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DOE ENVIRONMENTAL ASSESSMENT OF THE PROPOSED LOW-LEVEL WASTE PROCESSING AND SHIPMENT SYSTEM

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Environmental Assessment of the
Proposed Low-Level Waste
Processing and Shipment System

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Environmental Assessment

of the

Proposed Low-Level Waste Processing and Shipment System

Feed Materials Production Center

Fernald, Ohio

May 1985

U.S. Department of Energy
Washington, D.C.

SUMMARY

A Low-Level Waste Processing and Shipping System (LLWPSS) has been proposed for the Feed Materials Processing Center (FMPC), operated by NLO, Inc., for the Department of Energy and located at Fernald, Ohio. The waste management system will consist of new facilities and procedures for processing all low-level wastes currently generated at the FMPC into a dry, stable, environmentally safe form for packaging in Department of Transportation approved drums. The wastes will be shipped by truck for disposal at the Nevada Test Site. In the three-year period prior to completion of the new facilities, as much waste as possible will be processed into a dry compacted form with existing equipment, drummed, and also shipped to the Nevada Test Site by truck.

This environmental assessment considers the potential impacts associated with the proposal as well as the reasonable alternatives. The alternatives comprise continuation with the current mode of operation (i.e., no action), on-site storage of processed waste, rail transportation as an alternative to truck transportation, shipment of wastes to federal repositories other than the designated site (the Nevada Test Site), and waste form modification (fixation of waste into a cement-like grout).

The principal environmental benefit that will result from the proposed action is the cessation of increasing the inventory of low-level wastes currently stored on-site in pits and concomitant avoidance of increased potential contamination of the regional aquifer. The need for and possible implementation of remedial actions for wastes currently stored in the pits are not addressed in this assessment, but will be the subject of subsequent environmental reviews.

The relatively small construction effort associated with the proposed action (60 to 70 personnel over a 15-month period) will result in minimal impact to the environment. Radiation doses to the public from operating the waste management system, during and after the interim three-year period, will result in an increase in sitewide uranium emissions to the atmosphere of approximately 1%. The incremental radiation dose commitments due to these emissions will be less than 1% of the EPA limit of 25 millirem/year (40 CFR Part 61). For 320 truck shipments per year of waste (approximately

3,965 m^3), the total radiation dose to drivers will be less than 11.5 person-rem/year. Assuming a random selection of truck crews, resulting in one trip per month for each crew, each driver will be subjected to an annual radiation dose of about 216 millirem. The total annual population dose along the transportation route will be about 168 person-rem, which is a small fraction of the collective dose received by these people from natural background radiation sources. For a highly unlikely transportation accident involving the rupture of drums containing the radioactive waste, it is conservatively estimated that the maximally exposed individual can receive a lung dose of about 180 millirem which is less than two years of natural radiation exposure. Thus, the potential environmental impacts of the proposed action are judged not to be significant and much more favorable than that of the no-action alternative.

None of the alternatives considered offer overriding environmental advantages. Rail shipment would reduce the already low total dose commitment from transportation because the cross-country rail shipment route would traverse less populated areas. A low-level waste disposal site at Los Alamos National Laboratory would reduce the transportation distance and thus lower the already low radiation dose commitments by about 30%, if the FMPC waste could be accommodated. Utilization of the identified alternative waste form of cementitious grout would not alter the impact of normal operation of the proposed LLWPSS, but would reduce the potential impacts of transportation accidents. The alternative waste form would also be more costly. However, because the proposed action does not result in unacceptable environmental impacts or violation of existing (or proposed) regulations, use of these alternatives does not appear to be warranted.

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1. PURPOSE OF AND NEED FOR THE PROPOSED ACTION

1.1 PURPOSE

It is the purpose of the proposed action to treat, package, and ship low-level radioactive waste generated at the Department of Energy (DOE) Feed Materials Production Center (FMPC), shown in Fig. 1.1, to the Nevada Test Site. The FMPC is operated by NLO, Inc. of Fernald, Ohio. The Low-Level Waste Processing and Shipment System (LLWPSS) will* provide for processing and shipping wastes contaminated with low levels of radioactivity resulting from the production of uranium metal (Fig. 1.2) using various depleted, normal, or slightly enriched feed materials.[1] Management of important uranium resources already includes intensive recovery of normal and enriched uranium resulting in the final waste streams principally containing depleted uranium contamination.[2] To achieve its purpose, the proposed LLWPSS will include the structures, facilities, and equipment necessary for the conversion (with optimized volume reduction) of liquid, slurry, and solid wastes generated throughout the FMPC into a dry, stable, environmentally safe product suitable for handling, packaging, and transporting. Waste packaged and shipped to the Nevada Test Site will not contain hazardous waste materials as identified in 40 CFR Part 261. This system will replace the existing waste disposal (or storage) methods that utilize on-site, in-ground wet and dry chemical waste pits and storage silos.[3] Until the LLWPSS is fully operational, the FMPC proposes to ship as much of the waste as possible to the Nevada Test Site after using currently available volume reduction and drying equipment, thus also significantly reducing on-site waste disposal requirements during the interim.

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*The future tense is used throughout this assessment rather than the conditional, with the recognition that the proposed action will only occur if the Department of Energy takes action to proceed.

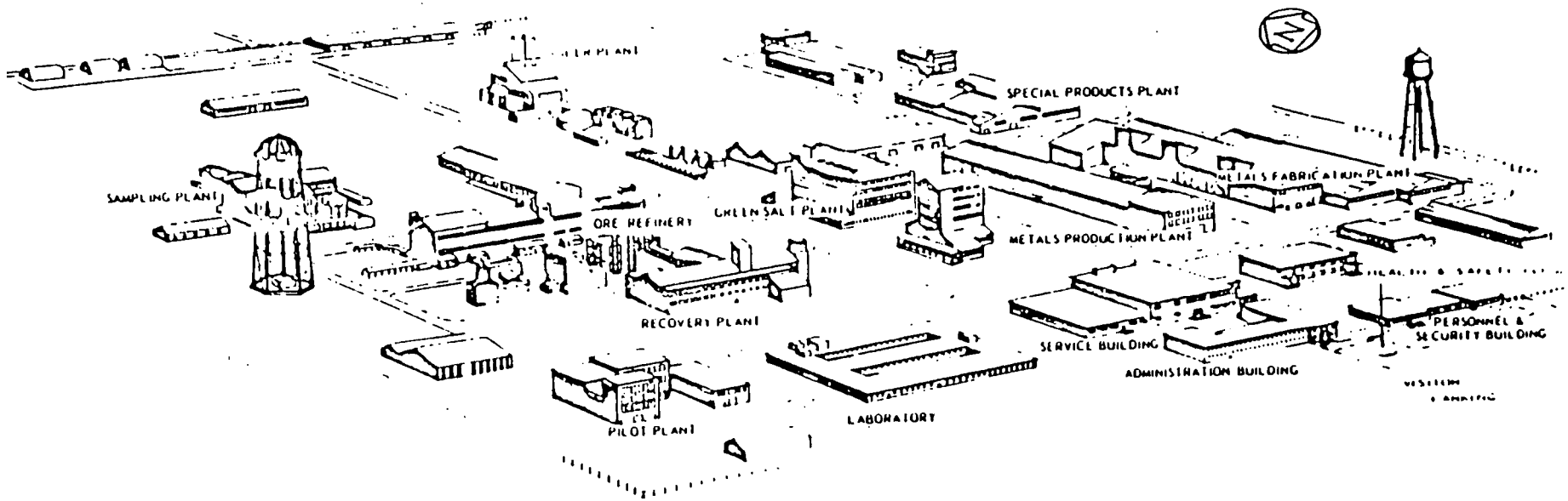

Figure 1.1 Principal facilities of the Feed Materials Production Center. Source: "Uranium Feed Materials Production Center," NLO, Inc., (public relations booklet), December 1982.

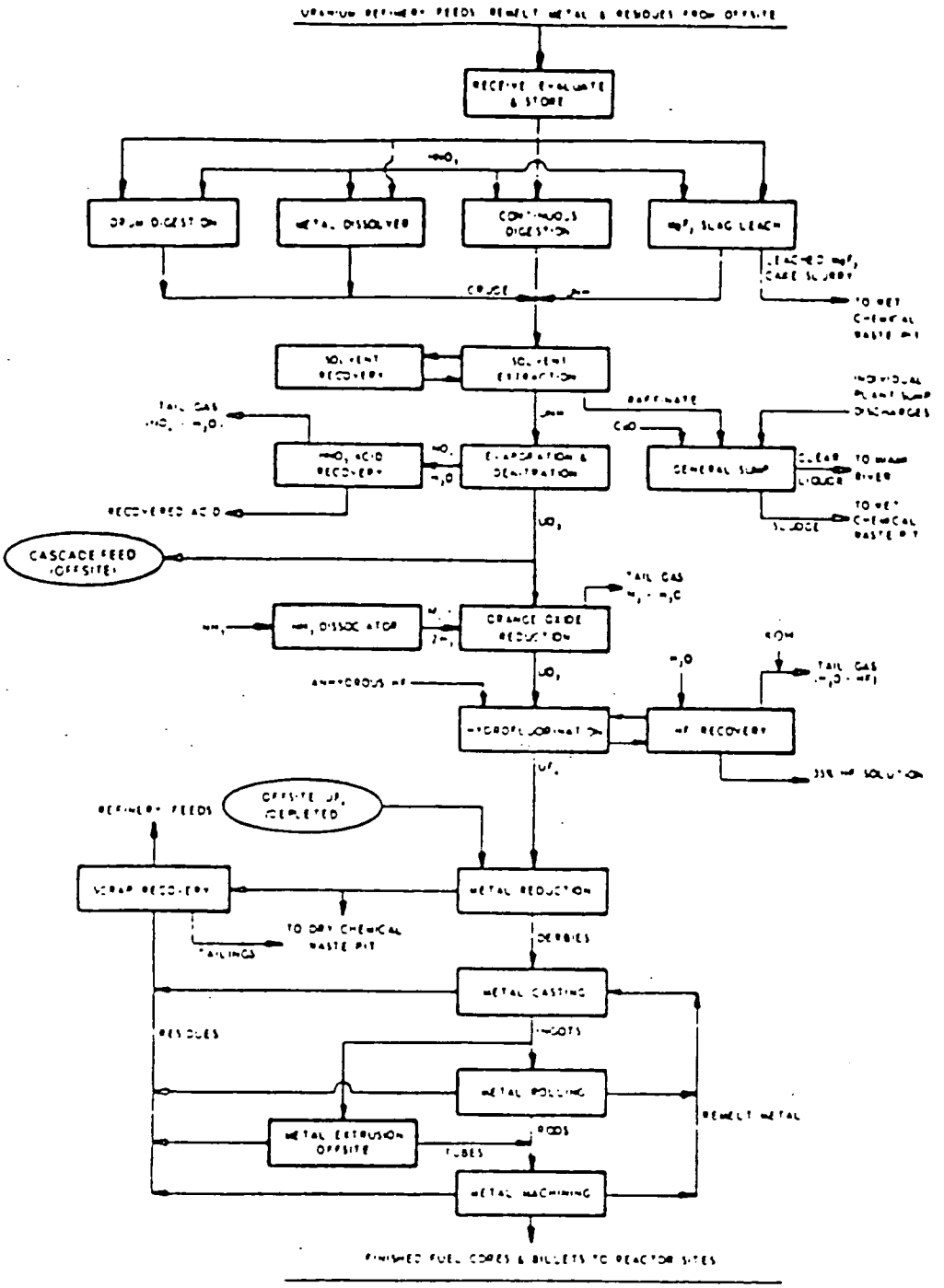

Figure 1.2 Schematic diagram of the several processes available for operation at the Feed Materials Production Center. Source: "Environmental Report of the Feed Materials Production Center," prepared by the BATTELLE Columbus Laboratories for NLO, Inc., January 1981.

1.2 NEED

The FMPC has been operating since 1952 and will continue operation for the foreseeable future. The facility (Fig. 1.1) consists of eight chemical and metallurgical plants with supporting facilities for smelting, refining, and converting uranium ore concentrates and recycle materials to metallic uranium in various shapes and forms for use in DOE defense programs. Operation of the FMPC results in the generation of a large volume of low-level radioactive wastes in the form of liquids, slurries (80-95% water), sludges, and dry solids that have been placed in either wet chemical or dry chemical waste pits and in concrete storage silos. The locations of the waste pits and silos (metal oxide tanks and K-65 tanks) in relation to the main production area are shown in Fig. 1.3. As indicated in a 1981 environmental report for the FMPC,[4] waste pits 1, 2, and 3 have been filled. Waste pit 5 has since reached full capacity, pit 4 is expected to be filled before October 1985, and only waste pit 6 will be available for continued storage of dry waste. The two K-65 tanks contain tailings with the equilibrium concentration of ^{226}Ra from processing pitchblende ore until 1959. One metal oxide tank contains similar tailings, with only a trace of radium, from processing U_3O_8 concentrates for DOE operations.[3] Thus, it is timely to consider the proposed action pursuant to federal regulatory policy to locate currently generated radioactive wastes at a few well-designed and well-controlled disposal sites.

