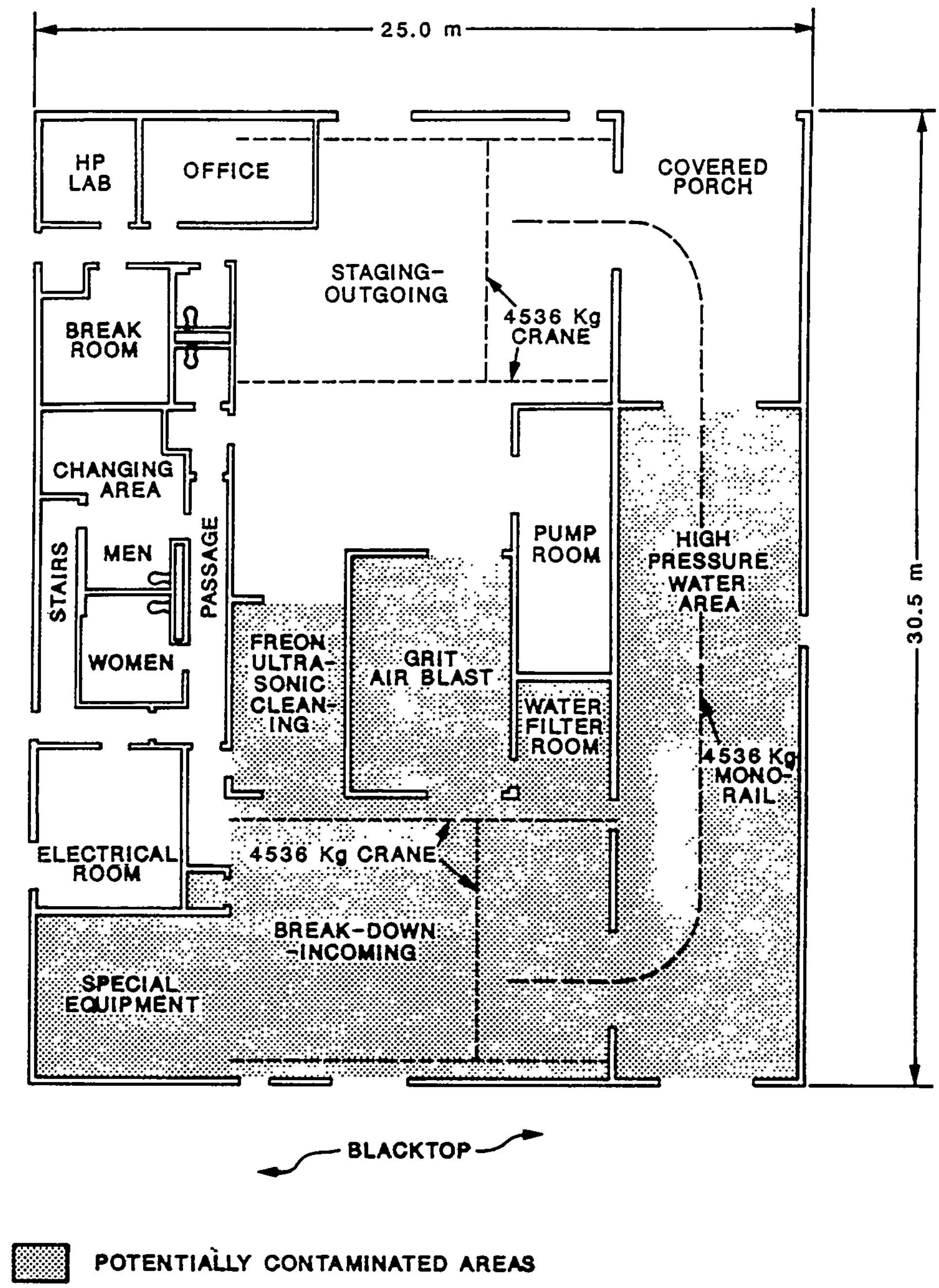

FIGURE 2-2

FLOOR PLAN FOR PROPOSED DECONTAMINATION AND DECOMMISSIONING BUILDING

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The administrative area will contain an office, a health physics counting laboratory, a personnel break room, and restrooms. This section of the building will remain "clean" (free from potential radioactive contamination associated with the process area). The administrative area has about 66 square meters of floor space. The change rooms contain showers, toilets, lavatories and lockers and have about 49 square meters of floor space. The electrical room has about 25 square meters of floor space.

The process area will house the material handling operations, the decontamination process stations, the water wash area, and auxiliary equipment. This 354-square-meter area will be considered potentially contaminated. Adjacent to the process area will be the pump room and staging out area for equipment and materials leaving the facility. Thus, work will proceed through the process area from north to south. The staging out area and pump room will occupy approximately 233 square meters. The second floor of the building (equipment platform) will house process exhaust system equipment and the heating and ventilation equipment. The equipment platform will have an area of 228 square meters and is considered "clean" because radioactive contamination will be internally confined within the process exhaust system.

Radiological monitoring within the facility will consist of: radiation surveying of equipment and materials to be decontaminated; monitoring of personnel having access to the process area; constant air monitoring within the breakdown area, grit blast room and staging out area; and stack effluent monitoring.

Criticality monitors are required in any area where 700-grams U-235 may be present (DOE, 1986a). Since this could be the case for the D&D facility, criticality monitoring instrumentation will also be provided. The FMPC plant is designed to process uranium materials enriched up to 19.99 weight percent U-235. Based on 1,000 assays of all process streams, an average of 85 percent of uranium material processed is actually depleted uranium, with U-235 enrichment 0.2 percent or less. Most of the remaining 15 percent of uranium material processed at the FMPC is not enriched to levels greater than two percent U-235 (Click, 1987). In practice, contamination present on all equipment and scrap to be processed through the D&D facility would be sampled and analyzed to determine U-235 enrichment level prior to transfer to the D&D area. Any materials with U-235 levels high enough to potentially pose a criticality hazard will be batch processed through the facility. In such instances, special procedures and criticality safe equipment may be employed as dictated by criticality analyses to be performed for this facility as part of the Final Safety Analysis Report and Operational Safety Report.

The new D&D facility is intended to control radioactive contamination through a combination of design features and operational procedures. All surfaces within potentially contaminated portions of the facility are proposed to have a polyurethane or epoxy finish to facilitate decontamination. Routine inspection and preventative maintenance will be implemented to assure that the integrity of protective finishes is maintained. Changing rooms for worker personnel, with a combined area of 49 square meters, will separate the clean administrative area from the potentially contaminated process area. Personnel will exit from the process area through the change rooms where radiological monitoring will occur. The spread of contamination will be further controlled by the facility ventilation system and spent water collection system (2.1.4 Waste Handling Systems).

The process area will be maintained at a negative pressure, with air flow from areas of lower contamination potential (the staging out area and equipment breakdown area) to areas of higher contamination potential (the decontamination process stations and water wash area). Air flow through the process area will be "once through," carrying airborne contamination to the process air exhaust system. The process air exhaust system will consist of two parallel trains of Medium Efficiency Particulate Air (MEPA) filters and High Efficiency Particulate Air (HEPA) filters. [These filters are capable of removing at least 95 percent and 99.97 percent of airborne particles with a diameter greater than 0.3 microns, respectively.] The total process air flow rate will be 5.9 cubic meters per second to the building stack.

Equipment platform air will be supplied through separate intake louvers and normally exhaust to the stack bypassing the filters. When filters or the abrasive-grit blast area are being cleaned, creating a potential for release of contamination to the equipment platform, equipment platform exhaust air will be routed through the MEPA and HEPA filters. The equipment platform exhaust will vary with seasonal ventilation requirements, with exhaust flow rates ranging from zero to 7.3 cubic meters per second. The administrative area of the facility will have a completely independent ventilation system.

The spent water collection system will consist of a series of trenches and piping leading to a central collection sump. Spent water generated in the process area will be filtered to remove radioactive particulates. The filtrate will be batch transferred to the FMPC General Sump. It is anticipated that less than 18,000 liters of contaminated water per day will be generated at the D&D facility. FMPC process knowledge about the origin of contaminated materials will be used to identify potential contributions to the liquid waste stream which may contain chemical constituents regulated under the Resource Conservation and Recovery Act (RCRA) or the Toxic Substances Control Act (TSCA). Potentially hazardous liquid waste resulting from D&D activities will be sampled and analyzed to determine whether regulated chemical components are present. Waste containing a hazardous chemical component will be disposed of in accordance with applicable requirements.

Generation of solid waste is expected to be in the range of fifty 55-gallon drums per year (5,700 kilograms) (A. M. Kinney, 1988). Solid wastes generated at the facility, such as contaminated clothing, wet filter cake, and spent filters, will be drummed and managed as low-level radioactive waste in accordance with DOE requirements. Decontaminated scrap material is not included in this estimated solid waste generation rate.

2.1.3 Process Description

A wide range of decontamination process and equipment options were considered during the conceptual design of the facility. Criteria for process selection included commercial availability; suitability to FMPC requirements; cost effectiveness; flexibility; and compliance with environmental, health and safety requirements.

A sufficient degree of redundancy exists in the capabilities of the selected processes to allow for flexibility and response to changing operational decontamination requirements. The cost effectiveness of the selected processes was assessed relative to alternative approaches including burial of contaminated equipment and purchase of new equipment. The productivity of the candidate processes was also considered.

Consideration was given to the cost of processing secondary wastes including the treatment of airborne and liquid waste streams. Decontamination processes were selected which minimize the generation of secondary wastes. The potential health and safety risks associated with the processes selected have been reviewed and found to be manageable through physical isolation, administrative control and training. Details of decontamination process steps are presented in the following sections.

2.1.3.1 Equipment Breakdown Area

The breakdown area would receive contaminated material of all types from various parts of the site. Where practical, articles with loose contamination will be bagged or enclosed prior to on-site transport to the D&D facility to minimize the spread of contamination. All such articles arriving at the D&D facility will remain enclosed until preparations for cleaning are completed.

A 4,536-kilogram live-load hoist, tramway carrier, and crane will be available in the breakdown area to facilitate handling of heavy equipment and scrap. A 4,536-kilogram live-load monorail hoist will also be available to transport materials between the breakdown area and the water wash area. The breakdown area is located inside the facility, occupying approximately 111 square meters of floor space. Here, contaminated articles will be surveyed, vacuumed, and reduced in size as necessary. A central vacuum system will be available to remove loose contamination. Cutting of scrap will be performed in the water wash area using ultra-high-pressure water and garnet.

The vacuum unit will pull a maximum of nine standard cubic meters of air per minute (Tope, 1987). Articles with visible contamination would be transferred to the water wash area prior to survey. After initial cleaning, such articles will be radiation surveyed to determine additional decontamination requirements based on decontamination goals and/or release criteria established for the particular article.

A small portion of the equipment breakdown area will be reserved for the decontamination of articles contaminated with hazardous substances for which a greater degree of segregation or special handling is required. Within this area, appropriate utilities would be provided so that when necessary, decontamination tasks can be performed inside a temporary enclosure without impact on other activities.

When an article leaves the equipment breakdown area, the lay-down space can be throughly cleaned using high pressure water. This potentially contaminated water will be directed to the spent water collection system. Ventilation air from the equipment breakdown air would also be potentially contaminated. Thus, it will serve in part as supply air to the decontamination process operations areas and will eventually be exhausted to the building stack through the exhaust filtration system. Radioactive solid waste generated in the equipment breakdown area will be disposed of in accordance with low-level waste management requirements (DOE, 1984a).

2.1.3.2 Water Wash Area

A separate decontamination area for vehicles and large equipment will be provided at the west side of the proposed D&D facility. Vehicles or large pieces of equipment will be driven through the wash area which will measure 6.1 meters wide by 21.3 meters long. The vehicle wash would utilize high pressure water spray to remove surface contamination. The system would be capable of delivering water at a nozzle pressure of 0.14 Newtons per square meter at a maximum water usage rate of 17 liters per minute. A chemical injector will be provided to enable the introduction of detergents and surfactants into the stream as needed. A sand injector system will be available for light grit blasting if required.

The water wash area will also house the ultra-high-pressure water system used to clean T-hoppers and scrap metal. The ultra-high-pressure water wash system would deliver up to 24.2 Newtons per square meter at a maximum water usage rate of 16 liters per minute.

Using specially shaped nozzles and accessories, the ultra-high-pressure water system has the capability for size reduction and removal of contamination embedded in the surface of metals. Abrasive grit injectors could also be activated to increase the effectiveness of this system. A single nozzle could decontaminate a swath five to eight centimeters wide, while an array of nozzles may be employed to decontaminate a larger area. The nozzles could be mounted on a hand-held lance, a robotic arm, or a motorized cart to cover a defined area at each sweep. Cleaning rates would generally range up to 11 square meters per hour. In addition, possible surfactants, detergents, and rust inhibitors will be utilized to enhance performance of the cleaning equipment. The materials used will be low phosphate and bio-degradeable in nature and therefore of no hazard to the environment.

Upon completion of high pressure water decontamination, the water wash area and associated equipment would be washed using the low-pressure hose. Process cleaning water used in decontamination would drain to the spent water collection system. Ventilation exhaust air from the water wash area would be directed through a mist eliminator and air heater designed to remove water droplets before processing through the MEPA/HEPA filtration system. Liquid wastes collected from the mist eliminator would be directed to the spent water collection system.

2.1.3.3 Freon/Ultrasonic Area

Freon decontamination is very effective and can be used on some materials that cannot be cleaned using conventional methods (e.g., electric motors or equipment). It will remove most organic materials as well as soil and other contaminants without attacking metals or many plastics.

The freon cleaning area is proposed to comprise approximately 22 square meters of floor space within the building. The process would use high-pressure jet nozzles within an enclosed, 0.87 cubic meter chamber. The system would utilize a solvent circulation and recovery system with a 150-liter capacity. The chamber would also house an ultrasonic submersion tank having a 315-liter capacity located beneath a removable floor panel. This ultrasonic tank would be used for cleaning small tools and equipment, as well as hard to reach places such as blind holes, crevices, and inaccessible internal surfaces. (Ultrasonic pulses induce cavitation in the freon solution and cause bubbles to form at the metal-surface interfaces. This method is less damaging than high-pressure water cleaning for certain types of equipment which may be adversely affected by the water stream impinging on delicate or corrodible parts.)

The freon solvent would be held in a 150-liter stainless steel holding tank. During cleaning, contaminated freon would be collected in a process sump and recycled in a subsequent purge and distillation cycle. During the purge cycle, air from the cleaning chamber would be processed through a roughing filter and an air compressor to condense the freon vapor. Air would then be returned to the chamber. Spent freon would be filtered through disposable, cotton-wound, charcoal filters to remove contaminants. Further purification would be accomplished by distillation. Interlock switches in the decontamination chambers would prevent opening of the chamber before the completion of the purge and distillation cycles.

2.1.3.4 Abrasive Grit Blast

The abrasive cleaning process system would be self-contained in a metal enclosure. It uses fine particles impacting a contaminated surface to remove embedded radioactive particles. Steel grit or shot would be used in most applications because it is durable, can be cleaned and recycled, and produces very little dust. Particle sizes varying from 20 mesh (841 μm) to 100 mesh (149 μm) size would be used depending on the application. Cleaning is more rapid with larger particles, but can leave a rough surface more susceptible to subsequent contamination.

The abrasive-grit blast system would be housed in a 40-square-meter portion of the building. The grit blast work area would be a glove box 2.3 meters long by 1.1 meters wide by 1.8 meters high having a weight capacity of 341 kilograms (primarily to accommodate the cleaning of process furnace pots). Abrasive material would be delivered with a bucket elevator through the air washer into a 0.25 cubic meter capacity feed hopper. Abrasives would be injected into a high-velocity jet of compressed air through an air blast hose inside the glove box.

Air abrasive blasting can generate large amounts of dust. Blasting operations would be performed under negative pressure relative to the operator area.

Contaminated grit would be removed from the chamber air during operation by passing exhaust air through a dust collector and subsequent process exhaust filtration.

Upon completion of decontamination operations, grit and debris would be removed from articles being cleaned by air cleaning before removing them from the enclosed chamber. Grit would be conveyed from the chamber and recycled through an air washer system which would separate the lighter contaminants from the heavier grit. The grit would be collected for return to the grit holding tank. The contaminants would blow through and fall into drums for disposal. Waste disposal would be accomplished in accordance with DOE requirements for low-level radioactive waste (DOE, 1984a).

2.1.3.5 Staging Out Area

Radiation surveys of all material undergoing any decontamination process would be made by health physics personnel prior to release to the staging out area. The staging out area would occupy 207 square meters adjoining exits from all process areas. Radiation surveys would be performed at these exit points.

Acceptable levels of residual contamination would be based on the intended use of decontaminated articles. Allowable surface contamination levels in Regulatory Guide 1.86 (U.S. AEC, 1974) would provide the basis for health physics survey release criteria. In general, decontaminated equipment would not be released from the D&D facility unless residual contamination levels were 20 percent or less of the removable contamination limits for alpha emitters and equal to or less than the limits for beta emitters. These limits constitute the release criteria for unrestricted off-site use. Higher residual radioactivity levels may be allowed for equipment destined for on-site use since radioactive contamination hazards are marked, monitored, and occupational exposure is controlled administratively. Contaminated items for use on-site are processed primarily to reduce occupational exposure. Criteria for decontamination levels for on-site use vary depending on intended use.

2.1.4 Waste Handling Systems

Radioactive waste is a byproduct of FMPC decontamination activities. The D&D facility will have its own liquid and airborne effluent treatment capabilities. Airborne effluents from the process area will be filtered prior to release as described in Section 2.1.2.

The spent water collection system will consist of a network of drainage control trenches which will channel all liquids from breakdown and process areas to an indoor sump. The sump will be equipped with a filtration system comprised of two bag filters arranged in series. The first will be a three-bag unit which will receive most of the solids; the second will serve as a backup unit. Water in the holding tank will be sampled and analyzed for radioactivity and hazardous chemical constituents prior to batch transfer to the FMPC General Sump. Depending on the results of the analyses, the tank contents will then be discharged to the appropriate plant sump for treatment. Operating the water wash area at full capacity will generate up to 5,800 liters of waste water per shift. Analyses of filtrate holding tank samples will provide a check on the contamination levels of D&D process waste water. Pressure differentials across the filters will be monitored to establish the schedule for changing out bag filters. Waste water will ultimately be discharged from the FMPC in accordance with NPDES permit limits. Since the primary purpose of this facility is filtering residue and not generating waste, it will not be necessary to revise the NPDES permit. The FMPC treatment facilities have sufficient capacity for treatment of all D&D generated waste streams.

Liquid effluents will drain into trenches which will be cleaned using low-pressure water hoses or a wet vacuum system. Filter residue from the bag filters and wet vacuum will be containerized for disposal as low-level radioactive waste in accordance with DOE requirements (DOE, 1984a).

The following are the anticipated waste contributions from each process activity:

- <u>Pressurized Water Sprays</u>: Pressurized water would be utilized in decontamination activities. The contaminated water would enter drainage trenches and sump drains from which it would be collected. Volatile chemical contaminants and oils will be removed from articles to be decontaminated prior to transport to the D&D facility.

  Air from the water wash area would exhaust at a velocity of 3.3 cubic meters per second, through a high velocity mist eliminator with a droplet removal efficiency rating of 98 percent for ten-micron droplets and 99 percent for 15-micron droplets. The air would then pass through an air heater capable of heating air to a 24 to 74 degrees centigrade range before entering the MEPA/HEPA filtration system (Tope, 1987).