1.3 SCOPE OF THE ENVIRONMENTAL REVIEW

This Environmental Assessment (EA) is prepared pursuant to Sect. 102 of the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190), as implemented by regulations promulgated by the President's Council on Environmental Quality (CEQ) (40 CFR Parts 1500-1508, November 1978) and DOE Guidelines. It is intended to provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement or a finding of no significant impact for the proposed DOE action to implement a new waste management system at the FMPC. The following are examined:

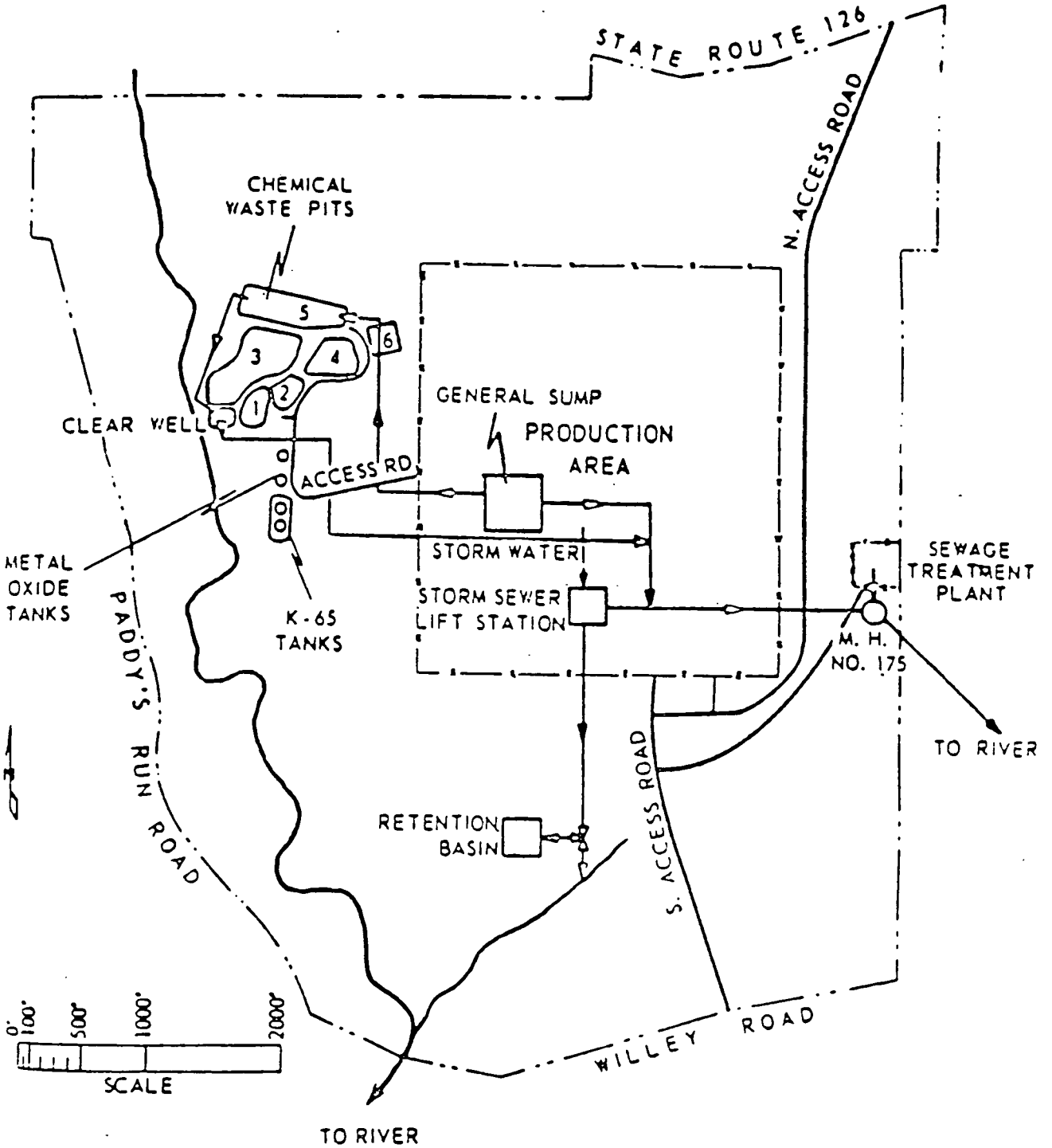

Figure 1.3 Line diagram of liquid and solid waste flow and location of waste storage pits and tanks. Source: "Environmental Report of the Feed Materials Production Center," prepared by the BATTELLE Columbus Laboratories for NLO, Inc., January 1981.

(1) changes that the action may cause within the area affected by ongoing FMPC operations or impacts that may result from transportation of the processed waste to the Nevada Test Site and

(2) alternatives including:

(a) no action,

(b) long-term storage of the processed wastes at FMPC,

(c) disposal of processed wastes at off-site locations other than the Nevada Test Site,

(d) alternative rail transportation of wastes, and

(e) alternative waste forms.

The scope of the assessment does not include evaluation of the existing production operations of the FMPC (which were examined in an environmental report[4] issued in 1981) nor of any possible subsequent action to modify existing production facilities at the FMPC. Specifically, the need for and possible implementation of remedial actions for wastes currently stored in the pits and silos are not addressed in this assessment but will be the subject of subsequent environmental reviews. This assessment also does not examine the environmental impacts of operation of the Radioactive Waste Management Site (RWMS) at the Nevada Test Site. The impacts of RWMS operation were examined in a Final Environmental Impact Statement for the Nevada Test Site.[6] Because the Nevada Test Site currently does not accept radioactive waste mixed with hazardous waste materials as identified in 40 CFR Part 261, no such waste will be included in the shipped materials.

2. ALTERNATIVES INCLUDING THE PROPOSED ACTION

The production processes at the FMPC generate relatively large quantities of solid and liquid low-level radioactive wastes. Due to the limited amount of storage space on-site, a new system is being developed for handling the currently generated low-level waste. The DOE has proposed to process the low-level waste using new treatment facilities at the FMPC and ship the processed wastes by truck to a federally owned repository at the Nevada Test Site. This chapter includes a detailed description of the proposed action, a brief discussion of the alternatives identified in Sect. 1.3, and compares the impacts of the proposed action and alternatives. The environmental impacts of the proposed action and alternatives are addressed in Chap. 4.

2.1 THE PROPOSED ACTION

The proposed action is the adoption of a Low-Level Waste Processing and Shipment System (LLWPSS) for management of the low-level radioactive wastes currently generated by routine operations of the FMPC. This action includes the following: (1) construction and operation of facilities for most practical treatment of the wastes to obtain a dry waste form, preferably the least volume, suitable for packaging and off-site transport; (2) implementation of long-term arrangements for commercial truck transportation of the dry wastes to the Nevada Test Site; and (3) burial of the solid waste drums at the Nevada Test Site. Because the construction effort will take about 3 years to complete, wastes generated during the interim period will be processed with currently available equipment and shipped to the Nevada Test Site. The interim operations will start as soon as possible and cease when the full facility is operational. The major difference between the interim phase and the fully operational phase is that the former will not include significant volume reduction of the wastes.

2.1.1 Description and Operation of New On-Site Facilities

The proposed LLWPSS, as described in the conceptual design report,[7] is composed of two parts. A low-level waste processing facility will include the structures and equipment for processing the liquid slurries, sludges, and solid wastes generated throughout the FMPC into a dry, stable product suitable for easy handling and packaging. A low-level waste shipping facility will include the structures and equipment for packaging the dry waste product in containers suitable for off-site shipment and storage. The FMPC management plan incorporating the features of the LLWPSS is shown in the logic diagram[3] of Fig. 2.1. The concept for the LLWPSS may change somewhat as waste treatment design and development is completed during the next year. However, as currently defined, the new facilities will be located within and as an extension of the existing Recovery Plant Building (see Fig. 1.1). Construction of the on-site facilities of the LLWPSS will begin in April 1987 and extend through June 1988. After three months of start up and acceptance testing, the new facilities described below will become operational in October 1988.

2.1.1.1 System Facilities

Filtration

Two diked holding tanks [190-m^3 (50,000-gal) total] will be used to hold waste slurries and sludges (up to 95% water content). Solids will be separated from these wet wastes by means of either a plate and frame filter press or a rotary vacuum filter. The filter cakes (50% water content) will be transferred to a rotary kiln for drying. Filtrate from the two filters will pass through a horizontal leaf polishing filter, stored for sampling, and then discharged if acceptable under applicable water quality standards through the existing wastewater discharge system to the Great Miami River. The vacuum pump exhaust will pass through a knock-out pot and high-efficiency particulate air (HEPA) filter prior to discharge to the atmosphere.

The principal waste streams to be handled in the filtration facility include neutralized refinery raffinates from the General Sump and sludges from

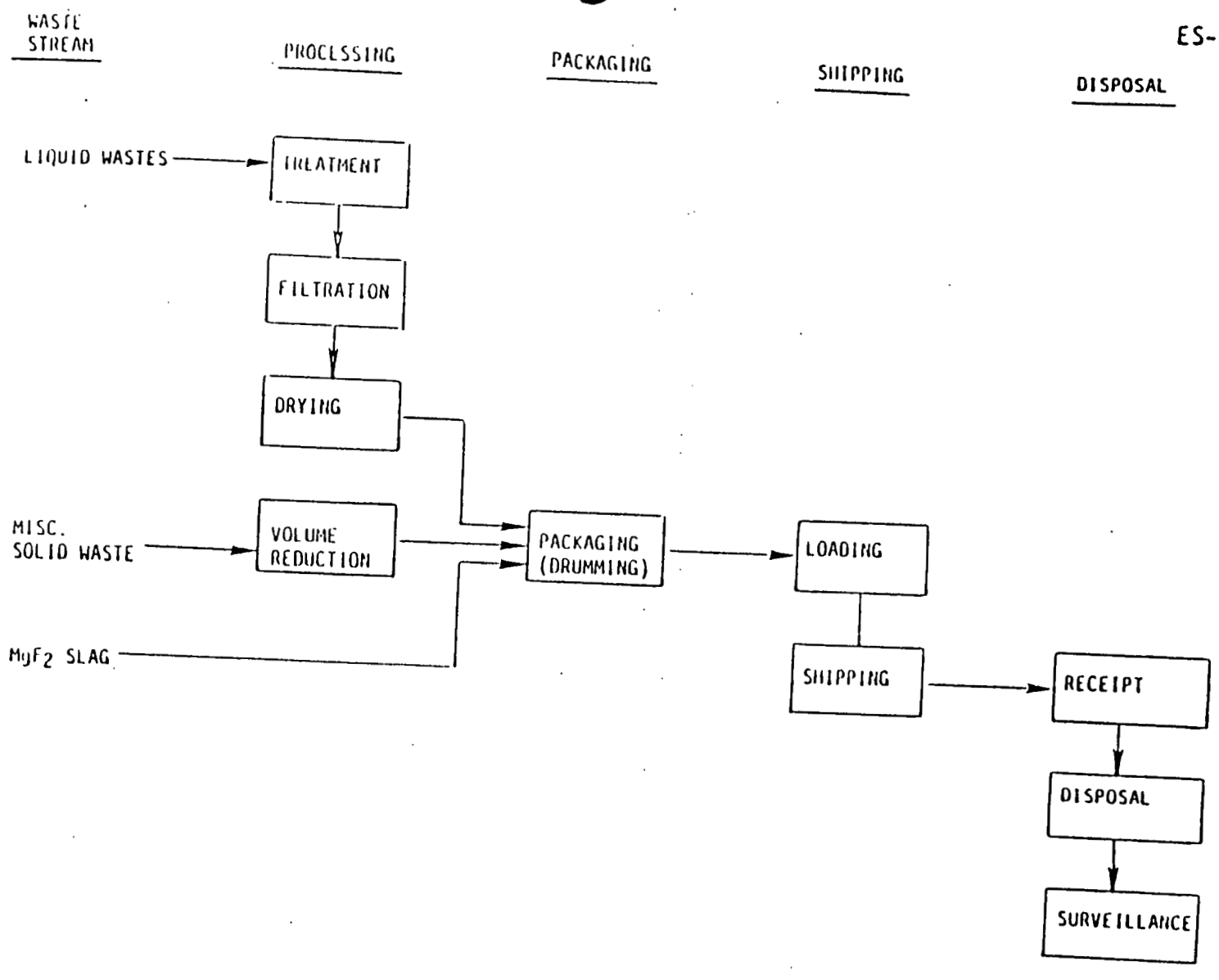

Figure 2.1 Low-Level Waste Management Program logic diagram for the Feed Materials Production Center. Source: "Draft Program Management Plan for FMPC Radioactive Waste Packaging/Shipping" provided as an enclosure in a letter from R. M. Spenceley, NLO, Inc., to Doyle R. Brown, Department of Energy, Oak Ridge Operations, Oct. 16, 1984.

the General Sump area. The neutralized raffinate will be processed through the filtration unit in 190-m^3 (50,000-gal) batches. Sixteen batches are expected to be processed each year during a 12-week period. The General Sump sludges will be processed as weekly 19-m^3 (5,000-gal) batches throughout the year. The wet solids recovered from these waste streams will consist of the oxides of calcium, aluminum, iron, and silicon. The uranium content of these filter cakes will be low, with refinery raffinate solids averaging about 0.05% of normal and enriched uranium.[2]

Rotary Kiln

Filter cakes from the filtration unit or from other in-plant process filters that require drying at temperatures up to 204°C (400°F) and coarse materials, such as uranium machining chips and turnings that require oxidation at approximately 650°C (1,200°F), will be processed through the rotary kiln. The exhaust from the kiln will pass through a quench chamber, baghouse, wet scrubber and HEPA filter prior to discharge to the atmosphere. The dry (calcined) powder product will be pneumatically transferred to a collection hopper.

Oversized particles that may not be thoroughly oxidized will be transferred to the Solids Handling Area for mechanical size reduction and recycled to the rotary kiln.

Oxidation Furnace

The purpose of the oxidation furnace is to provide combustion or oxidation of waste streams not suitable for the rotary kiln. The principal wastes include coarse pieces of uranium and magnesium and filter cartridges from process filters. Approximately 1,450 kg (3,200 lb) per month of uranium-bearing waste will be processed. Objects not completely oxidized in one pass through the furnace can be transferred to the Solids Handling Area for size reduction before recycling through the furnace. The dry (calcined) powder product will be conveyed to the collection hopper.

The furnace exhaust gases will pass through a quench chamber, baghouse, scrubber and HEPA filter prior to discharge to the atmosphere. Enclosed

equipment areas, such as the drum dumping station at the furnace input and vibrating screen at the furnace discharge, will be exhausted to the baghouse. All fugitive emission points where materials handling is open to the environment are hooded and exhausted to the collection system hopper, as is the fly ash from the baghouse.

Solids Handling Area

Dry solids (noncombustible) will be classified, separated, shredded, and crushed in the Solids Handling Area. Tramp metal, including unoxidized uranium, and other noncrushable material will be separated. Uranium will be sent to the oxidation furnace, but the other materials will be drummed for shipment. The principal materials processed through the size reduction equipment include refractory brick, crucibles, glass, graphite, uranium and other metal wastes, incinerator ash, and oversize slag. The dry particle product will be pneumatically conveyed to the collection hopper. Dust from the equipment operation and fugitive emissions will be collected and exhausted to the collection hopper.

Pneumatic Collection System

The collection system hopper, located in the Recovery Plant Building (see Fig. 1.1), will receive, by pneumatic lines, processed wastes and dust from the Solids Handling Area, dried waste and baghouse ash from the oxidation furnace and rotary kiln, and incineration ash and dried enriched slag filter cake from the refinery. In addition, about 3,380 kg (7,445 lb) per day of dry-powder depleted milled slag will be transported in hoppers from the metals production building and unloaded into pneumatic lines for transfer to the collection hopper. All transport air entering the collection hopper will be exhausted through a baghouse and HEPA filter prior to discharge to the atmosphere.

Drum Filling Station

An enclosed, automated station located beneath the collection hopper will package an average of 300 kg (660 lb) of calcined waste solids into each of the

0.2-m^3 (55-gal) drums to be shipped off-site. The enclosure will be ventilated and connected to the dust-collection equipment.

Drum Washer

An enclosed, automated station will use steam sprays to wash the outside surface of the filled drums to remove low-level radioactive dust. The dirty condensate will be collected in an underground tank for subsequent processing through the filtration facility. The drum-washing operation is necessary to ensure compliance with governmental requirements for shipping and storage of the drums.

2.1.1.2 System Operation

The annual output of the LLWPSS is projected to be 5,000 metric tons of dry solid (calcined) waste material with a volume of about 3,965 m^3 (140,000 ft^3).[3] In general, as-generated dry solid materials, including MgF_2, account for approximately 91% of the output. Wet solid materials (sludges, sump cakes, and filter cakes with a moisture content between 50 and 60% when entering the LLWPSS for processing) represent about 4% of the dry solids output. The dry solids extracted from the neutralized raffinate will account for about 5% of the output. The annual generation rate of dry solids will fill approximately 19,200 drums of 0.2 m^3 (55 gal).[3] The composition of the dry waste output will be approximately the following: 73% magnesium fluoride (MgF_2), 9% uranium, 3% nonoxidizable materials such as glass and metal, and 15% other materials, including oxides of calcium, aluminum, iron, and silicon, and inorganic salts.

Because most plant waste streams will be separately campaigned through the processing system, the output is not expected to be a homogeneous mixture. For example, the MgF_2 and solids from treatment of refinery raffinates contain normal and enriched uranium (about 1% ^{235}U) and are recycled through uranium recovery processes until the uranium content in the solid wastes is less than 0.05%, while most of the remaining wastes are contaminated with depleted uranium (about 0.3% ^{235}U) that is not worth recovering.[2] Calculations based on process material balances indicate that the latter waste

batches may average 30% depleted uranium. It has been estimated that a small percentage of the drums filled after processing specific batches of waste containing depleted uranium scraps could contain up to 50% of oxidized uranium.[2]

On the basis of the feed materials and reactants used at the FMPC, no significant quantities of heavy metals other than uranium will be generated. Toxicity testing of sludge from the existing wet chemical pit using the 1983 Extraction Procedure (EP), as defined by the Resource Conservation Recovery Act (RCRA), showed that the material was not an RCRA hazardous waste. The average concentrations of heavy metals in the 1983 EP extract were: arsenic, <0.02 ppm; barium, 1 ppm; cadmium, <0.1 ppm; chromium, <0.10 ppm; lead, <0.5 ppm; mercury, 0.003 ppm; selenium, <0.1 ppm; and silver, <1 ppm.

The packaging and shipping operations will be conducted in compliance with all applicable Department of Transportation (DOT) regulations, which are incorporated into, and functionally the same as, DOE and Nuclear Regulatory Commission requirements. On average, each drum of waste material will have 27 kg (59.4 lb)[3] of uranium, or 0.018 Ci on the basis of a specific activity of 6.77×10^{-7} Ci/g (10 CFR Part 20). However, drums with waste containing only normal or enriched uranium will probably have about 150g (0.33 lb) of uranium (about 0.1 mCi), and drums with only depleted uranium in the waste will have an average of 90 kg (200 lb) of uranium (43 mCi), on the basis of adjusted specific activities.

Before shipping, the filled drums will be washed, dried, and examined for removable external radioactivity and monitored for radiation levels. After compliance with DOT limits is assured and recorded, the drums will be available for loading. The wastes are expected to be shipped in closed trailers owned and operated by commercial carriers. Radiation levels for all loads of waste drums will be well within applicable DOT limits (49 CFR Parts 173 and 177).

Radiation levels for typical drummed waste were recently measured at the FMPC site.[8] The contact radiation levels ranged from 0.7 mR/h for drums with small amounts of enriched uranium to about 5 mR/h for drums with significant amounts of depleted uranium. Radiation levels at one meter ranged from 0.5 to 1.5 mR/h. These levels are similar to those for drums of U_3O_8 after uranium mill processing.[9] Measured levels in the truck cab after loading an enclosed trailer averaged about 0.5 mR/h for trailer-to-cab separations of

about one meter and less than 0.3 mR/h for a separation of two meters.[9] These truck cab radiation levels for FMPC wastes are higher than the 0.2 mR/h (or less) observed for truckloads of drummed U_3O_8[9] or for low-level radioactive wastes in general,[10] possibly because the FMPC data were obtained in a high background radiation zone. Nevertheless, the FMPC data are used in Chapter 4 of the assessment for analysis of radiation doses to of the truck drivers. It is assumed that an equal number of the two trailer-to-cab configurations are used, in which case the average radiation level in the truck cabs would be less than 0.4 mR/h.

2.1.2 Shipping Wastes

The FMPC plans to engage the services of a commercial carrier for truck shipment of all wastes to the Nevada Test Site. Rail shipping has been considered (see Sect. 2.2.3), but is not as likely at this time. Consistent with DOT regulations for highway transport (49 CFR Part 177), it may be expected that the shortest route along the interstate highway system will be followed to take advantage of the quality of interstate highways and minimize travel time and distance. The most probable route consists of State Highway 128 south to Interstate 74, west to the Interstate 465 bypass around Indianapolis, then west on Interstate 70 to its terminus in Utah, utilizing the bypasses around the cities of St. Louis, Kansas City, and Denver. The remaining segment consists of Interstate 15 to Las Vegas, Nevada, and U.S. Highway 95 to the federally owned Nevada Test Site. This route is 3,273 km (2,034 miles) in length with mileage by highway type as follows: interstate routes, 3,065 km (1,905 miles); U.S. routes, 169 km (105 miles); state routes, 29 km (18 miles); and local routes, 9.8 km (6 miles). The actual routing of shipments could vary depending on weather and highway conditions. Local and state restrictions pertaining to hazardous material transport could also affect route selection, particularly in congested areas. It is the carrier's responsibility to select the appropriate route, and it is DOE policy that the carrier's route selection conforms to applicable federal, state, and local regulations.

Drums will be loaded so as to prevent shifting and will be banded and shored as required. It is anticipated that 60 drums will be transported per vehicle load and that an average of 6 to 7 truckloads per week will be shipped to the Nevada Test Site, where the drums of waste will be unloaded for final disposal.

2.1.3 Disposal of Wastes at the Nevada Test Site

On arrival at the Nevada Test Site, trucks carrying the calcined wastes from the FMPC will enter the reservation at Guard Station 100 (see Fig. 2.2). After a security clearance check, the drivers will be badged and dispatched (no escort required) to the Radioactive Waste Management Site (RWMS) shown in Fig. 2.2. Site personnel will operate all equipment used for unloading of waste drums from the trucks and placing them in deep trenches at the RWMS. They will monitor entering trucks to ascertain that all shipments are in compliance with DOT regulations; they will also monitor departing trucks for contamination and perform any washing/decontamination operations required to allow the trucks to return to the public highway system. This additional waste handling at the Nevada Test Site may require a few additional operating personnel, but probably not more than three.

In addition to the residual radionuclides retained in geologic formations in the test areas, DOE/Defense low-level wastes (LLW) are already buried on-site. Through 1982, the inventory volume was 125,000 m^3 which is about 6.3% of identified DOE/Defense LLW waste volume.[11] This inventory consisted of 9.51×10^4 kg of uranium and thorium as well as other materials such as fission products, activation products, tritium and alpha emitters (<10 nCi/g). The inventory had a total gross activity of 5.45×10^6 Ci. The waste drums from the FMPC will add about 4,350 m^3 (including 350 Ci of uranium) annually to the waste inventory at the Nevada Test Site.

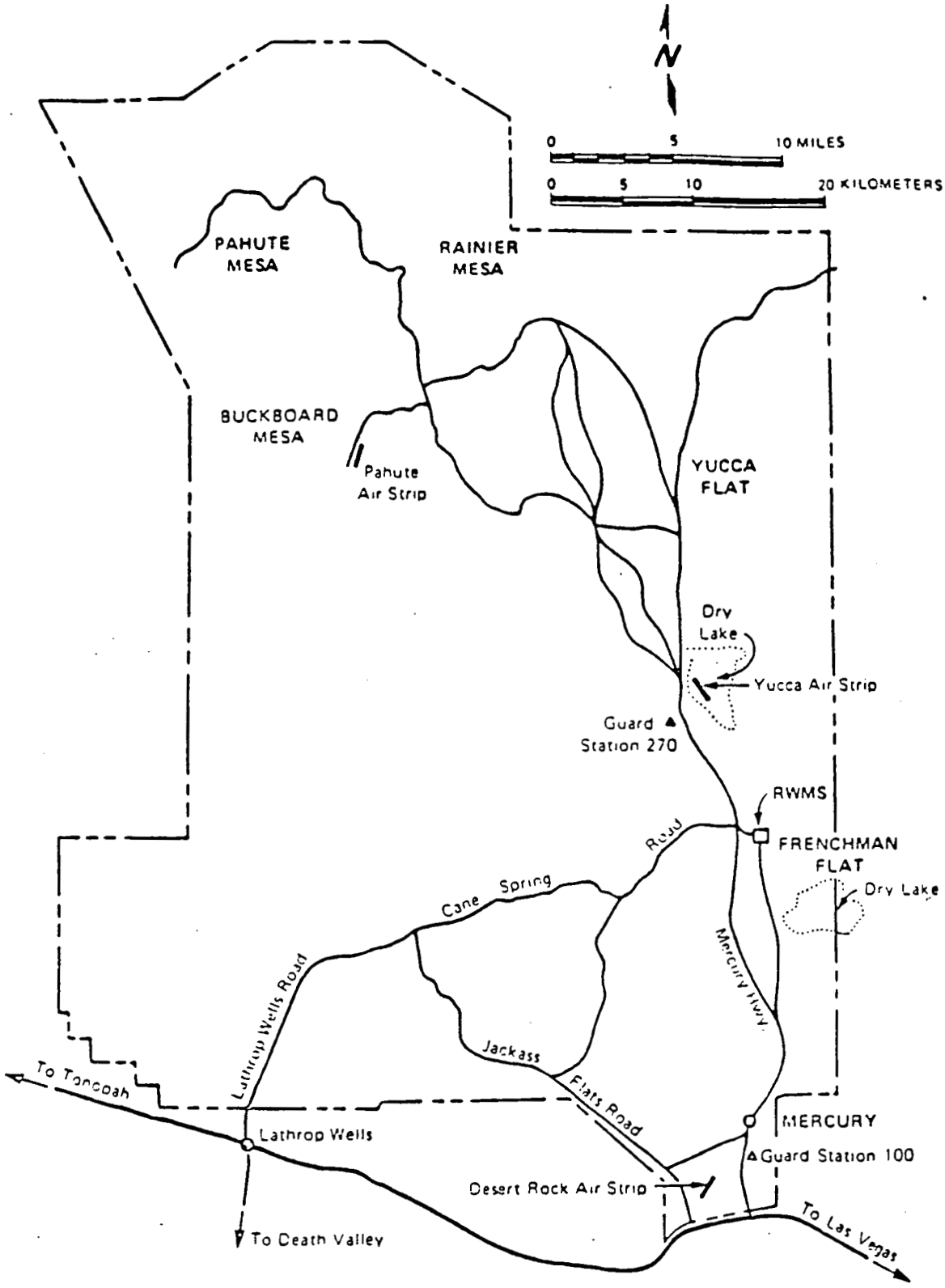

Figure 2.2 Location of the Radioactive Waste Management Site (RWMS) on the DOE Nevada Test Site. Source: "Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada," Energy Research and Development Administration, ERDA-1551, September 1977.