- Freon Cleaning System: Contamination removed during cleaning operations would be present in the liquid freon and could be suspended in the air of the glove box containment. Contaminants would be removed from the liquid freon by its passage through respective five-micron and one-micron, disposable, cotton-wound charcoal filters (Tope, 1987). Additional cleaning of the solvent would be accomplished through distillation. Residues removed from this process will be either a solvent or still bottom residues containing chlorinated fluorocarbons, which are classified by the EPA as hazardous waste (No. F001) and will be drummed and stored on site in accordance with applicable RCRA requirements for mixed hazardous and radioactive wastes.

  Air exhausted from the freon cleaning area will be directed to the building process exhaust system.

- Abrasive Grit System: Contamination removed during air abrasive blasting would be combined with abrasive grit. The mixture of recovered grit and contaminated particles would be separated by an air separator which would use the difference in specific gravity between the contaminated particles and the steel grit to segregate the waste. This solid waste would be drummed and treated in accordance with low-level radioactive waste requirements (DOE, 1984a). Contaminants removed from the furnace pots during this process include uranium and magnesium fluoride compounds.

  Air exhausted from the abrasive blast chamber would pass through a dust collector to remove excess particulate contamination before entering the building process exhaust. Dust would be removed from the collector as necessary and handled as low-level radioactive and/or hazardous chemical waste.

Articles processed through the facility with suspected RCRA material contamination will be batch processed. Process knowledge and preclassification will be used to identify the potential contaminants. Solid waste from such a batch process would be drummed and managed as a RCRA-regulated mixed waste.

2.1.5 Health, Safety and Environmental Quality Control Programs

The health, safety, and environmental quality controls described here are an integral part of the proposed D&D facility design in accordance with DOE health and safety objectives and regulatory requirements. They are not considered as additional "mitigation" measures for the purpose of this Environmental Assessment.

Construction and operational activities would be performed in accordance with Occupational Health and Safety regulations (29 CFR 1910) and DOE health and safety requirements (DOE, 1984b) in a manner designed to minimize worker exposure to radiological, chemical and safety hazards. Potential hazards would be identified by routine monitoring and safety surveys. Work procedures would be established for all activities to assure that radionuclide emissions are as low as reasonably achievable (ALARA) and that other safety objectives are met.

Soil samples taken near the proposed site of the D&D facility have shown slightly elevated levels of uranium (ORAU, 1985). Prior to the initiation of construction activities, a field survey would be conducted to identify the location and magnitude of existing surface contamination at the construction site. Based upon the results of this survey, a determination would be made concerning necessary precautions, if any, to be taken during facility construction. Surface contamination would be removed by surface stripping and boxing all soil above preset limits to assure worker safety. Boxed soil will be handled, stored and prepared for disposition/disposal in accordance with DOE approved site procedures.

The construction work for the proposed project would involve worker hazards associated with any construction activity and are not unique to the proposed facility. A safety and health plan would be prepared by the construction contractor and approved by WMCO before any site preparation or facility construction begins.

Once facility operations begin, each decontamination process area would have specific safety protection requirements. For example:

- Workers working near or with high pressure decontamination equipment would be required to wear special clothing and face protection to deflect back splashing spray and contamination. Hearing protection would also be required for the equipment operator.
- Freon 113 would be used in the freon cleaning area. This is a nonflammable liquid of low toxicity. Workers would wear radiation protection clothing and respiratory protection if required by the health physics work procedures. Special care would be taken to prevent release of Freon 113 to the process area. A freon detection monitoring system will operate continuously to detect any accidental

release. The audible and visual alarms will be located on the walls of the occupied process area. Freon vapors displace oxygen and, in high concentrations, can cause difficulty in breathing or suffocation. A freon detection monitor would be employed to alarm if freon is vented to the process area atmosphere and the area would be evacuated. Freon in the process area would be removed by charcoal filtration. During ultrasonic cleaning, safety procedures would prohibit worker contact with the tank. Further, precautions would be taken to make sure that any equipment entering the freon cleaning area would be dry and that no freon would remain on equipment exiting the area, since Freon 113 can decompose and form compounds that release free chlorine (phosgene and hydrochloric acid) upon contact with water or at temperatures above 65 to 150 degrees centigrade.

- Workers performing abrasive grit blasting would wear radiation protection clothing and respirators as necessary. Special care would be taken to evacuate all airborne grit and contamination residues before opening the grit blast cabinet to prevent release of particles to the area atmosphere.

Radiological safety would be maintained by performing operations within the facility in accordance with established health physics guidelines. These guidelines would indicate precautions to be taken when working in areas where airborne radioactivity or radiation levels exceed prescribed limits. These limits would be based on ALARA objectives and DOE limits for occupational radiation exposure of five rem (0.05 sieverts) per year to any worker. The facility design objective is to keep occupational exposures at less than 20 percent of this limit, or one rem per year per worker (DOE, 1986b).

Routine radiological monitoring would serve to identify sources of exposure to D&D facility personnel. Direct radiation levels would be monitored routinely using both portable instruments and passive dosimetry. Surface contamination levels would be surveyed routinely in order to assign adequate personal protective clothing and respiratory protection. General air samplers and continuous air monitors (CAMs) would be located in the breakdown area, the mezzanine and the outgoing staging area to monitor air quality. The facility will be designed to minimize the potential for airborne uranium concentrations that exceed 1.1×10^{-13} microcuries (0.004 becquerels) per milliliter averaged over a 40-hour week. This limit is based on the maximum permissible concentration levels for insoluble uranium-238, which is expected to be the most restrictive limit for the predominant contaminant at the D&D facility (Vaughan, 1985). Control zones would be established to minimize the spread of contamination.

Radiation monitors would be placed at the exit of controlled areas and all equipment and personnel leaving the radiation zones would be surveyed. All workers would remove personal protective clothing and shower prior to exiting the facility. Radiological health and safety procedures that prohibit smoking, drinking, and eating on the job would be enforced. A break room would be provided in the "clean" administrative portion of the facility. These safety and radiation controls are adequate to maintain personnel safety and to keep occupational radiation exposures within the limits for worker health protection.

2.2 DESCRIPTION OF PROPOSED ALTERNATIVES

Reasonable alternatives were examined in the process of selecting the preferred action. These include upgrading the existing D&D facility, shipping contaminated material off site for disposal, and taking no action. These alternatives are briefly described in the following sections.

2.2.1 Upgrade the Existing D&D Facility

The existing D&D facility, Building 69, is used for decontamination of FMPC site operation process equipment such as furnace pots and smaller items. D&D methods employed at the facility include nitric acid bath and low pressure steam cleaning. The equipment in use is relatively inefficient and not capable of meeting the decontamination throughput requirements of the site. For example, a furnace pot has to remain in the acid bath for at least one week and as long as three weeks to achieve decontamination goals. In addition, there are currently no facilities for thorough decontamination of vehicles and construction equipment for resale, although a "car wash" station is available to reduce contamination levels of on-site trucks.

The present facility could be refurbished to include more up-to-date decontamination technology and effluent controls such as are proposed for the new facility. This would improve both the decontamination efficiency and throughput rates, as well as control the discharge of airborne or waterborne contamination. Decontamination process options and capacity would be limited, however, due to the relatively small size of the existing building.

Implementation of this alternative would require that the present facility be closed for an extended period of time to complete modifications. During this time, no decontamination of process equipment could be performed on site. Contaminated metal scrap and equipment from current operations and scrap resulting from planned renovation projects would continue to accumulate at the FMPC site. This alternative could support production needs; however, continuing generation of scrap would remain a potential source of radioactive and chemical contaminant releases to the environment for the indefinite future.

2.2.2 Transport Contaminated Material Off Site for Disposal

The seven million kilograms of scrap anticipated to be processed through the proposed D&D facility could be shipped to an off-site disposal facility. Large equipment, scrap, and vehicles requiring decontamination could be size-reduced and disposed of as low-level radioactive waste as well. Under this alternative, contaminated waste material would be handled in accordance with DOE requirements for low-level radioactive waste disposal. Environmental consequences of a low-level waste shipment campaign have been considered in other environmental documentation (DOE, 1985) and have been shown to be acceptably low. However, the shipment of newly-generated material represents a 14-fold increase over the off-site shipment volume previously considered, and environmental impacts would be proportionately increased or spread over a longer duration.

This action would significantly reduce the quantity of material to be processed by the present facility. It would not address the need for increased efficiency and size capability for the decontamination of FMPC process equipment or accommodate environmentally acceptable decontamination of vehicles. This alternative is also expected to be of significantly higher cost than the preferred action.

2.2.3 No Action

The "no action" alternative would maintain the status quo. Small FMPC process equipment items would continue to be decontaminated at the present D&D facility with existing inefficient technology at a slow throughput rate. The present methods employed are not as effective in removing contamination as more modern processes. The out-of-service inventory of T-Hoppers awaiting decontamination and repair would continue to increase. Since no capability for thorough vehicle decontamination exists on site, routine maintenance activities would have to be performed on contaminated vehicles. This practice increases occupational exposure and is not in keeping with site ALARA goals. Contaminated vehicles would eventually have to be scrapped and replaced. Additional costs are associated with disposal of the scrap as low-level radioactive waste, including probable transport to a low-level waste disposal site, and vehicle replacement costs. While the design basis for the proposed D&D facility does not address the current backlog of contaminated metal and scrap equipment, failure to proceed with the proposed action would result in continuing increase in the volume of potentially contaminated scrap. The backlog of contaminated metal and scrap will be processed and recovered/recycled as a part of the Oak Ridge Metals Program. All necessary permits and separate NEPA documentation to support this effort will be prepared by DOE Oak Ridge Operations.

3.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

This section discusses the physical, biological, land use, and demographic characteristics of the FMPC site and vicinity which could potentially be affected by construction and operation of the D&D facility. This description provides the basis for the impact assessment described in Section 4.0.

3.1 TOPOGRAPHY

The FMPC site is situated in the Great Miami River Basin at an elevation of approximately 180 meters above sea level. The present landscape is characterized by broad flat plains, rolling surfaces along glacial moraines, and low, rounded bedrock hills which protrude through glacial deposits. The Great Miami River and its tributaries have removed substantial volumes of the glacial fill and have formed elevated terraces along the river. The FMPC is located on one of these terraces above the river and its flood plain. The Great Miami River flows in a southerly direction about one kilometer east of the site.

The 425-hectare FMPC site is relatively level in the area of the production facilities but slopes upward north of the production area, rising to an elevation of 210 meters at the northern edge of the site. Natural drainage is in a westerly direction to Paddy's Run at an elevation of 170 meters. This small meandering stream flows from north to south through the western edge of the property and discharges to the Great Miami River (Figure 1-1).

3.2 GEOLOGY AND SOILS

The geology of much of southwestern Ohio consists of relatively flat lying Paleozoic sedimentary rocks overlain by glacial drift deposits. In the vicinity of the FMPC, bedrock consists of indurated shale interbedded with thin limestone units of Late Ordovician age. No major geologic structures are reported to be present in the area.

Prior to glaciation, this region of southwest Ohio was drained by the Hamilton River system which was over 3.2 kilometers wide and cut down approximately 60 meters into the bedrock. Pleistocene glacial deposits associated with the Illinoian and Wisconsin glacial advances 100,000 to 400,000 years ago overlie the Paleozoic bedrock, filling in or covering preglacial topographic features.

Filling of the Hamilton River Valley with glacial outwash and till created extensive deposits and aquifers known as the "Hamilton Trough." The trough averages 3.2 kilometers in width and 45 to 60 meters in depth near the FMPC. The basal deposits in the Hamilton Trough consist of about 30 to 55 meters of sand and gravel glacial outwash. A continuous three- to six-meter thick "blue clay" layer occurs within the sand and gravel deposits forming the two sand and gravel aquifers discussed in Section 3.3.

The top of the clay layer separating the sand and gravel units at the FMPC is at a depth of approximately 38 meters. The uppermost six to 15 meters of the Hamilton Trough in the area of the FMPC consists of predominantly clay-rich till with local lenses of sand and gravel. Locally, sand and gravel deposits crop out at the surface.

The primary soil units present at the FMPC are the Fincastle Silt Loam, Henshaw Silt Loam, Ragsdale Silty Clay Loam, Xenia Silt Loam, Martinsville Silt Loam, Hennepin Silt Loam, and Genesee Loam. The Fincastle, Henshaw, and Ragsdale soils cover the majority of the site. These soils occur on relatively flat Wisconsin till plain surfaces and are composed of silty loam at the surface. The soils are poorly drained and are characterized by low permeability and seasonal wetness.

The Xenia and Martinsville soils occur in the southeastern portion of the FMPC. Xenia soils also occur along the north boundary. These soils are silt loams which are moderately well drained and have moderate permeability.

Hennepin and Genesee soils occur along Paddy's Run in the western portion of the site. Genesee soils consist of loam and sandy loam and occur in valley floors. Hennepin soils consist of silty loam and occupy slopes along margins of drainages.

Soil samples are taken at each of the air monitoring sampling stations (Figure 1-2) once a year in accordance with DOE requirements. These samples consist of ten cores, two centimeters in diameter and five centimeters deep. The core samples for each location are composited and analyzed for uranium concentrations.

No DOE or EPA standards have been established for most soil radionuclide levels. The NRC established a concentration of 35 pCi (1.3 Bq) of natural uranium per gram (= 50 ppm) of soils which is the level generally used as an interim guideline. DOE, however, requires that guidelines for residual radionuclide concentrations in soil material be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. A soil pathways study, which will establish soil guidelines for the FMPC, is currently underway at the University of Cincinnati and will be completed in 1988.

For the purposes of comparison, naturally-occurring uranium-238 concentrations in Ohio range from 0.6 pCi/g (0.02 Bq/g) to 2.2 pCi/g (0.08 Bq/g). Total uranium is approximately twice this concentration, since two major isotopes of uranium (U-238 and U-234) occur together naturally in soil.

Uranium concentrations measured in soil during 1987 are shown in Table 3-1.

TABLE 3-1
URANIUM CONCENTRATIONS IN SOIL(1)

LOCATION	URANIUM CONCENTRATION(2) (picocuries per gram)
AMS-1	4.9
AMS-2	11.0
AMS-3	56.0
AMS-4	5.2
AMS-5	8.4
AMS-6	10.4
AMS-7	4.1
AMD-8	2.7
AMS-9	3.2

(1) WMCO, 1988
(2) 0 to 5 cm depth

3.3 GROUND WATER HYDROLOGY AND WATER QUALITY

Previous research of the geology and ground water hydrology of the FMPC has identified the presence of three aquifers: (1) the surficial till or perched aquifer, (2) the shallow sand and gravel aquifer, and (3) the deep sand and gravel aquifer (Dames and Moore, 1985a, 1985b; and IT Corporation, 1986). The surficial clay-rich till layer discussed in Section 3.2 is characterized by saturated lenses of sand and gravel. These perched zones occur from 1.2 to 2.7 meters below the ground surface. The zones are probably laterally discontinuous and are unlikely to provide direct pathways for recharge to the lower two aquifers.

The two principal aquifers at the site are referred to as the shallow and deep sand and gravel aquifers. The shallow aquifer is approximately 23 meters thick and occurs below the clay-rich till. The deep aquifer, approximately 17 meters thick, occurs approximately 43 meters below the surface and is separated from the shallow aquifer by a three- to six-meter thick layer of "blue clay."

The shallow sand and gravel aquifer is unconfined throughout the area with depth to water being approximately 17 meters below the surface. Due to the presence of the semi-pervious "blue clay" bed, the deep aquifer is classified as a semi-confined or leaky-confined aquifer at the FMPC. The transmissivity of the shallow and deep sand and gravel aquifers is reported to range from 5.0×10^{-3} to 4.3×10^{-2} square meters per second (m^2/s). The hydraulic conductivity of these two aquifers is reported to range from 80 to 110 meters per day. Total porosity has been estimated at 25 to 35 percent (Dames and Moore, 1985a).

Between Paddy's Run and New Baltimore, ground water generally flows from northwest to south-southeast under the FMPC toward the Great Miami River. Ground water pumping at the FMPC and from industrial facilities east of the site may affect groundwater flow directions within the area.

The two sand and gravel aquifers qualify as a major ground water resource throughout the area. They are thought to be recharged with water over a large area and are not greatly affected by local precipitation. FMPC wells withdraw an average of 1,325 cubic meters of water per day. Other major ground water users within 5.6 kilometers of the site include the Southwestern Ohio Water Company, the Cincinnati Bolten Plant, and the Southwestern Butler County Water Association. These three organizations cumulatively withdraw approximately 125,000 cubic meters of water per day.

As part of on-going environmental characterization programs at the FMPC, samples of ground water have been collected for chemical analyses from both the FMPC and the surrounding area. This program includes sampling and analysis of 15 on-site wells and 22 off-site wells. Sampling of on-site wells is conducted to monitor the quality of ground water at the site in conjunction with the Resource Conservation and Recovery Act ground water monitoring requirements. Recent sampling results of the ground water quality underlying and in the vicinity of the FMPC can be found in DOE (1986c).

3.4 SURFACE WATER HYDROLOGY AND WATER QUALITY

Natural drainage from the FMPC site is toward Paddy's Run, an intermittent stream which runs from north to south along the western edge of the property (Figure 1-2). A storm sewer outfall ditch runs southward from the south central portion of the site to Paddy's Run at the south boundary. The surficial till or perched aquifer (Section 3.3) intersects Paddy's Run between Willey and New Haven roads. The exact location where Paddy's Run intersects the water table and becomes perennial varies seasonally.

Treated liquid waste, sewage, and some storm water flows from the FMPC to the Great Miami River through an underground pipe. This discharge is made in compliance with a National Pollution Discharge Elimination System (NPDES) permit. In addition, overflow from the storm sewer collection system is routed to Paddy's Run via the storm sewer outfall ditch described above (Figure 1-2).

Surface water samples have been collected for chemical characterization from both the FMPC site and surrounding area. Studies have indicated that the storm sewer outfall ditch is probably the primary pathway for uranium-bearing water to reach the shallow aquifer (Dames and Moore, 1985a) (Section 3.3). Water flowing into Paddy's Run from the Waste Storage Area (Figure 1-2) may also contribute uranium-bearing water (Dames and Moore, 1985a). Throughout most of the site, the clay-rich till minimizes infiltration of surface water into the sand and gravel aquifer. However, the till thins out in the southern part of the FMPC, allowing increased surface water percolation into the ground.

3.5 CLIMATE

The FMPC area climate is basically continental with a wide range of temperatures. The area is subjected to frequent changes in the weather due to the passage of numerous cyclonic storms during winter and spring and the occurrence of thunderstorms during the summer.

Mean annual precipitation is 102 centimeters which is, generally, distributed evenly throughout any 12-month period. Monthly maximum precipitation of approximately ten centimeters occur in May and July. Monthly minimum precipitation of approximately six and one-third centimeters occur in February, October, and December. The average annual precipitation measured at the FMPC over a 20-year period from 1960 to 1979 was 95.9 centimeters per year. Based on annual averaged data, the maximum recorded 24-hour storm event is 13.2 centimeters of precipitation. The heaviest precipitation, as well as the precipitation of the longest duration, is normally associated with low pressure disturbances moving in a general southwest to northeast direction through the Ohio valley south of the FMPC area.

Summers are warm and humid. The temperature may reach 40 degrees Celsius or more one year out of three. However, the temperature usually reaches 25 degrees Celsius or higher about 26 days each year. Winters are moderately cold with frequent periods of extensive cloudiness. The length of the freeze-free period is 190 days on the average. Freezing temperatures occur between late October and mid-April.

At the Greater Cincinnati International Airport, where climatic conditions closely approximate the FMPC site area, prevailing winds are from the south-southwest (toward the north-northeast) for all twelve months of the year. Average monthly wind speeds range from 10.8 kilometers per hour in August to 18.0 kilometers per hour in March. Channeling and surface friction in the valleys reduce the wind speed and direct the airflow along the river valleys, such as along the Great Miami River. A wind rose showing the wind direction frequencies and the average wind speeds for each direction is presented in Figure 3-1 (IT Corporation, 1986). [Meteorological data (DOC, 1985) used for dispersion modeling were provided by Oak Ridge National Laboratory and are summarized in Appendix A].

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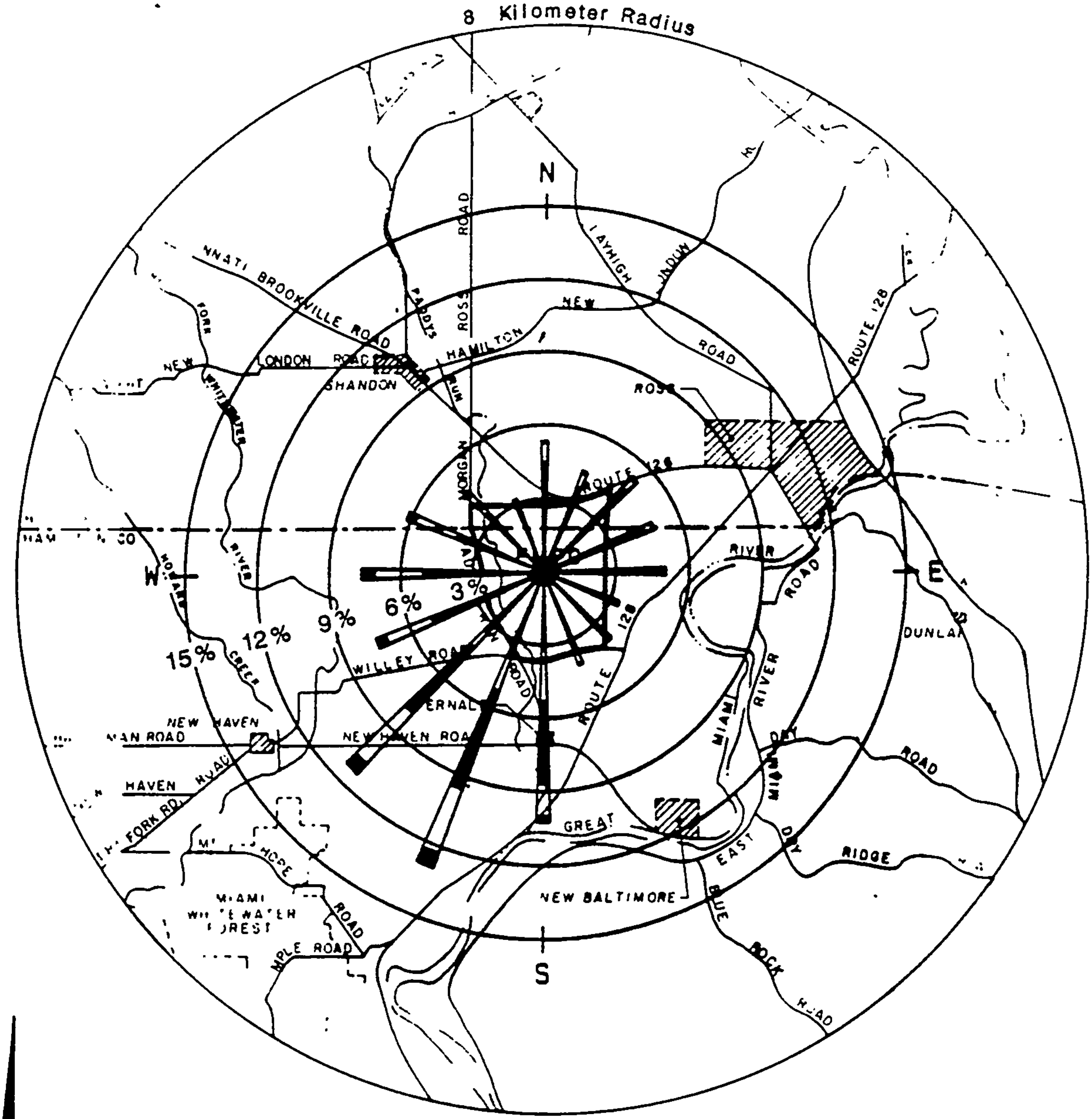

SCALE

0 1800 3600 Meters

LEGEND

2-6 7-11 12-19 20-30 31-39 > 39

WIND SPEED CLASSES
Km/Hr

FIGURE 3-1

WINDROSE FOR GREATER CINCINNATI INTERNATIONAL AIRPORT (1958-1962, 1970-1974) SUPERIMPOSED ON FMPC SITE

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The maximum wind velocity recorded at the airport was 64.4 kilometers per hour from the south-southwest. Wind records available for the FMPC show that there have been wind gusts in excess of 80.5 kilometers per hour on eleven occasions between 1960 and 1976; there have been gusts of up to 96.6 kilometers per hour on two occasions.

Ohio lies on the eastern edge of the area of the U.S. with the maximum tornado frequency, the center line of which extends from northern Texas to southwestern Iowa. During the 23-year period from 1953 to 1975, Ohio averaged about 13 tornados annually. During the 1900-1978 period, 15 tornados were observed in Hamilton County and eleven were seen in Butler County. Tornados may approach a location from any direction although about 90 percent come from the west through the southwest. Seventy percent of the tornados occur during April through July. The only tornado known to have touched the FMPC site occurred on May 10, 1969. There was no damage to the FMPC property, nor was there damage from another tornado which passed near the facility's northeast boundary on May 13, 1973.

3.6 AIR QUALITY

Air quality at and near the FMPC can be assessed for two regimes: (1) ambient air quality for the six criteria pollutants [sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO), lead (Pb), particulates, and ozone], and (2) ambient air quality for radionuclides and radon gas.

The Hamilton County-Butler County area is an attainment area for all criteria pollutants except ozone and carbon monoxide. The ozone nonattainment status is due in large part to automobile emissions and, to a lesser extent, industry hydrocarbon emissions. An inspection and maintenance program is to begin in the near future. FMPC emissions do not contribute significantly to ozone ambient concentrations. The CO nonattainment status may be changed to attainment status in the near future following review of additional data by the Ohio EPA.

Of the criteria pollutants, atmospheric emissions of concern at the FMPC are particulates, SO_2, CO, and NO_x. The OEPA establishes the limits for particulates emitted by the steam-generation plant at the FMPC. Electrostatic precipitators maintain these emissions at the FMPC below the limit of 0.09 kg (0.19 lb) per million British Thermal Units (BTU) input.

The OEPA also sets the limits for SO_2 emission for stationary facilities. Under these rules, SO_2 emissions from the steam-generation plant are limited to 1 kg (2.2 lb) of SO_2 per million BTU input from each of the two boilers. This limit could be reached if the FMPC used coal containing 1.3 percent or greater sulfur. To ensure that the SO_2 emission limits are not exceeded at the FMPC steam-generation plant, coal containing less than one percent sulfur is used.

Calculations developed at the FMPC conservatively estimate that a NO_x emission rate of less than or equal to 100 ppm will satisfy the State of Ohio regulation covering NO_x releases (e.g. "no visible plume"). The FMPC developed limits have been proven to meet the "visible plume" criteria for typical atmospheric conditions.

Monitoring data for criteria pollutants which would establish the ambient conditions downwind of the FMPC area are extremely sparse. Review of Hamilton County-Southwest Ohio Air Pollution Control Area (APCA) data indicates there are no monitoring stations near Fernald in the general downwind direction (northeast of the plant). The closest monitoring station is at Miamisburg which is over 48 kilometers northeast of the site.

Conversion of impure uranium and thorium compounds to reactor-grade feed materials at the FMPC involves operations which generate radioactive particulates and reaction products in an air stream. Before release to the atmosphere, this air is filtered or scrubbed.

Radiological air quality monitoring resulting from discharges at the FMPC is conducted by seven FMPC boundary Air Monitoring Stations. The locations of these Air Monitoring Stations (AMS) are shown in Figure 1-2. Particulate samples are collected weekly for a 168-hour sampling period at an air flow rate of about one cubic meter per minute on 20- by 25-centimeter glass fiber filters. The filters are analyzed for gravimetric particulate loading, gross radioactivity, and specific radionuclides.

TABLE 3-2

RADIONUCLIDE ANNUAL AVERAGE CONCENTRATIONS, 1987[1]
microcuries per milliliter (becquerel per milliliter)

SAMPLING LOCATION	URANIUM-234	URANIUM-235	URANIUM-238	THORIUM-232	PLUTONIUM-239/240	AIR PARTICULATES (micrograms per cubic meter)
AMS-1	9.7×10^{-16} (3.6×10^{-5})	4.5×10^{-17} (1.7×10^{-6})	8.0×10^{-16} (3.0×10^{-5})	1.6×10^{-17} (5.9×10^{-7})	4.6×10^{-18} (1.7×10^{-7})	29.0
AMS-2	9.5×10^{-16} (3.5×10^{-5})	4.3×10^{-17} (1.6×10^{-6})	8.7×10^{-16} (3.2×10^{-5})	7.9×10^{-18} (2.9×10^{-7})	2.8×10^{-18} (1.0×10^{-7})	31.9
AMS-3	2.2×10^{-15} (8.1×10^{-5})	1.1×10^{-16} (4.1×10^{-6})	2.4×10^{-15} (8.9×10^{-5})	1.4×10^{-17} (5.2×10^{-7})	3.1×10^{-18} (1.2×10^{-7})	31.9
AMS-4	6.1×10^{-16} (2.3×10^{-5})	2.7×10^{-17} (1.0×10^{-6})	5.5×10^{-16} (2.0×10^{-5})	6.1×10^{-18} (2.3×10^{-7})	$<1.2\times10^{-18}$ ($<4.4\times10^{-8}$)	34.7
AMS-5	5.6×10^{-16} (2.1×10^{-5})	2.6×10^{-17} (9.6×10^{-7})	5.6×10^{-16} 2.1×10^{-5})	6.8×10^{-18} 2.5×10^{-7})	$<1.8\times10^{-18}$ ($<6.7\times10^{-8}$)	30.7
AMS-6	7.5×10^{-16} (2.8×10^{-5})	3.6×10^{-17} (1.3×10^{-6})	7.2×10^{-16} (2.7×10^{-5})	1.3×10^{-17} (4.8×10^{-7})	$<1.3\times10^{-18}$ ($<4.8\times10^{-8}$)	33.5
AMS-7	4.8×10^{-16} (1.8×10^{-5})	2.2×10^{-17} (8.1×10^{-7})	4.1×10^{-16} (1.5×10^{-5})	9.9×10^{-18} (3.7×10^{-7})	$<1.4\times10^{-18}$ ($<5.2\times10^{-8}$)	34.8
AMS-8	2.1×10^{-15} (7.8×10^{-5})	9.9×10^{-17} (3.7×10^{-6})	2.0×10^{-15} (7.4×10^{5})	2.5×10^{-17} 9.3×10^{-7})	5.0×10^{-18} (1.9×10^{-7})	34.5
AMS-9	4.1×10^{-15} (1.5×10^{-4})	2.0×10^{-16} (7.4×10^{-6})	4.1×10^{-15} (1.5×10^{-4})	1.3×10^{-17} (4.8×10^{-7})	6.1×10^{-18} 2.3×10^{-7})	37.8
Standard Limit	9.0×10^{-14}[2] (3.3×10^{-9})	1.0×10^{-13}[2] (3.7×10^{-9})	1.0×10^{-13}[2] (3.7×10^{-9})	1.0×10^{-14}[2] (3.7×10^{-10})	4.0×10^{-14}[2] (1.5×10^{-9})	75.0[3]

(1) WMCO, 1988.
(2) Allowable off-site concentration for insoluble forms (Vaughan, 1985).
(3) Annual geometric mean, State of Ohio Ambient Air Quality Standard, Administrative Code Number 3745-17-02.

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The most recently published average concentrations in environmental samples (WMCO, 1988) of particulates uranium, thorium, and plutonium isotopes are summarized in Table 3-2. These results indicate that releases at the FMPC site boundary are well within the "safe" levels established by U.S. EPA's, National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements, and DOE criteria for off-site concentrations.

3.7 VEGETATION, WILDLIFE, AND AQUATIC ECOSYSTEMS

This section provides a description of vegetation, wildlife, and aquatic ecosystems in the general vicinity of the FMPC. A discussion of rare, threatened, or endangered species is also provided. Detailed information on FMPC site ecology is available in a three-volume report, "Biological and Ecological Site Characterization of the Feed Materials Production Center," prepared by Miami University of Ohio (Osborne et al., 1987).

3.7.1 Vegetation

The FMPC is part of a larger landscape mosaic comprised of several habitat types: woodlands (deciduous and coniferous); agricultural land in pasture or crops; and developed land. These habitat types are typical of southwest Ohio and the FMPC vicinity. The vegetation types occurring with the FMPC site boundary are illustrated in Figure 3-2.

Woodlands in the vicinity of the FMPC are typically located along streams and rivers and on steep slopes, or they are woodlots set in a matrix of agricultural land. Woodlands in this portion of Ohio are dominated by deciduous tree species.

Agricultural land in the vicinity of the FMPC is in pasture or crops. Crops grown in this area include soybeans, corn, wheat, vegetables, and hay. Pasture land vegetation is dominated by grasses and early successional and ruderal forbs. Fence rows separate many agricultural fields.

Developed land in the vicinity of the FMPC is primarily residential and typically consists of maintained lawn and planted horticultural and ornamental species. Other than the FMPC, little land in the immediate vicinity is in industrial use.

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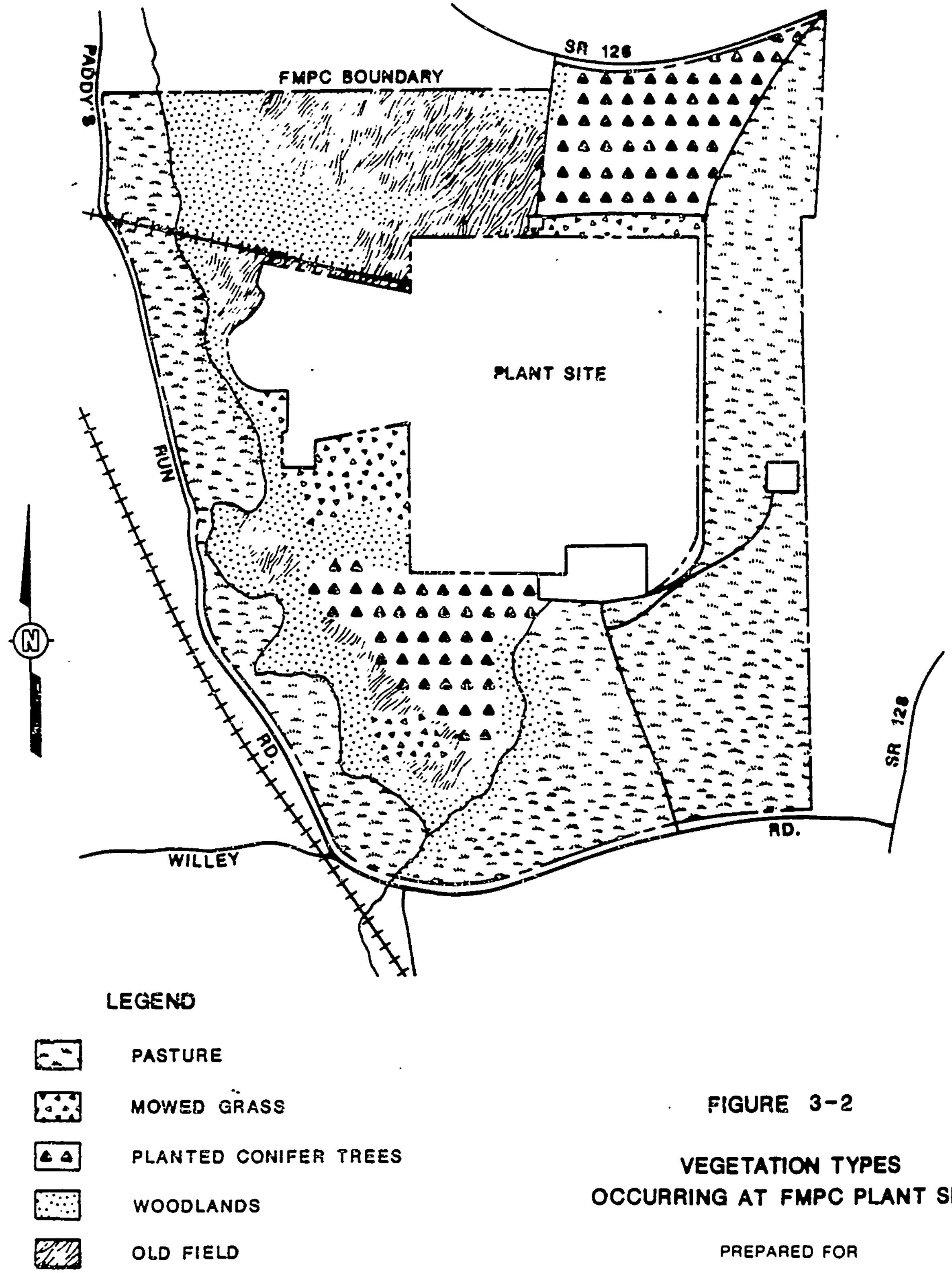

FIGURE 3-2

VEGETATION TYPES OCCURRING AT FMPC PLANT SITE

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The 425-hectare FMPC site has several habitats occurring within its boundaries: deciduous woodlands, coniferous woodlands, riparian woodlands, pasture, scrub, and developed land (Figure 3-2). Total woodlands occupy 162 hectares on the site and are in various successional stages and subject to occasional disturbance in the form of cattle grazing and "bush hogging" to clear understory vegetation. The successional age of the woodlands and the severity and frequency of disturbance in these areas have influenced their composition and structure. The youngest deciduous woodlands are dominated by shellbark hickory (Carya lacinosa) and white ash (Fraxinus americana). Other common species are hackberry (Celtis accidentalis), black cherry (Prunus serotina), boxelder (Acer negundo), and American elm (Ulmus americanus). The canopy of these woodlands does not exceed 20 meters in height.

More mature woodlands also exist on the site. These areas most closely resemble a mature forest in terms of species composition, canopy cover, and canopy height. The canopy of these woodlands is approximately 24 meters high with over 80 percent cover. The dominant species are sugar maple (Acer saccharinum) and boxelder. Other common species are black walnut (Juglans nigra), Ohio buckeye (Acsculus glabra), and American elm. The shrub layer is dominated by sapling sugar maple and Ohio buckeye.

Coniferous woodlands (pine plantations), planted in 1972, exist on site in two locations. Both areas consist of planted white pine (Pinus strobus) and Austrian pine (Pinus nigra).