2.1.4 Interim Management of Wastes

Construction of the LLWPSS is expected to take three years. As previously stated, the existing wet chemical waste pits are virtually full, and the one operating dry waste pit does not have adequate capacity to meet the needs of the FMPC for the next three years.[2,3] To avoid opening additional waste pits during this interim period, as much waste as possible will be processed with existing equipment and shipped to the Nevada Test Site for disposal. This will begin as soon as possible. The annual quantities of waste processed and shipped during this period will be roughly the same as the annual output of the fully operational waste management system (Sec. 2.1.1.2).

Much of the dry solid materials, which accounts for about 91% of the total waste (Sect. 2.1.1.2), will be packaged in drums using currently available equipment and procedures. This material includes the MgF_2 which can be readily prepared for shipment. Large pieces of uranium or contaminated equipment that cannot be effectively reduced in size will be stored either in warehouses or in the dry waste pit until the additional volume-reduction capability of the LLWPSS is available. In this interim management mode, the life of the dry waste pit will be extended beyond the scheduled startup of the LLWPSS.[2]

During installation of the LLWPSS facilities, the neutralized raffinate from the General Sump will be recycled through filters to remove most of the remaining suspended solids. If the filtered solids are too wet for further water removal with available equipment, they will be drummed and stored on-site for subsequent drying and calcining treatment either in the LLWPSS or in temporarily leased equipment that could be brought on-site, if necessary. The filtrate from this step will be recycled for contaminant removal until satisfactory for release to the Great Miami River in accordance with the National Pollutant Discharge Elimination System (NPDES) permit.

The slurries from the General Sump will be dried as much as possible with currently available equipment. Some of this material can be dried sufficiently for immediate shipment, and the remainder will be drummed and stored on-site for additional drying in either the LLWPSS equipment, when operational, or in temporarily leased equipment that could be brought on-site, if necessary.

Low-moisture-content sludges from existing filtration modules on the liquid waste streams at the plant's processing buildings will be sufficiently dried by available equipment and drummed for shipment.

Until some experience is gained during the interim operation, it is not possible to quantify the number of drums of dry waste that will be packaged for daily shipment or the amount of wet solids that will be drummed and stored for later drying. However, it is not anticipated that the daily shipment will be any greater than is expected when the LLWPSS is fully operational. Finally, if the interim on-site storage of drummed wet wastes becomes large enough to pose a serious on-site management problem in terms of either space, cost, or personnel radiation exposure, leased equipment could be brought on-site to provide the required additional treatment to further prepare these wastes for shipment to the Nevada Test Site disposal area.

2.2 ALTERNATIVES

2.2.1 No Action

Low-level radioactive wastes generated by the FMPC operations (Fig. 1.2) are currently placed in pits (Fig. 1.3). The no-action alternative implies continuation of on-site pit storage of the wastes without implementation of the LLWPSS. However, the only operational wet chemical pit (No. #5) is essentially at full capacity, and the FMPC has discontinued the discharge of waste into this pit. Therefore, an additional disposal pit for the low-level radioactive wet wastes would have to be provided to continue with on-site storage. Another storage pit for dry solid wastes would also be required within about two years.[2] The environmental impact of the no-action alternative is described in Sect. 4.5.1 and is compared with the proposed action in Sect. 2.3.

2.2.2 On-site Storage of Processed Wastes

The alternative of on-site storage of processed wastes consists of proceeding with the installation of the treatment facilities identified for the LLWPSS in Sect. 2.1.1, the initiation of the interim on-site waste management activities described in Sect. 2.1.4, and the provision of environmental isolation in on-site storage facilities of the dry wastes expected to be discharged from the treatment system. The final form of the waste (granular or powder) lends itself to bulk storage, such as in silos, or to compartmentalized storage in drums placed within warehouses. For either storage method, long-term surveillance to detect loss of the waste to the environment would be necessary. Also, processed wastes stored on the FMPC site may eventually have to be shipped to a disposal facility such as the Nevada Test Site whenever the facility is decommissioned because storage without routine surveillance may not be permitted by regulatory authorities.

Impacts of this alternative are discussed in Sect. 4.5.2 and compared with the proposed action in Sect. 2.3.

2.2.3 Rail Shipment of Processed Wastes

The nation's railroads have been engaged in litigation with industrial and governmental shippers of radioactive waste materials for more than 10 years in attempts to refuse to carry these materials.[12] The Interstate Commerce Commission has ruled against the carriers, and the federal courts have upheld the shippers. Nonetheless, to discourage rail shipment, the carriers often utilize higher freight rates for transport of radioactive waste materials,[9] and they also persist in demands for special trains. Further litigation is possible, although the railroads have apparently given up their alleged right of refusal to carry shipments of radioactive waste materials. Current DOE waste transportation policy is to accept any rail carrier's resistance to shipping low-level wastes and to use the highway transport alternative.[12] Because of these factors, shipment by rail is not currently an attractive alternative for transport of FMPC wastes, but it may become so in the future.

Rail shipment to the Nevada Test Site can be described in two ways: (1) waste drums can be placed directly aboard railcars at the plant site and unloaded onto trucks at the rail debarkation point at the Nellis Air Force Base near Las Vegas for truck delivery to the site, or (2) waste drums can be placed on truck trailers that ride "piggy-back" on the railcar to the debarkation point and are then pulled to the site. The latter procedure offers the advantage of reduced handling of the waste drums by rail carrier personnel at the origin and terminus of the rail shipment phase. The environmental impacts of rail shipment are discussed in Sect. 4.5.3 and compared with the proposed action in Sect. 2.3.

2.2.4 Disposal Sites

The Department of Energy has formulated a management plan[13] for the permanent disposition of high-level and transuranic wastes resulting from atomic energy defense activities in each of the states where such waste is located. The plan responds to Public Law 97-90, the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1982, which calls for the issuance of plans for the permanent disposal of high-level and transuranic wastes resulting from atomic energy defense activities. This plan, however, does not address management of low-level wastes generated by the same activities.

The vast majority of DOE low-level radioactive wastes are disposed of at the generating sites. There are, however, some shipments from one federally owned site to another as proposed for the FMPC wastes. Low-level radioactive wastes are routinely shipped from the Mound Facility (Miamisburg, Ohio) and the Rocky Flats Plant (Golden, Colorado) to the Nevada Test Site.

Shallow land burial of radioactive waste is currently practiced at the following federal facilities that may be considered as potential repository sites for the FMPC wastes: (1) the Savannah River Plant, (2) the Hanford Reservation, (3) the Idaho National Engineering Laboratory, (4) the Oak Ridge National Laboratory, (5) the Los Alamos National Laboratory, and (6) the Nevada Test Site. The selection of The Nevada Test Site as the repository for the FMPC wastes was a DOE administrative decision based on availability of disposal space and acceptable impacts at the site.[6]

The advantage, disadvantages, and potential impacts of using one of the other identified DOE sites for disposal of FMPC low-level wastes are discussed in Sect. 4.5.4 and compared with the proposed action in Sect. 2.3.

2.2.5 Improved Waste Forms

The only waste form that has been identified as an alternative to the proposed action (which has the objective of preparing and shipping a stable, low-volume, dry-powder waste form in compliance with federal and state regulations) consists of incorporating the waste powder product of the LLWPSS into a concrete-like grout that would increase resistance to dispersion of radioactive materials into the environment. Environmental advantages and disadvantages, including estimated costs, are discussed in Sect. 4.5.5, and this alternative is compared to the proposed action in Sect. 2.3.

2.3 COMPARISON OF ALTERNATIVES, INCLUDING THE PROPOSED ACTION

The potential environmental impacts associated with the proposed action are summarized in Table 2.1. The construction activity is expected to be typical of that for any large industrial facility (Sect. 4.1). Because of the relatively small size and short duration of the construction effort (60 to 70 personnel over a 15-month period) and the fact that it will take place in an already disturbed environment near existing structures, the construction impacts are expected to be minimal. Specifically, a noticeable increase in fugitive dust emissions and suspended solids in the storm sewer would occur. Any impacts from such increases would be of short duration and not significant. During operation of the LLWPSS, the most significant impact will be radiological in nature. Total uranium emissions from the FMPC to the atmosphere will increase by 1% and result in an incremental dose commitment of less than 1% of EPA standards to individuals outside the site boundary (Sect. 4.2.2). No significant change in radiation doses to the work force would be expected to occur. Truck drivers involved in the shipment of the waste to the Nevada Test Site will receive an estimated cumulative dose of less

Table 2.1. Summary of potential environmental impacts associated with proposed action

Activities	Land Use/Water Use	Ecology	Air Quality/ Water Quality	Work Force	Surrounding Population
FMPC Site					
Construction	Minimal land use for new structures	Negligible	Short-term fugitive dust emissions and suspended solids in storm sewer.	Small work crew	Minimal socioeconomic impacts
Operation	Negligible increase in current water usage; discontinue use of waste storage pits	Negligible	1% increase in uranium emissions to atmosphere. Negligible changes in liquid effluents	No significant change from existing operations.	Incremental radiation dose commitments less than 1% of EPA standards of 25 millirem/year (40 CFR Part 61)
Transportation					
Normal transport	None	None	None	Radiation dose commitment of less than 11.5 person-rem/year to truck drivers	Total radiation dose commitment of about 168 person-rem/year for waste transportation
Accidents	None	None	Potential release of small quantity of radioactive materials to atmosphere	Estimated radiation dose to lungs of 180 mrem for persons in accident area who inhale radioactive dust for 1 hour	Potential exposure to dispersed radioactive materials. Dose commitment would be small (few millirems)
Disposal at Nevada Test Site	Few acres of land each year. Negligible water usage	Minimal	Negligible change in air quality. Potential for groundwater contamination in long term	Small exposure to radioactivity	Potential exposure to radioactivity in long term

than 11.5 person-rem/year (Sect. 4.3.1). Assuming each two-person truck crew will transport one load per month, the dose per individual will be less than 216 millirem/year (Sect. 4.3.1). There will be a total dose of about 168 person-rem/year to the population along the transportation route from incident-free transportation of the waste. This is a small fraction of the dose received from natural background radiation sources by the same population group.

The accident frequency for trucks hauling FMPC waste is estimated to be about 1.1 occurrences per year, but rupture of containers with radioactive material is expected to occur in less than half of the accidents. A conservative estimate of radiation dose commitments during a severe transportation accident results in 180 millirem to individuals who remain in the contaminated area for at least one hour following the accident. This is less than two years of natural radiation dose.

The potential environmental impacts associated with interim waste management operations (Sect. 2.1.4) are expected to be similar in character and magnitude as for the fully operational phase. The major difference between the interim phase and fully operational phase is that the former will not include significant volume reduction of the wastes.

A qualitative comparison of major environmental impacts of the proposed action (base case) and reasonable alternatives is given in Table 2.2. The only environmental advantage of the no-action alternative (business as usual) would be to eliminate the radiation dose commitments associated with shipping the wastes to the Nevada Test Site (Sect. 4.5.1). However, the potential groundwater contamination associated with continued use of on-site storage pits is judged to significantly outweigh the relatively small transportation impacts (Table 2.1). Although groundwater contamination could also occur at the Nevada Test Site in the long term, it would be less of a problem since the environment is arid instead of humid as for the FMPC.

The alternative of on-site storage of processed waste (i.e., in silos or warehouses) would also eliminate the transportation impacts (Sect. 4.5.2). Such an alternative would of course be temporary since the waste would have to be permanently disposed of at some future date, possibly at the Nevada Test Site.

Table 2.2. Summary comparison of potential environmental impacts of proposed action and alternatives

Alternatives	Land Use/Water Use	Ecology	Air Quality/ Water Quality	Work Force [1]	Surrounding Population
Proposed Action	Reference case[2]	Ref. Case	Reference Case	Reference Case	Reference Case
No Action	More land for on-site storage (disposal) pits	Same[3]	Continued fugitive dust emissions from waste pits. Potential groundwater contamination from on-site storage pits	Continued exposure to radioactivity from on-site storage pits	Potential exposure to radioactivity in air and groundwater from on-site storage pits
On-site Storage of Processed Waste	More land for storage facilities	Same	Same	No exposure to radioactivity from transportation of waste	No exposure to radioactivity from transportation of waste
Rail Shipment of Processed Wastes	Same	Possibly greater since trans. accidents would likely occur in undisturbed areas	Same	Less exposure to radioactivity from transportation of waste	Less exposure to radioactivity from transportation of waste
Disposal Sites[4]	Same	Same	Same	Slight difference: exposures vary with transportation distances	Slight difference: exposures vary with transportation distances
Improved Waste Form	Possibly more land for a waste-cement mixing plant	Same	Same	Slightly greater exposures to radioactivity due to increased shipment volumes.	Potential exposures much less for transportation accidents

[1] Includes transportation personnel.

[2] Environmental impact is given in Table 2.1 for each impact area. The impacts in each area for other alternatives are compared to this reference case (proposed action).

[3] Indicates that the impact is essentially the same as for reference case (proposed action).

[4] Includes only acceptable alternative sites in the western United States: Hanford Reservation, Richland, Washington; Los Alamos National Laboratory, Los Alamos, New Mexico; and Idaho National Engineering Laboratory, Idaho Falls, Idaho.

The principal environmental advantage of rail (as opposed to truck) shipment would be to reduce the total radiation doses to populations along the transportation route and to transport crews. The population dose would be reduced because rail shipment would be through less populated areas (Sect. 4.5.3).