Riparian woodlands border Paddy's Run. The dominant species of this habitat type are eastern cottonwood, hackberry, American elm, and boxelder. Other common species are black walnut, Ohio buckeye, and American sycamore (Platanus accidentalis). Shrub layer species include boxelder hackberry, poison ivy, and trumpet creeper. Common herbaceous species are red fescue and goldenrod.

Land currently or recently used as pasture to graze dairy cattle occupies approximately 200 hectares of the FMPC. The vegetation of this habitat is dominated by red fescue. Other grasses such as timothy and Kentucky bluegrass are also present.

Developed land at the FMPC occupies approximately 63 hectares. Little vegetation exists in this portion of the site.

3.7.2 Wildlife

Wildlife populations at the FMPC and surrounding area are typical of those is southwestern Ohio where the land is a mixture of agricultural lands, woodlands, and developed land. This type of landscape creates large amounts of "edge" and "corridor" habitat which support the highest diversity of wildlife. These areas provide cover and denning areas for species which often range into other habitats during foraging activities. Two species of owls have been observed wintering on site: the eastern screech owl (Otus asio) and the great horned owl (Bubo virginianus).

The most common species of native mammals at the FMPC site and vicinity are white-tailed deer, eastern cottontail, fox squirrel, white-footed mouse, eastern chipmunk, woodchuck, and raccoon. The most abundant small mammal in the woodland areas on site is the white-footed mouse (Peromyscus leucopus noveboracensis). The house mouse (Mus musculus), is found throughout the entire region. The on-site white-tailed deer population, which is concentrated in the on-site pine plantations, has an estimated herd size of 16 to 18 individuals. This concentration of deer is typical of this region of Ohio.

Avian populations also had the highest diversities in the woodland areas. The most common summer species that have been observed are yellow-billed cuckoo (Coccyzus americanus), blue jay (Cyanocitta cristata), Carolina chickadee (Parus carolinensis), and American robin (Turdus migratorius). The most common winter species include Carolina chickadee, dark-eyed junco (Junco hyemalis), American goldfinch (Carduelis tristis), northern cardinal (Cardinalis cardinalis), and song sparrow (Melospiza melodia).

The most common avian species to utilize agricultural land at the FMPC during the summer months are eastern meadowlark (Sternella magna), red-winged blackbird (Agelaius phoeniceus), and European starling (Sturnus vulgaris). In addition, the Savannah sparrow (Passerculus sandwichensis) has been observed utilizing the site for breeding. This is unusual because the Savannah sparrow does not normally breed in southwestern Ohio.

Certain mammalian species rely on agricultural land as a major food source. Such animals as raccoon, woodchuck, and white-tailed deer range into these areas of the FMPC.

Wildlife utilizes developed land to a limited extent within the FMPC and the surrounding area. Certain mammalian species, such as opossum and raccoon, have habitats which encroach into developed areas. Numerous bird species, including starling, house sparrow, common grackle, mourning dove, and American robin, utilize developed sites in the area as feeding and nesting areas.

3.7.3 Aquatic Ecosystems

The aquatic environment of the FMPC is dominated by one intermittent, third order stream--Paddy's Run. Paddy's Run flows north to south along the FMPC's western boundary. The northern section is steeply graded and characterized by relatively high stream velocities and a rock/cobble substrate. The southern stretch, a depositional area due to its low stream gradient, is periodically dry from July to October. Paddy's Run eventually flows into the Great Miami River approximately three kilometers south of the FMPC site. Water in this stretch of the Great Miami River has high nutrient and ammonia concentrations and low dissolved oxygen due to municipal and industrial wastewater discharges into the river.

Fish

Paddy's Run maintains a relatively diverse and abundant fish population. While data on fish populations in off-site streams are limited, the populations are expected to be the same or similar species composition as Paddy's Run. A total of thirteen species of fish have been identified. This community is dominated by juvenile cyprinids and percids. Dominant species found during the Miami University study (Osborne et al., 1987) were the creek chub (Semotilus atromaculatus) and the bluntnose minnow (Pimephales notatus).

The orangethroat darter (Etheostoma spectabile) has also been identified as being dominant (Battelle, 1981). This species was commonly found during the Miami University (Osborne et al., 1987) study of Paddy's Run but was not found to be dominant. Differences in composition are probably attributable to differences in sampling intensity between the two studies. Other species commonly found in Paddy's Run reportedly include the stoneroller minnow (Campostoma aniomalum), rosefin shiner (Notropis ardens), Johnny darter (Etheostoma nigrum), and fantail darter (Etheostoma spectabile).

Distribution of fish species in the stream is dependent upon the physical microhabitats available, e.g., riffles or pools. White suckers, (Catostoma commersoni) silverjaw minnows, (Ericymba commersoni) rosefin shiners, and Johnny darters were found to be rare or absent from riffle areas but common in pools. Conversely, fantail darters were found to be common only in riffles.

Benthic Invertebrates

A total of 44 taxa of benthic invertebrates have been identified as existing in the stretch of Paddy's Run that flows through the FMPC site, immediately upstream (100 meters) and immediately downstream (100 meters). Four taxa were identified as being dominant in the Fall/Winter survey conducted during the Miami University study (Osborne et al., 1987): midges (Chironimidae), riffle beetle (Stenelmis sp.), mayfly (Caenis sp.), and stonefly (Allocapnia sp.). Seven other taxa were also commonly found throughout the stream: the mayfly (Stenonema bopunctatum), the isopod (Lirceus fontinalis), the caddisfly (Cheumatopsyche sp., Hydropsyche sp.), the segmented worm (Oligochaeta), the stonefly (Nemouridae), and the blackfly (Simulium sp.).

Caddisflies (Trichoptera) were the dominant taxa during the Summer (Battelle, 1981). Cheumatopsyche sp. was the most dominant species. Hydropsyche sp. and Chimaera sp. were also commonly found. Differences between the two studies are believed to be attributable to seasonal variations and differences in sampling intensities.

The abundance, types of species present, and species diversity in Paddy's Run appears to be typical of streams in southwestern Ohio. Similar benthic invertebrate assemblages have been documented in other studies (Osborne et al., 1987). Differences in both the number of taxa and the mean macroinvertebrate densities found along Paddy's Run appear to be attributable to natural variations in stream flow.

3.7.4 Threatened and Endangered Species

No federally endangered plant or animal species are known to exist at or in the vicinity of the FMPC. However, three species of birds that appear on the "Rare Species of Native Ohio Wild Animals" list (Ohio Department of Natural Resources, 1982) have been observed on site. A red-shouldered hawk (Buteo lineatus) was seen flying over the site during the Winter months of 1986-87. This species is listed as an uncommon breeder in the region and as a threatened breeder in Ohio. A northern harrier (Circus cyaneus) was sighted flying over the site in June 1986, although the bird was observed only once. It was presumed to be either a late migrating individual or an individual nesting off site. Cooper's hawks (Accipiter cooperii) were sighted on numerous occasions during the Summer and Winter of 1986-1987. Thus, the Cooper's hawks may have been breeding on site or, at least, utilizing habitats within the boundaries of the FMPC. The Cooper's hawk is listed as an uncommon but regular breeder in the region, a threatened breeder in Ohio, and an uncommon to common Fall migrant and Winter resident.

3.8 CULTURAL RESOURCES

The FMPC region has been extensively investigated for both historic and prehistoric (archeological) cultural resources. As a result, there are seven sites on the National Register of Historic Places within an 8.0 kilometer radius of the FMPC: two archeological districts, one historical district, two burial mounds or earthworks, and two historic structures (Figure 3-3). The archeological sites are associated with the Late Archaic Period (ca. 4000 to 1500 B.C.) and the Early Woodland Period (ca. 1500 B.C. to A.D. 100). Historic sites include the Whitewater Shaker Village which is situated about eight kilometers west of the FMPC.

The Miami Purchase Association for Historic Preservation conducted a reconnaissance level survey of the New Haven Trough area in the Spring of 1985 (Genheimer and Gatus, 1986). This investigation, which covered a 10,000,000 square meter area south and west of the FMPC, did not identify any sites eligible for inclusion on the National Register. However, Crosby Township has 240 surveyed historic properties including: Whitewater Shaker Village (10); New Haven (27); Fernald (11); and New Baltimore (11).

3.9 DEMOGRAPHY AND LAND USE

The FMPC is located in a rural area of northwestern Hamilton County and southwestern Butler County, approximately 32 kilometers northwest of downtown Cincinnati (Figure 1-1). Approximately the northern 30 percent of the property is in Butler County (Figure 1-1).

The 1984 estimated population for Hamilton County was 863,989; the estimated population for Butler County was 265,458. Hamilton County population decreased by 1.1 percent from 1980 to 1984 while Butler County population increased by 2.6 percent during the same period. Fernald and New Baltimore in Hamilton County and Shandon and Ross in Butler County are the communities closest to the FMPC site.

The population of the seven small communities nearest the FMPC, and their approximate distances from the site, are as follows:

COMMUNITY	1980 ESTIMATED POPULATION	APPROXIMATE DISTANCE FROM FMPC (kilometers)
Fernald	50*	2.5
Shandon	200*	4
Ross	2,767	3.5
New Baltimore	710	4
New Haven	300*	5
Harrison	5,855	10.6
Miamitown	1,559	8.1

*These are rough estimates only because population data are available on a "neighborhood" basis. Fernald and New Haven are part of the West Crosby Township neighborhood with a 1980 population of 1,760.

The land surrounding the FMPC is primarily used for pasture land and cultivated crops (Section 3.8.1). There are several small, scattered subdivisions north and northeast of the site.

The nearest public park or resource area is the 823-hectare Miami Whitewater Forest located approximately eight kilometers southwest of the FMPC site in northwest Hamilton County (Figure 1-1). Other recreational areas near the plant site include: Fort Scott Camps, 3.2 kilometers southeast of the FMPC, owned by the Archdiocese of Cincinnati; and Camp Ross Trails, a Girl Scouts of America camp located about 1.8 kilometers to the northeast.

Other than the Chesapeake and Ohio Railroad which runs along the west boundary, there are no major transportation arteries in the immediate vicinity of the FMPC site. Interstates 275 and 74 traverse the area east to west about 8.8 kilometers south of the FMPC (Figure 1-1).

3.10 OTHER ENVIRONMENTAL PARAMETERS

Due to the nature of the proposed action, description of the environmental parameters of noise, traffic, employment, and visual resources were not considered necessary for the impact assessment.

4.0 ENVIRONMENTAL CONSEQUENCES

This section examines the potential environmental consequences associated with the proposed action for and the alternatives to the construction and operation of a new D&D facility at the FMPC. The assessment is accomplished by defining the releases and release pathways, calculating the resulting exposure or contaminant levels, and assessing the resulting environmental, safety, and health-related impacts. Both routine operations and potential accidents were considered in the assessment. Section 4.1 defines the basis and methods for the assessment, Sections 4.2 through 4.4 address the proposed action, Section 4.5 examines the environmental impacts of the alternatives and Section 4.6 provides a comparative summary of the environmental consequences of each.

4.1 ASSESSMENT BASIS AND METHODOLOGY

In addition to the physical and operational descriptions previously provided, this assessment requires that the radiological characteristics of the contamination to be encountered be estimated. Using this information, releases during routine operations and under postulated accident conditions can be approximated. The environmental, safety, and health-related impacts of such releases can then be calculated by use of appropriate modeling methods.

4.1.1 Characterization of Potential Contaminants

Most scrap material and FMPC process items that would be processed at the proposed D&D facility could be contaminated with uranium metal and/or virtually any uranium compound that has ever been present on the FMPC site. Uranium compounds present in the greatest abundance are UO_2, UO_3, U_3O_8, UO_2F_2, and UF_4. UO_2F_2 is quite soluble and, if inhaled, may be readily absorbed from the respiratory and gastrointestinal tracts to the blood from which it may be taken up by other organs. Other compounds of uranium are only slightly soluble and tend to remain in the lung following inhalation. Approximately ten percent of the uranium contaminants will take the soluble form (Click, 1987). In addition to uranium, thorium processing operations have taken place at the FMPC. Insoluble oxides of thorium-232 are expected to be present in about ten percent of the material to be processed through the facility. Trace amounts of plutonium-239 oxides, up to ten parts per billion by weight of total residue, may also be present as surface contamination on items to be decontaminated. Oxides of this trace plutonium contamination are considered to be insoluble in form.

Uranium contaminants would be of varying isotopic composition dependent upon the level of U-235 enrichment. Based on assays of production material processed at the FMPC, the vast majority of the uranium contamination would be uranium "depleted" to levels of 0.2 percent U-235 and eight parts per million U-234. Slightly enriched uranium may also be present in the contamination found on FMPC process equipment. The maximum anticipated enrichment level is two percent U-235. Uranium products with enrichments as high as 19.99 percent U-235 can be handled at the FMPC plant (Click, 1987). Incoming items will be screened to assure that surface contamination in excess of two percent U-235 enrichment is not present prior to transport to the D&D facility. Any items which require decontamination and whose uranium contamination exceeds two percent U-235 will be specially handled in accordance with recommended criticality safety procedures and batch processed through the D&D facility. Strict administrative criticality procedures and controls will be developed and enforced based on specific source terms and risk assessments when materials are known to contain uranium enriched to levels greater than two percent.

An estimate of the isotopic composition of contamination which would be expected on an annual average basis was made using FMPC safety evaluation data. Annual releases, based upon the radioactive contamination to be processed through the D&D facility, were formulated using the following assumptions:

- 90 percent uranium compounds, of which ten percent is soluble and 90 percent is insoluble
  - 85 percent depleted uranium
    - U_{238} = 99.799 percent
    - U_{235} = 0.2 percent
    - U_{234} = $8x10^{-4}$ percent
  - ten percent natural uranium
    - U_{238} = 99.275 percent
    - U_{235} = 0.72 percent
    - U_{234} = $5.34x10^{-3}$ percent
  - five percent enriched uranium
    - U_{238} = 97.985 percent
    - U_{235} = 2 percent
    - U_{234} = $1.48x10^{-2}$ percent

- ten percent thorium-232
- $1x10^{-6}$ percent plutonium-239.

For the purposes of evaluating the radiological impacts of routine operations, all particulates released from the building stack after HEPA filtration are assumed to be in the respirable range, represented by a particle size of 0.3 microns in aerodynamic equivalent diameter (AED).

The radiological consequences of postulated accidental releases from the D&D facility are evaluated using conservative assumptions to ensure an overestimate of the potential impacts. The specific radioisotopes and compounds involved are selected to estimate the maximum resulting consequence as discussed in Section 4.4.

4.1.2 Dose Assessment Methodology

Potential releases of radioactive material associated with the proposed action and alternatives during routine operations and credible accidents were evaluated. Release source terms and pathways to the environment are based on conservative assumptions or, where available, site-specific data. Evaluations of hazards to workers are based on design criteria that have been established for the proposed action and on best industry practice. Accident assessments are based upon "worst case" conditions in the absence of known parameters. The dose assessment methodology and assumptions are detailed in Appendix A and are summarized below.

From the description of the proposed action and alternatives presented in section 2.0, airborne releases are identified as the principle environmental pathway of concern. As discussed in Sections 4.2.3 and 4.2.4, solid and liquid effluents from the proposed D&D facility are small in volume and are to be packaged or pretreated prior to release to the environment. Management of such wastes will be performed in compliance with requirements that are protective of public health and safety. Any spills of radioactive material (solid or liquid) will be managed according to the Spill Prevention, Control and Countermeasure (SPCC) Plan adopted for the FMPC. In the absense of any direct or uncontrolled solid or liquid effluents resulting from the proposed action, release pathways to groundwater, surface water and soil are concluded to be inconsequential.

The computer model AIRDOS.EPA, recommended by both the U.S. Environmental Protection Agency (EPA) and the DOE, was employed to calculate doses and evaluate resulting environmental consequences. This model utilizes meteorological data (collected at the Greater Cincinnati International Airport weather station), demographic data, release geometry, and local agricultural use data to project radiation doses to the human population residing within 80 kilometers of the site. Dose assessment for routine operations was accomplished by applying annual average meteorological conditions to the postulated releases and calculating the resulting air concentrations and surface contamination levels in all directions and at various distances from the FMPC. The radiological exposure is then calculated by summing the exposures from all potential pathways. The modes of exposure from airborne releases that are considered in the dose-to-man calculations include the following pathways: (1) direct radiation due to immersion in air, (2) exposure to contaminated ground surfaces, (3) inhalation of contaminated air, (4) immersion in water such as by swimming, and (5) ingestion of contaminated drinking water and food grown on contaminated land. To assess the maximum exposure to a member of the public, a hypothetical individual is assumed to reside at the FMPC site boundary at the point where the highest annual average concentration of contaminants would occur.

Accident assessments are accomplished in a similar manner, but assumed stable meteorological conditions which allow little dispersion of a release in order to estimate a maximum resulting hypothetical dose to man. The receptor for accident assessments is assumed to be a hypothetical member of the public who remains at the site boundary and at the center line of the release plume for the duration of each postulated accident.

4.2 PROPOSED ACTION ROUTINE OPERATIONAL CHARACTERISTICS

The proposed action involves both construction and operation of the proposed decontamination facility (Section 2.0). Releases may result from airborne particulates, liquid effluents, or the generation of solid waste. Expected quantities for each of these pathways are discussed below.

4.2.1 Nonradiological Releases to Air

Small quantities of criteria pollutants (CO, NO_2, SO_2, and particulates) may be emitted to the atmosphere from the use of diesel-powered equipment during facility construction. Dust control measures such as spraying water will be employed to minimize fugitive emissions from earth-moving equipment. Estimated total construction equipment usage includes (Shrimper, 1987):

- Grader — 160 hours
- Dozer — 346 hours
- Roller — 100 hours
- Off-highway trucks — 778 hours
- Miscellaneous (e.g., backhoe) — 368 hours

No nonradiological airborne emissions are anticipated during the proposed D&D facility operation. All motorized equipment will be electrically powered.

Estimates of off-site concentrations of criteria pollutants during facility construction were made treating the release configuration as a point source at the D&D site location. The total release was averaged over the construction period to give an average daily release. This daily release was assumed to occur throughout the year under annual average meteorological conditions. Projected annual average concentrations were calculated. From these, 24-hour, 8-hour, 3-hour and 1-hour average concentrations were estimated using published conversion factors (DaMassa, 1985). Off-site airborne concentrations resulting from emissions are shown in Table 4-1. As explained in Section 3.6, ambient air quality data on concentrations of criteria pollutants in the vicinity of the FMPC are not available for comparison.

The combined criteria pollutant emissions calculated using standard emission factors for this type of equipment (EPA, 1985) over the expected use duration are: 684 kilograms of CO; 3,980 kilograms of NO_2; 248 kilograms of SO_2; and 147 kilograms of particulates (lead emissions from diesel motors are negligible).

TABLE 4-1
AIRBORNE CONCENTRATIONS - NONRADIOLOGICAL EMISSIONS

POLLUTANT	AVERAGING PERIOD	CONCENTRATION (micrograms per cubic meter)	NAAQS LIMIT[1] (micrograms per cubic meter)
Sulphur Dioxide (SO_2)	Annual	0.14	80
	24-hour	0.54	365
	3-hour	1.22	--
Nitrogen Dioxide (NO_2)	Annual	1.37	100
Carbon Monoxide (CO)	8-hour	4.05	10,000
	1-hour	5.78	40,000
Particulate Matter (PM-10)[2]	Annual	0.08	50
	24-hour	0.32	150

[1] 40 CFR Part 50, National Ambient Air Quality Standards (Primary).
[2] Particulates are conservatively assumed to fall in the PM-10 range; i.e., are smaller than 10 microns in diameter.