No major advantages are apparent by shipping the waste to an alternative disposal site (e.g., Oak Ridge Reservation, Savannah River Plant, Los Alamos National Laboratory, Idaho National Engineering Laboratory, and the Hanford Reservation) instead of the Nevada Test Site (Sect. 4.5.4). The humid sites (Oak Ridge and Savannah River), which are closer to the FMPC, would be less desirable than the arid sites (Los Alamos, Idaho, and Hanford). Of the arid sites, only Los Alamos National Laboratory would be more advantageous (if the wastes could be accomodated) since the shipping distance would be 70% of that to the Nevada Test Site.

Finally, if the waste were incorporated into a cement-like grout, the potential impacts of transportation accidents would be reduced (Sect. 4.5.5) and the potential for groundwater contamination at the disposal site in the long term would also be reduced. Because the proposed waste form is not of environmental concern, neither of these characteristics of the improved waste form is judged at this time to be warranted from an environmental perspective.

In summary, the potential environmental impacts of the proposed action are judged not to be significant and much more favorable than that of the no-action alternative. No major environmental advantages are offered by either rail shipment or an alternative disposal site. An improved waste form (a cement-like grout) would offer environmental advantages, although at increased costs. The environmental impacts of the proposed action are not of such magnitude to warrant further consideration of these alternatives.

3. THE AFFECTED ENVIRONMENT

Those characteristics of the FMPC site that are germane to assessment of the environmental consequences of the proposed action and alternatives (Chapter 4) are described in this chapter. The characteristics of the proposed waste burial area at the Nevada Test Site are briefly described.[6] Because the impacts along the potentially variable shipping routes are so small and diffuse, the environment affected is not described here.

3.1 SITE LOCATION AND CHARACTERISTICS

The FMPC is located on a 425-ha (1,050-acre) site in a rural area about 32 km (20 miles) northwest of downtown Cincinnati, Ohio (Fig. 3.1). Most of the site, including that occupied by the production and waste management facilities, is located within Hamilton County, Ohio, although approximately 81 ha (200 acres) lie within Butler County. The land surrounding the FMPC site is used primarily for agriculture. The villages of Fernald, New Baltimore, Ross, and Shandon are all located within a few kilometers of the plant. Hamilton, Ohio (population 64,200) is approximately 16 km (10 miles) northeast.

The production facilities occupy approximately 55 ha (136 acres) near the center of the site. The waste storage facilities are located on the site west of the production area.

3.1.1 Site Topography

The FMPC is located in the Great Miami River Basin about 1.2 km (0.75 mile) west of the river. Natural drainage of the site is to Paddy's Run, which flows from north to south through the western edge of the site and drains into the Great Miami River.

The site is about 177 m (580 ft) above sea level and is relatively level over most of the production area. The site is on an elevated plain above the

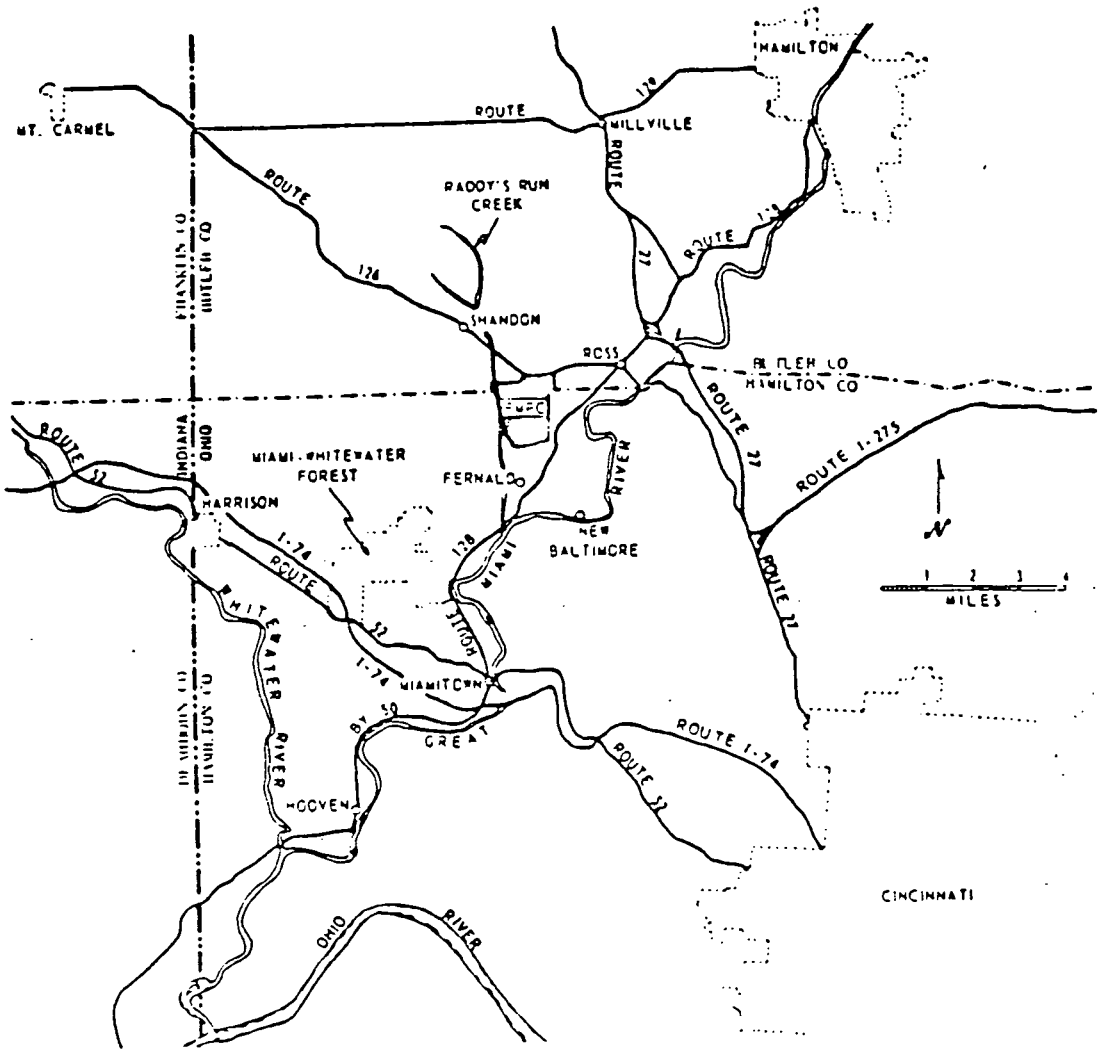

Figure 3.1 Location of the Feed Materials Production Center (FMPC) in southwestern Ohio. Source: "Feed Materials Production Center Environmental Monitoring Annual Report for 1983," D. A. Fleming and K. N. Ross, NLO, Inc., NLCO-2018, August 1984.

Great Miami River floodplain. The site slopes upward north of the production area, rising to an elevation of 213 m (700 ft) at the northern edge of the site. There is a downward slope on the western portion of the site to Paddy's Run at an elevation of 168 m (550 ft).

3.1.2 Land Use

Vegetation on the site is typical of that occurring in the region under similar land-use practices. Major vegetation types on the site are: grazed pasture areas on the east, north, and south sides; wooded areas along the stream beds and the north and northwest portions of the site; and a scrub growth area east of Paddy's Run. Neither adoption of the proposed action nor continued on-site waste storage (processed or not) would materially affect land use on the site.

3.1.3 Ecology

The terrestrial and aquatic ecology of the site was described in the FMPC Environmental Report.[3] Mammal populations and vegetation on or adjacent to the site are typical of those in southwestern Ohio, where the land is generally open and under cultivation. Livestock is pastured on approximately 132 ha (325 acres) of the FMPC site. When present, the aquatic biota in Paddy's Run is indicative of good water quality; however, because of the ephemeral nature of this stream, populations are very seasonal. Aquatic populations in the Great Miami River are characteristic of stressed streams and consist mainly of pollution-tolerant species from Dayton (upriver) to the confluence with the Ohio River. No rare or endangered species have been identified in the FMPC area.[3]

3.1.4 Meteorology

Over the 20 years from 1960 to 1979, the average annual precipitation measured at the FMPC was 96 cm (37.5 in.), ranging from 74 cm (29.1 in.) to 121

cm (47.6 in.). Rainfall is at a minimum in the fall. At the Greater Cincinnati International Airport the prevailing winds are from the south-southwest for all twelve months of the year. Average monthly wind speeds range from 10.8 km/h (6.7 mph) in August to 18 km/h (11.2 mph) in March. Prevailing winds should be about the same at the FMPC site.

3.1.5 Geology

The bedrock in the area is Ordovician shales and limestone, which is overlain with Pleistocene glacial deposits. These deposits filled in old river and stream channels and caused a pronounced softening of the topographic relief. The area is marked by broad flat plains, rolling surfaces along glacial moraines, and by low, well-rounded hills of bedrock that protrude through the glacial debris.

The glacial deposits average 3.2 km (2 miles) in width and about 31-61 m (150-200 ft) in depth. Recent erosion by the Great Miami River and its tributaries has removed substantial portions of the glacial fill, leaving terrace remnants standing higher than the adjacent bottomlands. The FMPC is located on the terrace.

The upper 15 m (50 ft) of deposits at the FMPC site is composed of a clay-rich till, which may be a remnant of a large glacial moraine. These deposits contain sufficient clay to render them nearly impervious to infiltration. However, in some areas, sand and gravel deposits extend to the surface. Beneath the till, about 31 m (150 ft) of sand and gravel fill the preglacial river valley. In the FMPC area, the sand and gravel deposits are divided into two units by a clay layer that is about 3 to 6 m (10 to 20 ft) thick. The top of this clay layer is about 38 m (125 ft) below the land surface. In some locations, the clay layer provides a confining unit for the lower sand and gravel aquifer.

3.1.6.1 Groundwater

Test borings for foundation design, well drilling, and waste pit excavation at the FMPC site show the existence of many groundwater aquifers in the glacial deposits. Most of these aquifers are shallow and quite localized, resulting primarily from infiltration of precipitation that is trapped by underlying clay units. Since the water level in the shallow wells west of the waste disposal area is higher than in wells on the east side, it is believed that the shallow groundwater moves eastward toward the production wells where water is pumped from the deep aquifer (see Fig. 3.2). The deep aquifer (thought to be artesian in the FMPC site) is undoubtedly supplied with water from a large recharge area and is not greatly affected by local precipitation. On the average, 1,325 m^3 (350,000 gal) of water per day are withdrawn from this deep aquifer by the FMPC production wells.

The physical characteristics of the sand and gravel deposits in the Great Miami River Basin give rise to groundwater resources that are of tremendous potential economic value. Other major groundwater users in the region are the Southwestern Ohio Water Company, the Cincinnati Bolton Plant, and the Southwestern Butler County Water Association.[3] These three organizations, which cumulatively pumped about 95 times the FMPC consumption, are located from 1.6 to 5.6 km (1 to 3.5 miles) distant from the FMPC in the E, ENE, and NE directions, respectively, and are hydraulically upgradient of the FMPC site.[4] Groundwater is also pumped, in smaller quantities, by local industry and by agricultural and residential users.

3.1.6.2 Surface Water

The FMPC site drains to Paddy's Run, which flows southward along the western boundary of the site and discharges about 3.2 km (2 miles) downstream into the Great Miami River. The FMPC waste storage pits are located east of

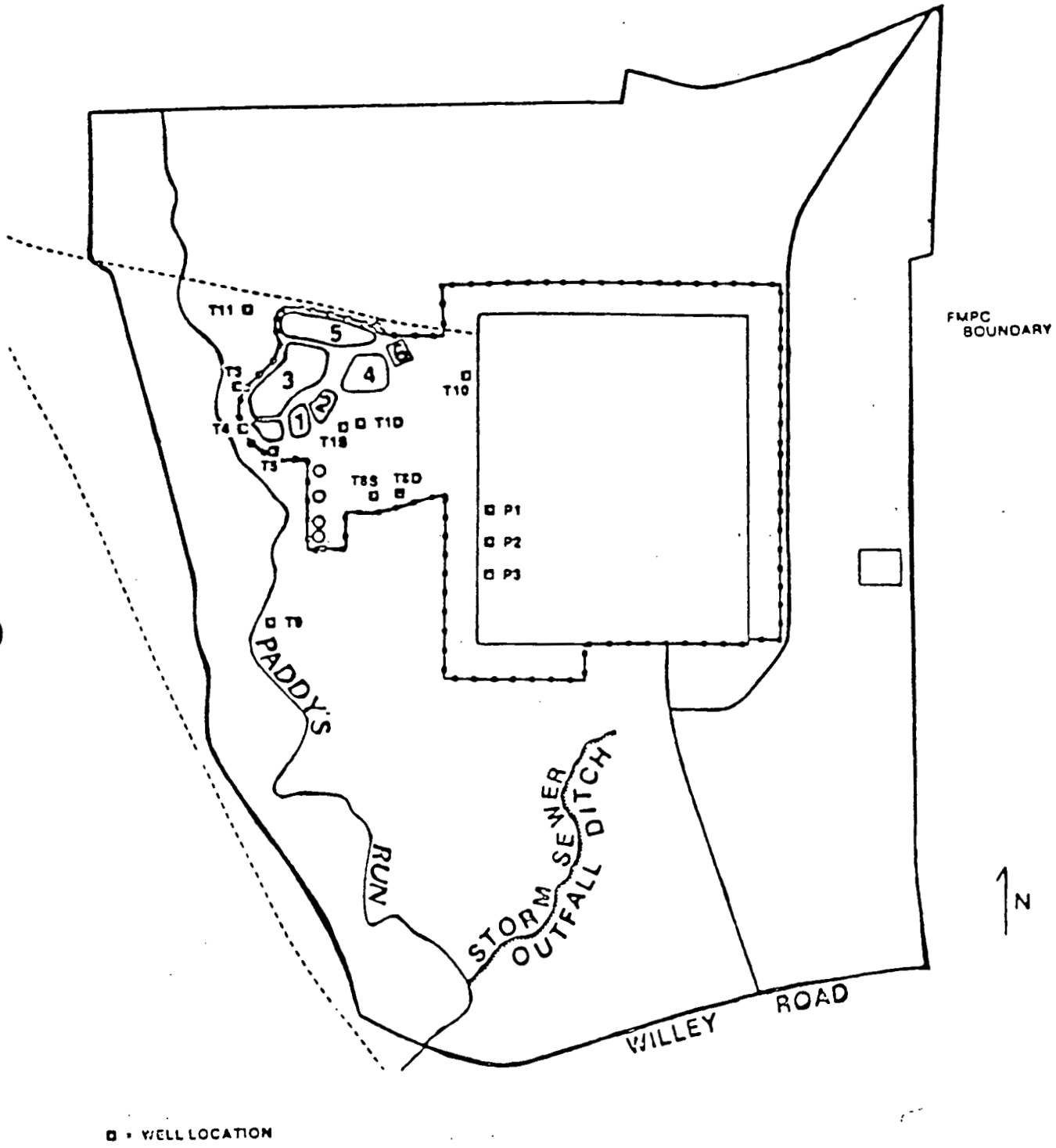

Figure 3.2 Location of on-site production and groundwater monitoring wells at the Feed Materials Production Center. Source: "Feed Materials Production Center Environmental Monitoring Annual Report for 1983," D. A. Fleming and K. N. Ross, NLO, Inc., NLCO-2018, August 1984.

and adjacent to Paddy's Run. Seepage from these pits could contaminate this creek.