4.2.2 Radiological Releases to Air

The D&D facility operations are likely to release small quantities of uranium, thorium, and trace impurities to the atmosphere even with all environmental control systems in place and operating properly. Releases during routine operation have been estimated from FMPC D&D facility design basis for each process area (Yuan, 1987), assuming operation for two shifts a day, five days a week throughout the year.

The average releases of radioactive contaminants from each D&D process prior to MEPA/HEPA filtration have been estimated to be:

- High pressure wash areas - 2,900 grams/day
- Freon decontamination - 29.3 grams/day
- Abrasive grit blast - 58.0 grams/day.

Using the projected isotopic composition of contamination identified in Section 4.1.1, and taking credit for 99.9 percent removal by the building HEPA filters (Elder et al., 1986), the calculated annual average release of each radionuclide to the atmosphere is shown in Table 4-2.

TABLE 4-2
D&D FACILITY ANNUAL AVERAGE RELEASES DURING ROUTINE OPERATIONS

ISOTOPE	SOLUBILITY[1] CLASS	RELEASE (curies per year)	RELEASE (becquerels per year)
U-234	S	8.47×10^{-6}	(3.13×10^{5})
U-235	S	5.11×10^{-7}	(1.89×10^{4})
U-238	S	2.32×10^{-5}	(8.58×10^{5})
U-234	I	7.62×10^{-5}	(2.82×10^{6})
U-235	I	4.60×10^{-6}	(1.70×10^{5})
U-238	I	2.09×10^{-4}	(7.73×10^{6})
Th-232	I	8.54×10^{-6}	(3.16×10^{5})
Pu-239	I	4.76×10^{-7}	(1.76×10^{4})

(1) S = soluble; I = insoluble.

Based on the release source terms in Table 4-2 and annual average meteorological conditions, maximum off-site air concentrations for each isotope were calculated and are presented in Table 4-3. The maximum off site air concentration is predicted to occur approximately 700 meters due north of the proposed D&D facility. Correspondingly, the maximum off-site surface deposition is predicted to occur due north at the site boundary.

TABLE 4-3
MAXIMUM ANNUAL AVERAGE AIR CONCENTRATION OF RADIONUCLIDES OFF SITE DUE TO ROUTINE OPERATION OF THE PROPOSED D&D FACILITY

ISOTOPE	MAXIMUM OFF SITE AIR CONCENTRATION µcuries (becquerels) per milliliter	DOE LIMIT[1] µcuries (becquerels) per milliliter
U-234	1.9×10^{-17} (7.0×10^{-13})	9.0×10^{-14} (3.3×10^{-9})
U-235	2.5×10^{-18} (9.1×10^{-14})	1.0×10^{-13} (3.7×10^{-9})
U-238	7.8×10^{-17} (2.9×10^{-12})	1.0×10^{-13} (3.7×10^{-9})
Th-232	2.7×10^{-18} (1.0×10^{-13})	1.0×10^{-14} (3.7×10^{-10})
Pu-239	1.5×10^{-19} (5.7×10^{-15})	4.0×10^{-14} (1.5×10^{-9})

(1) Allowable off-site concentration for insoluble forms (Vaughan, 1985).

4.2.3 Radiological and Nonradiological Releases to Land

Decontamination processes are anticipated to generate low-level radioactive solid waste such as contaminated metal flakes, paint chips and grit collected from vacuums, sump filtrate, and abrasive grit air separator waste stream. In addition, spent filters will be disposed as low-level radioactive waste. A maximum of fifty 55-gallon drums of low-level waste per year is anticipated. All low-level radioactive waste will be disposed of in compliance with applicable DOE requirements (DOE, 1984a).

A portion of the low-level radioactive waste could potentially contain chemical constituents regulated under the Resource Conservation and Recovery Act or the Toxic Substances Control Act. Waste generated in the D&D facility will be sampled and analyzed as required to determine whether hazardous constituents are present. Waste containing hazardous chemical components will be drummed and stored in accordance with applicable FMPC procedures.

Material which has been decontaminated to meet unrestricted use criteria will be sold or disposed of in conventional landfill disposal areas. The quantity of this material cannot be estimated at this time because the quantity will depend on the success achieved in decontamination. Uncontrolled releases of solid waste contaminated with radiological or chemically hazardous substances will be unlikely.

4.2.4 Releases to Surface Water

Potential pathways by which D&D facility operations could impact surface water quality include surface deposition of airborne particulates and discharge of D&D facility liquid wastes. Surface water contamination by runoff from the facility is not anticipated because items requiring decontamination will be stored under cover.

Possible maximum surface water concentrations resulting from surface deposition of airborne releases of uranium, plutonium and thorium isotopes are not expected to be significant. Maximum annual surface deposition from airborne releases occurs to the north of the facility and is shown in Table 4-4. A maximum surface water concentration in nonflowing water was calculated based on these annual deposition rates and assuming buildup occurs over the lifetime of the facility. The calculations are based on the assumptions that the radioactive compounds remain in suspension, that mixing depth averages one meter, that no contamination exits the water body and that the D&D facility operates for 25 years. The resulting concentrations shown in Table 4-4 are well below DOE health-based limits (Vaughan, 1985). Concentrations in flowing water will be lower than those reported below for nonflowing water.

TABLE 4-4
MAXIMUM SURFACE DEPOSITION AND SURFACE WATER CONCENTRATIONS FROM 25 YEARS OF ROUTINE OPERATIONS

RADIOISOTOPE	MAXIMUM SURFACE DEPOSITION microcuries (becquerels) per square meter	MAXIMUM SURFACE WATER CONCENTRATION microcuries (becquerels) per milliliter	DOE LIMIT(1) microcuries (becquerels) per milliliter
U_{234}	6.5×10^{-6} (2.4×10^{-1})	1.7×10^{-10} (6.1×10^{-6})	5.4×10^{-7} (2.0×10^{-2})
U_{235}	3.9×10^{-7} (1.5×10^{-2})	9.8×10^{-12} (3.6×10^{-7})	5.4×10^{-7} (2.0×10^{-2})
U_{238}	1.8×10^{-5} (6.5×10^{-1})	4.4×10^{-10} (1.6×10^{-5})	5.4×10^{-7} (2.0×10^{-2})
Th_{232}	6.5×10^{-7} (2.4×10^{-2})	1.6×10^{-11} (5.9×10^{-7})	5.4×10^{-8} (2.0×10^{-3})
Pu_{239}	3.5×10^{-8} (1.3×10^{-3})	9.1×10^{-13} (3.4×10^{-8})	2.7×10^{-7} (1.0×10^{-2})

(1) (Vaughan, 1985)

Liquids generated in the D&D process may be contaminated with radioactive or hazardous chemical materials. These liquids will be collected, filtered, and temporarily stored in the D&D facility, as described in Section 2.1.4. The liquid wastes would then be managed (as also described in Section 2.1.4) in a manner to ensure compliance with NPDES permit limits for waterborne discharges.

4.3 ROUTINE OPERATIONAL EXPOSURE RESULTING FROM PROPOSED ACTION

This section describes radiological and nonradiological exposures to workers and the public and evaluates possible public health and ecological consequences. The environmental consequences of radiological exposures are also summarized in Section 4.6.

4.3.1 Radiological Exposure to Workers

Radiation exposure to workers may result from direct (external) radiation and from inhalation of contaminated particles. The D&D facility design includes radiation contamination controls to assure that the DOE design goal limiting occupational exposure to 20 percent of allowable limits will be met (DOE, 1986b). For example, the facility design provides for adequate ventilation air flow rates in process areas, exhaust hoods for disassembly of contaminated articles, air flow from areas of low contamination potential to those of greater contamination potential, maintenance of a negative air pressure within the building, and use of shielding, radiation monitoring equipment and alarms as described in Section 2.0. Administrative controls for occupational exposure include personal dosimetry, health physics surveys and radiation protection procedures. Protective clothing and respiratory protection will be used as required. These controls will limit radiation exposure to workers to as low as reasonable achievable within the DOE limit of five rem (0.05 sieverts) per year (DOE, 1986b).

4.3.2 Radiological Exposure to the Public

Radiological exposure to the public during routine operations of the D&D facility was calculated using AIRDOS.EPA. Approximately 90 percent of the potential radiation exposure to humans would result from the inhalation pathway and ten percent from the ingestion pathway. There are two radiation dose limits of interest in evaluating exposures to members of the public: the DOE guideline of 100 millirem (1.0 millisieverts) per year effective committed dose equivalent to any member of the public from all routine operations and pathways at the FMPC (Vaughan, 1985) and EPA regulations for airborne emissions from DOE facilities which specify a limit of 75 millirem (0.75 millisieverts) per year committed dose equivalent to the critical organ of any member of the public (40 CFR 61, Subpart H). Exposures relating to each of these facility limits are addressed below. An additional calculation of interest is the projected collective radiation exposure to the entire population resulting from routine releases.

From the maximum anticipated release of each isotope, totaling 3.4×10^{-4} curies (1.2×10^{-7} becquerels) per year, an effective committed dose equivalent to the combined population within 80 kilometers of the site was calculated to be 0.42 person-rem ($4.2x10^{-3}$ person-sieverts). Based upon a total population of 2,597,913, the average effective committed dose equivalent per person would be about $1.6x10^{-4}$ millirem ($1.6x10^{-6}$ millisieverts). Thus, the average individual exposure is a small fraction of the effective committed dose equivalent limit of 100 millirem (1.0 millisieverts) per year for the FMPC (Table 4-5).

The same model was used to calculate the dose to a hypothetical individual who resides at the site boundary at the point of maximum annual air concentration resulting from routine releases from the D&D facility. Routine annual releases give this maximum individual an effective committed dose equivalent of 0.22 millirem ($2.2x10^{-3}$ millisieverts) during each year of operation. This exposure is a small fraction of the DOE prescribed maximum individual limit of 100 millirem (1.0 millisieverts) per year applicable to the FMPC (Table 4-5).

The EPA limit of 75 millirem (0.75 millisieverts) per year committed dose equivalent to the critical organ applies to a member of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public resides. For the FMPC, this point is at the site boundary approximately 700 meters north of the proposed D&D facility at an existing residence (U.S.G.S., 1981). An individual at this location is estimated to receive a committed dose equivalent to the critical organ of 1.5 millirem ($1.5x10^{-2}$ millisieverts). The critical organ (i.e., most exposed human organ) for exposure to the assumed mixture of uranium, thorium, and plutonium oxide from routine airborne emissions is the lung. Table 4-5 summarizes routine radiation exposure to members of the public from D&D facility operations and compares them with applicable dose limits.

TABLE 4-5
RADIATION EXPOSURES FROM ROUTINE OPERATIONS

	CALCULATED DOSE	ANNUAL DOSE LIMIT FOR ALL FMPC OPERATIONS
Effective Committed Dose Equivalent to Total Population/person-rem (person-sieverts)	0.42 (4.2×10^{-3})	none
Effective Committed Dose Equivalent to Average Individual/millirem (millisieverts)	1.6×10^{-4} (1.6×10^{-6})	none
Effective Committed Dose Equivalent to Maximum Individual/millirem (millisieverts)	0.22 (2.2×10^{-3})	100[(1)] (1.0)
Committed Dose Equivalent to Critical Organ/ millirem (millisieverts)	1.5[(2)] (1.5×10^{-2})	75[(3)] (0.75)

[(1)] Vaughan, 1985.
[(2)] In this case, the critical organ is the lung.
[(3)] 40 CFR 61, Subpart H, Committed Dose Equivalent for the Critical Organ.

4.3.3 Health Impacts Resulting from Routine Exposure

Potential risk to public health resulting from radiation exposure is principally in the form of an increase in cancers arising in a variety of organs and tissues. The cancer risk for the exposures calculated above are addressed in Section 4.6. No pathway for public exposure to potentially hazardous chemicals (such as Freon) resulting from routine D&D operations has been identified.

4.3.4 Ecological Impacts

Uranium and thorium compounds occur naturally in soils throughout the United States; they contribute to the "background" radioactivity levels in soils. Plutonium is present in soils in trace amounts due to fallout from atmospheric, weapons testing. Naturally occurring uranium concentrations in soils are about 1×10^{-12} curies (0.037 becquerels) per gram, and thorium concentrations are about 2×10^{-12} curies (0.074 becquerels) per gram (NCRP 45, 1975). Estimated average thorium-232 activity in the upper soil horizon nationwide is about 2.7×10^{-7} curies (1×10^{4} becquerels) per square meter (Whicker, 1987); uranium activity is estimated at 1.35×10^{-7} curies (5×10^{3} becquerels) per square meter. Plutonium deposition due to fallout has been estimated to be

1.4×10^{-12} curies (0.052 becquerels) per square meter (Eisenbud, 1987). Thus, as can be seen from Table 4-4, projected releases from routine operations at the D&D facility would contribute only an extremely small portion to existing natural background levels.

Maximum annual average off-site air concentrations during routine operations (Table 4-3) are estimated to be one thousand to one million times lower than the DOE recommended limits for the radioisotopes released. Surface contamination would be at one thousand to one hundred thousand times lower than natural background. These levels would have to be increased many orders of magnitude to cause adverse environmental impacts.

4.3.5 Impacts from Nonradiological Releases

As Table 4-1 indicates, the projected possible concentrations of nonradiological air pollutants associated with construction activities are minuscule when compared to the allowable National Ambient Air Quality Standards (NAAQS) concentration limits. Because these standards are based on achieving protection of public health and the environment, no deleterious consequences are foreseen for either human health or ecological systems. No criteria pollutant or hazardous chemical emissions are anticipated during operations.

4.3.6 Nonradiological Occupational Health and Safety

Nonradiological health and safety concerns such as industrial safety will be controlled through the application of the routine procedures described in Section 2.1.5. Work procedures would comply with DOE and OSHA requirements.

4.3.7 Impacts on Other Environmental Parameters

Ambient noise levels at the FMPC are not expected to be impacted by construction activities for the D&D facility. Noise would be generated by the operation of the D&D facility high-pressure wash and grit-blast systems. The high-pressure wash systems would operate at levels above 90 decibels. The grit-blast system would normally operate with a noise level of about 95 decibels and occasionally up to 125 decibels (Miller, 1987). No significant environmental impact would be expected because the equipment would be operated within the D&D building process enclosures which would serve to attenuate this noise. Wash and blast system operators would wear hearing protection in conformance with Occupational Safety and Health Administration (OSHA) standards.

The proposed action will not generate significant additional vehicle traffic or additional employment at the FMPC. Disturbed areas not occupied by the facility and adjacent paved areas would be revegetated after construction. No significant impacts upon cultural resources, land use, biological resources, visual resources or socioeconomics are anticipated.

4.4 POTENTIAL ACCIDENTAL EXPOSURE AND IMPACTS RESULTING FROM THE PROPOSED ACTION

This section assesses the environmental and health consequences of postulated accidents associated with the proposed action. A small probability exists that unplanned releases may occur during the course of decontamination process activities. For the purpose of evaluating the potential range of such events, credible accident scenarios were formulated and the resulting impacts evaluated. Environmental and health consequences from accidents are summarized in Section 4.6.

Most of the accident scenarios which could be considered as reasonably probable during D&D facility construction and its 25 year assumed operating lifetime are primarily of an industrial nature and not unique to a facility handling radioactive material. During construction these hazards are associated with the use of heavy equipment and handling of large structural components. Operational hazards include use of rotating equipment, high pressure systems, cranes and the decontamination process equipment itself.

Because of the nature of this operation, there would not be large inventories of radioactive material, or any significant amounts of highly radiotoxic materials present in the D&D facility. Accidents which result in the release of radioactive material would most likely occur within the process areas, where engineered design controls would minimize the environmental consequences. The accident scenarios postulated below do not assume any multiple failures, so any environmental release from the building would be reduced by at least a factor of 1,000 by the HEPA filtration system. Failure of the building filtration system is among the accidents analyzed.

Criticality accidents have not been considered in this analysis due to the small quantities and low level of U-235 enrichment anticipated to be present at the D&D facility. As stated in Section 2.1.2, contaminated material with U-235 enrichment levels potentially higher than two percent will be pre-screened prior to transport to the D&D facility. This material will be batch processed through the D&D facility using appropriate criticality controls to maintain criticality safety. DOE regulations require criticality monitoring of any facility where more than 700 grams of U-235 could be present (DOE, 1986a). Since this possibility could not be excluded, the D&D building would be equipped with criticality alarms. A criticality safety analysis will be performed by the FMPC safety evaluation group to address specific procedures and controls necessary for processing of contaminated material having U-235 enrichment levels above two percent.

The D&D facility will be equipped with a fire protection system designed to effectively suppress any fire in the building. Material to be decontaminated is not anticipated to have any finely divided pyrophoric contaminants and no fire related accident has been postulated. Accidents initiated by natural events, such as a tornado or earthquake were not considered a significant source of radioactivity release due to the DOE design requirements for the facility and the nature of the material to be processed. DOE facilities are designed to withstand natural events with any credible probability of occurring within the plant lifetime. The facility design is based on DOE criteria requirements with a design goal to limit maximum credible accidental releases to 25 rem effective committed dose equivalent to any individual off-site (DOE, 1983).

4.4.1 Release Scenarios

Three accidents were postulated to provide a basis for assessing the potential magnitude of impacts that could conceivably occur over the lifetime of proposed D&D facility operation. The accident scenarios were formulated from an examination of D&D process operations and design basis inventories and controls of radiological/hazardous materials. The two accidents with the greatest potential for radiological consequences both involve the release of radioactive particulates to the atmosphere. A third accident was also considered resulting in the release of Freon 113 to the atmosphere. No pathways were identified whereby accidental releases of liquids to the environment might be expected to occur. Airborne releases are the most likely pathway of accidental exposure to the public. Accidental releases of both soluble and insoluble forms of uranium were assessed. The highest dose occurs from accidents involving a release of soluble uranium. Exposure from releases are dominated by the ingestion of contaminated food and water. The three accident scenarios are discussed below.

(1) Failure of Filter on Portable Vacuum

The first postulated accident involves the postulated breach of the filter on one of the portable D&D facility vacuum units. Although roughing filters would be in use throughout the facility, the vacuum cleaner filter failure was judged to be the most severe accident because of the larger inventory of collected radioactive contamination associated with this particular equipment. The vacuum unit has a 75 liter (20 gallon) tank capacity. For the purpose of source term development, it was assumed that the entire contents of the tank could be released to the building process area with an assumed five percent respirable fraction. [This assumption accounts for probable agglomeration and plateout inside the vacuum canister, and is consistent with recommended release fractions for nonvolatile transuranic solids (Elder et al., 1986)]. In such an event, 99.9 percent of the airborne material would be removed by the facility filtration system prior to release to the environment.

The consequences of this accident would vary depending on the type of contamination present in the vacuum at the time of failure. In establishing the limiting accident, the solubility class of the uranium compounds and the U-235 enrichment level were varied. Criticality considerations would limit the allowable U-235 content to 700 grams regardless of the enrichment of the uranium. An assumption of 19.99 percent enrichment in U-235 results in a smaller total quantity of material available for release and thus does not produce the maximum potential off-site exposure. An assumption that the uranium is depleted in U-235 produces the highest off-site exposure as a result of the large quantity of material available for release. However, this assumption yields an unrealistically high mass of uranium in the vacuum canister. For the purpose of analysis, two source terms were assessed: one assuming uranium compounds enriched to 2 percent U-235 and one assuming enrichment at 19.99 percent. In both cases the compounds were assumed to be of a soluble form to maximize the resulting dose to man. The resulting environmental release was calculated to be 2.23×10^{-6} curies (8.24×10^{4} becquerels) of uranium enriched to 2 percent and 1.78×10^{-6} curies (6.57×10^{4} becquerels) of uranium enriched to 19.99 percent. The resulting exposure to an off-site individual is dominated by ingestion of food and water contaiminated by deposition of airborne particulates.

(2) Breach of a D&D Facility Process Exhaust HEPA Filter

The second postulated accident involves a breach of the building filtration system such that contaminated exhaust is released without the benefit of HEPA filter mitigation. The building exhaust ventilation system is designed so that only one-half of the total process exhaust air stream would discharge through each HEPA filter. It is unlikely that both HEPA filters would fail simultaneously; however, this scenario is considered to provide a bounding estimate for the worst possible airborne release.

Eighty-five percent of the material to be processed at the D&D facility is expected to be contaminated with depleted uranium. However, it is not possible to rule out the unlikely scenario where the postulated accident would occur during a time when material having enriched uranium contaminants was in all three D&D process areas simultaneously. Therefore, two source terms were considered: one assuming uranium at 2 percent enrichment and one assuming 19.99 percent enrichment. The accident release considered assumes that only soluble uranium compounds are present in the building at the time of the release. Airborne concentration of contaminants prior to the postulated accident was assumed to be at the daily average. The ventilation exhaust fans for the process exhaust are assumed to operate at their maximum rate of 354 cubic meters per minute for a 30 minute period before being secured. The resulting releases are calculated to be 1.2×10^{-4} curies (4.4×10^{6} becquerels) of uranium enriched at 2 percent and 9.5×10^{-4} curies (3.5×10^{7} becquerels) of uranium enriched at 19.99 percent.

(3) Release of Freon

A third accident scenario was developed in consideration of the potential adverse health effects of an accidental release of the Freon 113 solvent used in the Freon cleaning process area. As described in Chapter 2, the solvent tank has a total capacity of about 150 liters. It is extremely unlikely that the total volume of Freon 113 could be released to the facility process exhaust system due to safety controls and freon leak alarm monitors in the process area. However, as a worst conceivable accident, the entire contents of this tank was assumed to be vaporized and released from the building stack over a 30 minute period. The total inventory of Freon 113 released would be 234 kilograms [assuming a density of 1.56 grams per milliliter at room temperature (25°C)]. Decomposition of the Freon is considered unlikely at this temperature. Any spills of Freon, either inside or outside of the facility, will be contained and cleaned up in accordance with the FMPC Spill Prevention, Control and Countermeasure (SPCC) Plan.

4.4.2 Radiological Exposures Resulting from Accidents

The radiological exposures resulting from the accidents postulated above would be a function of the immediate conditions prevailing at the time of each event. In all cases, releases would be of short duration, measured in minutes, and the cloud of particulates or freon gas would be subject to the existing meteorological conditions (wind speed, wind direction, and atmospheric stability). Occupational workers at the scene of the accident would be trained to move upwind of the release, put on their respiratory equipment, and then respond to mitigate the magnitude of the accident.

Radiological exposure of the public as a result of the accidents described above was conservatively estimated by assuming that very stable meteorological conditions exist for the duration of the cloud passage. Wind speed was fixed at two meters per second and Pasquill atmospheric stability category F conditions were assumed (Elder et al., 1986). These conditions would result in a slow moving and concentrated cloud of particulates or gas off site.

For the purpose of dose assessment, it was assumed that a member of the public (maximum individual) was located at the FMPC facility site boundary in the downwind direction during cloud passage. This maximum individual was assumed to be exposed to the highest resulting air concentration of contamination, that being at the center line of the plume. Table 4-6 summarizes the exposure to this hypothetical individual for each of the postulated accidents. Because of the conservatism of the assessment assumptions, these exposures should be considered to be at the upper range of the possible exposures that would occur from the postulated events.

TABLE 4-6
CONSEQUENCES OF POSTULATED ACCIDENTS

ACCIDENT	RELEASE	CONSEQUENCE[(1)]
Vacuum Unit Failure 2% Enriched Uranium	2.2×10^{-6} curies (8.2×10^{4} becquerels)	1.2×10^{-5} rem (1.2×10^{-7} sieverts)
19.99% Enriched Uranium	1.8×10^{-6} curies (6.6×10^{4} becquerels)	1.0×10^{-5} rem (1.0×10^{-7} sieverts)
Building HEPA Filter Failure 2% Enriched Uranium	1.2×10^{-4} curies (4.4×10^{6} becquerels)	6.6×10^{-4} rem (6.6×10^{-6} sieverts)
19.99% Enriched Uranium	9.5×10^{-4} curies (3.5×10^{7} becquerels)	5.4×10^{-3} rem (5.4×10^{-5} sieverts)
Freon Release	234 kilograms	0.27 ppm[(2)]

(1) Maximum dose to any member of the general public expressed as the effective committed dose equivalent.
(2) For comparison, the recommended threshold limit value (TLV) for safe daily exposure to occupational workers is 1,000 ppm (Sax, 1984).

4.4.3 Health Impacts Resulting from Accidental Exposures

The health consequence of the radiation exposure to the hypothetical individual resulting from postulated accidents is principally an increase in the risk of cancer. This risk is discussed in Section 4.6.

4.4.4 Ecological Effects of Accidents

The effects of postulated accident scenarios on ecological systems were also considered. The maximum potential air concentrations and surface depositions of releases calculated under accident conditions are shown in Table 4-7. These levels of radioactivity are well below any known threshold of detection for ecological effects (Whicker, 1987). Freon levels are several orders of magnitude below the levels known to cause discernable effects in laboratory animals (Sax, 1984).

TABLE 4-7
PEAK AIR CONCENTRATION AND TOTAL GROUND DEPOSITION FOR ACCIDENTS

ACCIDENT	MAXIMUM OFF-SITE AIR CONCENTRATION(1)	MAXIMUM OFF-SITE SURFACE DEPOSITION(2)
Vacuum Unit Failure 2% Enriched Uranium	$2.0x10^{-14}$ µCi/ml ($7.4x10^{-10}$ Bq/ml)	$9.3x10^{-7}$ µCi/m^2 ($3.4x10^{-2}$ Bq/m^2)
19.99% Enriched Uranium	$1.6x10^{-14}$ µCi/ml ($5.9x10^{-10}$ Bq/ml)	$7.4x10^{-7}$ µCi/m^2 ($2.7x10^{-2}$ Bq/m^2)
Building HEPA Filter Failure 2% Enriched Uranium	$1.1x10^{-12}$ µCi/ml ($4.07x10^{-8}$ Bq/ml)	$5.0x10^{-5}$ µCi/m^2 (1.9 Bq/m^2)
19.99% Enriched Uranium	$8.5x10^{-12}$ µCi/ml ($3.2x10^{-7}$ Bq/ml)	$4.0x10^{-4}$ µCi/m^2 (14.8 Bq/m^2)
Freon Release	0.07 grams/m^3	None

(1) Peak air concentration occurs during cloud passage at nearest boundary approximately 450 meters to the east.
(2) At nearest site boundary.

4.5 EVALUATION OF ALTERNATIVES

A brief evaluation of the alternatives to the proposed actions considered by this environmental assessment is provided in this section. Where possible, quantitative estimates have been made of the routine operational and potential accident-related impacts for each.

4.5.1 Upgrade the Present D&D Facility

As discussed in Section 2.0, this alternative involves a major renovation of the existing D&D facility at the FMPC. Environmental impacts of this alternative would be associated with: 1) cessation of current decontamination of process equipment and temporary storage of such equipment on site; 2) decontamination of the existing structure in preparation for a major retrofit of decontamination process technology; and 3) retrofit and operation of the upgraded facility. The first phases of this project would result in additional accumulation of process equipment and scrap requiring radioactive decontamination. Process equipment would eventually be decontaminated in the upgraded facility; however, facility decontamination and renovation activities would add to the existing inventory of contaminated scrap and rubble at the

FMPC. This accumulated material would represent a potential source of release to the environment primarily as a result of weathering processes.

Retrofit and operation of the upgraded facility would result in impacts similar to but less than the proposed action. Construction activities would include utility upgrade, paving, and handling and installation of new decontamination process technologies similar to those planned for the proposed action. Operation impacts would be less than those anticipated for the proposed action, roughly proportional to the size difference of the two structures. The area available for decontamination process within the existing facility is approximately one third that of the proposed new D&D facility. Assuming throughput capacity would be similarly reduced, the environmental impacts of the operational phase of the renovated D&D facility would be approximately one third of those estimated for the proposed action. No accidents unique to this alternative have been identified.

The most significant environmental impact of this alternative is that associated with the limited throughput capacity of the existing D&D facility. It is anticipated that FMPC production equipment decontamination will be a priority and that the inventory of accumulated contaminated scrap and recyclable equipment would not be worked off but would continue to grow. As such, until the facility was expanded in capacity or a decision was made to dispose of the on-site inventory of scrap as low-level radioactive waste, the growing inventory would present an increasing risk of radioactive and chemical contaminant release to the environment.

4.5.2 Transport Contaminated Material Off Site for Disposal

As an alternative to the proposed action, the seven million kilograms of contaminated scrap projected to be processed by the proposed facility could be transported to an off-site, low-level radioactive waste disposal facility. A decision to dispose of this material as low-level waste rather than decontaminate the material for resale, recycle, or sanitary landfill disposal would require a significant increase in off-site, low-level waste shipments. An environmental assessment of such a low-level waste shipment campaign has previously been prepared (DOE, 1985). It is estimated that a decision to dispose would require at least a 14-fold increase over planned waste shipments. The waste volume reduction benefits associated with on-site decontamination of this scrap would also be lost.

This alternative does not address the need for increased efficiency and size capability for the decontamination of FMPC process equipment and vehicles. Use of the existing D&D facility for decontamination of FMPC process equipment would continue. There are currently no controls on emissions from this facility.

4.5.3 No Action

The no action alternative would only postpone the consequences of the proposed action or alternative because contaminated scrap will eventually have to be dealt with. The accumulated scrap would continue to contribute to ambient radiation levels on and off site and would remain a potential source of environmental contamination due to weathering processes. The no action alternative would offset some of the benefits derived from environmental, health and safety improvement projects on-going or planned at the FMPC since final disposition of the resulting low-level waste would not be resolved. The existing D&D facility would continue to be used for decontamination of FMPC process equipment. There are currently no controls on emissions from this facility.

4.6 COMPARISON OF ENVIRONMENTAL CONSEQUENCES

Potential risks to human health from routine operations related to D&D facility construction and operation and postulated accidents are compared in Table 4-8. Because of its smaller size and throughput capacity, the risk associated with Alternative 1, renovation of the existing D&D facility, are represented as being one third of the risk of the proposed action.

With respect to human health risks, the consequence of radiation exposure is reported as a risk of contracting a fatal cancer at any time in the future as a result of the estimated radiation exposure and a risk of serious genetic disorders per 30-year generation. In the health risk assessment, the following accepted principles have been employed:

- A carcinogenic risk due to radiation exposure is defined as the probability that a specified dose will cause fatal cancer in some fraction of the people exposed

- A genetic risk due to radiation exposure is defined as the probability that a serious genetic disorder will result per 30-year generation

- Dose-response relationship is chosen to be linear with no threshold, i.e., it is assumed that the probability of late stochastic effects (somatic and genetic) is proportional to radiation exposure received no matter how small that exposure

- Dose response is considered to be independent of dose rate (BEIR, 1980).

The absolute risk model as set forth by the Committee on the Biological Effects of Ionizing Radiations (BEIR, 1980) was used in addition to reports of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1977) and the ICRP (ICRP, 1977). A comparison of the proposed action and alternatives in terms of the risk of contracting a fatal cancer over the lifetime of exposed individuals or genetic disorder per 30-year generation is presented in Table 4-8. These risks consider only the exposures associated with releases of particulate contamination and do not include the risk of cancer or genetic disorders from other environmental causes. For comparison, the risk of contracting a fatal cancer during the lifetime of an individual from all natural and man-made causes has been estimated at 22 percent (2.2E-1) (DOCBC, 1987). The current incidence of human genetic disorders is approximately 107,000 cases per million liveborn (BEIR, 1980) or approximately 11 percent. As shown in Table 4-8, the increased risk represented by the proposed action or alternatives is negligible by comparison.

TABLE 4-8

COMPARISON OF CARCINOGENIC AND GENETIC RISK FROM RADIOLOGICAL EXPOSURE[1][2]

	ROUTINE OPERATIONS			POSTULATED WORST ACCIDENT[3]
	OCCUPATIONAL WORKER AVERAGE	PUBLIC AVERAGE INDIVIDUAL	PUBLIC MAXIMUM INDIVIDUAL	PUBLIC MAXIMUM INDIVIDUAL
Proposed Action: New D&D Facility	$1x10^{-4}$[4] ($1x10^{-3}$)	$1.6x10^{-11}$ ($1.6x10^{-10}$)	$2.2x10^{-8}$ ($2.2x10^{-7}$)	$5.4x10^{-7}$ ($5.4x10^{-6}$)
Alternative 1: Renovate Old Facility	$1x10^{-4}$[4] ($1x10^{-3}$)	$5.3x10^{-12}$ ($5.3x10^{-11}$)	$7.3x10^{-9}$ ($7.3x10^{-8}$)	$1.8x10^{-7}$ ($1.8x10^{-6}$)
Alternative 2: Off-Site Disposal	$1x10^{-4}$[4] ($1x10^{-3}$)	0[5] (0)	0[5] (0)	NE[6]
Alternative 3: No Action	$1x10^{-4}$[4] ($1x10^{-3}$)	0[5] (0)	0[5] (0)	NE[6]
Current Risk of Fatal Cancer (Genetic Effects)	$2.2x10^{-1}$ ($1.1x10^{-1}$)	$2.2x10^{-1}$ ($1.1x10^{-1}$)	$2.2x10^{-1}$ ($1.1x10^{-1}$)	$2.2x10^{-1}$ ($1.1x10^{-1}$)

(1) Health risks are expressed as the probability of an individual contracting a fatal cancer during their lifetime from each year of D&D operations. Risk of serious genetic effects per 30-year generation are shown in parentheses. Risks are expressed in exponential form, i.e., $1x10^{-4}$ is equivalent to one chance in 10,000

(2) Risk of contracting fatal cancer: $1x10^{-4}$ fatalities/rem for each year of operation. Risk of genetic effects: $1x10^{-3}$ genetic effects/rem for each year of operation (BEIR, 1980).

(3) Only the risk associated with the worst accident is reported. The probability of the accident is not included in this risk.

(4) Risk based upon assumption that involved worker exposure will be maintained below 10 millisieverts.

(5) No increased routine exposure to the public should result. Transportation impacts for Alternative 2 addressed by DOE, 1985.

(6) No accident was evaluated.

5.0 MITIGATION MEASURES

Health, safety, and environmental control programs and measures are described throughout this Environmental Assessment, particularly in Section 2.1.5. Most of these reflect DOE and/or EPA objectives and requirements. Because government programs with radiological implications are rigorously controlled, pertinent additional mitigation measures have not been identified.

6.0 PERSONS AND ORGANIZATIONS CONSULTED

The following individuals and organizations were consulted during the preparation of this EA:

- Richard Boisvert, State of Ohio Historic Preservation Office, Columbus, Ohio
- Rita Wynn, Ohio-Kentucky-Indiana Regional Council of Governments, Cincinnati, Ohio
- Oak Ridge National Laboratory, Oak Ridge, Tennessee
- F. Ward Whicker, Department of Radiology and Radiation Biology, Colorado State University, Fort Collins, Colorado
- Mary Ann Brown, Executive Director, Miami Purchase Association for Historic Preservation, Cincinnati, Ohio.

GLOSSARY

Accident Scenario:	Description of unforeseen events or circumstances which have a finite but low probability of occurring during the duration of the project.
Aerodynamic Equivalent Diameter:	The diameter of a uniform-density sphere that would have the same terminal velocity due to gravity in air as the particle under consideration.
ALARA:	DOE objective to maintain radiation exposure levels to as low as reasonably achievable.
BEIR:	Biological Effects of Ionizing Radiations (National Academy of Sciences Committee).
Becquerel (Bq):	A unit measuring the radioactivity of an element. One becquerel is defined as one nuclear disintegration per second.
CEQ:	U.S. Council on Environmental Quality.
CO:	Carbon monoxide.
Committed Dose:	The radiation dose accumulated over a period of years (in this case 50 years) of exposure resulting from radionuclides deposited within the body during the exposure period.
Coniferous:	Pertaining to cone-bearing species such as pines.
Critical Organ:	The human body organ receiving a radiation dose which results in the greatest overall risk to the body.
DOE:	U.S. Department of Energy.
DOT:	U.S. Department of Transportation.
Deciduous:	Pertaining to a tree or shrub that sheds its leaves seasonally.
Diatomaceous Earth:	Earth material abounding in fossilized plankton.
Dispersion:	The process of natural mixing in the atmosphere.
Dose:	A general term denoting the quantity of ionizing radiation received. Exposure dose is often used as the total amount of ionization that a given quantity could produce in air. The units are then roentgens. This should be distinguished from the absorbed dose, which is the energy absorbed in one gram of any material due to exposure to radiation. The unit for absorbed dose

is rads (gray). Finally, the biological dose or energy absorbed in biological tissue is given in rem and accounts for relative biological damage potential for the type of radiation absorbed. The units for the biologically absorbed dose are rem (sieverts).

Dose Equivalent:	The product of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of the radiation and its distribution in the human body. The unit of dose equivalent is the rem (sievert).
Dose Response:	The immediate and long-term results (effects) of exposure to a radiation dose.
EPA:	U.S. Environmental Protection Agency.
Edge Habitat:	The transition zone between two plant communities.
Effective Dose Equivalent:	The sum of the products of the dose equivalents to individual organs and tissues and appropriate weighting factors representing the risk relative to that of an equal dose to the whole body. The unit is the rem (sievert).
Environment:	The physical and biological surroundings (habitat) existing for humans, plants, and animals. Includes atmosphere, water, and land as well as the environment "built" or developed by man.
Environmental:	Pertaining to biosphere, the complex physical, chemical, and biotic factors which act upon an organism.
Environmental Impact:	The consequences, effects, or outcomes resulting from changes in the human or natural environment. In this EA, impacts are generally confined to human health effects or adverse effects on natural ecosystems.
Exposure:	Subject to effects of ionizing radiation or risk of ingestion/inhalation of a radionuclide. The product of dose rate and time.
FMPC:	Feed Materials Production Center, Fernald, Ohio.
Forb:	Broad-leaved herbaceous plant as distinguished from the grasses.
Greensalt:	Uranium tetrafluoride.
HEPA:	High efficiency particulate air filter capable of removing at least 99.97 percent of airborne particulates greater than 0.3 microns in diameter.