The Great Miami River flows southward about 1.6 km (1 mile) east of the plant site. The treated liquid process waste, sewage, and some storm water flows through a buried pipe to a discharge into the Great Miami River. Samples of these plant effluents are collected and analyzed to determine compliance with the National Pollutant Discharge Elimination System permit limits for the FMPC. Compliance was achieved for most of the parameters during 1983, as shown in the data presented in Table 3.1.

The results of analyses of water from the Great Miami River and Paddy's Run for nonradioactive pollutants are presented in Table 3.2 and show that no state standards for water quality were exceeded during 1983.

3.1.7 Ambient Radiological Characteristics

The radiological characteristics that exist at the FMPC site and environs as a result of historical plant operation are included in Feed Materials Production Center Environmental Monitoring Annual Report for 1983[1]. Air, water, soil, and milk samples are taken periodically and analyzed for radioactive materials. Figure 3.2 shows the location of groundwater monitoring wells; the location of on-site air sampling stations is shown in Fig. 3.3. Water samples are also taken from both Paddy's Run and the Great Miami River and the effluent streams that discharge into these surface water bodies. Soil samples are taken from various on-site and off-site locations. The milk samples are collected on a quarterly basis from a neighboring and a distant farm; the distant farm is used as a control.

Radionuclides found in these samples include cesium-137, neptunium-237, plutonium-238, plutonium-239, radon-222, radium-226, radium-228, ruthenium-106, strontium-90, technetium-99, thorium-228, thorium-232, and uranium. Of these, only uranium is pertinent to routine operation of the proposed Low-Level Waste Processing and Shipment System (Sect. 2.1.1). Both liquid effluents and airborne emissions from this waste management system will contain small quantities of uranium. Based on monitoring data, sitewide airborne uranium emissions in 1983 were estimated to be 117 mCi.[1] Although no such estimates

Table 3.1. Compliance of FMPC effluent discharges with National Pollution Discharge Elimination System standards in 1983

Location	Parameter	Daily Maximum Limit[1] mg/L	Daily Maximum Limit[1] kg/day	Daily Average Limit[1] mg/L	Daily Average Limit[1] kg/day	Compliance With Permit Limits: %
Manhole - 175	Suspended Solids	60	-	20	-	99
	Nitrate (N)	-	3180	-	1590	100
	Ammonia (N)	-	43	-	28	100
	Oil & Grease	15	-	-	-	97
	Residual Chlorine	0.10	-	-	-	100
	pH (Std. pH units)	6.5 10	-	-	-	100
General Sump & Clearwell Combined	Suspended Solids	-	12.8	-	6.2	100
	Chromium (+6)	-	0.008	-	0.004	94
	Chromium (total)	-	0.102	-	0.050	100
	Iron	-	0.85	-	0.41	100
	Nickel	-	0.256	-	0.124	100
	Copper	-	0.051	-	0.025	100
Storm Sewer Lift Station	Suspended Solids	100	-	30	-	98
	Oil & Grease	15	-	-	-	100
Sewage Treatment Plant	BOD, 5-day	40	10.0	20	5.0	100
	Suspended Solids	40	10.0	20	5.0	100
	Fecal. coliform (No. per 100 mL)	2000	-	1000	-	100
Storm Sewer Outfall	Suspended Solids	100	-	30	-	100
	Oil & Grease	15	-	-	-	100

[1]Permit limits are given in units of mg/L or kg/day except for pH and fecal coliform bacteria.

Source: D. A. Fleming and K. N. Ross, Feed Materials Production Center Environmental Monitoring Annual Report for 1983, NLCO-2018, August 1984.

Table 3.2. Average concentrations of nonradioactive contaminants in FMPC effluent discharged to the Great Miami River During 1983.

Contaminant	Sampling Point[1]	Number of Samples	Average Concentration mg/L	Average Concentration % of Standard	Detection Limit	Standard[2]
Fluoride	W1	52	0.5	25	0.1 mg/L	2.0 mg/L
	W3	52	0.5	25		
	W4	52	0.5	25		
	W5	12	0.2	10		
	W7	12	0.4	20		
	W8	12	0.1	5		
Nitrate Nitrogen	W1	52	6.5	30	0.3 mg/L	22 mg/L
	W3	52	6.5	30		
	W4	52	6.3	29		
	W5	12	2.7	12		
	W7	12	3.3	15		
	W8	12	1.8	8.2		
Chloride	W1	52	56	22	5 mg/L	250 mg/L
	W3	52	56	22		
	W4	52	54	22		
	W5	12	29	12		
	W7	13	20	8		
	W8	12	37	15		
pH[3]	W1	52	NA[4]	NA	NA	6.5 9.0
	W3	52				
	W4	52				
	W5	50				
	W7	26				
	W8	26				

[1]Samples W1, W3, and W4 are taken from the Great Miami River and Samples W5, W7, and W8 from Paddy's Run with the following general locations: W1 - upstream of FMPC discharge; W3 - downstream of FMPC discharge at Baltimore, Ohio; W4 - downstream of Paddy's Run inflow; W5 - upstream of plant site; W7 - immediately downstream of plant outfall ditch discharge at Willey Road; W8 - further downstream near Fernald, Ohio.

[2]Ohio EPA Water Quality Standards, Administrative Code Chapter 3745-1.

[3]pH is reported in standard units.

[4]Not applicable.

Source: D. A. Fleming and K. N. Ross, Feed Materials Production Center Environmental Monitoring Annual Report for 1983, NLCO-2018, August 1984.

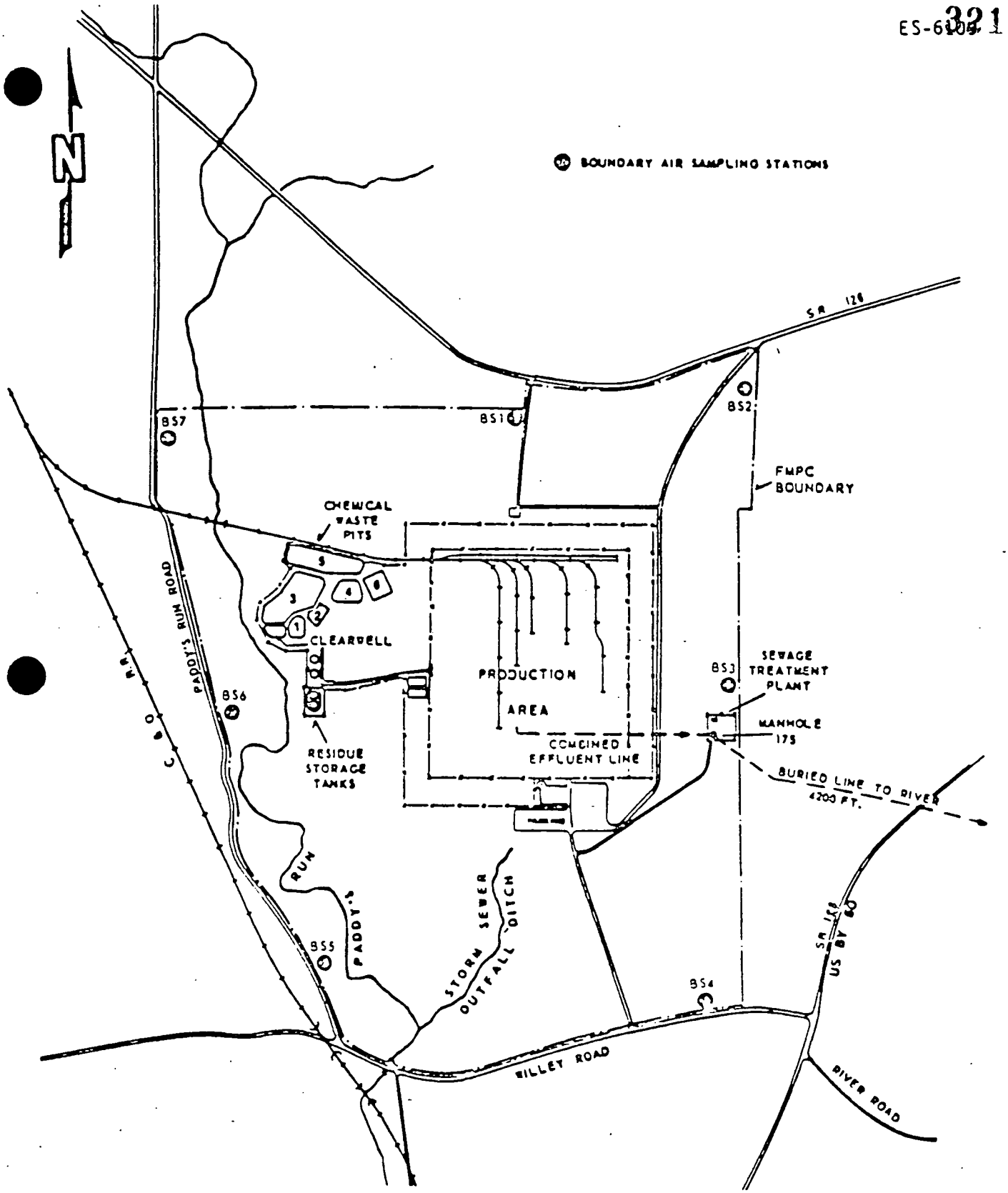

Figure 3.3 Location of on-site air sampling stations at the Feed Materials Production Center. Source: "Feed Materials Production Center Environmental Monitoring Annual Report for 1983," D. A. Fleming and K. N. Ross, NLO, Inc., NLCO-2018, August 1984.

are available for liquid effluents, average concentrations of uranium in the Great Miami River ranged from 2×10^{-3} to 0.1 mg/L. (Drinking water is distasteful at concentrations ranging from 3 to 5 mg/L.)

3.2 NEVADA TEST SITE REPOSITORY

The Nevada Test Site is located in Nye County in southern Nevada, with its southernmost point about 100 km (65 miles) northeast of Las Vegas. The site contains 3,500 km^2 (1,350 $miles^2$) of federally owned land with restricted access and varies from 46 to 56 km (28 to 35 miles) in width (east-west) and from 64 to 88 km (40 to 55 miles) in length (north-south) (see Fig. 2.2). Since 1951, various areas within the site have been used for nuclear weapons testing. The predominant features include the closed drainage basins of Frenchman Flat and Yucca Flat, where the early atmospheric tests were conducted. The geologic media in this area also permits the placement of nuclear devices at sufficient depth for proper containment and control of radiation during underground explosions. The water table is very deep and is not recharged by surface water in this area. Weather conditions permit year-round use of the site.

A program of geologic investigations has existed for some time at the Nevada Test Site for possible use of the site for retrievable storage of high-level commercial wastes as an adjunct to terminal disposal in geologic formations.[6] About 37 ha (92 acres) have been designated as the Radioactive Waste Management Site (RWMS) for disposal and long-term management of federally generated low-level wastes (see Fig. 2.2). A letter of authorization that will permit delivery of FMPC wastes to the site will be issued by the operator of the Nevada Test Site.

The RWMS occupies an area that has already been disturbed by atmospheric testing. Under low-level waste management funding, UCLA is actively replanting disturbed areas with indigenous desert vegetation. Use of the shallow-land burial facility at the RWMS for low-level radioactive waste from the FMPC would only slightly increase the affected area and delay eventual recovery of disturbed areas to a normal desert-type habitat. Shallow-land burial of the drums of FMPC waste is not expected to have an impact on the

groundwater resources with current climatological conditions. There may be an incremental impact of fugitive dust from trenching operations, but this is probably much smaller than the normal amount of wind-blown sand in the desert.

4. ENVIRONMENTAL CONSEQUENCES

Environmental impacts are associated with the following aspects of the proposed action: (1) modification of plant facilities, (2) shipment of processed waste for the indefinite future, (3) disposal of wastes at the Nevada Test Site, and (4) interim shipment of currently generated wastes. None of these activities comprises a precedent, but, rather these activities are typical of existing activities that are in routine practice in the United States. This chapter presents an analysis of the environmental impacts of the proposed action and of identified reasonable alternatives.