Habitat:	The physical environment where an organism lives.
Herbaceous:	Non-woody plants.
Millisievert:	One thousandth (0.001) sievert, equal to 100 millirem.
NEPA:	National Environmental Policy Act.
NFPA	Nation Fire Protection Association.
NO_x:	Nitrogen oxide.
NPDES:	National Pollutant Discharge Elimination System. Refers to a type of State of Ohio or federal permit for discharging wastewater to a surface water body. Derives from Section 402 of the federal Clean Water Act.
National Register of Historic Places:	A listing and designation of nationally significant historical or archeological sites given special protection under the federal Historic Preservation Act. The national Register is managed by the National Park Service.
OSHA:	U.S. Occupational Safety and Health Administration.
Off Site:	Any location beyond the site boundary where a member of the public can be legally situated beyond the control of the owner and operator of a nuclear facility.
Paddy's Run:	An intermittent stream (flowing only part of the year) running from north to south along the western boundary of the FMPC.
Population Dose:	An estimate of total radiation dose received by members of a population group. Units are person-rem (person-sieverts).
Rare, Threatened, or Endangered Species:	A classification of a terrestrial or aquatic plant or animal species given special protection under the federal Endangered Species Act.
Riparian:	Along the bank of a river or lake.
Ruderal:	A type of disturbed habitat.
SO_2:	Sulfur dioxide.
Sievert:	A unit of radiation energy deposited in tissue equivalent to one joule per kilogram.
Site Boundary:	The boundary of a property over which the owner or operator can exercise strict control without the aid of outside authorities. The site boundary does not have to be a fence or other physical barrier.

Site Specific Data:	Data collected for use in radiological assessment models applicable to the particular location for which assessment is performed.
Somatic:	Radiation effects manifested in the exposed individual.
Source Term:	The amount of radioactive material released from primary confinement to the biosphere in dispersible form (units are becquerels).
Species Diversity:	A measure of variety of different species of a community: describes the number of species within that community and their relative abundances.
Stochastic:	Effects whose probability of occurrence in an exposed population is a direct function of dose.
Third-Order Stream:	Classification of stream based on size; third-order streams are formed by the joining of two second-order streams which have lower yearly flow.
Unrestricted Use:	Meeting regulatory criteria established to protect public safety in any type of future use.
WMCO:	Westinghouse Materials Corporation of Ohio.
Worst Case:	Calculation made based on assumptions intended to bias results toward overestimation of impacts.

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APPENDIX A

DOSE ASSESSMENT METHODOLOGY

This appendix provides an overview of the methodology and assumptions used to assess the radiological consequences to members of the public from airborne radioactivity releases from the FMPC facility.

A.1 DOSE CALCULATION MODELING

The AIRDOS-EPA computer code was used to estimate the radiation dose to man resulting from the atmospheric release of radionuclides from thorium material removal activities at the FMPC. The version of the code used is the one codified in 40 CFR 61 Subpart H. The code, which is a modified version of AIRDOS-II, is described in Moore et al. (1979) and was used for both routine and accidental release assessments. Most input parameters required by the code characterize the area surrounding the site or are specific to the radionuclides released. As such, these input data were identical for both release assessments. Other input, such as the source terms and the meteorological assumptions used, were specific to the release assessment. The following discussion differentiates between routine release modeling and accident release modeling where differences exist.

A.2 OVERVIEW OF AIRDOS-EPA

In general, AIRDOS-EPA estimates the radiation dose to either a maximum individual or to a collective population resulting from the airborne release of radionuclides specified as input to the code. Based upon a characterization of the area surrounding the site and the meteorological conditions specified, the code estimates: (1) concentrations of radioactivity in air, (2) rates of deposition on ground surfaces, and (3) ground surface concentrations. These results are then coupled with intake rates for man to estimate the radiation dose to an adult receptor associated with all possible exposure pathways. For a maximum individual, doses are calculated along the release plume centerline. For a collective population dose, the model calculates an average concentration of the release plume for each sector (distance and direction pair) and uses this calculation to compute a dose.

A.3 METEOROLOGICAL MODELING

The area surrounding the FMPC site was modeled as a 80-kilometer radius circular grid system with the site located at the center. For the assessment of routine annual releases, site-specific meteorological data typical of annual average conditions were specified. First, the annual frequency of wind direction was determined for each of the 16 compass directions starting at direction 1 for winds toward the north and then proceeding counterclockwise through direction 16. Next, the frequency of each Pasquill stability category for each of the 16 compass directions was determined for the six stability classes ranging from A (very unstable) to F (extremely stable). The average wind speed was entered for each wind direction and Pasquill category. The average depth of the atmospheric mixing layer (lid) for the area was specified to limit the vertical dispersion of the plume after it travels some distance downwind of the source. The value used for the lid height was 700 meters for releases due to routine operations and accidents. The site-specific meteorological data used in the assessment of routine releases were taken from Greater Cincinnati International Airport and are summarized in Tables A-1 through A-4.

For the assessment of accidental releases, meteorological assumptions were specified to intentionally maximize the calculated dose consequences to a hypothetical off-site individual. The release was confined to a single 22.5° sector and, assuming a constant two-meter-per-second wind speed, a comparison was made of the ground level air concentrations at all distances downwind for each Pasquill stability class. The stability class and distance resulting in the highest off-site air concentration of released radionuclides was assumed for the duration of the accident. The meteorological assumptions determined in this manner for the assessment of accidental releases as derived above are summarized in Table A-5.

A.4 EFFLUENT MODELING

AIRDOS-EPA requires input describing the area or point of release. Releases due to routine D&D operations and accidents were assumed to occur as a point source at ambient temperature (20°C), 16.2 meters above the ground, with an effective stack velocity of 8.99 meters per second due to ventilation exhaust velocity. Stack data input is given in Table A-6. Effective stack heights were estimated using Rupp's equation for momentum dominated plumes (Rupp, 1948).

A.5 DISPERSION MODELING

The basic equation used to estimate plume dispersion in the downwind direction is the Gaussian plume model of Pasquill, 1961, as modified by Gifford, 1961. The values of the horizontal and vertical dispersion coefficients (σ_y and σ_z) used for dispersion and depletion calculations are those recommended by Briggs, 1969. With respect to deposition of radionuclides on ground surfaces, the code permits considering both dry deposition and scavenging. Dry deposition is the process by which particles deposit on grass, leaves, and other surfaces by impingement, electrostatic deposition, chemical reactions, or chemical reactions with surface components. The rate of deposition on earth surfaces is proportional to the ground-level concentrations of the radionuclides in air (Slade, 1987):

$$R_d = V_d \chi$$

where:

R_d = Surface deposition rate, pCi/cm^2-sec,
χ = Ground level concentration in air, pCi/cm^3, and
V_d = Deposition velocity, cm/sec.

It should be noted that even though V_d has units of velocity, it is a constant of proportionality and as such must be experimentally determined from field studies in which the ratio R_d/χ can be reliably determined. For particles less than 4 microns in diameter, V_d is set at 0.1 cm/sec (Heinemann et al., no date). This value is, however, based on vegetation cut at a specific height and fails to measure total deposition on a unit area basis. The value must therefore be divided by the fraction of atmospherically depositing nuclides intercepted by the above-ground edible portion of the vegetation to arrive at a total value of V_d. Using a mean forage grass interception fraction of 0.57 produces a deposition velocity (V_d) of 0.18 cm/sec for small particulates. Since specific values for V_d (total) have not been published for vegetable crops, it is assumed that the value is the same as that used for forage.

The rate of deposition by scavenging is a function of the precipitation rate since it is principally a mechanism of washout of particles from a plume by rain or snow. The scavenging coefficient is averaged over an entire year which includes all periods during which rain or snow does not fall. The treatment of scavenging can thus be described as a continuous removal of a fraction of the plume per second over the entire year. The scavenging coefficient thus has units of sec^{-1}. The rate of scavenging (R_s) in pCi/cm^2-sec is:

$$R_s = \chi_{ave} L$$

where:

= Scavenging coefficient, sec^{-1},
χ_{ave} = Average concentration of nuclide in a column of air to the lid height, pCi/cm^3, and
L = Height of the lid, cm.

The value for the total ground deposition rate used in assessing routine releases was the sum of the dry deposition and the scavenging rates. For accident release assessment, the scavenging rate due to precipitation was conservatively ignored, thus maximizing the plume concentration. The code maintains a mass balance along the plume to reduce the concentration of the plume by accounting for removal of the deposited fraction.

A.6 TERRESTRIAL MODELING

As previously described, the area surrounding the FMPC site was modeled as a 80-kilometer radius circular grid system with the site located at the center. For the circular grid, 15 distances were specified in each of the 16 compass directions, each distance representing the midpoint of a sector. The distances were specified as 250, 450, 675, 750, 1,500, 2,500, 3,500, 4,500, 7,500, 15,000, 25,000, 35,000, 45,000, 55,000, and 70,000 meters from the center of the site. Within each sector formed by the grid system, FMPC data used for population, agricultural and water area, and beef and dairy cattle were overlayed in arrays. These data are summarized in Table A-7.

Other factors used in modeling terrestrial and food crop transport are essentially those recommended by the U.S. Nuclear Regulatory Commission (NRC) (NRC, 1977), with a few modifications as indicated on Tables A-8 and A-9 to update data. The period of time allowed for long-term buildup of radioactivity on surface soils was 25 years, the anticipated duration of the operational lifetime of the proposed D&D facility. The depth of the plow layer was assumed to be 15 cm with an areal density of 215 kg/m^2 (Baes et al., 1979). The fallout interception fraction was set at 0.57 to be consistent with a deposition velocity of 0.18 cm/sec. The fallout interception fraction for food crops is the NRC recommended value of 0.20. The weathering removal rate constant used was 2.1×10^{-3} hr^{-1} and it was assumed that pasture grass was exposed for 720 hours during the growing season while crops were exposed for 1,440 hours. Agricultural productivity for the grass-cow-milk pathway was set at 0.28kg/m^2 and for produce and leafy vegetables 0.716 kg/m^2. Foraging animals were assumed to be on pasture during the 25-year duration of operations and received an additional food supply fraction of 0.47. Forage was assumed to be consumed at a rate of 15.6 kg/day dry weight (Baes et al., 1984).

The muscle mass of the steers at slaughter was 200 kg with milk production set at 11 liters/day. The fraction of the beef herd slaughtered each day is 2.7×10^{-3}, which allows for slaughter of the entire herd during each year of operation. Bioaccumulation factors were taken from Baes et al. (1984). All of the leafy vegetables and other produce were assumed to be grown in the assessment area.

A.7 DOSE MODELING

Using the ground-level concentrations in air and ground deposition rates computed from the meteorological input, the code estimates intake rates at specified environmental locations and calculates the resultant doses through various modes of exposure. For the purpose of assessing the total dose to the population, the air concentrations and ground deposition rates are average values in the cross wind direction over each sector. The average individual dose is then determined by dividing the population dose by the number of individuals in the exposed population. The dose to a maximum individual is determined directly by the code and assumes that the individual is located on the center line of the discharge plume at the point of highest off-site, ground-level concentration. Human inhalation rates, ingestion rates, and other factors utilized in modeling the dose receptors are summarized in Table A-10.

The modes of exposure considered in the dose include the following pathways: (1) immersion in air, (2) exposure to contaminated ground surfaces, (3) inhalation of contaminated air, (4) immersion in water such as by swimming in a river or lake, and (5) ingestion of contaminated water and food grown on contaminated land. The total dose to each of the following organs was calculated: total body, lungs, red bone marrow, lower large intestine wall, stomach wall, kidneys, liver, endosteal cells, thyroid, testes and ovaries. The doses calculated were 50-year dose commitments resulting from a one-year exposure for routine releases or one-time exposure for accident releases. (Only the most highly exposed organs are included in the results reported in the text.)

The internal dose conversion factors used in the calculation are those reported in Dunning (no date). The inhalation factors are based on the ICRP Task Group Lung Model, which simulates the behavior of particulate matter in the respiratory tract. The inhalation factors used correspond to a median aerodynamic diameter of 0.3 microns. The ingestion factors are based on a four-segment catenary model with exponential transfer of radioactivity from one segment to the next. Retention of nuclides in other organs is represented by linear combinations of decaying exponential functions. In both the inhalation and ingestion models, cross-irradiation (irradiation of one organ by nuclides contained in another) is included.

The Dunning dose factors are based on the same ICRP and NCRP models endorsed by DOE (Vaughan, 1985). DOE draft dose conversion factors are calculated for particles with an activity median aerodynamic diameter (AMAD) of 1 μm. Using DOE recommended methods, Dunning has calculated dose factors for 0.3 μm AMAD particles, but uses the same organ uptake fractions for daughter isotopes as for the parent. Comparison of the Dunning dose factors with those recommended by DOE indicates that Dunning's approach is slightly more conservative. Both Dunning and DOE recommended dose factors are included in Table A-11. External dose rate conversion factors developed by Kocher (1981), were used, as recommended by DOE.

Radionuclide-specific input parameters are summarized in Table A-11. The contaminants released were assumed to be in soluble and insoluble oxide forms for uranium and soluble thorium and plutonium as described in Table A-12. A quality factor of 20 was used in the calculation in accordance with the recommendation of ICRP Publication 26 (ICRP, 1977).

TABLE A-1
METEOROLOGICAL DATA - ASSESSMENT OF ROUTINE RELEASES

PARAMETER	VALUE (UNITS)	BASIS
Lid Height	700 (m)	ORNL, 1987
Average Temperature	293.3 (°K)	ORNL, 1987
Average Rainfall	102 (cm/yr)	ORNL, 1987
Frequency of Atmospheric Stability Class for Each Direction	Table A-2	ORNL, 1987
Frequencies of Wind Directions and True-Average Wind Speeds	Table A-4	ORNL, 1987
Frequencies of Wind Directions and Reciprocal - Averaged Wind Speeds	Table A-3	ORNL, 1987
Pasquill Category Temperature Gradients		ORNL, 1987
E	0.0728 (°K/m)	
F	0.1090 (°K/m)	

TABLE A-2

FREQUENCY OF ATMOSPHERIC STABILITY CLASSES FOR EACH DIRECTION

SECTOR	FRACTION OF TIME IN EACH STABILITY CLASS						
	A	B	C	D	E	F	G
1	0.0031	0.0517	0.0843	0.2477	0.2550	0.3582	0.0000
2	0.0052	0.0610	0.0901	0.2517	0.2765	0.3155	0.0000
3	0.0094	0.0809	0.1100	0.2354	0.2725	0.2919	0.0000
4	0.0018	0.0637	0.1005	0.2070	0.2392	0.3877	0.0000
5	0.0044	0.0606	0.1005	0.1932	0.2805	0.3608	0.0000
6	0.0064	0.0615	0.1156	0.2071	0.2523	0.3570	0.0000
7	0.0084	0.0654	0.1052	0.2089	0.2923	0.3157	0.0000
8	0.0018	0.0688	0.1012	0.2244	0.2631	0.3407	0.0000
9	0.0079	0.0508	0.1035	0.2393	0.3134	0.2851	0.0000
10	0.0106	0.0814	0.0787	0.3293	0.3183	0.1817	0.0000
11	0.0067	0.0607	0.0909	0.2823	0.3497	0.2096	0.0000
12	0.0051	0.0483	0.0765	0.3576	0.3406	0.1720	0.0000
13	0.0087	0.0576	0.0935	0.3757	0.3118	0.1466	0.0000
14	0.0031	0.0691	0.1201	0.3468	0.2358	0.2250	0.0000
15	0.0051	0.0476	0.1150	0.3252	0.2256	0.2815	0.0000
16	0.0048	0.0331	0.0918	0.2619	0.2320	0.3765	0.0000

TABLE A-3

FREQUENCIES OF WIND DIRECTIONS AND RECIPROCAL-AVERAGED WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)					
		A	B	C	D	E	F
1	0.120	1.28	2.26	2.62	3.69	3.60	1.58
2	0.040	1.39	1.64	2.41	3.43	3.54	1.56
3	0.050	2.32	1.78	2.83	3.40	3.71	1.65
4	0.040	2.57	1.80	2.99	3.40	3.06	1.58
5	0.060	2.37	1.88	2.86	3.58	3.43	1.71
6	0.040	2.37	2.22	2.73	3.38	3.42	1.86
7	0.040	2.28	1.76	2.54	3.66	3.72	1.80
8	0.040	2.57	1.73	3.13	3.90	3.61	1.69
9	0.050	1.38	2.05	2.64	4.21	3.96	2.21
10	0.030	2.37	1.82	3.42	4.48	4.25	2.29
11	0.040	1.17	1.93	3.51	4.59	4.53	2.30
12	0.060	1.56	1.98	3.02	4.73	4.26	2.32
13	0.090	1.49	1.83	3.02	4.63	3.87	1.93
14	0.070	0.99	1.95	3.61	4.75	3.79	1.65
15	0.100	1.81	2.26	2.68	4.62	3.71	1.50
16	0.120	1.53	1.86	2.69	5.04	3.77	1.58

WIND DIRECTIONS ARE NUMBERED COUNTERCLOCKWISE STARTING AT 1 FOR DUE NORTH

TABLE A-4

FREQUENCIES OF WIND DIRECTIONS AND TRUE-AVERAGE WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)					
		A	B	C	D	E	F
1	0.120	1.79	3.00	3.61	4.81	4.68	2.29
2	0.040	1.92	2.45	3.11	4.22	4.18	2.19
3	0.050	2.49	2.47	3.54	4.18	4.46	2.30
4	0.040	2.57	2.70	3.65	4.27	4.09	2.19
5	0.060	2.51	2.61	3.66	4.23	4.32	2.43
6	0.040	2.51	3.05	3.69	4.33	4.44	2.61
7	0.040	2.47	2.55	3.24	4.43	4.56	2.50
8	0.040	2.57	2.55	3.95	4.78	4.63	2.44
9	0.050	1.90	2.81	3.60	4.81	4.92	2.91
10	0.030	2.51	2.77	4.18	5.29	5.18	3.00
11	0.040	1.64	2.78	4.13	5.43	5.28	3.01
12	0.060	2.08	2.68	3.85	5.85	5.51	3.02
13	0.090	2.01	2.76	3.99	5.85	5.41	2.75
14	0.070	1.34	2.93	4.39	5.75	5.14	2.44
15	0.100	2.25	3.15	3.72	5.65	5.28	2.24
16	0.120	2.04	2.86	3.77	5.91	5.01	2.31

WIND DIRECTIONS ARE NUMBERED COUNTERCLOCKWISE STARTING AT 1 FOR DUE NORTH

TABLE A-5
METEOROLOGICAL DATA - ASSESSMENT OF ACCIDENT RELEASES

PARAMETER	VALUE (UNITS)	BASIS
Lid Height	700 (m)	Baes et al., 1984
Temperature	293.2 (°K)	ORNL, 1987
Rainfall	0.01 (cm/y)	Smallest non-zero value accepted by code
Frequency of Stability Class for Each Direction	100%, Class F, any single sector	Yields maximum off-site dose
Frequency of Wind Direction for True Averaged Wind Speed	100%, 2 (m/sec)	Yields maximum off-site dose
Frequency of Wind Direction for Reciprocal Averaged Wind Speed	100%, 2 (m/sec)	Yields maximum off-site dose
Pasquill Category Temperature Gradients		ORNL, 1987
E	0.0728 (°K/m)	
F	0.1090 (°K/m)	

TABLE A-6
STACK INFORMATION

PARAMETER	RELEASE DURING ROUTINE OPERATIONS	ACCIDENT RELEASES
Stack Height	16.2 (m)	16.2 (m)
Stack Diameter	0.914 (m)	0.914 (m)
Source Diameter	--	--
Effective Velocity of Stack Gas	8.99 (m/sec)	8.99 (m/sec)
Heat Release	0	0

TABLE A-7
POPULATION INPUT FOR FERNALD 0 - 80,000 m[1]

DIRECTION	DISTANCE TO MIDPOINT OF SECTOR (m)														
	250	450	675	750	1,500	2,500	3,500	4,500	7,500	15,000	25,000	35,000	45,000	55,000	70,000
N	0	0	1	0	13	102	51	51	0	2,830	17,015	4,142	5,351	4,916	16,336
NNW	0	0	0	0	13	29	43	43	0	1,626	2,436	4,103	3,294	17,174	51,716
NW	0	0	0	0	0	22	147	147	1,880	128	749	1,158	712	23,040	11,815
WNW	0	0	0	0	3	10	9	10	0	1,393	2,756	2,374	3,233	1,616	13,471
W	0	0	0	0	0	10	8	8	0	0	1,270	2,767	6,756	2,348	18,109
WSW	0	0	0	0	3	6	19	19	2,194	6,590	2,316	4,625	3,217	5,807	6,061
SW	0	0	0	0	6	48	27	27	0	1,676	6,413	6,014	2,608	1,442	4,019
SSW	0	0	0	0	16	42	67	67	0	8,163	4,573	4,357	3,401	3,645	7,795
S	0	0	0	0	10	38	91	0	48	10,679	12,064	12,658	5,317	1,159	10,176
SSE	0	0	0	0	0	13	179	179	0	63,585	139,295	76,739	10,793	6,032	7,745
SE	0	0	0	0	6	493	88	88	2,113	78,021	309,164	88,939	23,775	9,115	11,851
ESE	0	0	0	0	6	3	59	59	6,684	64,586	142,725	66,021	27,658	10,275	14,907
E	0	0	0	0	0	19	13	13	0	30,554	25,058	20,795	10,523	8,633	8,845
ENE	0	0	0	0	3	134	1,112	1,112	43	25,968	10,244	11,556	21,606	8,339	32,900
NE	0	0	0	0	6	323	29	29	805	62,936	11,543	58,810	34,968	62,144	519,911
NNE	0	0	0	0	3	10	45	45	758	6,777	3,944	3,253	6,520	12,140	70,312

[1] Dames and Moore, 1981.
[2] ORNL, 1987.