4.1 CONSTRUCTION IMPACTS

As indicated in Sect. 2.1.1, most of the LLWPSS construction activities will involve installation of equipment in the Recovery Plant or an extension thereof, thus limiting site involvement to a small area. There may also be the necessity for excavation for installation of additional services and for expansion of warehousing facilities used for temporary storage of filled drums ready for shipment.

The direct effects of this construction will include those short-term minor impacts common to all construction work. The effort will be managed to ensure proper work scheduling and operations of equipment to control dust, noise, diesel smoke, and traffic. None of these activities is expected to have a significant impact on the local environment. During excavation work, some particles of soil may be washed into the storm sewer system during periods of heavy rainfall, causing brief elevations in the quantity of suspended solids in the plant effluent and possibly causing short-term exceedances of the FMPC site National Pollutant Discharge Elimination System (NPDES) permit limit for suspended solids. The possibility for such violations will be minimized by proper work scheduling and erosion control measures during excavation, such as filtering excavation runoff through crushed rock to remove suspended solids before they are discharged to the storm sewer system. Regrading, site restoration, and reseeding of grassy areas at the conclusion of the work will

minimize any minor short-term impacts. Construction activities are not expected to have any long-term adverse impacts.

The construction phase of the proposed project will provide employment for 60 to 70 general construction personnel to be hired locally. A total employment requirement of 135,000 manhours has been estimated for the anticipated 15-month construction period of April 1987 through July 1988. This labor demand should not impact the socioeconomic structure in this community near the Cincinnati metropolitan area.

4.2 OPERATION IMPACTS

4.2.1 Land Use and Water Use

The only expected on-site land use will be for an extension of the Recovery Building and for possible additional warehouse space. No off-site land use is expected in conjunction with LLWPSS operation, except at the Nevada Test Site waste disposal area (see Sect. 3.2).

Water requirements for the LLWPSS will comprise a negligible increase in current water usage by the FMPC and will be easily supplied by the existing on-site production wells. There will be no measurable effects on the available local supply of water. Moreover, the groundwater quality will not be affected since the LLWPSS will be self contained: no effluents will be released to the groundwater system.

4.2.2 Airborne Emissions

During LLWPSS operations, the processing of wet wastes to a dry form, the processing of dry wastes to a form more easily handled, and the packaging of dry material will produce a small increment in the amount of airborne contaminants released by the FMPC. These contaminants will be controlled by appropriate ventilation, gas scrubbing, and dust collection equipment (Sect. 2.1.1) to meet DOE guidelines for maintaining emissions "As Low As Reasonably Achievable" (ALARA) through design considerations. The specific

controls that would be included in this project include: (1) a fabric filter baghouse dust collector (>98% efficient on the basis of FMPC experience) followed by a HEPA filter (99.97% efficient for particles greater than 0.3 micron diameter) for all air exhausted through the hopper of the pneumatic dry waste collection systems; (2) local exhaust ventilation hoods throughout the waste processing area routed to baghouse collectors and HEPA filters; (3) a quench chamber, baghouse collector, wet scrubber, and HEPA filter for both the rotary kiln and the oxidation furnace; and (4) routing of ventilation exhaust air from the waste packaging station through a baghouse collector and HEPA filter.

It is estimated that the airborne emissions that result after the application of these control devices to the activities of the LLWPSS may contain as much as 1.8 kg (4 lb) of uranium per year. Assuming that airborne uranium emissions have a normal isotopic distribution, the annual release would be equivalent to 1.2 mCi, which would represent an increase of approximately 1% in the sitewide FMPC uranium emissions on the basis of 1983 data (117 mCi) in the absence of the LLWPSS.[1] This result assumes that the LLWPSS activities do not reduce existing emission levels of production activities in any way. The incremental 50-year dose commitments to the maximally exposed off-site individual for the LLWPSS operation, on the basis of AIRDOSE and DARTAB computer calculations (ICRP-30), would be the following: whole body, 0.08 millirem; pulmonary, 0.26 millirem; kidney, 0.02 millirem; and endosteal tissue, 0.03 millirem. These doses are 0.02%, 0.02%, 0.001%, and 0.006%, respectively, of the limits established in DOE Order 5480.1A and less than 1.0% of the EPA standards (40 CFR Part 61). These increases are not judged to represent a significant impact.*

The land near the waste processing facilities will receive about a 1% increase of particulate deposits containing a small concentration of uranium

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*The impact of existing sitewide uranium emissions from the FMPC is under investigation by both the DOE and the EPA. Some model predictions indicate that these emissions could result in radiation dose commitments that exceed the limits called for in 40 CFR Part 61, thus necessitating mitigation or a variance to the regulation. In any case, the incremental impact that will result from the LLWPSS is judged to be sufficiently small to not influence any DOE action that could be required for compliance with the regulation.

from stack emissions while the LLWPSS facilities are operating, but uranium concentrations in the soil are not expected to add measurable levels to those resulting from FMPC operation since 1952. The termination of on-site disposal (storage) will permit the final closure of the waste pits and will probably result in less fugitive radioactive dust impacting the areas adjacent to the site. Therefore, off-site particulate deposits could be less. Periodic soil sampling can be continued to ascertain actual changes in uranium concentrations. The differential direct radiation exposure contribution to individuals from increased uranium concentrations in the local environment due to LLWPSS operation are not expected to be measurable.

4.2.3 Liquid Effluents

After the solid contaminants have been removed from the FMPC wet wastes in the LLWPSS operation, the remaining liquid effluent is similar in radionuclide content to the effluent that is being discharged from the existing FMPC waste treatment system to the Great Miami River. The liquid effluent from the LLWPSS facilities will also be combined with other plant effluents and be discharged to the Great Miami River. It is expected that the water quality of the combined effluent will remain well within regulatory limits. Therefore, no significant additional impact on the Great Miami River due to liquid effluents from the LLWPSS is expected. The combined liquid effluents will be sampled and analyzed for uranium, gross alpha, and gross beta content. The results will be reported to the state of Ohio in accordance with NPDES Permit No. OH 9580.

4.2.4 Ecological Effects

Because construction of the waste management facilities will take place within an already disturbed area near other buildings within the currently fenced production area, no adverse impacts on local flora and fauna are expected to occur as a result of project construction (Sect. 4.1). Incremental effects of operation of LLWPSS are so small that no adverse impacts on the local ecology are expected to occur.

4.2.5 Health and Safety Impacts

No significant impacts on FMPC employee health and safety are expected to occur as a result of this project. The design of this project will (1) comply with applicable DOE Orders [e.g., DOE Order 5483.1 A (Draft), Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned, Contractor-Operated Facilities]; (2) include features that will reduce the likelihood of an in-plant accident or release of radioactivity; and (3) limit the potential impacts of such conditions should they occur. Ventilation of operating equipment and local exhaust at work stations and dust emission points will be employed to control emissions in the workplace. Health and safety impacts on personnel will be minimized by the design of the facilities, by inspection and maintenance of equipment, and by adherence to standard operating procedures and plantwide safety and health program requirements. The quality of employee health and safety protection will be verified by annual employee physical examinations, plant inspections, air sampling programs, bioassay programs, and other aspects of the health and safety program.

The risk of failure of the treatment system will be minimized by design. The air handling and conveying systems will be operated under negative pressure so that a system rupture will leak inward and not cause discharge to the atmosphere. Filter efficiency and integrity will be verified by monitoring pressure differential across filters and by monitoring for contaminants in the stack discharge. Waste processing operations will be performed in controlled areas with proper floors, dikes, and sumps to contain spills. Criticality will not be a potential problem in this treatment system because of the low concentrations of enriched uranium present and the absence of a moderator. Procedural risks will be minimized by inspection and maintenance of equipment and facilities, adherence to standard operating procedures and plantwide environmental, safety, and health program requirements. The probability of accidents involving natural phenomena or human carelessness that could impact the proposed project is low. No earthquakes have occured at the FMPC, and the probability of damaging earthquakes (intensities of VII to IX on the Modified Mercalli scale) in the vicinity ranges from low to extremely low.

4.3 TRANSPORTATION IMPACTS

4.3.1 Normal Transport

No significant environmental impacts are expected from the normal transportation (no-accident case) of the FMPC waste since all procedures will be in compliance with applicable DOT and DOE requirements. External radiation from the packages and truck trailers will be in compliance with DOT limits established to allow safe transportation of radioactive materials with minimal exposures (49 CFR Parts 173 and 177). External radiation levels for a single drum will be about 0.7 to 5 mR/h at the surface and 0.5 to 1.5 mR/h hour at one meter (Sect. 2.1.1.2). The DOT Specification 17H drums with plastic linings[3] comply with DOT requirements and are approved for shipment as Type A packaging. This packaging has been tested in accordance with DOT regulations that require a water spray test, a free-drop test, a compression test, and a penetration test designed to ensure the suitability of the package for shipments of specified materials, which include the FMPC low-level wastes. These 17H drums will provide adequate containment for normal transport conditions and prevent members of the general public from being exposed to unnecessary levels of radiation.

Transportation of the FMPC wastes will result in exposures from external radiation of (1) drivers of vehicles carrying the waste, (2) persons handling the drums, (3) persons along the transportation route while the shipment is moving, and (4) persons in surrounding locations while the shipment is stationary. Radiation doses associated with transportation of U_3O_8 (natural uranium) have been calculated (NUREG-0170[14]) and can be used to provide an upper limit for doses associated with transportation of drums of FMPC wastes, which are similar to in radiation level to drums of U_3O_8.[9]

The exposure calculations for truck transportation of 40 drums of U_3O_8 over a route that was 5% urban (3861 persons/km^2), 5% suburban (719 persons/km^2), and 90% rural (6 persons/km^2) indicate a radiation dose of 1.6×10^{-4} person-rem/km per shipment.[14]

On the basis of a comparison of the activity levels of drums U_3O_8 and FMPC waste, it is reasonable to assume that a 60-drum truckload of FMPC waste

will not result in radiation exposures greater than a 40-drum load of U_3O_8. Therefore, the estimated number of FMPC waste shipments per year (320), travel distance (3,273 km), and the value of 1.6×10^{-4} person-rem/km per shipment result in a total dose commitment of 168 person-rem/year for truck shipment of FMPC wastes to the Nevada Test Site. The combined radiation exposure of the many persons (thousands) along the transportation routes or used in handling the drums (168 person-rem/year) is negligible when compared to the combined radiation exposure to the same population group from the annual natural radiation dose rate of about 100 millirem.

It is assumed that two drivers would be used to transport the FMPC wastes. From a transportation model,[14] it is estimated that the actual time the drivers would be in the truck cab during the trip to Nevada is 45 hours. With the average exposure in the cab of 0.4 mR/h (Sect. 2.1.1.2), each driver would receive a dose of about 18 millirem. For 320 trips per year, the total crew dose would be about 11.5 person-rem/year, which is about 6.8% of the total population dose calculated above.

For a large commercial truck fleet, it is estimated that assignment of a truck crew to a repeat trip of this nature would statistically occur about once a month, or 12 times per year.[15] Thus, the average annual dose for each driver would be about 216 millirem, which is within the measured doses (200 to 300 millirem/year) to drivers transporting low-level radioactive waste.[16] The DOE limit is 500 millirem/year.

4.3.2 Transportation Accidents

During the transport of the wastes, it is possible for an accident to occur that could result in the release of radioactive materials. The accident rate for trucks transporting radioactive materials is given as 1.06×10^{-6} accidents per kilometer for trucks carrying drums with solid waste.[14] For the transport of FMPC wastes to the Nevada Test Site, the accident rate would be 1.1 accidents per year. It is reasonable to assume that, at maximum, only about half of these accidents will result in a release of radioactive material (via drum ruptures). Thus, 0.5 accidents per year may result in local contamination events.

The amount of radioactive material released to the environment in an accident depends upon the severity of the accident as well as the package capabilities. For purposes of evaluating a worst-case scenario, it is assumed that 10% of the contents of one truckload of wastes with drums containing 30% of depleted uranium (rather than 9% of normal uranium) could be spilled (i.e., 0.25 Ci) over 100 m^2 of surface (road or ground) in an accident. The resultant surface contamination level would be 2.5×10^{-3} Ci/m^2. External radiation exposure levels at 1 m above such a surface would be about 1.5×10^{-2} mR/h, which is not significant in terms of direct radiation exposure.

The potential for internal exposure via resuspension of uranium into the air would be more significant. If it is assumed that 10^{-5} of the uranium is initially resuspended[11] in one meter over the contaminated area and virtually immediate dispersion increases the affected area by a factor of 100, then a level of 2.5×10^{-10} Ci/m^3 would be present over an area of 10^4 m^2. Inhalation of dust containing this concentration for one hour by truck crews, emergency personnel, or onlookers would result in an individual total-body dose of about 6.2 millirem and a dose to the lungs of about 180 millirem, assuming that resuspended particles are 0.3 micron in diameter. These doses are equivalent to less than two years of natural radiation exposure. Because the individuals are very unlikely to ever be involved in such an accident more than once in their life, the accident doses are not significant.

Inhalation of larger particles would result in smaller doses. For example, inhalation of 1-micron-diameter particles would result in doses about one-half as large as that estimated for 0.3-micron particles. Inhalation of 5-micron-diameter particles would result in doses about one-fifth as large. In reality, one would expect the resuspended dust to contain a mixture of particle sizes with many particles being greater than 0.3 micron in diameter and, thus, doses to be smaller than those given above.