Beef cattle for each sector: 10,000[2]
Dairy cattle for each sector: 10,000[2]
Cultivated agricultural land for each sector: 1×10^{20} m^2[2]

TABLE A-8
TERRESTRIAL MODELING ASSUMPTIONS

PARAMETER	VALUE (UNITS)	BASIS
Buildup Time for Surface Deposition	25 (years)	Facility Life/ Conservatism
Fraction of Locally Grown Produce	1.0	Conservatism
Fraction of Radioactivity Retained on Leafy Vegetables After Washing	0.5	NRC, 1977
Time Delay for Ingestion:		
Pasture Grass by Animals	0 (hrs)	Conservatism
Stored Feed by Animals	2160 (hrs)	
Leafy Vegetables by Man	24 (hrs)	
Produce by Man	24 (hrs)	
Removal Rate Constant for Physical Loss by Weathering	2.1×10^{-3} (/hr)	NRC, 1977
Period of Exposure During Growing Season:		NRC, 1977
Pasture Grass	720 (hrs)	
Crops and Leafy Vegetables	1440 (hrs)	
Agricultural Productivity per Unit Area:		Baes et al., 1979
Grass-Cow-Milk Pathway	0.28 (kg/m^2)	
Produce and Leafy Vegetable	0.716 (kg/m^2)	
Effective Surface Density of Soil	215 (kg/m^2)	Baes et al., 1979
Fraction of Yearly Feed from Pasture	.4	NRC, 1977
Daily Feed from Pasture	.43	NRC, 1977
Consumption Rate of Contaminated Feed or Forage by Animals	15.6 (kg/day)	Baes et al., 1979
Transport Time from Animal Feed-Milk-Man	2.0 (days)	NRC, 1977
Average Time from Slaughter of Meat to Consumption	20.0 (days)	NRC, 1977
Fraction of Meat Producing Herd Slaughtered Each Day	2.7×10^{-3}	ORNL, 1987
Muscle Mass of Meat Producing Animal	200 (kg)	ORNL, 1987
Milk Production of Cow	11 (l/day)	ORNL, 1987
Fallout Interception Fraction:		
Pasture	0.57	Miller, 1979
Vegetables	0.20	Chamberlain, 1970
Fraction of Food Grown in Local Gardens:		Conservatism
Produce	1.00	
Leafy Vegetables	1.00	NRC, 1977

TABLE A-9
BIOACCUMULATION FACTORS

ELEMENT	UPTAKE FRACTIONS		CONCENTRATION FACTORS	
	MILK (DAYS/LITER)	MEAT (DAYS/KG)	PASTURE	CROPS
Uranium	$6.0x10^{-4}$	$2.0x10^{-4}$	$8.5x10^{-3}$	$1.6x10^{-3}$
Thorium	$5.0x10^{-6}$	$6.0x10^{-6}$	$8.5x10^{-4}$	$3.3x10^{-5}$
Plutonium	$1.0x10^{-7}$	$5.0x10^{-7}$	$4.5x10^{-4}$	$1.8x10^{-5}$

From Baes et al., 1984.

TABLE A-10
DOSE RECEPTOR ASSUMPTIONS

PARAMETER	VALUE (UNITS)	BASIS
Breathing Rate of Man	9.17×10^5 (cm^3/hr)	NRC, 1977
Depth of Water for Immersion Dose	244 (cm)	Conservatism
Fraction of Time Spent Swimming	0.01	Conservatism
Rate of Human Ingestion:		NRC, 1977
Average Individual:		
Produce	190 (kg/yr)	
Milk	110 (l/yr)	
Meat	95 (kg/yr)	
Leafy Vegetables	18 (kg/yr)	ORNL, 1987
Maximum Individual		
Produce	520 (kg/yr)	
Milk	310 (l/yr)	
Meat	110 (kg/yr)	
Leafy Vegetables	64 (kg/yr)	

TABLE A-11
RADIONUCLIDE SPECIFIC PARAMETERS
SOLUBLE URANIUM-234

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[2] IMMERSION IN AIR $(Rem\text{-}cm^3/)Ci\text{-}hr)$	IMMERSION IN WATER $(Rem\text{-}cm^3/)Ci\text{-}hr)$	SURFACE $(Rem\text{-}cm^2/)Ci\text{-}hr)$
U_{234}	D	7.763E-9	7.75E-2	1.97E-4	1.84E-4

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation[1] Dose $rems/Ci^{-1}$	3.1E0	2.0	2.9E0	1.1E-1	1.8E1	1.0E-1	4.5E1	1.0E-1	1.0E-1	1.0E-1	1.0E-2
Ingestion[1] Dose $rems/Ci^{-1}$	1.0E0	3.7E-2	1.0E0	1.8E-1	6.6E0	3.7E-2	1.6E1	3.7E-2	3.7E-2	3.7E-2	4.1E-2
Photon Organ[2] Dose Fraction	0.0608	0.0369	0.0248	0.0286	0.0336	0.0310	0.0601	0.0545	0.0731	0.0272	0.0303
Inhalation[3]	2.7E0	1.2E0	2.6E0		1.7E1		4.1E1				
Ingestion[3]	2.6E-1	--	2.7E-1	1.8E-1	1.7E0		4.1E0				

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

TABLE A-11 (CONTINUED)
RADIONUCLIDE SPECIFIC PARAMETERS
SOLUBLE URANIUM-235

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[1] IMMERSION IN AIR $(Rem-cm^3/)Ci-hr)$	IMMERSION IN WATER $(Rem-cm^3/)Ci-hr)$	SURFACE $(Rem-cm^2/)Ci-hr)$
U_{235}	D	2.697E-12	7.82E1	1.75E-1	2.16E-2

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation[1] Dose rems/Ci^{-1}	2.9E0	1.8E0	2.8E0	1.1E-1	1.7E1	9.9E-2	4.4E1	9.9E-2	9.9E-2	9.9E-2	9.9E-2
Ingestion[1] Dose rems/Ci^{-1}	1.0E0	3.6E-2	1.0E0	1.9E-1	6.1E0	3.6E-2	1.6E1	3.6E-2	3.6E-2	3.6E-2	4.0E-2
Photon Organ[2] Dose Fraction	0.5409	0.5000	0.4795	0.4415	0.04678	0.4561	0.7222	0.6725	0.60901	0.3977	0.4503
Inhalation[3]	2.5E0	1.1E0	2.4E0	--	1.6E1		3.7E1				
Ingestion[3]	2.5E-1	--	2.5E-1	2.0E-1	1.6E0		3.7E0				

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

TABLE A-11 (CONTINUED)
RADIONUCLIDE SPECIFIC PARAMETERS
SOLUBLE URANIUM-238

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[1] IMMERSION IN AIR (Rem-cm³/)Ci-hr)	IMMERSION IN WATER (Rem-cm³/)Ci-hr)	SURFACE (Rem-cm²/)Ci-hr)
U_{238}	D	4.25E-13	5.20E-2	1.33E-4	1.26E-4

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation[1] Dose rems/Ci^{-1}	2.8E0	1.7E0	2.7E0	9.9E-2	1.6E1	9.3E-2	4.0E1	9.1E-2	9.1E-2	9.1E-2	9.1E-2
Ingestion[1] Dose rems/Ci^{-1}	9.4E-1	3.3E-2	9.8E-1	1.7E-1	5.9E0	3.4E-2	1.5E1	3.3E-2	3.3E-2	3.3E-2	3.6E-2
Photon Organ[2] Dose Fraction	0.0504	0.0275	0.0155	0.0202	0.0241	0.0227	0.0468	0.0415	0.0589	0.0198	0.0218
Inhalation[3]	2.4E0	1.0E0	2.4E0	--	1.5E1		3.6E1				
Ingestion[3]	2.3E-1	--	2.5E-1	--	1.5E0		3.7E0				

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

TABLE A-11 (CONTINUED)
RADIONUCLIDE SPECIFIC PARAMETERS
INSOLUBLE URANIUM-234

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[1] IMMERSION IN AIR $(Rem-cm^3/)Ci-hr)$	IMMERSION IN WATER $(Rem-cm^3/)Ci-hr)$	SURFACE $(Rem-cm^2/)Ci-hr)$
U_{234}	Y	7.76E-9	7.75E-2	1.97E-4	1.84E-4

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation[1] Dose rems/Ci^{-1}	2.3E+2	1.9E+3	4.2E-1	1.1E-1	2.70	1.5E-2	6.50	1.5E-2	1.5E-2	1.5E-2	1.7E-2
Ingestion[1] Dose rems/Ci^{-1}	2.6E-2	3.7E-3	1.0E-2	1.8E-1	6.6E-2	3.7E-4	1.6E-1	3.7E-4	3.7E-4	3.8E-4	4.5E-3
Photon Organ[2] Dose Fraction	0.0608	0.0369	0.0248	0.0286	0.0336	0.0310	0.0601	0.0545	0.0731	0.0272	0.0303
Inhalation[3]	1.3E2	1.1E3	--	--	--		--				
Ingestion[3]	2.5E-2	--	1.1E-2	1.8E-1	7.0E-2		1.7E-1				

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

TABLE A-11 (CONTINUED)
RADIONUCLIDE SPECIFIC PARAMETERS
INSOLUBLE URANIUM-235

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[1] IMMERSION IN AIR (Rem-cm^3/)Ci-hr)	IMMERSION IN WATER (Rem-cm^3/)Ci-hr)	SURFACE (Rem-cm^2/)Ci-hr)
U_{235}	Y	2.70E-12	7.82E+1	1.75E-1	2.16E-2

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation[1] Dose rems/Ci^{-1}	2.1E+2	1.8E+3	4.3E-1	1.2E-1	2.50	1.6E-2	6.30	2.5E-2	1.5E-2	1.6E-2	4.0E-2
Ingestion[1] Dose rems/Ci^{-1}	2.7E-2	3.7E-3	1.0E-2	2.0E-1	6.1E-2	4.2E-4	1.6E-1	3.6E-4	4.2E-4	1.2E-3	4.5E-3
Photon Organ[2] Dose Fraction	0.5409	0.5000	0.4795	0.4415	0.4678	0.4561	0.7222	0.6725	0.6901	0.3977	0.4503
Inhalation[3]	1.2E2	1.0E3	--	--	--		--				
Ingestion[3]	2.5E-2	--	1.0E-2	2.0E-1	6.3E-2		1.6E-1				

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

TABLE A-11 (CONTINUED)
RADIONUCLIDE SPECIFIC PARAMETERS
INSOLUBLE URANIUM-238

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[1]		
			IMMERSION IN AIR (Rem-cm^3/)Ci-hr)	IMMERSION IN WATER (Rem-cm^3/)Ci-hr)	SURFACE (Rem-cm^2/)Ci-hr)
U_{238}	Y	4.25E-13	5.2E-2	1.3E-4	1.3E-4

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation[1] Dose rems/Ci^{-1}	2.0E+2	1.7E+3	4.0E-1	1.3E-1	2.40	1.8E-2	5.90	1.6E-2	1.4E-2	1.4E-2	2.1E-2
Ingestion[1] Dose rems/Ci^{-1}	2.3E-2	3.3E-3	9.8E-3	1.7E-1	5.9E-2	3.4E-4	1.4E-1	3.3E-4	3.4E-4	3.9E-4	4.0E-3
Photon Organ[2] Dose Fraction	0.0504	0.0275	0.0155	0.0202	0.0241	0.0227	0.0468	0.0415	0.0589	0.0198	0.0218
Inhalation[3]	1.2E2	1.0E3	--	--	--		--				
Ingestion[3]	2.3E-2	--	1.0E-2	1.7E-1	6.3E-2		1.5E-1				

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

TABLE A-11 (CONTINUED)
RADIONUCLIDE SPECIFIC PARAMETERS
THORIUM-232

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[1] IMMERSION IN AIR (Rem-cm^3/)Ci-hr)	PHOTON DOSE RATE CONVERSION FACTORS[1] IMMERSION IN WATER (Rem-cm^3/)Ci-hr)	PHOTON DOSE RATE CONVERSION FACTORS[1] SURFACE (Rem-cm^2/)Ci-hr)
Th-232	Y	1.35E-13	9.42E-2	2.38E-4	2.15E-4

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation Dose[1] rems/Ci	1.9E+3	2.4E+3	6.0E+3	3.0E+4	3.8E+0	3.8E+0	3.8E+0	3.1E+1	3.9E+0	3.7E+0	3.7E+0
Ingestion Dose[1] rems/Ci	2.7E+0	5.5E+0	4.7E-3	6.8E+1	8.0E-3	4.6E-1	4.5E-3	3.8E+2	4.8E-3	4.6E-3	4.6E-3
Photon Organ Dose Fraction[2]	0.0906	0.0433	0.0657	0.1110	0.0551	0.0510	0.0984	0.0580	0.0620	0.1139	0.0490
Inhalation[3]	1.1E3	3.5E3	1.5E3				1.9E4				
Ingestion[3]	2.8E0	---	5.6E0				7.0E1				

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

TABLE A-11 (CONTINUED)
RADIONUCLIDE SPECIFIC PARAMETERS
INSOLUBLE PLUTONIUM-239

ISOTOPE	SOLUBILITY CLASS	DECAY CONSTANT (/DAY)	PHOTON DOSE RATE CONVERSION FACTORS[1] IMMERSION IN AIR $(Rem\text{-}cm^3/)Ci\text{-}hr)$	IMMERSION IN WATER $(Rem\text{-}cm^3/)Ci\text{-}hr)$	SURFACE $(Rem\text{-}cm^2/)Ci\text{-}hr)$
Pu_{239}	Y	7.86E-8	4.19E-2	1.06E-4	9.40E-5

CONVERSION FACTOR	EFFECTIVE[4]	LUNGS	RED MARROW	LLI WALL	KIDNEYS	LIVER	BONE SURFACE	THYROID	TESTES	OVARIES	STOMACH WALL
Inhalation[1] Dose rems/Ci^{-1}	5.7E+2	2.1E+3	4.6E+2	1.0E-1	2.3E-3	1.3E+3	5.7E+3	2.3E-3	7.2E+1	7.2E+1	4.6E-3
Ingestion[1] Dose rems/Ci^{-1}	5.9E-2	2.9E-7	6.1E-2	2.0E-1	3.3E-7	1.6E-1	7.6E-1	2.8E-7	9.7E-3	9.7E-3	4.4E-3
Photon Organ[2] Dose Fraction	0.0735	0.0490	0.0393	0.0435	0.0420	0.0413	0.0769	0.0683	0.0873	0.0370	0.0418
Inhalation[3]	3.3E2	1.2E3	2.8E2	--		8.1E2	3.5E3		--	--	
Ingestion[3]	5.8E-2	--	5.9E-2	2.0E-1		1.6E-1	7.8E-1		9.6E-3	9.6E-3	

(1) From Dunning, no date, particle size 0.3 microns, ingestion fraction 2.0E-1 (D) class.
(2) From Kocher, 1981.
(3) From Vaughan, 1985, particle size 1 micron, ingestion fraction 5.0E-2 (W) class.
(4) Effective committed dose equivalent.

MIS:6402-TA-11/1G

TABLE A-12

ROUTINE AND ACCIDENT RELEASE SOURCE TERMS

ISOTOPE	SOLUBILITY	ROUTINE RELEASE curies (becquerels)	VACUUM ACCIDENT RELEASE 2% ENRICHED curies (becquerels)	VACUUM ACCIDENT RELEASE 19.99% ENRICHED curies (becquerels)	HEPA FILTER FAILURE RELEASE 2% ENRICHED curies (becquerels)	HEPA FILTER FAILURE RELEASE 19.99% ENRICHED curies (becquerels)
U_{234}	D	8.47×10^{-6} (3.13×10^{5})	1.58×10^{-6} (5.85×10^{4})	1.66×10^{-6} (6.12×10^{4})	8.45×10^{-5} (3.13×10^{6})	8.85×10^{-4} (3.27×10^{7})
U_{235}	D	5.11×10^{-7} (1.89×10^{4})	7.51×10^{-8} (2.78×10^{3})	7.50×10^{-8} (2.78×10^{3})	3.99×10^{-6} (1.48×10^{5})	3.99×10^{-5} (1.48×10^{6})
U_{238}	D	2.32×10^{-5} (8.58×10^{5})	5.75×10^{-7} (2.13×10^{4})	4.63×10^{-8} (1.71×10^{3})	3.04×10^{-5} (1.12×10^{6})	2.48×10^{-5} (9.18×10^{5})
U_{234}	Y	7.62×10^{-5} (2.82×10^{6})	--		--	
U_{235}	Y	4.60×10^{-6} (1.70×10^{5})	--		--	
U_{238}	Y	2.09×10^{-4} (7.73×10^{6})	--		--	
Th_{232}	Y	8.54×10^{-6} (3.16×10^{5})	--		--	
Pu_{239}	Y	4.76×10^{-7} (1.76×10^{4})	--		--	

D = Solubility class for highly soluble uranium compounds as defined in ICRP 30 (ICRP, 1979).
Y = Solubility class for insoluble isotopes as defined in ICRP 30 (ICRP, 1979).