Resuspended particulate matter in the air over the accident site would be further dispersed and diluted in the atmosphere as the plume moves away from the site. The extent of this dispersion would be dependent upon meteorological conditions at the time of the accident. Thus, with increasing time after an accident, individual exposures become lower.

Quality assurance will address all aspects of the packaging and shipping of the low-level radioactive waste to minimize or to prevent the loss of material in transportation accidents. Quality assurance will include required quality control to determine that the packaging meets the necessary quality of design and construction requirements. Before each shipment, quality control measures will include verification: (1) that the package is in an unimpaired physical condition; (2) that the bolted drum closure ring is properly installed, secured, and free of defects; and (3) tnat each special instruction for filling, closing, and preparation of the packaging for shipment has been followed. General quality control will include operating procedures and practices that will incorporate all other applicable requirements of 49 CFR Part 173.40. Shipment of radioactive materials will follow all applicable requirements of 49 CFR Part 177 ("Carriage By Public Highway") including routing, loading and unloading, rules for vehicles and shipments in transit, and accidents.

4.4 INTERIM SHIPPING OF SOLID WASTE

Shipment of compacted dry wastes to the Nevada Test Site will begin during the latter part of 1985. These wastes will also be transported in DOT-approved type 17H drums of 0.2-m^3 (55-gal) capacity. However, since the waste form is expected to be less dense than the form that will be produced after operation of the LLWPSS begins, the dose commitment to the truck crews and general population for each shipment will be proportionately less, possibly only 70% of the doses described in Sect. 4.3. However, more shipments will be required, and the annual dose commitments will be about the same.

Under accident conditions, pathways for ingestion and inhalation of radioactive or other hazardous dust is not expected to differ significantly from the pathways when the LLWPSS shipments are initiated. The principal mode of transfer will be from air-blown material in both cases. In neither case is it likely that the public will be exposed to significant amounts of radiation because the concentration of radionuclides is very low and measures will be taken under accident conditions by federal, state, and local emergency

personnel to remove spilled materials and to decontaminate the area as quickly as possible.

4.5 IMPACTS OF ALTERNATIVES

4.5.1 No Action

The no-action alternative consists of continued operation of the FMPC without adoption of the new waste management policy, including the LLWPSS and interim activities (Sect. 2.2.1). Additional on-site storage pits for both wet and dry wastes would eventually be needed. Development of the storage pits would result in incremental land use impacts, although not significant. Continued on-site pit storage of wastes also has the potential for increasing contamination of the groundwater supply on and adjacent to the FMPC site (see Sect. 3.1.7.3). This aspect of the no-action alternative is deemed most important since groundwater contamination would be a long-term problem. However, there would be little change in the radiation exposures to employees or the general population resulting from the continued on-site storage of unprocessed wastes.

4.5.2 On-site Storage of Processed Wastes

This alternative consists of storing the processed wastes in an on-site storage facility such as silos and warehouses, thus eliminating usage of the storage pits (Sect. 2.2.2). On the basis of lowest cost, minimum space requirement, and better shielding for the radioactive wastes, concrete silos (above ground to eliminate interaction with groundwater) are the preferred structures for storage. Compared to the proposed action, on-site storage of processed wastes would eliminate the principal impacts associated with cross-country waste shipment (routine or accidental radiation exposure of the public) and with waste disposal at the Nevada Test Site (land use and personnel radiation exposure). At the FMPC site, this alternative would eliminate the

potential for further groundwater contamination associated with the current operation and the no-action alternative, and would probably reduce population radiation exposures because of improved control and containment of dust during storage. Land use impacts may be greater for aboveground storage facilities of processed wastes than for the no-action alternative, but only in the sense of on-site area committed.

4.5.3 Rail Shipment of Processed Wastes

Shipment of wastes to the Nevada Test Site by rail and truck combination (see Sect. 2.2.3) has the following advantages over full-distance trucking: (1) number of shipments would be reduced if larger quantities are shipped on a railcar; (2) accidental spillage (low probability) is less likely to affect humans because of lower populations along rural rights-of-way, where potential accidents are more probable than in urban areas; (3) dose commitments to short-haul truck crews are far less than for full-distance truck crews; and (4) dose commitment to the general public is less because of the lower population along railroad rights-of-way, but only if inner-city routes can be avoided.

It has been estimated that railcar shipment of 40 drums of U_3O_8 results in a population exposure of 2×10^{-5} person-rem/km per railcar shipment[11]. Following the methodology outlined in Sect. 4.3.1 for truck shipment, rail transport of the FMPC waste (60 drums per rail car) would require 320 railcar shipments/year of about 3,300 km, which would result in an annual population exposure of about 21 person-rem. In this case, however, the crew would receive only 1% (0.2 person-rem) of the total, the handlers of the waste drums would receive about 90% (19 person-rem), and the population along the route would receive about 9% (1.8 person-rem).

Disadvantages of rail shipments of these wastes include: (1) reduced flexibility in selecting alternate routes after shipment of a given railcar load has begun, (2) reduced administrative control of individual shipments by the shipper and carrier organizations, and (3) greater ecological impact of accidental spillage if larger quantities are shipped on a railcar than on a truck.

The environmental advantages and disadvantages of rail shipment of low-level radioactive materials probably have less influence in selecting or rejecting this transportation alternative than does economics, which is most often evaluated on a case-by-case basis. Current examples of rail transport of radioactive materials are occasional deliveries of U_3O_8 from domestic uranium mills in the Rocky Mountain area to a UF_6 production plant at Metropolis, Illinois,[9,17] and shipment of foreign-supplied U_3O_8 from U.S. seaports to Paducah, Kentucky[9]. Recognition by rail carriers that the FMPC radioactive waste is similar to U_3O_8 may someday result in competitive freight rates from rail carriers for the FMPC wastes.

4.5.4 Disposal Sites

Major disposal sites for low-level wastes generated by the DOE are located at the Los Alamos National Laboratory (LANL), the Idaho National Engineering Laboratory (INEL), the Nevada Test Site, the Oak Ridge Reservation, the Hanford Reservation, and the Savannah River Plant (Table 4.1). Wastes contaminated with low levels of uranium have been disposed of at each of these sites in shallow trenches. Table 4.1 lists 1982 data on the estimated total usable burial area and the annual waste volumes buried at the sites.

Burial of the estimated 4,350 m^3 of drummed FMPC waste at the LANL, INEL, and Oak Ridge sites (if at all possible) would have a significant impact on the waste operations at the sites because of the much larger volumes that would have to be accomodated. Specifically, based on 1982 data (Table 4.1), the increase in annual waste volume would be 86% for the LANL site, 132% for the INEL site, and 305% for the Oak Ridge site. The annual increase for the remaining sites would be much less: <10% for the Nevada Test Site, 34% for the Hanford site, and <28% for the Savannah River Plant. Moreover, the Oak Ridge, Hanford, and Savannah River sites are in the process of developing new waste disposal facilities to generally improve waste management operations and to provide additional disposal capacity. The time of availability of these new disposal areas for the FMPC wastes, if they could accomodate the additional waste, is unknown. Based on these data, it appears that the Oak Ridge Reservation, which is nearest to the FMPC, would be the least preferable disposal site.

Table 4.1 Status of DOE low-level waste disposal sites as of 1982

	Disposal Site Size (ha)	Estimated Total Usable Burial Area (ha)	Volume of Waste Burial Annually ($10^3 m^3$)	Climate	Distance From FMPC (km)
Los Alamos National Laboratory	36.4	24.7	4.6	Arid	2300
Idaho National Engineering Laboratory	35.6	31.6	3.0	Arid	3040
Nevada Test Site	42.5	a	39.2	Arid	3273
Oak Ridge Reservation	27.5	5.8	1.3	Humid	470
Hanford Reservation	>405	b	11.6	Arid	3630
Savannah River Plant	78.8	72.7	22.4	Humid	1240

[a]The availability of land that could be used for shallow-land burial is not clearly defined because of the classified nature of the site. A land usage factor is not applicable at the Nevada Test Site because of the abundance of potentially usable land.

[b]There appears to be no problem in designating additional land for shallow-land burial as it is needed.

Source: Department of Energy, Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/NE-0017/2, September 1983. Adapted from Tables 4.2 and 4.17.

The lower shipping distances (and thus lower shipping costs and potential environmental impacts enroute) would favor the Oak Ridge and Savannah River sites and to a lesser extent the Los Alamos site over the Nevada Test Site (preferred alternative). However, the potential long-term environmental impacts of disposal (contamination of groundwater) would favor the arid sites (Table 4.1) over the humid Oak Ridge and Savannah River sites. The potential environmental impacts of low-level waste disposal in shallow trenches are deemed much more significant (particularly in humid locations) than the relatively insignificant consequences of low-level waste transportation (Sect. 4.3). Hence, because of the lower transportation distance, only the arid Los Alamos site would offer an apparent advantage over the Nevada Test Site. This advantage, however, is not overriding since the transportation impacts associated with shipment to the Nevada Test Site are relatively small, and the total distance from FMPC to the Los Alamos National Laboratory is about 70% of the distance to the Nevada Test Site.

4.5.5 Improved Waste Forms

The only alternative waste form that has been identified for shipment from the FMPC is a concrete-like grout formed by mixing the dry powder waste either with cement and water or with an organic polymer.[18] The principal advantage of this waste form is a virtual absence of measurable radiation dose to individuals at the scene of a transportation accident (drivers, emergency personnel, or onlookers) involving rupture of the waste containment drums because of a much lower dispersion factor for concrete-like waste form compared to that for the dry powder form.[19] There would be a reduced amount of low-level waste in each drum resulting in a lower radiation dose rate in the truck cab, thus lowering the dose to the drivers of each load. However, since the total annual low-level waste load is not changed, the annual doses to all affected groups would not be expected to change. Finally, the potential adverse effects on groundwater would be much lower because the leach rate of the low-level waste fixed in cement would be very low.

The major disadvantages of this alternative are (1) the additional on-site land used for a cement-waste mixing facility, (2) the potential for increased

occupational exposures at the mixing facility, (3) the increased number of shipments of waste, and (4) the increased volume of disposal space needed at the Nevada Test Site. Two studies have also shown that this alternative is not as cost-effective as the proposed action.[18,19]

5. LIST OF PREPARERS

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D. Fleming; M.S., Environmental Health	Dose calculations
T. Poff; M.S., Environmental Science	Waste Management
Department of Energy, Oak Ridge Operations	
D. R. Brown; M.S., Civil Engineering	Oversight of NEPA Review

6. REFERENCES

1. D. A. Fleming and K. N. Ross, Feed Materials Production Center, Environmental Monitoring Annual Report for 1983, NLCO-2018, NLO, Inc., August 1984. Cincinnati, Ohio.

2. Telephone communication from T. A. Poff, NLO, Inc., Cincinnati, Ohio, to N. E. Hinkle, Oak Ridge National Laboratory, Oak Ridge, Tenn., October 1984.

3. Draft Program Management Plan for FMPC Radioactive Waste Packaging/Shipping, sent to Doyle R. Brown, U.S. DOE, Oak Ridge, Tenn., by R. M. Spenceley, NLO, Inc., Cincinnati, Ohio, October 16, 1984.

4. Environmental Report of the Feed Materials Production Center, prepared by the BATTELLE Columbus Laboratories for NLO, Inc. Cincinnati, Ohio. January 1981.

5. R. M. Spenceley, NLO, Inc., Cincinnati, Ohio, letter with attachments to Johnnie B. Cannon, Oak Ridge National Laboratory, Oak Ridge, Tenn., December 7, 1984.

6. Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada, ERDA 1551, U.S. ERDA, September 1977.

7. Conceptual Design Report - Low-Level Waste Processing and Shipment System, Feed Materials Production Center, NLO, Inc., Cincinnati, Ohio (Management Review Issue). Prepared by Lockwood Greene Engineers, Inc., Oak Ridge, Tenn., for U.S. DOE, May 21, 1984.

8. Telephone communication from T. A. Poff, NLO, Inc., Cincinnati, Ohio, to N. E. Hinkle, Oak Ridge National Laboratory, Oak Ridge, Tenn., January 11, 1985.

9. Telephone communication from Ron Yates, Allied Chemical Company, Metropolis, Illinois, to N. E. Hinkle, Oak Ridge National Laboratory, Oak Ridge, Tenn., January 3, 1985.

10. Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants, WASH-1238, U.S. Atomic Energy Commission, December 1972.

11. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/NE-0017/2. Prepared by the Oak Ridge National Laboratory for the U.S. DOE, September 1983.

12. Draft Environmental Impact Statement, Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site, DOE/EA EIS-0109D, U.S. DOE, August 1984.

13. The Defense Waste Management Plan, DOE/DD-0015, U.S. DOE, June 1983.

14. Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes. NUREG-0170, Vol. 1, U.S. NRC, December 1977.

15. Telephone communication from Earl Rutenkroeger, Tri-State Motor Transit, Joplin,Missouri, to N. E. Hinkle, Oak Ridge National Laboratory, Oak Ridge, Tenn., January 15, 1985.

16. Telephone communication from Joe Sawyer, NUS Corp., Chicago, Illinois, to J. B. Cannon, Oak Ridge National Laboratory, Oak Ridge, Tenn., January 14, 1985.

17. Allied Chemical Application for Renewal of Source Material License SUB-526, UF_6 Conversion Plant, Allied Chemical Company, July 1982, Metropolis, Illinois.

18. R. M. Spenceley, NLO, Inc., Cincinnati, Ohio, letter with attachment to M. R. Theisen, U.S. DOE, Oak Ridge, Tenn., March 27, 1984.

19. Les Dole, Oak Ridge National Laboratory, letter to D. E. Large, U.S. DOE, Oak Ridge, Tenn., May 17, 1984.